DESCRIPTIONS OF NORTHEAST ASIA METALLOGENIC BELTS

By Sergey M. Rodionov[1], Alexander A. Obolenskiy[2], Elimir G. Distanov[2], Gombosuren Badarch[3], Gunchin Dejidmaa[4], Duk Hwan Hwang[5], Alexander I.Khanchuk[6], Masatsugu Ogasawara[7], Warren J. Nokleberg[8], Leonid M. Parfenov[9], Andrei V. Prokopiev[9], Zhan V. Seminskiy[10], Alexander P. Smelov[9], Hongquan Yan[11], Yuriy V. V. Davydov[9], Valeriy Yu. Fridovskiy[12] , Gennandiy N. Gamyanin[9], Ochir Gerel[13], Alexei V. Kostin[9], Sergey A. Letunov[14], Xujun Li[11], Valeriy M. Nikitin[12], Vladimir V. Ratkin[6], Vladimir I. Shpikerman[15], Sadahisa Sudo[7], Vitaly I. Sotnikov[2], Alexander V. Spiridonov[14], Vitaly A. Stepanov[16], Fengyue Sun[11], Jiapeng Sun[11], Weizhi Sun[11], Valeriy M. Supletsov[9], Vladimir F. Timofeev[9], Oleg A. Tyan[9], Valeriy G. Vetluzhskikh[9], Koji Wakita[7], Yakov V. Yakovlev[9], and Lydia M. Zorina[14]

Edited by Sergey M. Rodionov[1], Alexander A. Obolenskiy[2], Zhan V. Seminskiy[10], Tatiana V. Bounaeva[14], and Warren J. Nokleberg[8]

[1] Russian Academy of Sciences, Khabarovsk
[2] Russian Academy of Sciences, Novosibirsk
[3] Mongolian Academy of Sciences, Ulaanbaatar
[4] Mineral Resources Authority of Mongolia, Ulaanbaatar
[5] Korean Institute of Geology, Mining, and Mineral Resources, Taejon
[6] Russian Academy of Sciences, Vladivostok
[7] Geological Survey of Japan/AIST, Tsukuba
[8] U.S. Geological Survey, Menlo Park
[9] Russian Academy of Sciences, Yakutsk
[10] Irkutsk State Technical University, Irkutsk
[11] Jilin University, Changchun
[12] Yakutian State University, Yakutsk
[13] Mongolian University of Science and Technology, Ulaanbaatar
[14] Russian Academy of Sciences, Irkutsk
[15] Russian Academy of Sciences, Magadan
[16] Russian Academy of Sciences, Blagoveschensk

Introduction and Companion Studies

The metallogenic belts of Northeast Asia are herein synthesized, compiled, described, and interpreted with the use of modern concepts of plate tectonics, terranes and overlap assemblages, and mineral deposit models. The data supporting the compilation are: (1) comprehensive descriptions of mineral deposits; (2) compilation and synthesis of a regional geodynamics map the region at 5 million scale with detailed explanations and cited references; and (3) compilation and synthesis of metallogenic belt maps at 10 million scale with detailed explanations and cited references. These studies are part of a major international collaborative study of the *Mineral Resources, Metallogenesis, and Tectonics of Northeast Asia* that was conducted from 1997 through 2002 by geologists from earth science agencies and universities in Russia, Mongolia, Northeastern China, South Korea, Japan, and the USA.

Several companion studies, that are part of the study of NE Asia, are closely related to this paper. These companion studies are: a detailed geodynamics map of Northeast Asia (Parfenov and others, 2003); a compilation of major mineral deposit models (Rodionov and Nokleberg, 2000; Rodionov and others, 2000; Obolenskiy and others, 2003b); a series of mineral deposit location and metallogenic belt maps (Obolenskiy and others, 2003A); and a database on significant metalliferous and selected nonmetalliferous lode deposits, and selected placer districts (Ariunbileg and others, 2003).

Metallogenic belts are characterized by a narrow age of formation, and include districts, deposits, and occurrences. The metallogenic belts are synthesized for the main structural units of the North Asian Craton and Sino-Korean Craton, framing orogenic belts that consist of collage of accreted tectonostratigraphic terranes, younger overlap volcanic and sedimentary rock sequences, and younger stitching plutonic sequences. The major units in the region are the North Asian Craton, exterior passive continental margin units (Baikal-Patom, Enisey Ridge, Southern Taymir, and Verkhoyansk passive continental margin units), the early Paleozoic Central Asian orogenic belt, and various Mesozoic and Cenozoic continental margin arcs. Metallogenic belts are interpreted according to specific geodynamic environments including cratonal, active and passive continental margin, continental-margin arc, island arc, oceanic or continental rift, collisional, transform-continental margin, and impact.

Previous metallogenic units published by various authors for studies of metallogenic zonation include this by Bilibin (1955) Itsikson and others (1965), Shatalov (1965), Itsikson (1973, 1979), Guild (1978), Scheglov (1980), Mitchell and Garson (1981). Radkevich (1982), Tomson (1988), Zonenshain and others (1992) Koroteev (1996), Parfenov and others (1999). Sukhov and others (2000), and Plyuschev (2001). These metallogenic units include: (1) planetary deposit-hosting province or planetary metallogenic belt ($\geq$1000 by 10^3 km^2); (2) deposit-hosting belt or metallogenic belt (150 to 1000 by 10^3 km^2); (3) deposit-hosting system or metallogenic system (40 to 150 by 10^3 km^2); (4) deposit-hosting zone or metallogenic zone (20 to 40 by 10^3 km^2); (5) deposit-hosting subzone or metallogenic subzone (2 to 20 by 10^3 km^2); and (6) ore district (0.4 to 2.0 by 10^3 km^2).

However, often determination of differences between some of these metallogenic units is difficult. Examples are metallogenic system versus metallogenic zone, or ore district versus deposit-hosting subzone. For this study, only a two simple terms are employed: metallogenic belt and contained district. Generally, the size of metallogenic belts is partly a function of the scale of the analysis. This study has synthesized and compiled metallogenic belts at 5 M scale.

In this study, a metallogenic belt is essentially the synonymous with the term *mineral resource tract* as originally defined by Pratt (1981) and used for assessment of mineral resource potential in the USA, as in exemplified in Luddington and Cox (1996). The metallogenic belt maps and underlying regional geologic (terrane and overlap assemblage maps) constitute a basic part of the three-part methodology of quantitative mineral resource assessment as described by Cox (1993) and Singer (1993, 1994).

Concepts and Problems for Synthesis of Metallogenic Belts

The following concepts are employed for the synthesis of metallogenic belts.

Mineral Deposit Association. Each mineral resource tract (or metallogenic belt) includes a single mineral deposit type or a group of coeval, closely-located and genetically-related mineral deposits types.

Geodynamic Event for Deposit Formation. Each metallogenic belt contains a group of coeval and genetically related deposits that were formed in a specific geodynamic event. Examples are collision, continental-margin arc, accretion, rifting, and others.

Favorable Geological Environment. Each metallogenic belt is underlain by a geological host rock and (or) structure that is favorable for a particular suite of mineral deposit types.

Tectonic or Geological Boundaries. Each mineral resource tract (or metallogenic belt) is usually bounded by favorable either stratigraphic or magmatic units, or by major faults (sutures) along which substantial translations have occurred.

Relation of Features of Metallogenic Belt to Host Unit. The name, boundaries, and inner composition of each metallogenic belt corresponds to previously define characteristics of rocks or structures hosting the deposits, and to a suite of characteristics for the group of deposits and host rocks.

With these definitions and principles, the area defined for a metallogenic belt is predictive or prognostic for undiscovered deposits. Consequently, the synthesis and compilation of metallogenic belts is a powerful tool for mineral exploration, land-use planning, and environmental studies.

For modern metallogenic analysis, three interrelated problems exist.

(1) What is the relation of geodynamics to regional or global metallogeny? As discussed by Zonenshain and others (1992) and Dobretsov and Kirdyashkin (1994), this problem includes the role of convective processes in mantle and mantle plumes, the global processes of formation of the continents and oceans, the dynamics of development of major tectonic units of the earth's crust, metallogenic evolution of the earth, and the role mantle processes in the origin of major-belts of deposits.

(2) What is relation of regional metallogeny to individual lithosphere blocks? As discussed by Guild (1978), Mitchell and Garson (1981), and Koroteev (1996), this problem includes the genesis of specific metallogenic belts as a function of specific geodynamic environments using the modem concepts of plate tectonics.

And (3) what is the relation of metallogeny to individual tectonostratigraphic terranes and overlap assemblages? As discussed by Nokleberg and others (1993, 1998) and Parfenov and others (1999), this problem includes the genesis of specific metallogenic belts in individual fault-bounded units of distinctive stratigraphy, defined as tectonostratigraphic terranes, and in younger overlapping assemblages often containing igneous rocks formed in continental margin or island arcs, along rift systems in continents, or along transform continental margins.

Methodology of Metallogenic Analysis, Key Definitions, Geologic Time Scale, and Time Spans

Methodology of Metallogenic and Tectonic Analysis

The compilation, synthesis, description, and interpretation of metallogenic belts of Northeast Asia is part of a intricate process to analyze the complex metallogenic and tectonic history of the region. The methodology for this type of analysis of consists of the following steps. (1) The major lode deposits are described and classified according to defined mineral deposit models. (2) Metallogenic belts are delineated. (3) Tectonic environments for the cratons, craton margins, orogenic collages of terranes, overlap assemblages, and contained metallogenic belts are assigned from regional compilation and synthesis of stratigraphic, structural, metamorphic, isotopic, faunal, and provenance data. The tectonic environments include cratonal, passive continental margin, metamorphosed continental margin, continental-margin arc, island arc, transform continental-margin arc, oceanic crust, seamount, ophiolite, accretionary wedge, subduction zone, turbidite basin, and metamorphic. (4) Correlations are made between terranes, fragments of overlap assemblages, and fragments of contained metallogenic belts. (5) Coeval terranes and their contained metallogenic belts are grouped into a single metallogenic and tectonic origin, for instance, a single island arc or subduction zone. (6) Igneous-arc and subduction-zone terranes, which are interpreted as being tectonically linked, and their contained metallogenic belts, are grouped into coeval, curvilinear arc-subduction-zone-complexes. (7) By use of geologic, faunal, and paleomagnetic data, the original positions of terranes and their metallogenic belts are interpreted. (8) The paths of tectonic migration of terranes and contained metallogenic belts are constructed. (9) The timings and nature of accretions of terranes and contained metallogenic belts are determined from geologic, age, and structural data; (10) The nature of collision-related geologic units and their contained metallogenic belts are determined from geologic data. And (11) the nature and timing of post-accretionary overlap assemblages and contained metallogenic belts are determined from geologic and age data.

Key Metallogenic and Tectonic Definitions

For the compilation, the following definitions are adapted from Coney and others (1980), Jones and others (1983), Howell and others (1985), Monger and Berg (1987), Nokleberg and others (1987, 1994a, c, 2001), Wheeler and others (1988), and Scotese and others (2001).

Accretion. Tectonic juxtaposition of two or more terranes, or tectonic juxtaposition of terranes to a craton margin. Accretion of terranes to one another or to a craton margin also defines a major change in the tectonic evolution of terranes and craton margins.

Accretionary wedge and subduction-zone terrane. Fragment of a mildly to intensely deformed complex consisting of varying amounts of turbidite deposits, continental-margin rocks, oceanic crust and overlying units, and oceanic mantle. Divided into units composed predominantly of turbidite deposits or predominantly of oceanic rocks. Units are interpreted to have formed during tectonic juxtaposition in a zone of major thrusting of one lithosphere plate beneath another, generally in zones of thrusting along the margin of a continent or an island arc. May include large fault-bounded units with a coherent stratigraphy. Many subduction-zone terranes contain fragments of oceanic crust and associated rocks that exhibit a complex structural history, occur in a major thrust zone, and possess blueschist-facies metamorphism.

Collage of terranes. Groups of tectonostratigraphic terranes, generally in oceanic areas, for which insufficient data exist to separate units.

Craton. Chiefly regionally metamorphosed and deformed shield assemblages of Archean and Early Proterozoic sedimentary, volcanic, and plutonic rocks, and overlying platform successions of Late Proterozoic, Paleozoic, and local Mesozoic and Cenozoic sedimentary and lesser volcanic rocks.

Craton margin. Chiefly Late Proterozoic through Jurassic sedimentary rocks deposited on a continental shelf or slope. Consists mainly of platform successions. Locally has, or may have had an Archean and Early Proterozoic cratonal basement.

Cratonal terrane. Fragment of a craton.

Continental-margin arc terrane. Fragment of an igneous belt of coeval plutonic and volcanic rocks, and associated sedimentary rocks that formed above a subduction zone dipping beneath a continent. Inferred to possess a sialic basement.

Deposit. A general term for any lode or placer mineral occurrence, mineral deposit, prospect, and (or) mine.

Island-arc terrane. Fragment of an igneous belt of plutonic rocks, coeval volcanic rocks, and associated sedimentary rocks that formed above an oceanic subduction zone. Inferred to possess a simatic basement.

Metallogenic belt. A geologic unit (area) that either contains or is favorable for a group of coeval and genetically-related, significant lode and placer deposit models. With this definition, a metallogenic belt is a predictive for undiscovered deposits.

Metamorphic terrane. Fragment of a highly metamorphosed or deformed assemblage of sedimentary, volcanic, or plutonic rocks that cannot be assigned to a single tectonic environment because the original stratigraphy and structure are obscured. Includes intensely-deformed structural melanges that contain intensely-deformed fragments of two or more terranes.

Metamorphosed continental margin terrane. Fragment of a passive continental margin, in places moderately to highly metamorphosed and deformed, that cannot be linked with certainty to the nearby craton margin. May be derived either from a nearby craton margin or from a distant site.

Mine. A site where valuable minerals have been extracted.

Mineral deposit. A site where concentrations of potentially valuable minerals for which grade and tonnage estimates have been made.

Mineral occurrence. A site of potentially valuable minerals on which no visible exploration has occurred, or for which no grade and tonnage estimates have been made.

Oceanic crust, seamount, and ophiolite terrane. Fragment of part or all of a suite of *eugeoclinal* deep-marine sedimentary rocks, pillow basalt, gabbro, and ultramafic rocks that are interpreted as oceanic sedimentary and volcanic rocks and the upper mantle. Includes both inferred offshore oceanic and marginal ocean basin rocks, minor volcaniclastic rocks of magmatic arc derivation, and major marine volcanic accumulations formed at a hotspot, fracture zone, or spreading axis.

Overlap assemblage. A postaccretion unit of sedimentary or igneous rocks deposited on, or intruded into, two or more adjacent terranes. The sedimentary and volcanic parts either depositionally overlie, or are interpreted to have originally depositionally overlain, two or more adjacent terranes, or terranes and the craton margin. Overlapping plutonic rocks, which may be coeval and genetically related to overlap volcanic rocks, link or stitch together adjacent terranes, or a terrane and a craton margin.

Passive continental margin terrane. Fragment of a craton margin.

Post-accretion rock unit. Suite of sedimentary, volcanic, or plutonic rocks that formed in the late history of a terrane, after accretion. May occur also on adjacent terranes or on the craton margin either as an overlap assemblage or as a basinal deposit. A relative-time term denoting rocks formed after tectonic juxtaposition of one terrane to an adjacent terrane.

Pre-accretion rock unit. Suite of sedimentary, volcanic, or plutonic rocks that formed in the early history of a terrane, before accretion. Constitutes the stratigraphy and igneous geology inherent to a terrane. A relative-time term denoting rocks formed before tectonic juxtaposition of one terrane to an adjacent terrane.

Prospect. A site of potentially valuable minerals in which excavation has occurred.

Significant mineral deposit. A mine, mineral deposit, prospect, or occurrence that is judged as important for the metallogenesis of a geographic region.

Subterrane. A fault-bounded unit within a terrane that exhibit similar, but not identical geologic history relative to another fault bounded unit in the same terrane.

Superterrane. An aggregate of terranes that is interpreted to share either a similar stratigraphic kindred or affinity, or a common geologic history after accretion (Moore, 1992). An approximate synonym is *composite terrane* (Plafker and Berg, 1994).

Tectonic linkage. The interpreted association of a suite of coeval tectonic units that formed in the same region and as the result of the same tectonic processes. An example is the linking of a coeval continental-margin arc, forearc deposits, a back-arc rift assemblage, and a subduction-zone complex, all related to the underthrusting of a continental margin by oceanic crust.

Tectonostratigraphic terrane. A fault-bounded geologic entity or fragment that is characterized by a distinctive geologic history that differs markedly from that of adjacent terranes (Jones and others, 1983; Howell and others, 1985).

Transform continental-margin arc. An igneous belt of coeval plutonic and volcanic rocks, and associated sedimentary rocks that formed along a transform fault that occurs along the margin of a craton, passive continental margin, and (or) collage of terranes accreted to a continental margin.

Turbidite basin terrane. Fragment of a basin filled with deep-marine clastic deposits in either an orogenic forearc or backarc setting. May include continental-slope and continental-rise turbidite deposits, and submarine-fan turbidite deposits deposited on oceanic crust. May include minor epiclastic and volcaniclastic deposits.

Geologic Time Scale and Time Spans

Geologic time scale units are according to the IUGS Global Stratigraphic Chart (Remane, 1998). For this study, for some descriptions of metallogenic belt and geologic units, the term *Riphean* is used for the Mesoproterozoic through Middle Neoproterozoic (1600 to 650 Ma), and the term *Vendian* is used for Neoproterozoic III (650 to 540 Ma).

According to the main geodynamic events and the major deposit-forming and metallogenic belt-forming events for Northeast Asia, the following twelve time spans are used for groupings of metallogenic belts.

Archean (> 2500 Ma)
Paleoproterozoic (2500 to 1600 Ma)
Mesoproterozoic (1600 to 1000 Ma)
Neoproterozoic (1000 to 540 Ma)
Cambrian through Silurian (540 to 410 Ma)
Devonian through Early Carboniferous (Mississippian) (410 to 320 Ma)
Late Carboniferous (Pennsylvanian) through Middle Triassic (320 to 230 Ma)
Late Triassic through Early Jurassic (230 to 175 Ma)
Middle Jurassic through Early Cretaceous (175 to 96 Ma)
Cenomanian through Campanian (96 to 72 Ma)
Maastrichnian through Oligocene (72 to 24 Ma)
Miocene through Quaternary (24 to 0 Ma)

Mineral Deposit Models

For descriptions of metallogenic belts, lode mineral deposits are classified into various models or types. Detailed descriptions are provided in the companion paper by Obolenskiy and others (2003B). The following three main principles are employed for synthesis of mineral deposit models for this study. (1) Deposit forming processes are close related to rock forming processes (Obruchev, 1928) and mineral deposits originate as the result of mineral mass differentiation under their constant circulation in sedimentary, magmatic, and metamorphic circles of formation of rocks and geological structures (Smirnov, 1969). (2) The classification must as understandable as possible for the appropriate user. And (3) the classification must be open so that new types of the deposits can be added in the future (Cox and Singer, 1986).

For this study, lode deposits are grouped into the hierarchic levels of metallogenic taxons according to such their stable features as: (a) environment of formation of host rocks, (b) genetic features of the deposit, and (c) mineral and (or) elemental composition of the ore. The six hierarchial levels are as follows.

Group of deposits
- Class of deposits
  - Clan of deposits
    - Family of deposits
      - Genus of deposits
        - Deposit types (models)

The deposit models are subdivided into the following four large groups according to major geological rock-forming processes: (1) deposits related to magmatic processes; (2) deposits related to hydrothermal-sedimentary processes; (3) deposits related to metamorphic processes; (4) deposits related to surficial processes and (6) exotic deposits. Each group includes several classes. For example, the group of deposits related to magmatic processes includes two classes: (1) those related to intrusive rocks; and (2) those related to extrusive rocks. Each class includes several clans, and so on. The most detailed subdivisions are for magmatic-related deposits because they are the most abundant in the project area. In the below classification, lode deposit types models that share a similar origin, such as magnesian and (or) calcic skarns, or porphyry deposits, are grouped together under a single genus with several types (or species) within the genus.

Some of the below deposit models differ from cited descriptions. For example, the Bayan Obo type was described previously as a carbonatite-related deposit. However, modern isotopic, mineralogical, and geological data recently obtained by Chinese geologists indicate that the deposit consists of ores that formed during the Mesoproterozoic in a sedimentary-exhalative process along with coeval metasomatic activity and sedimentary diagenesis of dolomite, and alteration. The sedimentary-exhalative process consisted of both sedimentation and metasomatism. Later deformation, especially during the Caledonian orogeny, further enriched the ore. Consequently, the Bayan Obo deposit type is related to sedimentary-exhalative processes, not to magmatic processes. However, magmatic processes also played an important role in deposit formation. This deposit model is part of the family of polygenetic carbonate-hosted deposits. Similar revisions are made for carbonate-hosted Hg-Sb and other deposit models.

Table 1. Hierarchial ranking of mineral deposit models.

Deposits related to magmatic processes
- Deposits related to intrusive magmatic rocks
  - I. Deposits related to mafic and ultramafic intrusions
    - A. Deposits associated with differentiated mafic-ultramafic complexes
      - Mafic-ultramafic related Cu-Ni-PGE
      - Mafic-ultramafic related Ti-Fe (±V)
      - Zoned mafic-ultramafic Cr-PGE
    - B. Deposits associated with ophiolitic complexes
      - Podiform chromite
      - Serpentinite-hosted asbestos
    - C. Deposits associated with anorthosite complexes
      - Anorthosite apatite-Ti-Fe-P
    - D. Deposits associated with kimberlite
      - Diamond-bearing kimberlite
  - II. Deposits related to intermediate and felsic intrusions
    - A. Pegmatite
      - Muscovite pegmatite
      - REE-Li pegmatite
    - B. Greisen and quartz vein
      - Fluorite greisen
      - Sn-W greisen, stockwork, and quartz vein
      - W-Mo-Be greisen, stockwork, and quartz vein
    - C. Alkaline metasomatite
      - Ta-Nb-REE alkaline metasomatite
    - D. Skarn (contact metasomatic)
      - Au skarn
      - Boron (datolite) skarn
      - Carbonate-hosted asbestos
      - Co skarn
      - Cu (±Fe, Au, Ag, Mo) skarn
      - Fe skarn
      - Fe-Zn skarn
      - Sn skarn
      - Sn-B (Fe) skarn (ludwigite)
      - W±Mo±Be skarn
      - Zn-Pb (±Ag, Cu) skarn
    - E. Porphyry and granitoid pluton-hosted deposit
      - Cassiterite-sulfide-silicate vein and stockwork
      - Felsic plutonic U-REE
      - Granitoid-related Au vein
      - Polymetallic Pb-Zn ± Cu (±Ag, Au) vein and stockwork
      - Porphyry Au

Porphyry Cu (±Au)
Porphyry Cu-Mo (±Au, Ag)
Porphyry Mo (±W, Bi)
Porphyry Sn
III. Deposits related to alkaline intrusions
A. Carbonatite-related deposits
Apatite carbonatite
Fe-REE carbonatite
Fe-Ti (±Ta, Nb, Fe,Cu, apatite) carbonatite
Phlogopite carbonatite
REE (±Ta, Nb, Fe) carbonatite
B. Alkaline-silisic intrusions related deposits
Alkaline complex-hosted Au
Peralkaline granitoid-related Nb-Zr-REE
Albite syenite-related REE
Ta-Li ongonite
C. Alkaline-gabbroic intrusion-related deposits
Charoite metasomatite
Magmatic and metasomatic apatite
Magmatic graphite
Magmatic nepheline
Deposits related to extrusive rocks
IV. Deposits related to marine extrusive rocks
A. Massive sulfide deposits
Besshi Cu-Zn-Ag massive sulfide
Cyprus Cu-Zn massive sulfide
Korean Pb-Zn massive sulfide
Volcanogenic Cu-Zn massive sulfide (Urals type)
Volcanogenic Zn-Pb-Cu massive sulfide (Kuroko, Altai types)
B. Volcanogenic-sedimentary deposits
Volcanogenic-hydrothermal-sedimentary massive sulfide Pb-Zn (±Cu)
Volcanogenic-sedimentary Fe
Volcanogenic-sedimentary Mn
V. Deposits related to subaerial extrusive rocks
A. Deposits associated with mafic extrusive rocks and dike complexes
Ag-Sb vein
Basaltic native Cu (Lake Superior type)
Hg-Sb-W vein and stockwork
Hydrothermal Iceland spar
Ni-Co arsenide vein
Silica-carbonate (listvenite) Hg
Trap related Fe skarn (Angara-Ilim type)
B. Deposits associated with felsic to intermediate extrusive rocks
Au-Ag epithermal vein
Ag-Pb epithermal vein
Au potassium metasomatite (Kuranakh type)
Barite vein
Be tuff
Carbonate-hosted As-Au metasomatite
Carbonate-hosted fluorspar
Carbonate-hosted Hg-Sb
Clastic sediment-hosted Hg±Sb
Epithermal quartz-alunite
Fluorspar vein
Hydrothermal-sedimentary fluorite
Limonite from spring water
Mn vein

Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) volcanic-hosted metasomatite
Polymetallic (Pb, Zn, Ag) carbonate-hosted metasomatite
Rhyolite-hosted Sn
Sulfur-sulfide (S, FeS_2)
Volcanic-hosted Au-base-metal metasomatite
Volcanic-hosted Hg
Volcanic-hosted U
Volcanic-hosted zeolite

Deposits related to hydrothermal-sedimentary processes
VI. Stratiform and stratabound deposits
Bedded barite
Carbonate-hosted Pb-Zn (Mississippi valley type)
Sediment-hosted Cu
Sedimentary exhalative Pb-Zn (SEDEX)
VII. Sedimentary rock-hosted deposits
Chemical-sedimentary Fe-Mn
Evaporate halite
Evaporate sedimentary gypsum
Sedimentary bauxite
Sedimentary celestite
Sedimentary phosphate
Sedimentary Fe-V
Sedimentary siderite Fe
Stratiform Zr (Algama Type)
VIII. Polygenic carbonate-hosted deposits
Polygenic REE-Fe-Nb deposits (Bayan-Obo type)

Deposits related to metamorphic processes
IX. Sedimentary-metamorphic deposits
Banded iron formation (BIF, Algoma Fe)
Banded iron formation (BIF, Superior Fe)
Homestake Au
Sedimentary-metamorphic borate
Sedimentary-metamorphic magnesite
X. Deposits related to regionally metamorphosed rocks
Au in black shale
Au in shear zone and quartz vein
Clastic-sediment-hosted Sb-Au
Cu-Ag vein
Piezoquartz
Rhodusite asbestos
Talc (magnesite) replacement
Metamorphic graphite
Metamorphic sillimanite
Phlogopite skarn

Deposits related to surficial proceses
XI. Residual deposts
Bauxite (karst type)
Laterite Ni
Weathering crust Mn (±Fe)
Weathering crust and karst phosphate
Weathering crust carbonatite REE-Zr-Nb-Li
XII. Depositional deposits
Placer and paleoplacer Au
Placer diamond
Placer PGE
Placer Sn
Placer Ti-Zr

REE and Fe oolite

Exotic deposits

Impact diamond

Tabular Descriptions for Sizes of Lode Deposits

Size categories for lode mineral deposits, adapted from Guild (1981), are listed below. These size categories define the terms *world class, large, medium, and small*. These size categories are used mainly in the parts of Table 1 on the lode deposits in the Russian Far East where specific tonnage and grade data are not yet available. The *small* category may include occurrences of unknown size. Units are metric tons (tones) of metal or mineral contained, unless otherwise specified.

Table 2. Size categories for lode mineral deposits, adapted from Guild (1981).

Metal	World Class >	Large >	Medium >	< Small
Antimony		50,000	5,000	
Barite ($BaSO_4$)		5,000,000	50,000	
Chromium (Cr_2O_3)		1,000,000	10,000	
Cobalt		20,000	1,000	
Copper	5 million	1,000,000	50,000	
Gold		500	25	
Iron (ore)		100,000,000	5,000,000	
Lead	5 million	1,000,000	50,000	
Magnesium ($MgCO_3$)		10,000,000	100,000	
Manganese (tons of 40% Mn)		10,000,000	100,000	
Mercury (flasks)		500,000	10,000	
Molybdenum	500,000	200,000	5,000	
Nickel	1 million	500,000	25,000	
Niobium-Tantalum (R_2O_5)		100,000	1,000	
Platinum group		500	25	
Pyrite (FeS_2)		20,000,000	200,000	
Rare earths (RE_20_3)		1,000,000	1,000	
Silver		10,000	500	
Tin		100,000	5,000	
Titanium ($Ti0_2$)		10,000,000	1,000,000	
Tungsten	30,000	10,000	500	
Vanadium	30,000	10,000	500	
Zinc	5 million	1,000,000	50,000	

ARCHEAN METALLOGENIC BELTS (> 2500 MA)

West Aldan Metallogenic Belt of Banded Iron Formation (BIF), and Au in Shear Zone and Quartz Vein Deposits (Belt WA) (Russia, Southern Yakutia)

This Archean to Paleoproterozoic metallogenic belt is hosted in the West Aldan granite-greenstone composite terrane (unit WA). The West Aldan belt contains large BIF deposits (banded magnetite quartzite), Au and Pt occurrences in greenstone belts, apatite-magnetite, magnetite-skarn, and zircon-ilmenite deposits. The age of BIF deposits is 3.0 to 2.7 Ga. The age of the Au occurrences is Late Archean and Paleoproterozoic. The main deposits are at Tarynnakh, Nelyuki, and Dagda (BIF) and at Lemochi and Olondo (Au in shear zone and quartz vein).

The West Aldan granite-greenstone composite terrane consists of linear greenstone belts composed of Archean metavolcanic and metasedimentary rock dated at 2.7 to 3.2 Ga that are intruded and surrounded by tonalite, trondhjemite gneiss, granite, and crystalline rocks. Units are metamorphosed under a wide range of temperatures and pressures, including granulite facies. Orthogneiss is composed mainly of tonalite, and trondhjemite and occurs in the Olekma complex that contains several large linear blocks separated by four longitudinal belts. The complex is about 300 km long and 30 km wide. The complex also contain greenstone slabs in the Subgan complex and the Kurulta granulite complex. Bounding the greenstone belts is blastomylonite. These various complexes and slabs form separate terranes and thereby the West Aldan terrane is a composite terrane.

Tarynnakh Banded Iron Formation Deposit

This deposit (Akhmetov, 1983; Gorelov and others, 1984; Bilanenko and others, 1986; Biryul'kin and others, 1990) consists of three deposits separated by gneissose granite, gneiss, and schist of varying composition. The deposits are dominated by fine-grained hornblende-actinolite-magnetite ferruginous quartzite. Cummingtonite-magnetite, chlorite-magnetite, and magnetite varieties also occur. Fe quartzite is interlayered with biotite-quartz and muscovite-sericite-quartz schist (sometimes with garnet, staurolite, kyanite, sillimanite, and andalusite) and quartzite in units ranging up to 1.4 to 3.3 km thick, as well as with amphibole-plagioclase schist and amphibolite that is 0.5 to 7 m wide and granitoid as thick as 0.2 to 8 m. Units are metamorphosed to epidote-amphibolite facies at moderate pressures. The deposits extend for 22.5 km and have a thickness of 330 m. The deposits dip predominantly west at high angles (60 to 90°). The structure of the bodies is mainly controlled by sublongitudinal faults. The deposit is large with estimated reserves of about 2 billion tonnes averaging 28.1% total Fe.

Charskoye Group of Banded Iron Formation (BIF, Superior Fe) Deposits

This group of deposits (Petrov, 1976; Myznikov, 1995; M.N. Devi and others, 1979, written commun.) occurs in the northern Chita Oblast on the left bank of the Chara River in the Kodar Ridge in the western Aldan Fe distict and comprises part of the western flank of Chara-Tokka Fe district. It extends along a submeridional trend for 185 km and is 50 km wide The main ferruginous quartzite deposits occur at Sulumatskoye, Severnoye, and Yuzhnoye, Nizhne Sakukan, Sakukannyrskoye, and Oleng-Turritakhskoye. The age of deposits is 2.6 to 2.5 Ga (Arkhangelskaya, 1998). The deposits form a cluster near a fault basin filled with highly metamorphosed Archean volcanogenic and clastic rocks that exhibit multiple granitization and ferruginous-siliceous metasomatism events (Myznikov, 1995). Ferruginous quartzite and other ferruginous-siliceous rocks in the Chara group occur along three submeridional-striking bands. The deposits consist of steeply dipping layers of magnetite. There are ten mineral types Fe deposits. The most characteristic are banded magnetite quartzite, biotite-hornblende-magnetite quartzite, massive magnetite, and hypersthene-magnetite schist. The deposit is large with an average grade of 28% Fe.

Olondo Au in Shear Zone and Quartz Vein Deposit

This deposit (Popov and others, 1990; Popov and others, 1997; Zhizhin and others, 2000; Smelov and Nikitin, in press) consists of quartz veins and massive carbonate and amphibole-quartz-sulfide metasomatite zones cutting metabasalt and meta-ultramafic rock of the Olondo greenstone belt. Au content of the metavolcanic host rocks increases with intensity of metasomatism to a maximum grade of 0.2 to 0.5 g/t. The deposits vary from a few centimeters to 10 to 15 m wide and dip steeply. The average grade is 3-5 g/t Au, up to 2.5 g/t Pt.

Origin and Tectonic Controls for West Aldan Metallogenic Belt

The belt is hosted in the West Aldan granite-greenstone composite terrane composed of linear greenstone belts composed of metavolcanogenic and sedimentary rock with isotopic ages of 2.8-3.2 Ga. These units are surrounded by tonalite-trondhjemite gneiss, granite, and highly metamorphosed (up to the granulite facies) crystalline rock. The BIF deposits (magnetite quartzite) occur in stratiform layers and lenses in metabasalt and amphibolite, and less frequently in siliceous metavolcanic rock and schist. The BIF deposits are interpreted as forming in a back-arc basin and (or) island arc. The Au occurrences are mainly in shear zones that cut metabasalt, amphibolite, and ultramafic rock, and are interpreted as forming during amalgamation of terranes at about 2.6-2.5 Ga or during later Paleoproterozoic tectonic events.

REFERENCES: Arkhipov, 1979; Bilanenko and others, 1986; Gorelov and others, 1984; Popov and others, 1997; Parfenov and others, 2001.

Sutam Metallogenic Belt of Banded Iron Formation (BIF) Deposits (Belt ST) (Russia, Aldan-Stanovoy Shield)

This Archean metallogenic belt occurs in the southern part of the Central Aldan granulite-orthogneiss superterrane in the Sutam high-temperature and high-pressure granulite-paragneiss terrane. The age of the belt is interpreted as Archean (>2500 Ma). Gneiss in the Sutam terrane is dated at 2.5 to 3.0 Ga. The main BIF deposit is at Olimpiyskoe. Most of the terrane (60%) consists of paragneiss in the Seim Group and the rest (40%) is granite-and enderbite-gneiss. The Seim Group consists mainly (80%) of garnet-biotite gneiss and plagiogneiss, sometimes with sillimanite and cordierite, and lesser hypersthene-biotite, two-pyroxene, and diopside-amphibole plagiogneiss. Also occurring are quartzite, calc-silicate rock, and coarse-grained marble. The rest of the group (20%) consist of two-pyroxene, two-pyroxene-amphibole, and rarely olivine-two-pyroxene schist and magnetite quartzite. Sm-Nd isotopic ages for paragneiss parental rock range from 2.5 to 2.9 Ga whereas for orthogneiss range up to 3.0 Ga. Coeval metamorphism occurred after 2.5 Ga. The upper age limit of the early granulite metamorphism of the Seim Group rocks is constrained by the time of formation of garnet-biotite roddingite gneiss along the Seim thrust with Rb-Sr isotopic ages of 2.28±0.06 Ga (Gorokhov and others, 1981). The belt contains BIF composed of magnetite quartzite related to mafic and ultramafic rock. Most extensively studied is the Olimpiyskoe deposit (Kadensky, 1960; Nikitin, 1990).

Olimpiyskoe Banded Iron Formation (BIF, Superior Fe) Deposit

This deposit (Nikitin, 1990) consists of eleven lenticular deposits of medium-and coarse-grained banded hypersthene-magnetite quartzite. The deposits occur in an area that is 11 km long and ranges from 3 to 4 km wide and contains two rock groups. The first and main group consists of magnetite-hypersthene and magnetite-two mica gneiss interbedded with amphibole-two mica and magnetite-two mica-plagioclase schist in the core of an aniform. The Fe ore horizon with magnetite and hypersthene-magnetite quartzite occurs in the outer part of the antiform. The second-group occurs in the core of a synform and consists of feldspar quartzite interlayered with garnet-and sillimanite quartzite. Beds of diopside-bearing rocks and coarse-grained marble also occur. Occurring in the second-group rocks is a Fe horizon of magnetite hypersthene and spessartine-magnetite hypersthene. The deposits vary from 0.5 to 4 km thick and 20 to 200 m long. The deposit is large with resources of 500 million tonnes of Fe to a depth of 300 m, and 900 million tonnes to a depth of 500 m.

Origin and Tectonic Controls for Sutam Metallogenic Belt

Two rock groups containing BIF occur in the Sutam belt. The first is magnetite-hypersthene and magnetite-two pyroxene gneiss interbedded with amphibole-two pyroxene and magnetite-two pyroxene-plagioclase schist. The Fe deposit horizon consisting of magnetite and hypersthene-magnetite quartzite occurs in the outer part of the antiform. The second rock group consists of feldspar quartzite interlayered with garnet-and sillimanite-bearing varieties. Beds of diopside-bearing rocks and coarse-grained marble also occur. Related to the second rock group is another Fe ore horizon containing magnetite hypersthene and garnet-magnetite hypersthene. Two rock groups together form a highly metamorphosed greenstone sequence.

REFERENCES: Parfenov and others, 1999; Kadensky, 1960; Nikitin, 1990; Gorokhov and others, 1981; Dook and others, 1986; Khil'tova and others, 1988; Parfenov and others, 2001.

Sharizhalgaiskiy Metallogenic Belt of Banded Iron Formation and Talc (magnesite) Replacement Deposits (Belt Shz) (Russia, East Sayan)

This Archean metallogenic belt occurs in the Sharyzhalgay tonalite, trondjemite-gneiss and Onot granite-greenstone terranes of the North Asian Craton that is partly overlapped by the Riphean and Paleozoic sedimentary rocks. The belt occurs in the southeastern part of East Sayan Mountains in the Sharyzhalgay uplift, extends for over 150 km and is 50 km wide. The betl is controlled by the Major Sayan and branches of the Tochersky faults. The Sharyzhalgay terrane consists of biotite and biotite-hornblende gneiss, schist, amphibolite, and biotite-hypersthene and biotite-two pyroxene gneiss, granulite, ferruginous quartzite, and coarse-grained marble. The sedimentary rock of the terrane are metamorphosed to glanulite and amphibolite facies. The Sharyzhalgay series in the Sharyzhalgay terrane has U-Pb, Rb-Sr, and Sm-Nd isotopic ages ranging from 2.42 to 3.12 Ga. The Onot granite-greenstone terrane is a fragment of a greenstone belt composed calc-alkaline bimodal metavolcanic rock overlapped by metamorphosed sedimentary rock that are metamorphosed to biotite and garnet-biotite gneiss, sillimanite schist, ferruginous quartzite, and dolomite with interbedded amphibolite, magnesite rock and talc rock. Sedimentary rock of the Onot terrane are dated as Paleoproterozoic. The deeply metamorphosed sequences in the Sharyzhalgay uplift host numerous of ferruginous quartzite deposits in East Sayan Fe district (Uchitel and others, 1966). The major deposits are the Kitoy group of occurrences, the Onot group of deposits, and deposits at Sosnovy Baits, Baikalskoye, and Savinskoye.

Savinskoe Talc (magnesite) Replacement Deposit

This deposit (Baranov and others, 1971; Poletaev, 1973; Scherbakov and Poletaev, 1977; Romanovich and others, 1982; Urasina and others, 1993) occurs on the western side of the Onot graben containing Paleoproterozoic volcaniclastic and carbonate sedimentary rock. Commercial magnesite deposits are hosted in a suite of biotite-amphibole schist, magnesian limestone, dolomite, and amphibolite. The deposits occur along a major fault that extends over over 25 km. The deposit is large with reserves of about 300 million tones and resources of 2.5 billion tonnes. Magnesite is coarse crystalline.

Origin and Tectonic Control for Sharizhalgaiskiy Metallogenic Belt

Some deposits (Kitoy group and Baikalskoye deposit) occur in the Archean sequences, whereas others (Onot group-Sosnovy Baits deposits) occur in the Proterozoic sequences (Mikhailov, 1983). The bedded form of ferruginous quartzite and spatial location in the beds of two-pyroxene schist are interpreted as the results of metamorphism of ferruginous volcanic and sedimentary sequences (Uchitel, 1967; Shafeev and others, 1977).

REFERENCES: Baranov and others, 1971; Mikhailov, 1983; Poletaev, 1973; Romanovich and others, 1982; Urasina and others, 1993; Uchitel, 1967; Uchitel and others, 1966; Shafeev and others, 1977; Scherbakov and others, 1977.

Yanbei Metallogenic Belt of Metamorphic Graphite Deposits (Belt YB) (North-Central China)

This Late Archean metallogenic belt is hosted in marine clastic and carbonate sedimentary basins in a granulite-paragneiss sequence in the southeastern Erduos terrane in the Sino-Korean Craton. The belt formed during sedimentation and subsequent regional metamorphsim associagted with folding and thrusting. This metallogenic belt occurs in the Yanbei area in northeastern Shanxi Province, is100 km long, and ranges up to 30 km wide.

Graphite deposits occur in the Upper Jining Group and are hosted in metamorphosed sedimentary rock. The significant deposit in the belt is Xinghe.

Xinghe Metamorphic Graphite Deposit

This deposit (Lu Liangzhao and others, 1996) occurs in multiple layers that are strongly controlled by folding. The deposits are usually stratiform, lensoid, and hook-shaped. A single deposit is generally 100 to 600 m, up to 1000 m long, 4 to 40 m thick, and averages 20 m thick. Deposits are concordant to host rocks, are trend east-west, but locally changeto northeast and northwest trends, and dip from 50 to 60 degrees. The primary ores exhibit gneissic structure and of lepidoblastic texture, and are composed of graphite, plagioclase, quartz, microcline, biotite, and garnet. The fixed carbon in the ores is averages 2.5% to 5%, and locally up to 8.7%. The size of graphite flakes is usually 1 to 1.5 mm, and 0.027 to 0.054 mm thick. Graphite flakes the 2H hexagonal type. The degree of graphite formation is 0.85 to 1. The host strata are in the Khondalite of the Upper Jining Group. The deposit is large.

Origin and Tectonic Controls for Yanbei Metallogenic Belt

The southeastern Archean Erduos terrane that hosts the Yanbei metallogenic belt is derived form shallow marine clastic and carbonate sedimentary rock that formed along a Late Archean passive continental margin (Lu Liangzhao and others, 1996) and was regionally metamorphosed to granulite facies. The host rocks are part of the Late Archean Upper Jining Group that is part of a khondalite assemblage.

REFERENCES: Lu Liangzhao and others, 1996.

Jidong Metallogenic Belt of Banded Iron Formation (BIF, Algoma Fe) and Au in Shear Zone and Quartz Vein Deposits (Belt JD) (North China)

This Archean and Proterozoic metallogenic belt is hosted in a marine volcaniclastic sedimentary basin in the West Liaoning-Hebei-Shanxi terrane in the Sino-Korean Craton in the East Hebei Province. Major deposits are a BIF deposit at Shuichang and a Au in shear zone and quartz vein deposit at Jinchangyu. The belt formed during two events: volcanism and sedimentation; and regional metamorphism, up to granulite facies, associated with folding and thrusting. A large number of BIF deposits, including those of Shuichang, Miyun, Shirengou, and Sijiaying, and several Au deposits. The metallogenic belt trends east-west, is about 300 km long, and 50 km wide. The BIF deposits at Shuichang, Miyun, Shirengou, and some Au deposits are hosted in granulite facies supracrustal rocks of the Qianxi Group) whereas the Sijiaying BIF deposit is hosted in amphibolite facies supracrustal rocks of the Dantazi Group. The host rocks are derived from volcaniclastic and clastic sedimentary rock that formed ikn small volcaniclastic basins, or in aulacogens (Yan Hongquan, 1985).

Shuichang Banded Iron Formation (BIF, Algoma Fe) Deposit

This deposit (Zhang Yixia and others, 1986) occurs in the Qian'an iron mine that is part of two belts if BIF deposits, western and the eastern belts. The western belt is 15 km long, 2 km wide, extends in north-northeast, and contains the relatively large Shuichang deposit. The eastern belt is relatively small. The two belts are occur in different parts of a complicated fold. The Shuichang deposit consists of multiple layers of stratiform and lensoid deposits. The average thickness of a single deposit is 10 m and locally ranges up to 170 to 300 m. The ores are mainly banded with minor laminations. Locally paragneiss structures occur. The main minerals are coarse-grained magnetite and quartz, and minor pyroxene and garnet. Host rocks are granulite facies biotite microgneiss, sillimanite gneiss derived from mafic volcanic rock, intermediate volcanic graywacke, felsic volcanic graywacke, and muddy siltstone that formed in a moderately deep Archean volcanic and sedimentary basin. Rb-Sr isotopic age of the sequence is more than 3,500 Ma. The deposit is large and contains reserves of greater than 100 million tonnes, ranging from 20 to 35% Fe.

Sijiaying Banded Iron Formation (BIF, Algoma Fe) Deposit

This deposit (Zhang Yixia and others, 1986; Wu Huikang, 1993; Wu Jiashan and others, 1998) consists of multiple stratiform deposits in host rocks of biotite microgneiss, K-feldspar microgneiss, and minor intercalated amphibolite, quartzite, and marble. The deposit occurs in a gently-dipping anticline and syncline. Fe minerals are mainly laminated, minorly banded and massive, and are composed of fine-grained magnetite and quartz. Some parts of the deposit are composed of hematite, with minor actinolite, tremolite, amphibole, and sulphides. The host strata are Archean amphibolite facies metamorphic derived from mafic volcanic lava, felsic volcanic graywacke, felsic volcanic graywacke and carbonates that formed in a deep marine basin. The BIF belt is 25 km long and trends north-south. The deposit is large and contains reserves of 2,200 million tonnes grading 30% Fe, and locally up to 50% Fe.

Jinchangyu Au in Shear Zone and Quartz Vein Deposit

This deposit (Zhang Yixia and others, 1986; Xu Enshou and others, 1994; Wu Jiashan and others, 1998) consists of fine and dense Au-bearing quartz veinlets that occur parallel to schistosity in mylonite, and in veinlets and disseminations in mylonite. The ore minerals are mainly composed of pyrite and minor chalcopyrite, chalcocite, gold, and calaverite. Gangue minerals are albite, quartz, sericite and minor chlorite and calcite. Host rock alterations are albite, silica, sericite, chlorite, pyrite, and carbonate alteration. The deposit occurs in a tonalite, trondhjemite, and granodiorite terrane in the North China Platform. Host rocks are derived from mafic volcanic rock, volcanic graywacke, and BIF that were were metamorphosed into granulite, pyroxene gneiss, and amphibolite. The isotopic age of the metamorphic rock is 3.5 Ga. The metamorphosed supracrustal rocks are interpreted by some workers as a greenstone belt. Shearing and retrograde metamorphism at greenschist facies probably occurred at 2.5 to 2.6 Ga, 1.7 to 1.8 Ga., or later. Widely overprinted Jurassic and Cretaceous magmatism modified the deposits and some workers interpreted these deposits as related to Mesozoic magmatism. Hart and others(2002) show that three ages for white mica from the Jinchangyu deposit exhibit argon loss and a decrease in apparent age from approximately 204 to 180 Ma, thereby indicating an early Early Jurassic or older age for mineralization. The deposit is large with reserves of 19 tonnes and an average grade of 7.53 g/t Au.

Origin and Tectonic Controls for Jidong Metallogenic Belt

The BIF deposits are interpreted as forming in a volcanic and sedimentary basin that formed along an unstable protocontinental margin, or in a fragment of Archean craton (Zhang Yixia and others, 1986). The Au deposits are interpreted as forming during retrograde metamorphism to greenschist facies. Archean BIF deposits have a Rb-Sr isotopic age greater than 3,500 Ma. Proterozoic or younger ages for Au deposits are abased on isotopic ages of 2.5 to 2.6 Ga., 1.7 to 1.8 Ga., or younger values. The hoste Archean Liaoning-Hebei-Shanxi terrane contains the following maor units: (1) tonalite-trondhjemite and granodiorite; (2) gneiss and amphibolite; and (3) enderberite gneiss. The oldest U-Pb age of zircon of chrome mica in quartzite is 3,720 to 3,600 Ma (Wu Jiashan and others, 1998). Highly-metamorphosed supracrustal rocks comprise a minor part of the terrane, and are interpreted as forming an active continental margin (Lu Liangzhao and others, 1998).

REFERENCES: Zhang Yixia and others, 1986; Wu Jiashan and others, 1998; Hart and others, 2002.

Liaoxi Metallogenic Belt of Banded Iron Formation (BIF, Algoma Fe) and Au in Shear Zone and Quartz Vein Deposits (Belt LX) (Northeastern China)

This Archean metallogenic belt is hosted in marine volcaniclastic and sedimentary basins and greenstone belts of West Liaoning-Hebei-Shanxi terrane in the Sino-Korean Craton in the western Liaoning Province. The belt is 100 km long and ranges up to 50 km wide. BIF deposits occur in the Xiaotazhigou Formation of the Archean Jianping Group and are hosted in mafic volcanic rock and in mafic and felsic volcanic and sedimentary rock. Au deposits occurs in the Archean Jianping Group and are hosted in microgneiss and marble. The most significant deposits in the belt are the Baoguosi Fe and Paishanlou Au deposits.

Baoguosi Banded Iron Formation (BIF, Algoma Fe) Deposits

This BIF deposit (Xu Guangsheng, 1993) occurs in the middle member of the Xiaotazhigou Formation of the Archean Jianping Group. The formation consists of: (1) lower migmatitic biotite-plagioclase gneiss intercalated with plagioclase amphibolite and magnetite quartzite; (2) middle migmatitic biotite-plagioclase gneiss intercalated with granulite, magnetite quartzite and amphibolite; and (3) upper interbedded gneissic migmatite and migmatitic plagioclase amphibolite. The deposits are stratiform and layered. Mainly two types of ores exist. One type is magnetite quartzite type and the other is as hematite pseudomorph quartzite type. The deposit minerals are mainly of magnetite and quartz. Secondary minerals are hematite, pyrite, tremolite, actinolite, chlorite, and biotite. Typical deposit structures are gneissic, banded, and massive, and typical deposit textures are medium-to coarse-grained, crystalloblastic and xenomorphic granular crystalloblastic. Alterations are chlorite, biotite, sericite, and carbonate alteration. The deposits are interpreted as a metamophosed Archean sedimentary sequence. The deposit is large with an average grade of 33.78% Fe, 0.015% S, 0.01% P for magnetite quartzite; and 35.81% Fe, 0.015% S, and 0.01% P for hematite quartzite. Reserves are 107.9 million tonnes.

Paishanlou Au in Shear Zone and Quartz Vein Deposit

This deposit (Shen Baofeng and others, 1994) consists of 13 lensoid deposits that range up to 1000 m long along a mylonite schistosity. The shear zone trends east-west for 20 km and ranges from 2 to 4 km wide. The deposit in the shear zone is 3000 m long and 250 to 460 m wide and forms veinlets and disseminations in altered mylonite. The deposit minerals are gold, electrum, pyrite, and chalcopyrite, and the gangue minerals are quartz, feldspar, ankerite, sericite, chlorite, and others. The diameter of gold grain is 0.001 to 0.015 mm, and the average Au fineness is 929. Pyrite forms two stages. The early stage fine and Au-bearing and occurs along the mylonite schistosity. The late stage is coarse-grained, barren, and occurs as fine veinlets cutting the mylonite schistosity. The deposit alteration zones are: an internal zone of zone of pyrite and sericite; an intermediate zone of ankeritie; and an outer zone of chlorite. The host rocks are the Archean Jianping Group composed of microgneiss and marble. The Paishanlou deposit is the largest of several deposits that occur along the east-west-trending shear zone. The deposit is large with reserves of 25.88 tonnes Au and an average grade of 4.00 g/t Au.

Origin and Tectonic Controls for Liaoxi Metallogenic Belt

The belt is hosted in the Liaoxi greenstone belt. The BIF deposits are interpreted as as forming in a rift along a Late Archean continental margin (Shen Baofeng and others, 1994). The eastern Archean Liaoning-Hebei-Shanxi terrane (Liaoxi area) that hosts the Liaoxi metallogenic belt deposits consists of the following major units: (1) a greenstone belt (Xiaotaziguo, Dayinzi and Waziyiu formations; and (2) tonalite, trondhjemite-granodiorite, and others rocks. The Au depositsare interpreted as forming during retrograde metamorphism to greenschist facies and associated thrusting.

REFERENCES: Xu Guangsheng, 1993; Shen Baofeng and others, 1994.

Liaoji Metallogenic Belt of Banded Iron Formation (BIF, Algoma Fe), Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types), and Au in Shear Zone and Quartz Vein Deposits (Belt LJ) (Northeastern China)

This composite Late Archean metallogenic belt is hosted in marine volcaniclastic and sedimentary basins and greenstone belts of the Jilin-Liaoning-East Shandong terrane in the Sino-Korean Craton. The belt contains numerous BIF deposits in the Anshan-Benxi area, some volcanogenic Cu-Zn massive sulphides, and Au shear zone and BIF deposits in the Liaobei and Jiapigou areas. The belt extends northeast from the eastern Liaoning Province into the northeastern Jilin Province, and is about 1000 km long and 100 km wide. The deposits in the belt are hosted in the supracrustal rocks of the Anshan, Qingyuan, and Longgang Groups that are metamorphosed at amphibolite facies. These groups are derived from a sequence of mafic, intermediate, and siliceous volcanic rock and clastic sedimentary rock formed in small volcanic and sedimentary basins along an ancient continental margins. Because of the ancient geologic units and lack of detailed data, several mineral deposit types are combined into a composite belt. Large BIF deposits in Anshan-Benxi area have been the main source of ore for the Anshan Steel Company. The significant Fe deposit is at Gongchangling. The volcanogenic Cyprus Cu-Zn massive sulfide deposit at Hongtoushan well-known deposit. Au deposits in the Jiapigou area are related to ductile shear zones.

Gongchangling Banded Iron Formation Deposit (BIF, Algoma Fe)

This deposit (Cheng, Yuqi others, 1994) consists of several layers in host metamorphic rock of the Archean Anshan Group occur in a anticlinorium that was intruded and reworked during two periods of granite plutonism at about 2,100 to 2,300 Ma, and 1,700 to 1,900 Ma. The host metamorphic rocksx ared biotite microgneiss, amphibolite, mica schist, biotite gneiss, and garnet-chlorite schist that are derived form volcanic and sedimentary units. There are one to eight deposit beds, and individual deposit beds range from several meters to several tens of meters thick and from several hundred meters to 1 km long. Textures in the deposit layers are banded, paragneissic, and massive, and the ore minerals are coarse-grained magnetite, quartz and minor amphibole. Moderate amount of rich ores, with over 509% Fe consist mainly of magnetite, maghemitite, graphite, quartz, garnet, cummingtonite, pyrite, and pyrrhopyrite with mainly massive textures and local porous textures. There are two different interpretations for the origin of the Fe-rich ores: formation during hydrothermal reworking of lean ore, or enrichment of primary siderite (BIF) beds during regional metamorphism. The metamorphic age of the Anshan Group, that hosts the Gongchangling Fe deposit, 2,500 to 2,650 Ma. The age of the source rocks is probably older than 2,800 Ma (Cheng Yuqi, 1986). The deposit is large with reserves of 760 million tones and an average grade of 32.82% Fe.

Hongtoushan Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai type) Deposit

This deposit (Zhang Qiusheng and others, 1984a, b; Ge, Chaohua and others, 1989) consists of chimney, vein, and stratiform deposits hosted in the lower and middle parts of the Hongtoushan Formation of Archean Anshan Group. The Hongtoushan Formation consists of biotite-plagioclase-gneiss and amphibole-plagioclase gneiss, with intercalations of felsic gneiss and magnetite quartzite. Ore mainly consists of pyrite (50%), pyrrhotite (20%-30%), chalcopyrite (1%-10%), sphalerite (1%-15%), as well as small amount of galena, cubanite, and chalcocite. The ores are massive, brecciform, banded, and disseminated. Limited proximal wall rock alterations were developed, including silica alteration, sericite alteration, chlorite alteration, tremolitization and cordieritization. The deposit occurs at the southern margin of Tieling-Qingyuan uplift, north side of the Hunhe fracture zone. The deposit is medium-size with reserves of 471,500 tonnes Cu grading 1.72% Cu reserves of 688,400 tonnes grading 3.04% Zn.

Jiapigou Au in Shear Zone and Quartz Vein Deposit

This deposit (Xu Enshou and others, 1994) consists of sulphide-poor Au veins that occur in a northwest-trending belt that is concordant to a northwest-trending hosting shear zone. More than ten Au deposits occur in the northwest-trending shear zone that is 40 km long and ranges from 5 to 10 km wide. Ore minerals are pyrite, minor chalcopyrite, galena, sphalerite, scheelite, wolframite, pyrrhotite, siderite, and scarce sulfosalt minerals. Alterations consists of formation of quartz, sericite, carbonate, pyrite, and chlorite. Au/Ag ratio of the ores is high, and the Au fineness is 820. The deposit is hosted along the northern boundary of the Jilin-Liaoning-Shangdong tonalite, trondhjemite, granodiorite terrane of the North China Platform. The supracrustal rocks are mafic and intermediate volcanic rock and sedimentary rock metamorphosed to amphibole and local granulite facies. The oldest isotopic age is 3.0 Ga. Younger heating events occurred at mainly 2.5 to 2.6 Ga, and 1.9 to 1.6 Ga. Many workiers suggest that the supracrustals in the area comprise a greenstone belt (Cheng Yuming and others, 1996). The origin of the deposit is debated with some geologists interpreting the deposits as related to magmatism during the Hercynian and (or) Yanshan Orogeny. Hart and others (2002) show that the gold deposits in the Jiapigou district are about 220 Ma according to SHRIMP U-Pb zircon dating on syn-gold mineralization felsic dikes and ^{40}Ar-^{39}Ar dating on gold-related sericite (Y. Qiu, unpublished data, 2004).The deposit is large with reserves of 17 tonnes gold and an average grade of 5 to 10 g/t Au.

Origin and Tectonic Controls for Laioji Archean Metallogenic Belt.

The BIF and massive sulfide deposits in the belt are interpreted as forming during volcanism and sedimentation in an island arc. The Au shear zone deposits are interpreted as forming during retrograde metamorphism to greenschist facies. Shen Baofeng and others (1986) interpret that the greenstone belts in Northern Liaoning (Hunbei) area formed in a tectonic setting similar to of a modern active continental margin, while the greenstone belts in Anshan-Benxi and Jiapigou areas formed along a rift along a continental margins that was contemporaneous with regional metamorphsim, folding and thrusting. The Archean Jilin-Liaoning-East Shandong terrane that hosts the metallogenic belt consists of mainly of the following units: (1) tonalite, trondhjemite, granodiortie; and (2) gneiss and amphibolite. The major disticts in Anshan-Benxi area in the northern Liaoning and Jiapigou areas are hosted in the northern Liaoning and Jiapigou greenstone belts respectively. The U-Pb age of zircon in the trondhjemite (mylonite) is 3,804 Ma (Wu Jiashan and others, 1998). Hu Guiming and Wang Shoulun and others (1998) iinterpret the Jilin-Liaoning-East Shandong terrane as the Liaoji amalgamation terrane (block) that contains several small terranes. Some of these small terranes are interpreted as fragments of continental nuclei whereas others are interpreted as greenstone belts derived form oceanic crust.

REFERENCES: Cheng Yuqi, 1986; Shen Baofeng and others; 1986; Wu Jiashan and others, 1998; Hart and others, 2002.

Wutai Metallogenic Belt of Banded Iron Formation (BIF, Algoma Fe) Deposits (Belt WT) (North China)

This Archean metallogenic belt is hosted in marine volcaniclastic and sedimentary basins and greenstone belts of West Liaoning-Hebei-Shanxi terrane in the Sino-Korean Craton. The significant BIF deposits are at Baizhiyuan and Jinganku. This metallogenic belt occurs in the Wutaishan area in western Shanxi Province. The belt is is 200 km long and ranges up to 20 km wide. BIF deposits occur in the Baizhiyuan Formation and Jinganku Formation of the Wutai Group with isotopic ages of >2500 Ma). The host units are mafic and felsic volcanic rock, and sedimentary rock. The significant deposit is at Baizhiyuan.

Baizhiyan Banded Iron Formation (BIF, Algoma Fe) Deposit

This deposit (Shen Baofeng and others, 1994) consists of several stratiform layers that are concordant to the host amphibolite, mica schist and gneiss. Individual Fe layers are 30 to 50 m thick and range up to 3 to 5 km long. The ores are mainly banded and are composed of an oxide facies (magnetite and quartz), a silicate facies (magnetite, quartz, and grunerite), and a carbonate facies (siderite, ferrodolomite, and other minerals). The host units are part of the Late Archean Wutai Group that is derived from mafic and felsic volcanic rock, sedimentary rock, and canbyite formation in a greenstone belt regionally metamorphosed to greenschist facies. In the area of the deposit is a group of similar, moderate to large Fe deposits that occur in a northeast-trending belt. The deposit is large with reserves of 179.7 million tonnes with average grade of 33.31% Fe, 0.26% S, and 0.06% P.

Origin and Tectonic Controls for Wutai Metallogenic Belt

The Wutai greenstone belt that hosts the BIF deposits is interpreted as forming in an immature to mature island arc. The southwestern Archean Liaoning-Hebei-Shanxi terrane (Wutaishan area) that hosts the Wutai metallogenic belt of BIF deposits consists of the following major units: (1) greenstone belts consisting of fine-grained biotite gneiss, plagioclase amphibolite, metamorphosed ultramafic rock; chlorite schist, chlorite-albite schist, plagioclase quartzite, quartzite, and phylllite (Wutai Group); and (2) tonalite, trondhjemite, and granodiorite. The Wutai greenstone belt is interpreted as forming in a rift along a continental margin (Shen Baofeng and others, 1994). However, Luo Hui and Li Zenhui (1986) interpret the Wutai greenstone belt and related BIF deposits as forming in an immature to mature island arc.

REFERENCES: Hui and Li Zenhui, 1986; Shen Baofeng and others, 1994.

PALEOPROTEROZOIC METALLOGENIC BELTS (2500 to 1600 MA)

Uguy-Udokanskiy Metallogenic Belt of Zoned Mafic-Ultramafic Cr-PGE (± Cu, Ni, Au, Co, Ti, or Fe), Sediment-Hosted Cu, and Ta-Nb-REE Alkaline Metasomatite Deposits (Belt UU) (Russia, Aldan-Stanovoy Shield)

This Paleoproterozoic metallogenic belt is hosted in the West Aldan cratonal terrane and Kodar-Udokan basin. The belt occurs in the Olekma-Vitim Mountains along the Kalar, Udokan and Kodar ridges, and Udokan, Verkhne-Kalar and Verkhne-Chara basins. The belt extends for 250 km and ranges from 25 to 225 km. The Western Aldan cratonal terrane, known in Transbaikalia as the Chara block, consists of a 12-km-thick sequence of schist, gneiss, quartzite, local marble and amphibolite, and zones of granitized and metamorphosed volcanic and sedimentary rock, mafic and ultramafic intrusions, plagiogranite gneiss, plagiogranite, granite, migmatite and metasomatite (Chechetkin and others, 1995). The Paleoproterozoic Kodar-Udokan basin is composed of a 9 to 12 km thick sequence of carbonate and clastic units in the Paleoproterozoic Udokan complex, and metasomatic and intrusive granitoids and gabbros. The Udokan complex consists of: (1) carbonaceous sandstone and shale flysch (Kodar series); (2) variegated carbonate and siltstone and sandstone molasse (Chiney suite); and (3) variegated siltstone and sandstone molasse (Kemensky series). Sedimentary rocks are regionally and contact metamorphosed during granitization and variable-age magmatic events including: migmatitic granite of Kuandinsky complex, Kodar complex granitoids, and dikes; gabbro, anorthosite, and norite of the Chiney complex; alkaline metasomatite of the Katuginsky complex (all Proterozoic); ultramafic, mafic, and alkaline rocks of the Paleozoic Ingamakit-Sakunsky complex in the Baikal rift system; Mesozoic alkaline granitoids and nepheline syenite magmatic units in the Transbaikalia sedimentary and volcanic-plutonic belt. The major sediment-hosted Cu deposits, that occur in part of the Olekma-Vitim Cu metallogenic province, are at Burpalinskoye, Krasnoye, Udokan, Pravo-Ingamakit, Sakinskoye, Sulbanskoye, and Unkurskoye. The major zoned mafic-ultramafic Cr-PGE (± Cu, Ni, Co, Ti, or Fe) deposit is at Chiney, and the major This Nb-REE alkaline metasomatite deposit is at Katuginskoye that is related to the Paleoproterozoic Kuandinsky migmatite and granite complex, and REE deposits related to the Paleoproterozoic Kadar granitoid complex. The belt is fairly promising for Cu, Ti, Ni, V, Pt, Au, Ni, Ta, and REE deposits.

Udokanskoye Sediment-Hosted Cu Deposit

This deposit (Chechetkin, and others, 1985, 1995; Volodin and others, 1994) occurs in the Kodar-Udokan basin and has an isotopic age of 2.0 to 1.8 Ga (Arkhangelskaya, 1998). The sedimentary rock of the Udokan complex in the basin contain Cu-bearing stratigraphic layers at Chitkandinsky, Alexandrovsky, Sakukansky, Ikabiisky, and Neminginsky. The Cu layers are composed of quartz sandstone with lenses and beds of calcareous sandstone, siltstone, and argillite. These layers are concordant with host rocks and extend from several hundred m to a few kilometers and up to 21.4 km at the Udokan deposit. Deposits occur in beds, parting, lenses, and nests. Ore minerals occur as disseminations, veinlets, nests, semi-massive, and massive. The main ore minerals are chalcocite, covellite, bornite, chalcopyrite, pyrite, and pyrrhotite. Also occurring are Pb, Zn sulfides, and native gold and silver (Chechetkin and others, 1995). The deposit size is unknown and has an average grade of 1.86-2.43% Cu, 13.6 ppm Ag, 0.51 ppm Au, 0.0004% Tl.

Usuu Sediment-Hosted Cu Deposit

This deposit (Davydov and Chiryaev, 1986) consists of Cu occurrences in the Goruoda Formation that extends for 25 km along the eastern flank of the Uguy basin. The formation exhibits lagoonal and bar facies. Three thick horizons of Cu deposits occur. The lower horizon contains carbonate rock and sandstone. The deposit consists of rare Cu-sulfides in disseminations. The middle horizon contains quartz sandstone bearing, and more abundant Cu-sulfides in disseminations. Thickness of the horizon ranges locally up to 60 m with Cu grades of up to 1%. The upper horizon contains disseminated Cu-sulfides in brecciated sandy dolomite and cross-bedded sandstone with a carbonate matrix. The upper horizon is 84 m thick, and Cu grade is 0.11 to 1%. Ore minerals are chalcopyrite, bornite, chalcocine, and pyrite, with subordinate magnetite and hematite, and rare fahlore, covellite, galena, and native copper. Hypergeneic malachite, azurite, and chrysocolla also occur. The deposit is small.

Chineyskoye Zoned Mafic-Ultramafic Cr-PGE (± Cu, Ni, Co, Ti, or Fe) Deposit

This deposit (Melnikova and others, 1983; Gongalsky and others, 1995) occurs in the Chiney stratified gabbro and anorthosite pluton in the Chiney complex bearing that contains both Ti-Fe-V, Cu, and PGE deposits (Gongalsky and others, 1995). The Chiney pluton occurs at an intersection of sublatitudinal system of faults along the southern margin of the Kodar-Udokan basin and the northwestern-striking faults along the margin of the Kodar-Udokan zone. Cu sulfides occur in (1) thin laminated Ti magnetite; (2) highly alkaline rocks in the endocontact of the pluton; (3) leucogabbro; (4) sandstone; (5) skarn; and (6) tectonic zones. Chalcopyrite is predominant (90%). Occurring are endocontact disseminations (pyrrhotite-chalcopyrite, pyrite-chalcopyrite), and exocontact disseminations and masses (pyrrhotite-chalcopyrite, bornite-chalcopyrite and chalcopyrite). Ores minerals are pentlandite, sphalerite, minerals of linnaeite, arsenides, and sulfoarsenides. Disseminated Cu sulfides (1-3%) occurs in all varieties units of the Chineisky massif. The deposit is large with an average grade of 0.40-16.75% Cu, 0.1-72.0 ppm Pt; 1-255 ppm Pd; 0.15-9.60 ppm Au, 0.027-0.260% Ni; 0.005-0.01% Co.

Katuginskoye Ta-Nb-REE Alkaline Metasomatite Deposit

This deposit (Beskov, 1995; Sobachenko, 1998) contains Zr and cryolite and has an isotopic age of 2.0 to 1.6 Ga (Arkhangelskaya, 1998). The deposit is related to the Katuginsky alkaline metasomatite complex that occurs along a thick structural zone at the junction of Archean Stanovik and Paleoproterozoic Kodar-Udokan structures. The structural zone contains major faults and numerous ruptures, intrusive and extrusive rock of various compositions and with a wide range of metamorphic facies (greenschist to granulite), and granitoids formed by palingenesis, granitization, and alkaline metasomatism. The alkaline-granite REE metasomatite deposits formed during the latter event (Arkhangelskaya, 1974). The deposit consists of microcline-albite-quartz metasomatite with finely impregnated REE minerals. Deposit is divided into two blocks (Western and Eastern) by a northeast-striking fault. The eastern block is uplifted 400 m relative to the western block. In plan view, the ore body is triangular with outcrops of rocks elongated in western and southeastern directions. The internal structure of metasomatite bodies is conformable with structure of enclosing gneiss and schist. The thickness of metasomatites in Eastern body is 600 m, and Western body is over 900 m. Dark mineral assemblages are biotite, biotite-riebeckite, riebeckite-arfvedsonite, arfvedsonite-aegirine varieties of microcline-albite-quartz metasomatite. The main ore minerals are pyrochlore, zircon, rare-earth fluorite, gagarinite, and cryolite. The content of pyrochlore increases 10-fold from biotite through arfvedsonite to arfvedsonite-aegirine metasomatites (from 700 to 63,100 ppm). Chemical composition and REE concentrations (Ta, Nb, TR, Zr) indicate a deep, possibly mantle origin of solution forming alkaline metasomatites and associated economic REE deposit. The deposit is large.

Origin and Tectonic Controls for Uguy-Udokanskiy Metallogenic Belt

The Udokan basin that hosts this metallogenic belt contains thick (up to 10,000 m) clastic and minor carbonate rocks that are intrude by zoned mafic-ultramafic plutons and granite with isotopic ages of about 2.0 to 1.8 Ga. The rocks are deformed, folded, and zonally metamorphosed up to amphibolite facies. The Cr and PGE deposits that occur in zoned mafic-ultramafic plutons, and Cu deposits that occur in clastic sedimentary rocks are interpreted as forming along a passive continental-margin rift. The younger Ta-Nb-REE alkaline metasomatite deposits are interpreted as forming during later collision and intrusion of anatectic granite.

REFERENCES: Bogdanov and Apol'sky, 1988; Chechetkin and others, 1995; Arkhangelskaya, 1998; Parfenov and others, 1999, 2001.

Kalar-Stanovoy Metallogenic Belt of Au in Shear Zone and Quartz Vein Deposits (Belt KS) (Russia, Aldan-Stanovoy Shield)

This latitudinal Paleoproterozoic Kalar-Stanovoy metallogenic belt extends for 300 km along the Kalar tectonic melange zone and ranges up to 100 km wide. The isotopic age of the belt is about 2,000 Ma. The Kalar tectonic melange zone separates the West Aldan granite-greenstone terrane from the Tynda tonalite, trondhjemite, gneiss terrane to the south. The zone consists of extensive, major thrust and strike-slip faults and companion folds, and contains a large number of tectonic slabs that differ in composition, age, and metamorphic grade. Examples of tectonic slabs are granulites in the Khani-Kurul'ta, Zverev, and Iengra blocks, orthogneiss (tonalite and trondhjemite), anorthosite, granite, and Archean and Paleoproterozoic greenstone belts. The metallogenic belt contains numerous Au occurrences, as at Pravokabaktanskoe and Namarskoe, and deposits, as at Ledyanoe and Skalistoe, that are related to diaphthorite formed in Archean and Paleoproterozoic rocks. Also occurring are Ti-magnetite and apatite occurrences and deposits in mafic and ultramafic rock.

Ledyanoe Au in Shear Zone and Quartz Vein Deposit

This deposit (Glukhovsky and others, 1993; Koshelev and Chechyotkin, 1996; Moiseenko and Eirish, 1996) occurs in shear zone and quartz vein and mineralized zones in blastomylonite that cut retrograded Paleoproterozoic gabbro and anorthosite, leucocratic anorthosite and rare melanocratic anorthosite, charnockite, and pegmatoid granitoid. The veins vary from 0.2 to 0.5 to 4 m thick and are 2 km long. The deposit occurs in an area with dimensions 6 by 3 km. The veins are concordant with blastomylonite, and dip both steeply south and north. Wallrock blastomylonite is cut by quartz and carbonate veinlets that comprise 15 to 30% rock volume. The veins consist of white saccharoidal cavernous quartz and sulfides (pyrite, and rare chalcopyrite, galena, sphalerite, pyrrhotine) that comprise 5% rock volume. Grade ranges from 11.7-30 g/t Au.

Origin andTectonic Controls for Kalar-Stanovoy Metallogenic Belt

The belt interpreted as forming during the collision between Tynda and West Aldan terranes in Aldan-Stanovoy region and during subsequent collapse of orogenic belt. The cause of collision was amalgamation of terranes during the formation of the North Asia Craton. Au deposits occur shear zones that cut metamorphosed mafic and ultramafic and plutonic rock..

REFERENCES: Fedorovskiy, 1972; Beryozkin, 1977Koshelev and Chechyotkin, 1996; Moiseenko and Eirish, 1996;; Bushmin and others, 1983; Dook and others, 1986; Rudnik, 1989; Jahn and others, 1990; Kovach and others, 1995b; Parfenov and others, 1999, 2001.

Amga-Stanovoy Metallogenic Belt of Au in Shear Zone and Quartz Vein Deposits (Belt AS) (Russia, Aldan-Stanovoy Shield)

This Paleoproterozoic metallogenic belt is related to Amga tectonic melange zone and has an isotopic age of about 2000 Ma. The belt is 600 km long and 75 km wide and consists of tectonically juxtaposed blocks and sheets of Archean and Paleoproterozoic rock complexes with varying degrees of metamorphism. The Au deposits occur mainly in zones with blastomylonite and diaphthorite formed in mafic and ultramafic rock. Some zones consist of actinolite-plagioclase schist with carbonate minerals and biotite Au grade ranges up to 1.0 to 2.0 g/t. Zones of blastomylonite developed in granitoid contain concordant quartz veins with low sulfide deposit with grades that range up to 10 g/t Au (Popov and others, 1999). Large Au deposits are not known.

Origin and Tectonic Controls for Amga-Stanovoy Metallogenic Belt

The belt is interpreted as forming during the collision of the West-Aldan and Tynda composite terranes and the Central Aldan superterrane in the Aldan-Stanovoy region and during subsequent collapse of orogenic belt. The reason for collision is unclear. The Au deposits occur in shear zones that cut metamorphosed mafic, ultramafic, and other plutonic rocks.

REFERENCES: Parfenov and others, 1999, 2001; Popov and others, 1999.

Upper Aldan Metallogenic Belt of Piezoquartz Deposits (Belt UA) (Russia, Aldan-Stanovoy Shield)

This Late Paleoproterozoic metallogenic belt is hosted in the Nimnyr granulite-orthogneiss terrane in the Central Aldan superterrane. The piezoquartz deposits occur in quartzite in high-alumina gneiss and mafic schist. Two rock crystal districts occur: the Upper Aldan (Perekatnoye deposit) and Upper Timpton (Bugarykta deposit).

Perekatnoye Piezoquartz Deposit

This deposit (Dorofeev and others, 1979) consists of piezoquartz quartzite in high-alumina gneiss and mafic schist. The rock crystal deposits tend to occur at rupture intersections, and in fold flexures and periclines. They form single veins that range from 0.5 to 2 m thick and 20 to 30 m long, and veins that range from 1 to 30 m thick with an average of 5 to 15 m, and lengths of a few tens of meters to 400 m, with an average of 100 to 200 m. Most important are pipe veins and stockworks that are a few tens of meters across. The veins consist of rock crystal or smoky quartz, clay in voids, K-feldspar, and rare crystals of hematite, chlorite, sericite, tourmaline, albite, epidote, and adularia. Rock crystals occur on void walls or in lower parts of the voids in clay. The voids occur in quartz veins, at contacts of veins and the host rocks, or in adjacent host rocks that are altered to sericitie, chlorite, and epidote. The deposits cut Paleoproterozoic metadiabase dikes, and rock crystal clasts occur in Vendian conglomerate. The veins have K-Ar isotopic ages of 1830 to 1750 Ma. The deposit is large.

Origin and Tectonic Controls for Upper-Aldan Metallogenic Belt

The belt is interpreted as forming during a post-collisional tectonic event, possibly in a rift. Deposits occur in Late Archean and Paleoproterozoic piezoquartzite associated with high-alumina gneiss and mafic schist metamorphosed to granulite facies.

REFERENCES: Arkhipov, 1979; Parfenov and others, 1999, 2001.

Nimnyr Metallogenic Belt of Apatite Carbonatite Deposits (Belt NM) (Russia, Aldan-Stanovoy Shield)

This Paleoproterozoic metallogenic belt is related to carbonatite plutons in the Nimnyr orthogneiss and granite gneiss terrane in the Central Aldan superterrane. The age of the belt is interpreted as late Paleoproterozoic and has isotopic ages of 1800 to 1900 Ma. The main deposit is the Seligdar apatite carbonatite mineral deposit. The metallogenic belt extends longitudinally for 400 km in the northern Aldan-Stanovoy shield and is 40 km wide in the central part. The belt contains eleven deposits and occurrences related to carbonatite plutons.

Seligdar Apatite Carbonatite Deposit

This deposit (Smirnov, 1978; Entin and others, 1991) consists of apatite in an asymmetric carbonatite stock with dimensions of 2 by 1.02 km. At a depth of 1.6 km, the stock narrows to a few hundred square meters. The stock contains carbonatite composed of: apatite and carbonate; apatite, quartz, and carbonate; martite, apatite, quartz, and carbonate; martite, apatite, and carbonate; and quartz. Occurring in the periphery are apatite-quartz-feldspar metasomatite and tourmaline-K-feldspar-quartz metasomatite. Both early and late stage carbonatite occur. The early carbonatite occurs in veins, vein zones, and stockworks in a mafic complex and in crystalline basement of the Aldan-Stanovoy shield. Thickness of the veins varies from a few centimeters to 30 to 40 m and the length varies from a few meters to 500 m and rarely up to 1.5 km. The early carbonatite is mainly calcite rich with lesser feldspar, magnetite, serpentine, phlogopite, and apatite. The late carbonatite occur in dikes and stocks that intrude the early carbonatite, and consists of dolomite, anhydrite, apatite, quartz, chlorite, and lesser barite. Martite also occurs along with rare tourmaline, fluorite, sulfates, and apatite. A typical lithology consists of apatite-silicified rock with hematite that resembles jaspilite. The deposit is large with reserves of 1,616 million tonnes averaging 6.72% P_2O_5.

Origin and Tectonic Controls for Nimnyr Metallogenic Belt

The metallogenic belt is related to carbonatite that is interpreted as forming during interplate rifting. Deposits consist of apatite-carbonate, apatite-quartz-carbonate, martite-apatite-quartz-carbonate, and martite-apatite-carbonate and apatite-carbonate-quartz that is related to and hosted in asymmetrical carbonatite stocks.

REFERENCES: Smirnov, 1978; Entin and others, 1991; Parfenov and others, 1999, 2001.

Dyos-Leglier Metallogenic Belt of Fe Skarn Deposits (Belt DL) (Russia, Aldan-Stanovoy Shield)

This Paleoproterozoic(?) metallogenic belt is related to Nimnyr orthogneiss and granite gneiss terrane and Timpton-Uchur granulite-paragneisss terrane in the in Central Aldan granulite-orthogneiss superterrane. The isotopic age of the belt is interpreted as 1.9 Ga. The major Fe skarn deposits are at Tayozhnoe, Dyosovskoe, and Emeldzhak. The metallogenic belt extends 400 km in southwest-northeast accross the Nimnyr and Timpton-Uchur terranes. The major deposits are in the South Aldan and Emeldzhak districts. The South Aldan Fe district occurs in the central part of the Aldan-Stanovoy shield, about 80 to 130 km north of the Berkakit railway station, and contains the Leglier, Dyos, and Sivagli groups of deposits that comprise 32 Fe skarn deposits and occurrences. The largest are at Tayozhnoe and Dyosovskoe. The Emeldzhak district occurs in the northeastern part of the Dyos-Leglier metallogenic belt, extends over an area of 100 by 25 sq. km, and contains several phlogopite-magnetite deposits and occurrences in Paleoproterozoic amphibole-diopside gneiss, coarse-grained marble, and biotite gneiss. These deposits are genetically related to magnesian skarn.

Dyosovskoe Fe Skarn Deposit

This deposit (Biryul'kin and others, 1990) consists of Fe skarn that extend sublatitudinally for 20 km and range from 1-3 km wide. The Fe ore horizon occurs in three parallel synforms overturned to the N that dip at 30-70° and are complicated by larger folds and zones of longitudinal thrust and strike-slip faults. Structures causes sharp variations in thickness of ore horizon both along strike and downdip. Thickness of Fe ore bodies varies from 1 to 40 m. Diopside-magnetite and serpentine-magnetite are predominate. Deposit is metamorphosed to amphibolite facies. Deposit and host rock contain irregularly distributed pyrite, pyrrhotite, and chalcopyrite in disseminations. The deposit is large with resources of 700 million tonnes ore, with concentrate grading 66.7% Fe and Mn, and 0.43% Cu and Co. Impurities are 1.11% S, 0.12% P, 0.02% Zn.

Tayozhnoe 2 Fe Skarn Deposit

This deposit (Bilanenko and others, 1986; Biryul'kin and others, 1990; Kovach and others, 1995a, 1995b) is 200 m thick and consists of magnetite skarn, magnesian skarn, amphibole-diopside rock, coarse-grained marble, and biotite gneiss of Paleoproterozoic age with an isotopic age of 2.3 to 2.1 Ga. Subjacent rocks are amphibole gneiss and schist, and the overlying rocks are high-alumina and quartz gneiss. Metamorphic rocks are intruded by metamorphosed ultramafic rock and metagabbro, and diorite. Host rocks are metamorphosed to granulite facies. In plan the deposit is horseshoe shaped, curved to the northwestern, and in section forms a recumbent synform that dips steeply southwest. Concordant and en-echelon deposits are 2 km long and range from 10 to 100 km thick. The major sulfides are pyrite, pyrrhotite, and chalcopyrite. Some layers contain ludwigite and ascharite. Gangue minerals are diopside, olivine, chinohumite, salite, hornblende, and phlogopite in various combinations. The deposit is large with resources of 1.2 billion tonnes grading 20-60% Fe with an average grade of 39.8% Fe, 2.12% S, and 0.1% P_2O_5.

Origin and Tectonic Controls for Dyos-Leglier Metallogenic Belt

The belt is interpreted as forming during a late-stage or post-collisional tectonic event. Deposits consist of magnetite skarn, magnesian skarn, amphibole-diopside rock, calciphyre, and biotite gneiss that are metamorphosed to amphibolite facies. Host rocks are amphibole gneiss and schist and high-alumina gneiss and quartzite-gneiss that are intruded by metamorphosed ultramafic rock, gabbro, and diorite that are metamorphosed to granulite facies. Deposits range from concordant to en-echelon.

REFERENCES: Arkhipov, 1979; Bilanenko and others, 1986; Kovach and others, 1995a, 1995b; Parfenov and others, 1999, 2001.

Timpton Metallogenic Belt of Phlogopite Skarn Deposits (Belt TM) (Russia, Aldan-Stanovoy Shield)

This Paleoproterozoic metallogenic belt is related to replacements in Nimnyr orthogneiss and granite gneiss terrane in Central Aldan superterrane and in the eastern Amga tectonic melange zone. The age of the belt is interpreted as Paleoproterozoic (about 2000 Ma). The metallogenic belt extends for 250 km and ranges from 250 km wide to the south and to 50 km to the north. The phlogopite deposits and occurrences occur mainly in Paleoproterozoic diopside and phlogopite-diopside schist, marble, and coarse-grained marble that are metasomatized into coarse-grained phlogopite-diopside skarn with isotopic ages of 1.9 to 1.8 Ga. Some deposits and occurrences are in synforms along fold hinges and centroclinals, and the cores of superposed transverse folds. Several dozen phlogopite deposits and prospects occur in the belt. The length of the deposits ranges from 0.7 to 2.5 km and the width from 0.2 to 0.5 km. The deposits contain several parts, each consisting with two or more phlogopite zones with thicknesses from a few meters to several tens of meters, and lengths from 10 to 20 m to several hundreds of meters. The main deposit is at Nadyozhnoe.

Nadyozhnoe Phlogopite Skarn Deposit

This deposit (Biryul’kin and others, 1990; Kovach and others, 1995a, 1995b) consists of phlogopite occurring in Paleoproterozoic diopside and phlogopite-diopside schist, marble, and coarse-grained marble that are metasomatized into coarse-grained phlogopite-diopside skarn with isotopic ages of 1.9 to 1.8 Ga. The deposit occurs on the northern limb of a latitudinal synform, extends for 5 km, and ranges from 100 to 150 km wide. Twenty mica-bearing zones occur that are concordant with host rocks. The zones vary from 20 to 200 m long and 3 to 12 m thick, and consist of skarn with phlogopite, diopside, hornblende, scapolite, apatite, and actinolite. Phlogopite forms nest-like accumulations varying in size from 0.5 to1 m to 1.5 to 6 m, with an average of 1 to 2 m. Phlogopite rarely occurs in thin veins. Phlogopite content ranges from 15 to 86.9 kg/m3. Almost all deposits are associated diopside-magnetite skarn. Local diopside and diopside-scapolite-plagioclase metasomatite contain molybdenite. The deposit is large with resources of about 7,000 tonnes grading 45.1 kg/m^3 phlogopite.

Origin and Tectonic Controls for Tympton Metallogenic Belt

The belt is interpreted as forming during a late-stage or post-collisional tectonic event. Deposits occur in diopside and phlogopite-diopside schist, marble, and calciphyre that are metasomatized into coarse-grained phlogopite-diopside skarn.

REFERENCES: Murzaev, 1974; Arkhipov, 1979; Parfenov and others, 1999, 2001.

Tyrkanda-Stanovoy Metallogenic Belt of Au in Shear Zone and Quartz Vein Deposits (Belt TS) (Russia, Aldan-Stanovoy Shield)

This Paleoproterozoic(?) metallogenic belt is hosted in the Tyrkanda tectonic melange zone between the East Aldan superterrane and Central Aldan superterrane. The zone consists of tectonic slabs of paragneiss and anorthosite that are bounded by narrow blastomylonite zones with local abundant granite bodies. The age of the belt is interpreted as 1.9 Ga. The belt extends for 700 km and varies from 20 to 150 km wide. The main deposit is the Au in shear zone Kolchedannyi Utyos deposit and the belt contains several Au occurrences.

Kolchedannyi Utyos Au in Shear Zone and Quartz Vein Deposit

This deposit (Karsakov and Romanovsky, 1976; Moiseenko and Eirish, 1996) consists of a northwestern-trending linear system that contains close-spaced quartz-pyrite veins with irregular, indistinct contacts. The veins are hosted in pyroxene, biotite-pyroxene, and hornblende-pyroxene gneiss and schist interlayered with amphibolite, marble, and garnet-and graphite-bearing rocks. The ore minerals occur in disseminations, masses, and local breccia, and are mainly pyrite (20 to 90%) with lesser chalcopyrite (5 to 15%), and magnetite, sphalerite, and pyrrhotine. Quartz (from 30 to 70%) occurs in honeycombed frameworks, veinlets and nests, and sometimes crystal druses. The deposits are separated by silicified barren gneiss and pegmatoid microcline-plagioclase metasomatite. At the surface, deposits are oxidized to limonite, lazurute, malachite, and jarosite. The average grade ranges from 1-2-120 g/t, Au, 6-20 g/t Ag, and locally up to 64.1 g/t Ag.

Origin and Tectonic Controls for Tyrkanda-Stanovoy Metallogenic Belt

The belt interpreted as forming during collision between the Tynda composite terrane and Central Aldan and East Aldan superterranes. The reason for collision is unclear. in the Aldan-Stanovoy region and during subsequent collapse of orogenic belt. Au shear zone deposits cut metamorphosed mafic and utramafic bodies and plutonic rocks.

REFERENCES: Karsakov and Romanovsky, 1976; Moiseenko and Eirish, 1996; Parfenov and others, 1999, 2001.

Davangra-Nalurak Metallogenic Belt of REE Placer Occurrences and Banded Iron Formation (BIF, Superior Fe) Deposits (Belt DN) (Russia, Aldan-Stanovoy Shield)

This Paleoproterozoic metallogenic belt is hosted in grabens filled with late Paleoproterozoic clastic and carbonate sedimentary rock. The belt occurs along the southern margin of the Sutam granulite-paragneiss terrane in the Central Aldan granulite-orthogneiss superterrane and in the Tyrkanda tectonic melange zone. The age of the belt is interpreted as late Paleoproterozoic. The belt occurs in the latitudinal Atugey-Nuyam and Davangra-Khugdin grabens filled with thick quartz sandstone, arkose, and gravelstone that are correlated with the Kebekta Formation in the Uguy graben to the west. Middle Proterozoic siltstone in the grabens contains concordant hematite beds that range from 0.3 to 3 m thick and extend for 40 km. The major deposit is at Atugey.

Various REE placer occurrences (Arkhipov, 1979) are hosted in in gravelstone and conglomerate in the the Atugey-Nuyam graben and range from 15 to 30 long and a few to 150 m thick. Monazite and zircon comprise up to 95% heavy mineral concentrates. Samples from the conglomerate and gravelstone horizons contain from 0.1 to 0.8% Ce, 0.01 to 0.1% Y, 0.03 to 0.05% La, 0.01 to 1% Tb, and up to 0.005% Nb.

Atugey Banded Iron Formation (BIF, Superior Fe) Deposit

This deposit (Klimov, 1979) consists of concordant beds of hematite that range from 0.3-3 m thick and extend for 40 km. The beds are interbedded with siltstone in the middle part of Proterozoic sandstone units in the Atugey-Nuyam graben. REE occurrences are in gravelstone and conglomerate horizons that range from 15-30 m long and vary from a few meters to 150 m thick. Principal minerals in the heavy fractions of rocks are monazite and zircon (up to 95%). Samples from the conglomerate-gravelstone horizons contain 0.1-0.8% Ce, 0.01-0.1% Y, 0.03-0.05% La, 0.01-1% Tb, and up to 0.005% Nb. Grade ranges from 29.6 to 70.7% Fe, 0.01 to 0.05% S, and 0.1 to 0.2% P_2O_5.

Origin and Tectonic Controls for Davangra-Nulurak Metallogenic Belt

The belt is interpreted as forming in grabens in a Precambrian intracratonic basin that formed during intracontinental rifting. Source rocks for REE minerals are interpreted as granitoids in the Central Aldan superterrane and alkalic volcanic rocks that erupted during rifting. Placer deposits occur in thick quartz and arkose sandstone, and gravelstone horizons.

REFERENCES: Arkhipov, 1979; Parfenov and others, 1999, 2001.

Uchur Metallogenic Belt of Phlogopite Skarn Deposits (Belt UH) (Russia, Aldan-Stanovoy Shield)

This Paleoproterozoic metallogenic belt is hosted in the Uchur granulite-paragneiss terrane in the northeastern Timpton-Uchur granulite-paragneiss terrane in the East Aldan superterrane. The age of the belt is interpreted as Paleoproterozoic (about 2000 Ma). Phlogopite skarn, and W and Mo skarn deposits and occurrences extend over a 50 by 70 km area and are hosted in diopside gneiss, marble, with ages of 2.3 to 2.1 Ga. Deposits occur in diopside and phlogopite-diopside schist, marble, and calciphyre that are metasomatized into coarse-grained phlogopite-diopside skarn. Some deposits are controlled by synforms and fold hinges, and cores of superposed transverse folds that were favorable for phlogopite. Deposits consist of phlogopite, diopside, hornblende, scapolite, apatite, and actinolite. Phlogopite generally occurs in masses and rarely as thin veins. Almost all phlogopite deposits are associated diopside-magnetite metasomatite. The major deposit is at Megyuskan.

Megyuskan Phlogopite Skarn Deposit

This deposit (Biryul'kin and others, 1990) consists of phlogopite skarn that occurs on the limbs of the Bas-Muguskan synform. The skarn forms lenticular bodies that are concordant with the host phlogopite-diopside and scapolite-diopside metasomatite. Several deposits vary from 4 to 12 m thick and extend up to 250 m length. Phlogopite forms veins and nests, and the size of phlogopite crystals is 30 to 40 cm. Most common defects are undulation, cracks, and intergrowths The phlogopite is low Fe with a light color. The deposit is large with resources of 7.5 thousand tonnes phlogopite with average content of 46 to 79 kg/m^3 phlogopite.

Origin and Tectonic Controls for Uchur Metallogenic Belt

The belt is interpreted as forming during a late-stage or post-collisional tectonic event as a result of collision between the Central Aldan and East Aldan superterranes. The reason for the collision is unclear.

REFERENCES: Parfenov and others, 1999, 2001.

Kavakta Metallogenic Belt of Magmatic and Metasomatic Apatite(?) (Belt KV) (Russia, Aldan-Stanovoy Shield)

This Paleoproterozoic(?) metallogenic belt occurs in the Amga tectonic melange zone. The belt extends latitudinally for 25 km and is 25 km wide. The belt contains apatite-Ti magnetite deposits that are hosted in Paleoproterozoic zoned mafic and ultramafic plutons. The age of the belt is interpreted as Paleoproterozoic. The major deposit is at Kavakta.

Kavakta Mafic-Ultramafic Related Ti-Fe (V) Deposit

This deposit (Stogniy and others, 1992) consists of apatite and Ti-magnetite hosted in the central part of a pluton with a core of dunite, peridotite, troctolite, and anorthosite, and a margin of of norite, magnetite-bearing gabbro and norite, and gabbro. The ultramafic rock contains sulphides, including pyrite, chalcopyrite, pyrrhotine, minor pentlandite, and rare mackinawite, cubanite, valleriite, violarite, and bornite. The pluton intrudes biotite and amphibole-biotite gneiss with bands and lenses of amphibolite. The host rocks are metamorphosed to amphibolite facies. The pluton contains two deposits. The first apatite and Ti magnetite body occurs in the northeastern part of the pluton and is 4.5 km long and about 1.5 km wide. The other deposit occurs in the western and southwestern parts of the pluton and is 0.5 to 10 km wide and extends for 5.25 km. The deposit is large with reserves of apatite & Ti magnetite ores are 5 billion tonnes grading 15% Fe, 3.6% TiO_2, 2.3% P_2O_5 , 0.06% V_2O_5.

Origin and Tectonic Controls for Kavakta Metalogenic Belt

The belt is interpreted forming during rifting related to break up of a hypothetical Late Archean continent at 2.5 to 2.3 Ga.

REFERENCES: Stogniy and others, 1992; Kislyi and Utrobin, 1994; Parfenov and others, 1999, 2001.

Baladek Metallogenic Belt of Anorthosite Apatite-Ti-Fe-P Deposits (Belt Bal) (Russia, Far East)

This early Paleoproterozoic metallogenic belt is hosted in Baladek cratonal terrane that consists chiefly of a crystalline basement complex and younger stratified units. The basement complex consists of anorthosite, gabbro and anorthosite, gabbro, gabbro and norite and pyroxenite. The anorthosite is intruded by granite and granodiorite. U-Pb isotopic age for igneous host rocks is about 1,700 Ma. Ti-P occurrences are related to anorthosite intrusions. No economic deposits are known. The major deposits are at Bogidenskoe and Gayumskoe.

Bogidenskoe Anorthosite Apatite Ti-P Deposit

This deposit (Panskikh and Gavrilov, 1984; Neimark and others, 1992) consists of densely disseminated, massive lenticular, and sheeted bodies that occur in strongly stratified, rhythmic layers in olivine gabbro, syenite, syenite, anorthosite, norite, and pyroxenite. The sheeted deposits extend over 10 km along strike. Ore minerals are alternating massive, spotted, and disseminated apatite-ilmenite, Ti-magnetite, and ilmenite. Apatite contains up to 2.4% F. Ti magnetite contains up to 21% TiO_2 and from 0.3 to 1.1% V_2O_5. Ilmenite contains up to 3.1% Fe_2O_3. U-Pb isotopic age for igneous host rocks is 1,700 Ma. Deposit occurs in the upper basins of the Bogide and Soroga Rivers. The deposit is large with apatite grade of 3 to 15% and average of 5.7% P_2O_5. Deposit contains an estimated 34.3 million tonnes P_2O_5 and extends to depth of 400 m.

Gayumskoe Anorthosite Apatite Ti-P Deposit

This deposit (Panskikh and Gavrilov, 1984; Neimark and others, 1992) consists of a group of closely-spaced, veined and stock-like bodies (nelsonite) of apatite, ilmenite, titanomagnetite in anorthosite that occurs in lenticular and irregular bodies of olivine gabbro, gabbro and pyroxenite, pyroxenite, and dunite. Apatite is a hydroxyl-F-bearing variety and contains up to 2.75% H_2O. Titanomagnetite contains from 3.8 to 21% TiO_2. Ilmenite is fairly oxidized and contains up to 2.5% Fe_2O_3. U-Pb isotopic age for igneous host rocks is 1,700 Ma. Deposit occurs in the upper reaches of the Gayum River. The deposit is large, average grade is 8.7% P_2O_5, locally up to 31.6% P_2O_5, and contains an estimated 40 million tonnes P_2O_5.

Maimakanskoe Anorthosite Apatite Ti-P Deposit

This deposit (Panskikh and Gavrilov, 1984; Neimark and others, 1992) consists of sparsely to densely disseminated, sheeted and lenticular, apatite-ilmenite-Ti magnetite deposits in olivine gabbro, gabbro and norite, gabbro and pyroxenite, and pyroxenite. Ore minerals are massive apatite, apatite-ilmenite, ilmenite, and apatite-ilmenite-Ti magnetite in steeply dipping (50 to 60°) in nelsonite veins that are hosted in coarse-grained anorthosite. The main ore minerals are apatite, ilmenite, and Ti magnetite and comprise up to 80% the deposit. Apatite contains F. Ti magnetite averages 13.6% TiO_2 and 0.37% V_2O_5. Ilmenite contains 6 to 7% Fe_2O_3. Apatite content ranges up to 50 to 60% in masses, but averages 15 to 20%. U-Pb isotopic age for igneous host rocks is 1,700 Ma. Deposit occurs in the upper reaches of the Maimakan River near Kendeke Spring, and occurs over an area of approximately 30 km^2. The deposit is large, contains an estimated 63 million tons P_2O_5, and extends to 400 m depth.

Dzhaninskoe Anorthosite Apatite Ti-P Deposit

This deposit (Panskikh and Gavrilov, 1984; Neimark and others, 1992) consists of sparsely disseminated apatite, ilmenite, and Ti magnetite in melanocratic olivine gabbro and pyroxenite that form stock-like bodies in anorthosite. Apatite contains up to 1.14% F. Ti magnetite contains up to 10.7% TiO_2 and 0.28% V_2O_5. Ilmenite contains 7.8% Fe_2O_3. U-Pb isotopic age for igneous host rocks is 1,700 Ma. Deposit occurs on the right bank of the Dzhana River near the mouth of the Kurung River. The deposit is large, has a low grade of up to 4% P_2O_5, contain an estimated 78 million tons P_2O_5, and extends to a depth of 400 m.

Origin and Tectonic Controls for Baladek Metallogenic belt

Anorthosite hosting the belt is interpreted as forming during interplate magmatism.

REFERENCES: Panskikh and Gavrilov, 1984; Neimark and others, 1992; Nokleberg and others, 1998, 1999, 2000, 2003; S.M. Rodionov, this study.

Mugursk Metallogenic Belt of Banded Iron Formation (BIF) Deposits (Belt MG) (southeastern Tuva, Altai-Sayan folded area, Russia)

This Paleoproterozoic metallogenic belt is hosted in the Sangilen passive continental margin terrane and occurs in southeastern Tuva in the Sangilen Upland. The belt extends latitudinally for 70 km and is hosted in Precambrian rocks with ferruginous quartzite. The base of the host Precambrian rock sequence consists of uniform mica-plagioclase gneiss about 3000 m thick with garnet, sillimanite, and amphibole. The BIF deposit is hosted in gneiss and quartzite-graphite-schist in the upper part of the sequence. Ferruginous quartzite deposits occur mainly in the Erzin River basin in the Erzin Fe district (Matrosov and Shaposhnikov, 1988) that contains the Mugurskoye, Aryskanskoye, and other deposits. The more prospective deposit is at Mugurskoye. Abundant staurolite gneiss and numerous occurrences of corundum hornfels are high-alumina and ferrous host rocks in the Sangilen terrane.

Mugurskoye Banded Iron Formation (BIF) Deposit

This deposit (Matrosov and Shaposhnikov, 1988)consists of steeply-dipping layers of ferrous quartzite hosted in Precambrian metamorphic rock. The enclosing host rocks are micaceous quartzite, biotite schist, amphibolite, marble, ferrous quartzite, graphite schist. Ore layer varies from 4 to 10 m thick, extends up to 8 km along strike, and is strongly corrugated into small folds. Deposit layers consist of magnetite quartzite, hematite-magnetite quartzite, amphibole-magnetite quartzite, garnet-amphibole-magnetite schist, and high magnetite layers. Major minerals are quartz, magnetite, hematite, amphibole, cummingtonite, and grunerite. Secondary minerals are garnet, apatite, biotite, plagioclase, and pyrite. S content ranges from is 0.1 to 0.3% (sometimes up to 1.5 to 2%), and P content ranges from 0.2 to 0.4% (sometimes up to 0.8 to 1.9%). The deposit is small with an average grade of 30 to 47% Fe.

Origin and Tectonic Controls for Mugursk Metallogenic Belt

The belt is interpreted as forming in Tuva-Mongolian microcontinent margin as a fragment of Laurasia. BIF deposits occur in metamorphosed Paleoproterozoic sedimentary rocks (Zonenshain and others, 1990; Berzin and others, 1994).

REFERENCES: Matrosov and Shaposhnikov, 1988; Zonenshain and others, 1990; Berzin and others, 1994.

Khan Hohii Metallogenic Belt of Banded Iron Formation (BIF) Deposits (Belt KH) (Northwestern Mongolia)

This Paleoproterozoic(?) metallogenic belt is hosted in the Khan Hohii and the North Songino fragments of the Baydrag cratonal terrane. The major group of occurrence is at Tomorchuluut and is hosted in Fe quarzite (Bahteev and others, 1984). These belt extends along an east-west trend for about 100 km long and is about 50 km wide.

Tomorchuluut Banded Iron Formation (BIF) Deposit

This deposit (Filippova, 1977; Bakhteev and others, 1984) consists of bodies of silica-magnetite lenses and layers in Paleoproterozoic gneiss and greenstone schist. Bodies trend northwest, are concordant with host rock, and occur in an area 2.5 by 0.2 km. Approximately 10 occurrences similar to, and in the vicinity of the deposit, occur in a horizon of amphibolite and schist, in an northeast-trending area that is 17 km long. The length of silica-magnetite bodies ranges from tens of m to 2,000 m, and thickness ranges from 5 to 60 m. Main ore mineral is magnetite. The deposit is small with resources of 18 million tonnes magnetite grading 24-41% Fe.

Origin and Tectonic Controls for Khan Hohii Metallogenic Belt

The BIF is hosted in Paleoproterozoic gneiss, amphibolite, crystalline schist marble and quartzite derived from a volcanic and clastic sedimentary rock basin that is interpreted as forming along a continental margin arc.

REFERENCES: Bahteev, and Chijova, 1990; Tomurtogoo and others, 1999.

Tarvagatai Metallogenic Belt of Banded Iron Formation (BIF, Algoma Fe); and Mafic-Ultramafic Ti-Fe Occurrences (Belt TA) (Central Mongolia)

This Paleoproterozoic(?) metallogenic belt is hosted in the Paleoproterozoic Tarvagatai fragment of the Baydrag (unit BD) cratonal terrane. The belt consists of BIF and mafic-ultramafic related Ti-Fe deposits. The major deposits are the Salbart occurrences and Most uul group occurrences in the northern and parts of the southern Tarvagatai fragment, respectively. The northeast-striking metallogenic belt is approximately 150 km long and 60 km wide.

BIF Occurrences

Various BIF occurrences, as in the Salbart Group are are hosted in lower Proterozoic gneiss, amphibolite, schist, marble, and quartzite in the Baydrag metamorphic complex (Bahteev and others, 1984). The host rocks are derived from volcaniclastic clastic sedimentary rock that formed in a small volcanic and sedimentary basin.

Most uul Mafic-Ultramafic Fe-Ti Occurrences

Various mafic-ultramafic related Fe-Ti occurrences in the Most uul group are related to early Proterozoic gabbro and anorthosite in the Most uul complex that consists of gabbro, pyroxenite, anorthosite, and gabbro (Izoh and others, 1984). The complex intrudes the Baydrag metamorphic complex and has isotopic ages for anorthosite of 1800 to 3000 Ma (Kozakov, 1986). The Baydrag complex is interpreted as forming in a continental margin arc. The Most uul massif that crops out over 150 km^2. The massif consists mainly of anorthosite (90%). Main ore minerals are magnetite and ilmenite. Early magmatic disseminated and massive ore minerals occur mostly in an inner contact facies peridotite that is 1.0-2.0 km wide. Ore minerals constitute up to 30-40% host rock, form lenses ranging from 25-40 m up to 200 m thick, and up to hundreds meter long Early magmatic stage contains an average 5.0-6.0% TiO_2. Postmagmatic ore occurs mostly in the central part of the massif, and is related to replacement veins and veinlets. The ore minerals are magnetite, ilmenite, and apatite. One zone is appoximately 50 m by 70 m. Grades are 30-40% Fe in peridotite and 50-60% Fe in post-magmatic zones, and 6-16% TiO_2 and 12-16% TiO_2, respectively.

Origin and Tectonic Controls for Tarvagatai Metallogenic Belt

The BIF occurrences are hosted in lower Proterozoic gneiss, amphibolite, schist marble and quartzite derived from a volcaniclastic and sedimentary sequence deposited in a small volcaniclastic basin. The anorthosite hosting the Ti-Fe occurrences is interpreted as forming in a continental margin arc.

REFERENCES:; Izoh, Polyakov, and Krivenko, 1984; Kozakov I.K., 1986; Bahteev, and Chijova, 1990; Tomurtogoo and others, 1999.

Baydrag Metallogenic Belt of Banded Iron Formation (BIF) Deposits (Belt BD) (Central Mongolia)

This metallogenic belt occurs in the Paleoproterozoic Baydrag cratonal terrane and contains major BIF deposits in the Baidrag group. The northwest-striking metallogenic belt extends 400 km and ranges from 30 km to 50 km wide. BIF occurrences are are hosted in Paleoproterozoic gneiss, amphibolite, schist, marble, and quartzite in the Baydrag metamorphic complex. U-Pb isochron and Pb-Pb thermoisochron zircon ages for tonalite gneiss of the Baydrag metamorphic complex range from 2,650± 30 Ma to 2,800 Ma, and are 2,400 Ma for charnockite of the Bombogor intrusive complex (Zaitsev and others, 1990).

Baydragiin Gol III BIF Occurrence

This occurrence (Andreas, 1970) consists of layered silica-magnetite bodies hosted in a Paleoproterozoic unit of gneiss and quartzite. The bodies trend northwest are concordant with host gneiss. The length of the silica-magnetite bodies is approximately 4500 m, and thickness ranges from 10 to 100m. The main ore mineral is magnetite and the average grade is 25.7% Fe.

Origin and Tectonic Controls for Baydrag Metallogenic Belt

The BIF deposits are hosted in Paleoproterozoic gneiss, amphibolite, crystalline schist marble and quartzite derived from a volcanic and clastic sedimentary rock basin. Host rocks are intruded by the Bombogor intrusive complex that is interpreted as forming in a continental margin arc.

REFERENCES: Andreas and others, 1970; Filippova and Bydrin, 1977; Bahteev, and Chijova, 1990; Zaitsev, Mitrofanov, and others, 1990; Tomurtogoo and others, 1999.

Yinshan Metallogenic Belt of Banded Iron Formation (BIF, Algoma Fe) Deposits (Belt YS) (North-Central China)

This Late Paleoproterozoic metallogenic belt is related to marine volcaniclastic rocks overlapping the Archean Yinshain terrane. The belt occurs in the Yinshan Mountains in southwestern Inner Mongolia, is about 200 km long, is over 30 km wide, and strikes east-west. The deposits are hosted mainly in the late Paleoproterozoic Changcheng System. The significant deposit is at Shanhemen.

Sanheming Banded Iron Formation (BIF, Algoma Fe) Deposit

This deposit (Li Rangdao, 1993) consists of stratiform and layered Fe bodies in the Paleoproterozoic Sanminghe Group that is divided into six units, from lower to upper: lower amphibolite, lower magnetite quartzite, schist, middle amphibolite, upper magnetite quartzite, and upper amphibolite. Varied small dikes also occur. Host rocks are metamorphosed to amphibolite and greenschist facies. The deposits are stratiform and layered. Two Fe horizons occur. Deposit minerals are mainly magnetite, hematite, and limonite, and minor pyrite, tremolite, and biotite. Typical textures are idiomorphic-hypidiomorphic, xenomorphic granular, and granoblastic. Disseminated and banded structures are common. Deposit is divided into quartz-magnetite, quartz-amphibole-magnetite, amphibole-magnetite, and amphibole-rich magnetite types. The second and third types are most important. The deposit is large with resources of 167 million tonnes grading 34.82% Fe, 42.78% SiO_2, 0.2467% S, 0.0102% P, and 0.0058% As.

Origin and Tectonic Controls for Yinshan Metallogenic Belt

Deposits are hosted in a marine overlap volcaniclastic assemblage that is interpreted as forming in in an aulacogen.

REFERENCES: Li Rangdao, 1993.

Qinglong Metallogenic Belt of Banded Iron Formation (BIF, Algoma Fe) and Clastic-Sediment-Hosted Sb-Au Deposits (Belt QL) (North China)

This Paleoproterozoic metallogenic belt is hosted in marine volcaniclastic and sedimentary basins of West Liaoning-Hebei-Shanxi terrane in the Sino-Korean Craton in the Jidong area (Eastern Hebei Province). The major Fe deposit is at Zhalanzhangzi, and the major Au deposits is at Qinglonghe. This metallogenic belt is 80 km long and ranges up to 30 km wide. BIF deposits are related to the Paleoproterozoic Zhuzhangzi Group and clastic-sediment-hosted Sb-Au deposits are related to the Paleoproterozoic Zhangjiagou Formation in the Qinglonghe Group.

Zhalanzhangzhi Iron (BIF, Algoma Fe) Deposit

This deposit (Zhang Yixia and others, 1986) consists of bedded and stratiform deposits. The main deposit bed is more than 2000 m long and 10 to 30 m thick and is hosted in tourmaline microgneiss, garnet-mica schist in an asymmetric fold. The deposit occurs in the core and at limbs of the fold. The deposits dip between 60 to 70 degree. Deposits are mainly banded, and consist of magnetite, quartz, actinolite, tremolite, and cummingtonite, with minor calcite, garnet, biotite, and pyrite. Grain size is about 0.05 mm. The total Fegrade of of the ores is low and some ores contain high sulphur. The host rocks (Zhuzhangzhi Group) is interpreted as forming in an aulacogen filled mainly with clastic sedimentary rock, carbonates, and intercalated lesser mafic and more abundant of felsic volcanic rock. Host rocks are metamorphosed to amphibolite facies. The deposit is large with reserves of 200 million tonnes Fe.

Qinglonghe Clastic-Sediment-hosted Au-Sb Deposit

This deposit (Wu, Ruzhuo and Hu, Lunji, 1992) occurs in the metamorphosed clastic rocks of the Paleoproterozoic Zhangjiagou Formation. The deposits are veined, stratiform, lenticular. Deposit controls are distribution of the strata and faults. Most deposits show concordant relation to their hosts, and only a few veins cut bedding of host rocks. The two main deposits types are disseminated-veinlet and Au-bearing quartz vein. Main ore minerals are pyrite, arsenopyrite, and gold, and subordinate minerals are pyrrhotite and chalcopyrite. Gangue minerals are plagioclase, quartz, muscovite, biotite, chlorite, calcite, and barite. Deposit minerals display idiomorphic-hypidiomorphic granular textures, and massive and disseminated structures. Sequence of formation of ore minerals is: arsenopyrite, Au-pyrite, and Au-pyrrhotite with chalcopyrite and fine grained pyrite. Five deposits stages are recognized: Au-bearing silica alteration; milky white quartz vein; pyrite; carbonate; and muscovite-potassic feldspar-quartz vein. The Proterozoic strata are interpreted as providing initial Au and with remobilization and concentration in later geological events. The deposit is medium size.

Origin and Tectonic Controls for Qinglong Metallogenic Belt

BIF is hosted in marine volcaniclastic and clastic sedimentary rocks with minor conglomerate that are metamorphosed to amphibolite and greenschist facies. The belt is interpreted as forming in a passive continental margin or aulacogen that was subsequently regionally metamorphosed and thrusted (Zhang Yixia and others, 1986).

REFERENCES: Zhang Yixia and others, 1986.

Yanliao 1 Metallogenic Belt of Chemical-Sedimentary Fe and Mn Deposits (Belt YL-1) (North China)

This Late Paleoproterozoic metallogenic belt is hosted in lower part of Sino-Korea platform sedimentary cover and occurs in the eastern Yanshan Mountains in the East Hebei Provinces. The belt is 200 to 300 km long, over 50 km wide, and strikes in east-west. The deposits in the belt are mainly hosted in the late Paleoproterozoic Changcheng System. The host rocks are siltstone, quartzite, and schist. The significant deposit is at Pangjiapu.

Pangjiapu Chemical-Sedimentary Fe and Mn Deposit

This deposit (He, Beiquan, 1993) consists of bedded and stratiform deposits that are concordant to host sandstone and argillite in the Lower Changlinggou Formation in the Mesoproterozoic Changcheng System of the North China Platform. The deposits are 2,000 to 5,000 m long, 460 to 2,000 m wide and 0.18 to 5.38 m thick. Deposit minerals are hematite, minor magnetite, siderite, quartz, chamosite, and calcite. The deposit is interpreted as forming in an oxidation zone in a shallow sea to tidal environment. The deposit is medium-size with reserves of 100 million tonnes grading 45% Fe.

Origin and Tectonic controls for Yanliao 1 Metallogenic Belt.

The belt is interpreted as forming during sedimentation in a shallow marine basin (Yanliao Basin) along Late Paleoproterozoic passive contimental margin of Sino-Korean Craton (Wang Hongzhen, 1985). The Paleoproterozoic part of the basin consists of the following geological units from older to younger: (1) quartz sandstone intercalated with conglomerate and shale; (2) shale with mainly ferrous sandstone at the bottom; (3) dolomite intercalated with shale and sandstone; (4) quartz sandstone intercalated with siltstone, dolomite, and intermediate to mafic volcanic rock; (5) dolomite and dolomitic limestone and minor basal Mn bearing shale and dolomite.

REFERENCES: Wang Hongzhen, 1985

Jiliaojiao Metallogenic Belt of Sedimentary Metamorphic Borate, Sedimentary Metamorphic Magnesite and Talc Replacement, Banded Iron Formation (BIF, Superior Fe), Korean Pb-Zn Massive Sulfide Metamorphic Graphite, and Au in Shear Zone and Quartz Vein Deposits (Belt JLJ) (Northeastern China)

This Late Paleoproterozoic metallogenic belt contains numerous large to super-large deposits. The belt extends from the Eastern Jilin Province, to Liaodong Peninsula, and farther south to Shandong Peninsula. The belt is 800 km long and 50 to 100 km wide, and is hosted in the Paleoproterozoic East Shandong-East Liaoning-East Jilin rift basin that overlaps the Archean Jilin-Liaoning-East Shandong terrane of the Sino-Korea Craton. The varied deposits in the belt are closely related to a extensive and thick sequence of volcanic rock, clastic rock, and carbonate (Ji'an, Laoling, Laohe, Jingshan and Fenzishan Groups). Metallogenic belt is a composite that includes several mineral deposit types. The most significant deposits are at Wengquangou, Xiafangshen, Fanjiapuzi, Dalizi, Qinchengzi, Zhangjiagou, Baiyunshna, Nancha, and Nanshu.

Wengquangou Sedimentary Metamorphic Borate Deposit

This deposit (Peng, and others, 1993; Editorial Committee of the Discovery History of Mineral Deposits of China, 1996) is hosted in an unusual Paleoproterozoic volcanic and sedimentary sequence, including tourmaline-bearing rock, and albite-and microcline-bearing rocks. Ludwigite also occurs. The deposit is hosted in Mg magnesian carbonates and Mg silicate rock metamorphosed to amphibolite facies and intensely deformed at about 1.9 Ga. Nine stratiform deposits occur in metamorphosed rock units in a syncline that extends in east-west for about 4.5 km. The largest no.1 lode extends 2,800 m east-west and 1,500 m wide north-south, and averages 45 m thick. Deposit types are metasedimentary (type A) and hydrothermal (type B). Type A is conformably hosted in stratiform magnesian carbonates (mainly magnesite). Suanite [$Mg_2(B_2O_5)$] is the main ore mineral and suggest derivation from B-and Mg-carbonate originaly deposited in evaporite-related sedimentary rock. Type B occurs in stratiform Mg-silicates in breccia or deformed bands and are the most important deposits in the area. Breccia fragments consist of laminated, fine-grained farsterite and diopside in a matrix of suanite and magnesite. Breccia contains fractured Mg-silicates with irregular shape fragments in the matrix. Deposit averages about 30.65% Fe and to 7.23% B_2O_3. Many interpretations exist for the the origin of mineral deposit, including metasomatism, migmatization hydrothermal activity, metamorphosed hydrothermal-sedimentary deposit, and others. A recent study suggests formation during metamorphism of an evaporite sequence in a Paleoproterozoic rift (Peng and others, 1993; Peng and Palmer, 1994). The deposit is superlarge with reserves of 21.9 million tonnes B_2O_3.

Xiafangshen Sedimentary Metamorphic Magnesite Deposit

This deposit (Li, Yuya and others, 1994) occurs in the Proterozoic Eastern Liaoning rift zone in the Paleoproterozoic Dashiqiao Formation. The host rocks are mainly two-mica quartz schist, sillimanite-kyanite-straurolite two-mica schist, magnesite marble, and dolomitic marble, with a total thickness of 3516 m. Deposit layers occur in a north-northeast-striking monocline that extends 3,250 m. Deposits are multiply layered and stratiform. thelowest deposit is dominant, extends 3,626 m along strike and averages 205 m thick. Deposit minerals are mainly massive with secondary banded deposits consisting of magnesite and minor talc, tremolite, dolomite and clinochlorite. Magnesite is dominantly medium-and coarse-grained and contains 47.30% MgO. The deposit is superlarge with reserves of 258 million tonnes.

Fanjiapuzi Talc (Magnesite) Replacement Deposit

This deposit (Li, Yuya and others, 1994) occurs in the eastern Liaoning Proterozoic rift zone and closely associated with Mg host rocks in the upper part of the Paleoproterozoic Dashiqiao Formation. The deposit occurs on the north limb of a north-northeast-trending synclinorium in the huge Yingkou-Dashiqiao-Fanjiapuzi magnesite belt. Deposits are stratiform and lenticular and are comfortable with wallrocks. Coarse-grained magnesite often occurs in talc ores. Where talc content is over 70%, hand sorting produces a high quality, rose or white ores that contains 30 to 32% MgO, 59 to 62% SiO_2, <19% CaO and <0.5% Fe_2O_3. Where ore whiteness is over 85 and talc content is between 50% and 90%, flotation process produces a high quality talc powder. The deposit is superlarge with reserves of 36 million tonnes.

Dalizi Banded Iron Formation (BIF, Superior Fe) Deposit

This deposit (Zhang, Qiusheng, and others, 1984a, b) consists of various bedded, stratiform and lens-shaped deposits that occur in a 10-km-long area that is. A single deposit ranges to 10 to 30 m thick. Deposits are concordant to the deposit-hosting strata. Three types of deposits are recognized according to major ore minerals, siderite, hematite, and magnetite. Siderite deposits are mostly bedded, are concentrated in carbonate rocks, are rich in Pb and Zn, and have potential for stratiform Pb-Zn deposits. Hematite deposits, that are closely associated with magnetite deposits, are massive and banded. The host strata is metamorphosed to greenschist facies and consists of silty mudstone and carbonate rocks of the Paleoproterozoic Laoling Group that are intensely folded. Deposit swarms are clustered in axes of transverse folds. The primary sedimentary environment is interpreted as a secondary shallow basin that formed in a Paleoproterozoic rift. Siderite is concentrated in carbonate sedimentary facies. The deposit is medium size.

Qingchengzi Korean Pb-Zn massive Sulfide Deposit

This deposit (Tu, Guangzhi, and others, 1989; Zhang, Qiusheng, and others, 1984b) consists of stratiform, feather, and vein masses of mainly galena, sphalerite, pyrite, and pyrrhotite, with minor arsenophyrite, chalcopyrite, bornite, and tetrahedrite that are hosted in marble of the Proterozoic Liaohe group. Ore minerals are medium-to coarse-grained, and vary from euhedral or subhedral. Ores are of the structures of dissemination, band, veinlet, network, breccia, crushed grain etc. The deposit occurs at the intersection of Yingkou-Kuandian uplift and Qianshan Mountain Range. The deposit is large with reserves of 728,900 tonnes Pb, 349,300 tonnes Zn. Average grade is 2.64% Pb, 1.90% Zn.

Baiyunshan Au in Shear Zone and Quartz Vein Deposit

This deposit (Xu Enshou, Jin Yugui, Zhu Fengshan and others, 1994) consists of lensoid, lenticular, nested, and irregular masses of pyrite, pyrrhotite, chalcopyrite, arsenopyrite, galena, and sphalerite, and gangue minerals, including quartz, sericite, K feldspar, calcite, and dolomite. Ore minerals occur along interformational folds in phyllite, mica schist, and dolomite. Ores minerals vary from massive to disseminated. Host rocks altered to quartz, sericite, and pyrite. Gold varies from fine-grained to microscopic and grades into electrum. Host rocks are slightly metamorphosed Paleoproterozoic carbonaceous, volcanic, clastic, and carbonate rocks of the Liaohe Group that is part of the Sino-Korean Craton. The deposit is medium size.

Nancha Au in Shear Zone and Quartz Vein Deposit

This deposit (Wang, Enyuan, 1989) consists of gold, pyrite, arsenopyrite, pyrrhotite, chalcopyrite, and minor galena, sphalerite, bornite, chalcocite, and magnetite. Ore minerals vary from disseminated, fine veined, brecciated, and banded. Textures are idiomorphic, hypidiomorphic-xenomorphic, and metasomatic replacement. This deposit is more than 3000 m long, strikes northwest, and is several hundred meters wide. From the southwest to northeast, three mineralized sectors are recognized. The main deposits in the first sector occur in a structurally altered zone between basal schist, quartzite, and marble of the Huashan Formation and an upper, thick dolomite marble of the Zhenzhumeng Formation. The deposits in the second and third sectors occur in a structurally altered zone in thick dolomitic marble of the Zhenzhumen Formation. The sectors vary from stratiform or lenticular, and a single sector ranges from several tens to a hundred meters long. Wide-spread carbonate and silica alteration is associated with the deposit. Other important alterations formation of arsenopyrite and pyrite. The deposit origin is controversial. The deposit is medium size.

Nanshu Metamorphic Graphite Deposit

This deposit (Zhang, Qiusheng, and others, 1984) consists of a graphite-bearing horizon that is hosted in the Paleoproterozoic Jingshan Group in three sequences: (1) marble and amphibole-plagioclase gneiss intercalated with graphite gneiss; (2) amphibole-plagioclase intercalated with marble and graphite gneiss; and (3) marble and amphibole-plagioclase gneiss. The first and second sequences contain major graphite layers. Graphite occurs in crystalline and amorphous forms. Amorphous graphite masses are soft and massive, and occur along bedding and cleavage, and are intercalated in lenses with host rocks. Crystalline graphite masses are apparently bedded, multiply layered, lenticular, and concordant to host gneiss and marble. The deposits vary from 50 to 1000 m long and extend 50 to 400 m downdip. Grade and thickness are relatively constant. Main ore mineral is graphite and gangue minerals are biotite, tremolite, quartz, microcline, plagioclase, muscovite, hypersthene, clinozoisite, garnet, apatite, and sphene. Other recoverable sulphide-minerals include pyrite, pyrrhotite, chalcopyrite, bornite, and sphalerite. Deposit exhibits gneissic, banded, and granoblastic structures. Ore mineral texture is mainly lepidoblastic. The deposit is interpreted as forming from metamorphism of organic carbon in clastic sedimentary rock that was deposited in a shallow marine environments. The deposit is large.

Origin and Tectonic Controls for Jiliaojiao Metallogenic Belt.

The belt is interpreted as forming in a passive continental margin, possibly as part of the Paleoproterozoic East Shandong-East Liaoning-East Jilin rift. The parental rocks include intermediate and siliceous volcanic rock, clastic rocks, and very thick carbonates. During metamorphism to amphibolite and greenschist facies the host rocks were transformed into: (1) fine grained biotite, hornblende or diopside-bearing gneiss, leucocratic gneiss intercalated with graphite biotite gneiss, Al-rich gneiss, schist, amphibolite, marble and Ca-Mg silicate granofels; and (2) phyllite, muscovite-biotite schist, fine-grained leucocratic gneiss, and dolomitic marble. The environment of formation and deposit controls are debated (Zhang Qiusheng and others, 1984, Fang Ruiheng, 1994, Peng and others, 1993).

REFERENCES: Zhang Qiusheng and others, 1984, Peng and others, 1993; Fang Ruiheng, 1994.

Luliangshan Metallogenic Belt of Banded Iron Formation (BIF, Superior Fe) and Au in Shear Zone and Quartz Vein Deposits (Belt LL) (North China)

This Early Paleoproterozoic metallogenic belt is hosted in the Hutuo rift basin and occurs in the Luliangshan Mountains in the Northeast Shanxi Province. The belt is over 200 km long, varies 40 to 60 km wide, and is hosted in the Hutuo Group overlap assemblage in the Archean Liaoning-Hebei-Shanxi terrane. BIF deposits are related to metamorphic clastic rocks and marble, whereas shear zone Au deposits are hosted in metamorphosed clastic rocks of the Hutuo Group. Metallogenic belt is a composite that includes several mineral deposit types. The significant deposits are at Yuanjiachun (BIF) and Hulishan (shear zone Au).

Yuanjiachun Banded Iron Formation (BIF, Superior Fe) Deposit

This deposit (Zhang, Qiusheng, and others, 1984a, b) consists of bedded and stratiform Fe deposits that are concordant to host rocks that consist of clastic rock, mudstone, carbonate rocks and minor volcanic rock that are metamorphosed to greenschist facies. The Fe beds strike north-south for several to more than ten kilometers, and are 300 m thick. Ore minerals are mainly oxides and consist of specularite, hematite, magnetite, quartz, cummingtonite, and stilpnomelane. Deposit minerals occur in silicate and carbonate rocks with laminated and stripped structures. Host rocks are part of the Paleoproterozoic Luliang Group. Original sedimentary environment interpreted as a second-order basin in a rift zone along a craton margin. The deposit is similar to Superior Lake Fe deposits. The deposit is large with reserves of 895 million tonnes grading 32.37% Fe.

Hulishan Au in Shear Zone and Quartz Vein Deposit

This deposit (Chang, Xiangyang, and Tian, Rongqing, 1998) occurs in an intensely deformed zone that consists of isoclinial folds developed in metamorphosed volcanic and sedimentary rock of the Wutai Group and metamorphosed conglomerate of the Hutuo Group. Deposit occurs in bands, veinlets, disseminations and stockworks. Bands consist of quartz, sericite, limonite, and sulphide minerals. Gold occurs along schistosity as disseminations and streaks. Disseminations, veinlets, and stockworks contain mainly pyrite, chalcopyrite, and pyrrhotite. Ore minerals are Au, pyrite, chalcopyrite, pyrrhotite, magnetite, and native lead, and minor galena and bornite. Gangue minerals are quartz, sericite, chlorite, calcite, siderite, and Fe-dolomite, and minor apatite, tourmaline, corundum, amphibole, and fluorite. Gold mostly occurs in quartz and limonite or between the two minerals. Au fineness is high (Au+Ag greater than 98%). Proximal alteration consists of silica, sericite, chlorite, carbonate, and pyrite alterations. Deposit is interpreted as forming in the late stage of evolution of an Archean greenstone belt that has a Pb-Pb isotopic age of 2230±130 Ma. Deposit interpreted as forming during shearing and deformation. The deposit is medium size.

Origin and Tectonic Controls for Luliangshan Metallogenic Belt

The BIF iron and shear zone Au deposits are interpreted as forming in the Paleoproterozoic Hutuo rift or foreland basin (Zhai Mingguo and others, 2000) that was superposed on the Archean Sino-Korean Craton. The Paleoproterozoic overlap assemblage of the Archean Liaoning-Hebei-Shanxi terrane consists of the following geological units from the bottom to the top: (1) metaconglomerate, quartzite, feldspar quartzite, phyllite, and dolomite; (2) phyllite, dolomite, sandy slate and quartzite intercalated with metabasalt; (3) metaconglomerate, phyllite, plagioclase quartzite, and quartzite. A U-Pb zircon isotopic age for metabasalt is 2,366 Ma. Both the strata and the deposits are regionally metamorphosed, folded, and sheared to greenschist facies (Zhang Qiusheng and others, 1984).

REFERENCES: Zhang Qiusheng and others, 1984; Zhai Mingguo and others, 2000.

Oryudong-Gapyeong Metallogenic Belt of Metamorphic Graphite Deposits (Belt OM) (South Korea)

This Late Paleoproterozoic and Early Mesoproterozoic metallogenic belt is hosted in the Gyeonggi migmatitic gneiss terrane. Isotopic ages for the terrane range from 1800 to 1400 Ma. The deposits occur in an Archean and Proterozoic metamorphic complex that consists of biotite schist, some chlorite schist, injection gneiss, and marble. Injection gneiss is intercalated with banded structure of 10 to 15 m width. Crystalline graphite is mainly hosted in biotite schist. The major deposits are at Oryudong and Gapyeong.

Oryu-dong Metamorphic Graphite Deposit

This deposit (Lee, 1960) occurs in Proterozoic schist and consists of graphite lenses that generally occur parallel to the host-rock. Weathered ore is higher in grade and can be distinguished from the non-weathered ore by appearence and chemical analysis. The deposit is hosted mainly in Proterozoic granitic gneiss and schist. Crystalline graphite occurs in lenses that parallel schistocity. Strike and dip are variable; however, general strike is northeast with dips to southwest or northeast. The deposits were formed contemporaneously with granitic gneiss and schist.

Carbon was derived from organic matter. The graphite is variable grade and crystallinity. Average grades of outcrop samples are: 14.55% F.C:, 80.41% ash, 1.14% VM, and 1.11% H_2O. Average grade of drill core is 14.51% F.C., 80.86% ash, 4.92% VM, and 0.21% H_2O. Grade ranges up to high. The deposit is small with reserves of 2,592 tonnes ore.

Origin and Tectonic Controls for Oryudong-Gapyeong Metallogenic Belt

This belt is hosted in Paleoproterozoic metamorphic complex composed of biotite schist, lesser chlorite schist, injection gneiss and marble. Injection gneiss intercalated with banded structure of 10 to 15 m thick. Crystalline graphite mostly associated with biotite schist. The belt is interpreted as forming during metamorphism of marine sedimentary rocks.

REFERENCES: Lee, 1960; Cho, Moon, Lee, and Lee, 1977; Duk Hwan Hwang, this study

Yangyang Metallogenic Belt of Regionally Metamorphosed BIF Deposits (Belt YG) (South Korea)

This Proterozoic metallogenic belt is hosted in the Proterozoic Gyeonggi Group and Proterozoic Kyeonggi Gneiss Complex (both parts of South China Craton, Gyenggi granulite-paragneiss terrane), and the Jurassic Daebo Granite. The Gyeonggi Group consists mainly of Precambrian metasedimentary rock, including chlorite-sericite-quartz schist and hornblende-biotite-gneiss, and trends north-northeast to south-southwest. The Jurassic Daebo Granite consists of schistose granite, biotite granite, syenite, and felsite porphyry. The major deposit is at Yangyang.

Yangyang Metamorphosed Banded Iron Formation (BIF, Superior Fe) Deposit

This deposit (Kim and others, 1959) consists of metamorphic magnetite that is hosted in Precambrian biotite gneiss that trends north-northeast to south-southwest, and in syenite intruding the gneiss. The west side of the syenite contains many lenticular-shaped xenoliths of calcsilicate rock, tactite, and amphibolite derived from metasomatized impure limestone. Fe bodies are hosted in the syenite, and are closely associated with tactite or amphibolite. Fe bodies also occur in gneiss, are irregular but generally lenticular, and extend north-south. Three major bodies are at Tapdong, Tomok, and Nonhwa. The ore mineral is mainly magnetite, and gangue minerals are hornblende, epidote, and biotite. Magnetite is commonly massive and compact, but also platy and brittle. The origin of the magnetite deposits is interpreted as a polymetamorphosed BIF deposit that was intruded by syenite. Host limestone was metamorphosed and metasomatized to calc-silicate rock. The deposit is small with an average grade of 55% Fe and reserves of 2,020,280 tonnes ore.

Origin and Tectonic Controls for Yangyang Metallogenic Belt

The metamorphosed BIF deposits are interpreted as forming during contact metasomatism of BIF and formation of magnetite skarn during intrusion of Jurassic Daebo Granite.

REFERENCES: Kim and others, 1959; Kim and others, 1965; Park, and Hwang, 1995; Duk Hwan Hwang, this study.

MESOPROTEROZOIC METALLOGENIC BELTS (1600 to 1000 MA)

Ingili Metallogenic Belt of Stratiform Zr (Algama type) and REE (±Ta, Nb, Fe) Carbonatite Deposits (Belt Ing) (Russia, Far East)

This Mesoproterozoic metallogenic belt occurs at the southern boundary between North Asian Craton and the Verkhoyansk fold and thrust belt. The belt contains a Zr deposit at Algama and several Zr occurrences.

Ingili REE (±Ta, Nb, Fe) Carbonatite Deposit

This deposit (Onikhimovsky and Belomestnykh, 1996) occurs in circular alkaline intrusive body composed of ijolite-melteigite, syenite, and theralite of Precambrian(?) age. Alkaline igneous rock intrudes Archean amphibolite and gneiss, and Neoproterozoic calcareous and clastic rock. Deposit consists of two types of carbonatite - calcite and dolomite. Calcite carbonatite contains Ta-Nb minerals and forms small (up to 150 x 200 m) bodies of irregular shape. Nb and Ta occur in pyrochlore and zircon. Dolomite carbonatite contains REE minerals in veins that are 10 to 80 m long and 0.1-2 to 3 m thick. The deposit is small with an average grade of 1.4% REE oxides; up to 1.1% Nb_2O_5.

Algama Stratiform Zr (Algama Type) Deposit

This deposit (Onikhimovskiy and Belomestnykh, 1996; Buryak and others, 1999) is hosted mainly in subhorizontal dolomite marble that along with other sedimentary rock, form the Neoproterozoic and early Paleozoic sedimentary cover of the Stanovoy block of the North Asian Craton. This deposit consists of hydrozircon and baddeleyite in lenses and veins that occur mainly in a layer of cavernous dolomite marble that ranges up to about 40 m thick. The lenses and veins are subhorizontal, are near surface, and are associated with units containing intensive karsts. The ore occurs mainly as breccia composed of fragments of metamorphic quartz and dolomite cemented by an aggregate of hydrozircon and baddeleyite. Baddeleyite also occurs as loose aggregates formed by weathering of primary ore. Some caverns in the dolomite contain colloform, sinter-type aggregates of hydrozircon and baddeleyite, but breccia ores predominate. The host dolomite is not hydrothermally altered. The deposit is large and has reserves of 73,150 tonnes ZrO_2 with an average grade of 4.62% ZrO_2, and resources of 93,668,900 tonnes ore grading 1.14% WO_3, 0.84% Hf, 0.07% Y, and 0.12% Nb.

Origin and Tectonic Controls for Ingili Metallogenic Belt

The deposit is interpreted as forming in two stages. Initial chemical-sedimentary deposition of disseminated Zr in shallow marine dolomite. Subsequent concentration during diagenesis, karst formation, and hydrothermal fluids associated with intrusion of rift-related mafic and ultramafic dikes.The deposit formed at hypsometric levels making paleosurface of ground water.

REFERENCES: Buryak and others, 1999.

Tagulskiy Metallogenic Belt of Muscovite Pegmatite, REE-Li Pegmatite, and Mafic-Ultramafic-Related Ti-Fe Deposits (Belt Tag) (Russia, East Sayan)

This Mesoproterozoic(?) metallogenic belt occurs in Tumanshet and Birusa paragneiss terranes of the North Asian Craton. The belt occurs in the Paleoproterozoic Elashsky graben in the northwestern part of East Sayan Mountains, and is 140 km long and 120 km wide (Bryntsev, 1994). The belt along regional of northwest-striking faults (Birjusinsky, Khultsaisky, Belsky, and Kansky faults) and formed during primarily Proterozoic interplate mafic and siliceous magmatism and hydrothermal activity. The metallogenic belt is related to the Mesoproteroterozoic(?) Sayan collisional granitic belt that consists of granite, subalkaline, alkaline granite, and granosyenite plutons and related rocks. Deposits in the belt occur in large districts and consists of: (1) muscovite pegmatite at Gutaro-Birjusinsky; (2) REE pegmatite at Vishnyakovskoye; (3) mafic-ultramafic Fe-Ti at Malo-Tagulskoye. The belt is promising for discovery of new REE and Ti deposits.

Vishnyakovskoye REE-Li pegmatite Deposit

This deposit (Vakhromeev and others, 1983; Makagon and others, 1983; Ryabtsev, 1998) occurs in the Tagul-Tumanshet mobile zone and consists of gently-lying veins in fine-grained ortho-amphibolite, and metamorphosed diabase and gabbro. Pegmatite veins are tabular, upper veins are arched, and range up to 12 m thick and 2 km long. The average grade in explores bodies ranges up to 0.018% Ta_2O_5. The deposit contains both Ta and Li-Ta facies. The Ta facies (with an average grade of 0.026% Ta_2O_5) occurs in the upper, central, and eastern parts of the deposit. The Li-Ta facies (with an average grade 0.014% Ta_2O_5) occurs in deeper layers on the western and southwestern flanks of the deposit. 89% Ta is contained in tantalite, vodginite, microlite, ixiolite, 3.6% in cassiterite, 10.7% as microtraces in rock-forming minerals. Petalite is the primary lithium mineral. Mica and K-feldspar contain Cs and Rb. Pegmatites also contain widespread apatite, beryl, topaz, and fluorite. Pegmatite veins occur in the exocontact zone of the granitoid mass. The deposit is large with an average grade of 0.014-0.026% Ta_2O_5.

Malo-Tagulskoye Mafic-Ultramafic-related Ti-Fe Deposit

This deposit (Mekhonoshin and others, 1986; Starostin 1998) occurs in the Malotagulsky massif of metagabbro in blocks that total 160 km^2. Fault zones bound occurrences that are about 2 km long and 300-800 m wide. Wall rocks include amphibolite, migmatite, and eclogite. Ore bodies are a series of steeply dipping lenses and layers that extend for 1750 m and are 10-25 m thick. The deposit consists of: (1) disseminations in metagabbro, including magnetite, ilmenite, titanomagnetite, ferri-ilmenite (magneto-ilmenite), hematite with gradational contacts with host rocks; (2) sideronite that consists of silicate minerals with titano-magnetite, ilmenite, and spinel; and (3) thin veinlets and large crossing veins of titano-magnetite and ilmenite which are divided into high-grade (15-24% TiO_2) and medium grade (8-13% TiO_2). The following stages formed the deposit: (1) magmatic with formation of mafic rocks from tholeiitic magma in island arc; (2) progressive metamorphism at granulite facies resulting in initial eclogite, formation of titano-magnetite-ilmenite melts, and formation of oxidized ore minerals in disseminations; and (3) retrograde metamorphism at amphibolite facies and granitization with formation of most ore mineral masses). Age of deposit is interpreted as Mesoproterozoic. The deposit is large and the average grade in disseminated ore is 4.7% TiO_2, and 26.8% Fe.

Origin and Tectonic Controls for Tagulskiy Metallogenic Belt

The belt is interpreted as forming during widespread mafic and siliceous intraplate magmatism. Belt occurs along northwest-striking regional faults that controlled a Proterozoic magmatic and hydrothermal system.

REFERENCES: Makagon and others, 1983; Vakhromeev and others, 1983; Mekhonoshin and others, 1986; Bryntsev, 1994; Makagon, 2000.

Darvi Metallogenic Belt of Sedimentary Bauxite and Sedimentary Fe-V Occurrences (Belt DR) (Mongolia)

This Mesoproterozoic metallogenic belt is related to sedimentary layers in the Baydrag cratonal terrane in the Govi-Altai region. The main sedimentary bauxite deposit is at Alag uul. The Alaguul diaspore deposit is hosted in Riphean sedimentary rocks in the Darvi fragment of the Baydrag terrane.

Alag Uul Sedimentary Bauxite Deposit

This deposit (Pinus and others, 1984) is hosted in intercalated chloritite, amphibolite, graphite-bearing metaclastic rock and is closely spatially related to sedimentary Fe deposits (Zaitsev and others, 1984). The Riphean diaspore bauxite occurs in a zone up to 10 km long and 5 km wide. The belt is interpreted as forming during bauxite sedimentation in a Riphean sedimentary basin that overlapped the Baydrag cratonal terrane and subsequent regional metamorphism of sedimentary bauxite. The average grades are 49% Al_2O_3, 36% of Fe_2O_3, 2% SiO_2, 4% TiO_2. Probable reserves are 100,000 tonnes bauxite.

Origin and Tectonic Controls for Darvi Metallogenic Belt

The belt is interpreted as forming during bauxite sedimentation in Lower to Middle Riphean sedimentary basin along a passive continental margin.

REFERENCES: Pinus and others, 1984; Zaitsev and others, 1984; Tomurtogoo and others, 1999.

Tseel Metallogenic Belt of Muscovite Pegmatite and Banded Iron Formation (BIF) Deposits (Belt Tse) (Mongolia)

This metallogenic belt is hosted in the Tseel metamorphic terrane. The major deposits are in the Bodonch district (muscovite pegmatite), and Ikh Ganga district (BIF). Sokolov and Zaitsev (1990) name this belt as the Altai belt of muscovite and REE-muscovite pegmatite. We interpret that the REE pegmatite deposits formed in the younger Permian Turgen metallogenic belt. Kovalenko and others (1990) report that potential exists for stratiform scheelite deposits in Precambrian metamorphic schist of the Tseel metamorphic block.

Bodonch Muscovite Pegmatite District

This deposit (Kleiner and others, 1977) consists of eight mica bearing pegmatite bodies that occur in Lower and Middle Devonian metasedimentary rocks that are metamorphosed to garnet-biotite and biotite gneiss and intercalated with two-mica and garnet-two mica schists that are intruded by small, late Paleozoic granite plutons. Muscovite is abundant metamorphic mineral in schist. Conformable pegmatite veins range up to 1.5 km long and 2-5 m thick. Muscovite crystals in pegmatite veins are mainly small, but locally range up to 25 cm. Pegmatite minerals are quartz, muscovite, and microcline, and rare beryl, tourmaline, apatite and garnet. A Pb-Pb zircon isochron age for related aplite is 780 Ma. Deposit is located in the large Bulgan pegmatite zone of the southern slope of the Mongolian Altai. The deposit was mined from 1960 to 1970 and is exhausted.The deposit is small and grades up to 170 kg/m3 muscovite.

Ikh Ganga Banded Iron Formation Occurrence

This occurrence (Baikova and others, 1987) occurs in the eastern part of the belt in a Precambrian metamorphic complex in the Tseel block in an area about 0.5 km by 6 km. The deposit consists of lenses and layers of length about 250 to 400 m long and 10 m to 80 m thick that are composed of biotite-garnet, pyroxene-epidote-garnet-magnetite and massive magnetite beds. Metamorphic garnet deposits occur at Altanhudag in the Tseel block. Grade ranges from 53% to 67% FeO and 42% to 52% Fe, and with a trace of Co, Ni, V and Mn. Local placer garnet deposits occur and are derived from garnet-jedrite-biotite lode metasomatitic bodies (Sokolov and Zaitsev, 1990). The metasomatites are extensive and occur in the Tseel, Bodonch and Uench blocks. A muscovite pegmatite with a 780 Ma isotopic age intrudes garnet-jedrite-biotite metasomatite (Sokolov and Zaitsev, 1990).

Origin and Tectonic Controls for Tseel Metallogenic Belt

The belt is interpreted as forming during Fe sedimentation in an early to middle Riphean sedimentary basin and during granitoid magmatism along an active continental margin.

REFERENCES: Kleiner and others, 1977.

Tsenhermandal-Modot Metallogenic Belt of Metamorphic Graphite Deposits (Belt TsM) Mongolia)

This Mesoproterozoic(?) metallogenic belt is hosted in Ereendavaa fragment of Argunsky passive continental margin terrane. The metamorphic graphite deposits and occurrences occur in a northeast-striking zone along the North Govi-South Hentei regional fault. Deposits and occurrences are hosted in Paleoproterozoic gneiss and marble, and also in middle and upper Riphean metamorphosed clastic and carbonate rocks. The deposits occur mainly in the southwestern Ereendavaa terrane, southeast of Ulaanbaatar. Age of metamorphism of host rocks is not known. Graphite deposits and occurrences are interpreted as forming during late Riphean metamorphism. The major deposit is at Zulegt.

Zulegt Metamorphic Graphite Deposit

This deposit (Milin and Stepanenko.,1967; P.Shaandar and others, written commun., 1992) consists of graphite-bearing quartzite and graphite skarn lenses that occur in intensively deformed Proterozoic metamorphic rock. The average thickness of the graphite-bearing quartzite bed is 20 meters and the length is 100-150 m. The average graphite content is 3.91-7.86%. The graphite skarn occurs in about 200 bodies with a thickness of 0.1-11 m. The deposit contains phenorocrystalline and coarse squamose types.The deposit age is interpreted as Proterozoic. The deposit is small with reserves of 0.96 million tonnes grading 6.28-10.65% graphite

Origin and Tectonic Controls for Tsenhermandal-Modot Metallogenic Belt

This belt is interpreted as derived from carbon-and iron-bearing sedimentary rocks that precipitated in a basin along Riphean passive continental margin that was regionally metamorphosed in the upper Riphean.

REFERENCES: Kleiner and others, 1977.

Langshan-Bayan Obo Metallogenic Belt of Sedimentary Exhalative Pb-Zn (SEDEX) and Polygenetic REE-Fe-Nb Deposits (Belt LB) (Northwestern and North-Central China)

This Mesoproterozoic metallogenic belt occurs in the central part of Inner Mongolia, along the Yinshan Mountains. The belt is 600 km long and 50 km wide, strikes northeast in the western part, and changes to east-west strike in the eastern part. The belt is hosted in the Early Mesoproterozoic Zhangbei-Bayan Obo-Langshan rift-related metasedimentary and metavolcanic rocks deposit onthe Sino-Korean Craton. The sedimentary exhalative Pb-Zn (SEDEX) and Pb-Zn-Cu deposits in the belt are large to superlarge, and the Bayan Obo Fe-Nb-REE deposit is world class. The stratigraphic horizons hosting SEDEX deposits are in the Mesoproterozoic Zhartaishan and Agulugou Formations though the horizon varies for different SEDEX deposits (Xu Guizhong and others, 1998). The Bayan Obo Fe-Nb-REE deposit is hosted in the 8th of 9 members in the Mesoproterozoic Bayan Obo Group. The significant deposits in are at Bayan Obo and Hugeqi.

Bayan Obo Polygenic REE-Fe-Nb Deposit Deposit

This deposit (Lin Chuanxian and others, 1994; Lin, Chuanxian and others, 1994; Tu Guangzhi, 1996; Qiao, Xiufu and others 1997) occurs in am east-west trending Mesoproterozoic rift zone along the northern margin of Sino-Korean Craton. The mining district containing the deposit contains several ore bodies that occur in a zone that is about 18 km long along an east-west trend and 5 km wide. Host strata are quartzite, slate, limestone, and dolomite that is main host rock. The bodies are stratiform and lenticular, with masses, bands, layers, and veins, and disseminations. Based on mineralogy, nine types of ores are identified about sixty Nb, REE, Ti, Zr, Nb, and Fe minerals including 19 new minerals such as Huanghoite and others. Besides clear features of hot water sedimentation, the deposit also exhibits Mg, Fe, Na and F metasomatism. Sm-Nd monazite isochron age for bastnaesite and riebeckite is 1200 to 1300 Ma, whereas Th-Pb and Sm-Nd age of Ba-REE-F carbonates and aeschynite is 474 to 402 Ma. Recent years Qiao Xiufu and others (1997) suggest that some host strata are early Paleozoic. The deposit is superlarge with reserves of 40.1 million tonnes with average grade of 3-5.4% REE; Reserves of more than 1 million tonnes Nb_2O_5 have an average grade of 0.1-0.14% Nb_2O_5.

Huogeqi Sedimentary Exhalative Pb-Zn (SEDEX) Deposit

This stratiform deposit (Ge, Chaohua and others, 1994) occurs in the Langshan Mountains and consists of stratiform bodies hosted in phyllite, schist, and quartzite of the Proterzoic Langshan group that has a Rb-Sr isotopic age of 1100 Ma. Ore minerals are mainly chalcopyrite, pyrite, pyrrhotite, magnetite, galena, and sphalerite, with small amounts of arsenopyrite and hematite. Wall rocks are altered to silica, diopsie-grunerite, biotite, sericite, and chlorite. The deposit is large with reserves of 0.973 tonnes Pb, 0.782 tonnes Zn, 0.711 million tonnes Cu. Average grades of Pb, Zn, and Cu are 1.44%, 1.46%, 1.35%, respectively.

Origin and Tectonic Controls for Langshan-Bayan Obo Metallogenic Belt

The Bayan Obo deposit interpreted as a SEDEX deposit related to a carbonatite magma and associated hydrothermal activity. The belt hosted in a Mesoproterozoic overlap sedimentary assemblage deposit formed in the Zhangbei-Bayan Obo-Langshan rift along the passive continental margin of the Sino-Korean Craton. The Early Mesoproterozoic overlap assemblage hosting the belt in the Yinshan Archean terrane consists of: (1) metasedimentary schist, biotite gneiss, quartzite, marble, (2) metaconglomerate, quartzite, stromatolite-bearing crystalline limestone, phyllite, slate, mica schist, actinolite schist, and minor metamorphosed intermediate and siliceous volcanic rock of the Zhartai Group with an age of 1500 to 1600 Ma; and (3) Phyllite, slate, quartzite, meta-sandstone, and dolomite of the Bayan Obo Group with an age 1350 to 1650 Ma. Some authors interpret the assemblage as the Mesoproterozoic Langshan-Zhartaishan basin that formed along the northwestern margin of North China Plate (Xu Guizhong and others, 1998). The world class Bayan Obo Fe-Nb-REE deposit is a non-conventional super-large of deposit (Tu Guangzhi, 1998) is unique in the world. The origin is still debated (Chao ECT and others, 1992, Tu Guangzhi, 1998). Tu Guangzhi (1998) suggested that Bayan Obo deposit is a SEDEX deposit related to the carbonatite magma and associated hydrothermal activity. Various studies on the Bayan Obo deposit focus on the syngenetic nature of igneous carbonatite and the epigenetic replacement of the sedimentary dolomite. These two types processes are not strictly exclusive and both may be part of a SEDEX deposit model.

REFERENCES: Chao Ect and others, 1992.Shi Lindao and others, 1994; Tu Guangzhi, 1998; Xu Guizhong and others, 1998; Xu Guizhong and others, 1998.

Wuenduermiao Metallogenic Belt of Volcanogenic-Sedimentary Fe Deposits (Belt WD) (North-Central China)

This Mesoproterozoic through early Neoproterozoic metallogenic belt occurs in the eastern Inner Mongolia and is hosted in the Mesoproterozoic through Middle Ordovician Wenduermiao accretionary wedge terrane. The belt extends east-west, is more than 80 km long and 20 km wide. The significant deposit is at Wundurmiao.

Wuenduermiao Volcanogenic-Sedimentary Fe Deposit

This deposit (Chen Qi and others, 1994) consists of several stratiform deposits of banded magnetite hematite quartzite, and hematite jasper silexite. Fe oxide minerals are very fine-grained. The host rocks metamorphosed mafic lava, spilite tuff and argillite that are strongly folded. A Sm-Nb isotopic age for host rocks in the deposit is 1500 to 850 Ma. The host rocks are part of an ophiolite suite composed of chert, pillow lava, and ultramafic rock. The host rocks are metamorphosed into quartzite, sericite schist, Fe ore, greenschist, and glaucophane schist. The belt is 50 km long and 20 km wide and contains more than ten moderate and small Fe deposits and occurrences. The deposit is medium size with reserves of 120 million tonnes total FE with an average grade of 36.04%Fe (20-57.8% Fe).

Origin and Tectonic Controls for the Wenduermiao Metallogenic Belt

The belt is interpreted as forming during Mesoproterozoic volcanism and sedimentation with subsequent metamorphism and deformation occurring during accretion of the Wenduermiao terrane The Wenduermiao terrane hosting the metallogenic belt consists of an ophiolite complex and was interpreted as early Paleozoic. Recent studies suggest the Wenduermiao Group Mesoproterozoic.

REFERENCES: Chen Qi and others, 1994.

Yanliao 2 Metallogenic Belt of Chemical-Sedimentary Fe-Mn and Sedimentary-Exhalative Pb-Zn (SEDEX) Deposits (Belt YL-2) (Northern and Northeastern China)

This Mesoproterozoic metallogenic belt is hosted in the Jixian Group in platform sedimentary cover rocks on the Sino-Korea Craton. The belt occurs in the eastern Yanshan Mountain in the West Liaoning and Northeast Hebei Provinces, is 200 to 300 km long, over 50 km wide, and strikes in east-west. The belt is the continuation of the Yanliao Mesoproterozoic metallogenic belt. The deposits are mainly hosted in the Neoproterozoic Jixian Group with isotopic ages of 1400 to 1100 Ma. The host rocks for the deposits are variably-colored siltstone and silty shale and intercalated with limestone. The significant deposits are at Wafangzi and Gaobanhe.

Wafangzi Chemical-Sedimentary Fe-Mn Deposit

This deposit (Ye, Lianjun and others, 1994) consists of stratiform and lensoid masses. The thickness of a single layer is only 10 to 30 cm. The deposit comprises three layers that are 1 to 2 m thick on average. These three layers are hosted in pelitic rock the middle part of the Mesoproterozoic Tieling Formation of the Jixian Group in a northeast-striking anticlinorium. The deposit occurs on the southeastern limb of the anticlinorium. The ores are divided into three types: (1) sedimentary manganite and rhodochrosite with para-oolitic, banded, massive, and psephitic textures; and (2) contact metamorphic ores consisting of bixbite, braunite, manganoferrite, coarse-grained rhodochrosite, Ca-rhodochrosite, Mn-olivine, Mn-garnet, diopside, and sulphides; (3) oxidized ores consisting of massive, banded, and radiating psilomelane, pyrolusite, calcite, dolomite, and quartz. The sedimentary environment is interpreted as shallow marine or nearshore. To the west of the deposit are a group of smaller sedimentary Mn deposits. The deposit is large with reserves of 37.69 million tonnes grading 18-24% Mn.

Gaobanhe Sedimentary Exhalative Pb-Zn (SEDEX) Deposit

This deposit (Tu Guangzhi and others 1994) consists of nine stratiform deposits that occur in an east-west-trending belt that is 6 km long and 3 km wide. The host rocks are Mn shale and dolomite of late Proterozoic Gaoyuzhuang Formation. Ore minerals are mainly sphalerite, galena, and pyrite, and the ore varies from massive to banded. Framboidal, colloform and pelletoidal pyrite are common. The deposit occurs in the east-west-trending Yanliao basin on the Sino-Korea Craton. The deposit is medium size with an average grade of about 2% Zn and a lower concentration of Pb.

Origin and Tectonic Controls for Yanliao 2 Metallogenic Belt

The belt is interpreted as forming in a shallow marine basin on the Sino-Korea Craton and is hosted in the Middle and Neoproterozoic Hebei-Liaoning sedimentary basin. The Mesoproterozoic part of the basin consists of: (1) sandy-muddy dolomite; (2) dolomite; (3) shale; (4) quartz sandstone, dolomite, and limestone, dolomitic limestone; (5) sandstone and siltstone; (6) muddy limestone. The Yanliao oceanic basin changed from shallow sea in the Jixianan period to an epicontinental sea in the Qinbaikou period (Wang Hongzhen, 1985). The Mn deposits of the Wafangzi type are interpreted as forming in a shallow oceanic basin.

REFERENCES: Wang Hongzhen, 1985.

Fanhe Metallogenic Belt of Carbonate-Hosted Pb-Zn (Mississippi Valley type) Deposits (Belt FH) (Northeast China)

This Early to Middle Mesoproterozoic metallogenic belt is hosted in the small Fanhe Mesoproterozoic sedimentary basin (too small to show at 5 M scale) in part of the Sino-Korea platform sedimentary cover. The belt occurs in the eastern Liaoning Province, is 80 km long, over 30 km wide, and strikes north-northeast. The isotopic ages for the Fanhe Group range from 1600 to 1300 Ma. The host rocks for the deposits are siltstone and silty shale, dolomite and limestone. The significant deposit is at Chaihe.

Chaihe (Guanmenshan) Carbonate-Hosted Pb-Zn (Mississippi Valley type) Deposit

This deposit (Rui, Zongyao, 1994; Tu, Guangzhi, and others, 1994) consists of about 150 pod-like, stratiform, vein-type deposits. Host rocks are mainly banded dolomite of Early Mesoproterozoic Fanhe group. Ore minerals are mainly galena, sphalerite, pyrite, and others. that occur in masses, veinlets, and disseminations. The deposit is controlled by a northeast-striking fracture zone that is the secondary structure of major Yilan-Yiton fault zone. This fault zone occurs between the Fanhe basin and Tieling-Jingyu uplift. The deposit is medium-size with reserves of 147,800 tonnes Pb, 391,500 tonnes Zn, and an average grade of 3.90% Pb and 8.18% Zn.

Origin and Tectonic Controls for Fanhe Metallogenic Belt

The belt is interpreted as forming in Fanhe Group that occurs in a small Mesoproterozoic aulacogen superposed on the Sino-Korean Craton. The Fanhe Group consists of: (1) quartz and feldspar sandstone (Dahongyu Formation) that is 570 m; thick (2) dolomite (Gaoyuzhuang Formation) that is 1190 m thick; and (3) shale, quartz sandstone, and dolomite (Yanzhuang Formation) that is about 2,800 m thick. The Pb-Zn deposits occur in the.upper part of dolomite horizons. The Fanhe Pb-Zn deposit may be transitional between Mississippi Valley and the SEDEX types (Rui Zonggyao, 1994).

REFERENCES: Tu Guangzhi and others, 1989, Rui Zonggyao, 1994.

Chungnam Metallogenic Belt of Banded Iron Formation (BIF, Superior Fe) and Metasomatic U(?) Deposits (Belt CN) (South Korea)

This Late Paleoproterozoic and Early Mesoproterozoic metallogenic belt occurs in the Gyenggi granulite-paragneiss terrane in the Ogcheon Group (part of the South China Craton) that is intruded by the Jurassic Daebu Granite belt. Isotopic age of the metallogenic belt ranges from 1400 to 800 Ma. The Ogcheon Group consists of graphitic black schist, mica schist, quartz schist, and granite gneiss. The Daebu granite belt consists of biotite granite, granite porphyry, and quartz porphry. The major deposits are at Seosan, and Kongju.

Seosan Banded Iron Formation (BIF, Superior Fe) Deposit

This deposit (Kim, 1965) of zones or lenses in Precambrian quartz schist that is intruded by various probable Cretaceous igneous intrusives. The ore bodies are generally low grade hematite and magnetite and are interpreted as a dynamo-metamorphic deposit of sedimentary origin that was enriched in the northern area by thermal metamorphism following intrusion of granite gneiss. The ore minerals exhibit five textures: fine banded, medium banded, coarse banded, coarse spotted , and massive. In the southern area, hematite is dominent exhibits a well-developed banded structure, with alternating hematite and silica bands parallel to schistosity of the country rock. In the northern area, most of the ore minerals are coarse-grained spotted or massive with various ratios of hematite to magnetite. A ratio of 7:1 to 5:1 is dominant in medium banded type. The deposit averages 5 to 60 meters wide and 30 to 200 meters long. Assays reveals traces of TiO_2, S, and P. SiO_2 content is high, varies inversely with Fe. The deposit is medium-size with average grade of 31.42% Fe and a resource of 5,222,000 tonnes and reserve of 1,476,000 tonnes Fe.

Kongju Metamorphic Graphite and Metasomatic U Deposit

This deposit (Yun and Kim, 1959) is hosted in Proterozoic graphitic black shale in the Kongju Formation. Seven drill holes peneterate the deposit. The host rocks consists of Precambrian metasedimentary rock, mostly mica schist, and granite gneiss, and Jurassic intrusive rocks. Graphite deposit consists of recrystallized graphite, quartz, feldspar, muscovite, and biotite with minor zoisite, chlorite, zircon, pyrite, sphene, galena, uraninite, and V-oxides. Size of crystalline graphite flakes ranges from 0.5 mm to 1 mm mostly. Minimum size is 4 microns. Size of uraninite is 6 to14 microns. Average grade is 24.4% C, 0.03% U_3O_8, and 0.08% V_2O_8. Graphite formed in two stages: (1) carbonaceous material in arenaceous sedimentary rock recrystallized to crystalline graphite during regional metamorphism,; and (2) carbon dioxide from limestone that was converted to graphite during intrusion of younger granitoids. Uranite is interpreted as forming in a reducing environment from U that was absorbed in the carbonaceous material during circulation of U-bearing ore solution. V-oxide(?) replaced carbonaceous material during circulation of V-bearing solution. The graphite deposits are at Sohak-ri, Kaeryong-myon, Kongju-gun, Chungchong-namdo. The deposit is small with an average grade of 0.0385% U_3O_8 and reserves of 2,560,000 tonnes ore.

Origin and Tectonic Controls for Chungnam Metallogenic Belt

The belt is hosted in middle Proterozoic Gyeonggi metamorphic complex and Ogcheon Group that consists of graphitic black schist, mica schist, quartz schist and granite gneiss. Graphite deposits occur in zones or lenses in quartz schist. Uranite interpreted as forming in a reducing environment from U that was absorbed in the carbonaceous material, during circulation of U-bearing ore solution.

REFERENCES: Kim, and Yun, 1959; Koo and others, 1977; Kim, 1965; Duk Hwan Hwang, this study.

Koksung Metallogenic Belt of Metamorphic Graphite Deposits (Belt KO) (South Korea)

This Mesoproterozoic and Neoproterozoic metallogenic belt is hosted in Yeongnam Metamorphic Complex (part of Sino-Korean Craton, Yeongnam granulite-paragneiss terrane) and Jurassic Daebu granite belt. The major deposit is at Koksung. The age of the belt ranges from 1400 to 800 Ma. The Yeongnam terrane consists of leucogranite gneiss, hornblende plagioclase gneiss, biotite gneiss and biotite schist.

Koksung Graphite Deposit

This deposit (Lee, 1960) occurs at Songjongni, Ogok-myeon, Koksung-gun, Chollanam-do province and is an undeveloped, newly-discovered graphite occurence. Host rocks chiefly consist of granite gneiss, biotite schist with variable graphite content, and graphite-biotite schist with small amount of graphite. In the biotite schist zone are six ore shoots with relatively good content of graphite that is lenticular and extremely irregular. The deposit is small with an average grade of 5.46% F.C. and reserves of 6,770 tonnes.

Origin and Tectonic Controls for Koksung Metallogenic Belt

The belt is hosted in Yeongnam Metamorphic Complex that consists of leucogranite gneiss, hornblende plagioclase gneiss, biotite gneiss, and biotite schist. Graphite deposits occur in granite gneiss and graphite bearing biotite schist generally minor graphite.

REFERENCES: Lee, 1962; Duk Hwan Hwang, this study.

NEOPROTEROZOIC METALLOGENIC BELTS (1000 to 540 Ma)

Igarsk Metallogenic Belt of Sediment-Hosted Cu Deposits (Belt IG) (Western margin of North Siberian Craton, Russia)

This Vendian to Early Cambrian metallogenic belt occurs in the northwestern North Asian Craton Margin and consists of lenses of red-bed sedimentary rocks that occur in a Vendian submontane basin in the Riphean Igarsk uplift (Dyuzhikov and others, 1988). The belt occurs in a sublongitudinal, narrow band up to 100 km long. The host late Riphean and Early Cambrian sedimentary rocks occur in three structural levels: (1) intensely deformed clastic and carbonate rock of the Ludovsk and Gubinsk Series (early and middle Riphean); (2) clastic and carbonate deposits of the Chernorechensk Series, and red-bed clastic rocks of the Izluchinsk Series (late Riphean); and (3) carbonate rock with rare sandstone and siltstone of the Vendian and Early Cambrian Sukharinsk Series. There are two persistent horizons of Cu deposits. The lower horizon occurs in a transitional zone between the Izluchinsk red-bed suite and the underlying grey sedimentary rock of the Chernorechensk suite. This horizon is about 5 m thick (rarely up to 15 meters) and consists of of fine-grained disseminated digenite, bornite, and chalcopyrite. The upper horizon occurs at the base of marine grey deposits of the Sukharinsk suite and overlying red-beds of the Izluchinsk suite. The horizon is 10 to 30 m thick. Cu-rich areas often occur in the upper ore horizon (Graviiskoye and Sukharinskoye deposits). Two types of deposits are distinguished, deposits directly connected with host strata and crosscutting high-grade deposits in fracture zones. The major deposit is at Graviiskoye.

Graviiskoye Sediment-Hosted Cu Deposit

This deposit (Rzhevskiy and others, 1980; Gablina and others, 1986; Djuzhikov and others, 1988; Lurie, 1988) is hosted in late Riphean red and grey sedimentary rock consisting of alternating argillite, clay limestone, and marl). Southern, northern, central, and eastern deposits are recognized. The Southern and Northern deposits occur in basal layers of lagoon sedimentary rock. The Southern deposit is 3.3 km long, and the Northern deposit is 1 km, and both fary from a few meters to 60 m thick. Sulfide minerals occur in streaks. Main ore minerals are diagenite, bornite, chalcopyrite, and pyrite. Slight silica alteration of wall rocks occurs. The Central deposit occurs above a paleouplift between two reefs. The deposit is 900 m long and up to 70 m thick. Main ore minerals are djurleite and bornite that occur in lenses and streaks. Sparse chalcopyrite and galena occur at the deposit periphery. Wall-rock alteration consists mainly of intense silica alteration with widespread antraxolite. The Eastern deposit consists of numerous lenses and ore-bunches of Cu minerals in conglomerate and breccias in the reef shelf. Main ore minerals are digenite and bornite with rare chalcopyrite, galena, and pyrite. Wall-rock alteration consists of carbonate minerals, and sparse antraxolite. The deposit is small.

Origin and Tectonic Controls for Igarsk Metallogenic Belt

The belt forms the northern large margin of the Pribaikal-Yeniseisk Cu belt (Malich and others, 1987). The late Precambrian deposits of Cu sandstone and Cu slate in the Igarsk uplift. The Cu-bearing rocks coincides with the late Riphean Norilsk-Turukhansk aulacogen. Cu deposits are related to the zones of lateral pinching of red-bed molasse sedimentary rock that formed in the final stage of development of orogen basin (Malich and Tuganova, 1980). Cu minerals were deposited in a katagenesis environment during migration of groundwater. Metals precipitated along the hydrosulfuric geochemical barriers. Deposits are interpreted as forming along flexures, anticline uplifts, and fracture zones that were favorable to migration of Cu-bearing groudwaters (Lurie, 1988).

REFERENCES: Malich, Tuganova, 1980; Malich and others, 1987; Djuzhikov and others, 1988; Lurie, 1988.

Isakovsk Metallogenic Belt of Volcanogenic-Sedimentary Mn and Volcanogenic Cu-Zn Massive Sulfide (Urals type) Deposits (Belt IS) (Yenisei Ridge, North-Asian Craton Margin, Russia)

This Middle and Late Riphean metallogenic belt is hosted is hosted in the Isakov island arc terrane that contains Middle to Late Riphean rhyolite and basalt. The belt occurs in the northwestern Yenisei Ridge in a synclinorium that extends sublongitudinally along Yenisei River for more than 250 km, and ranges up to 60 km wide. Volcanic and sedimentary rocks consist of basalt porphyry, diabase, andesite, dacite, rhyolite porphyry, and tuff (Kornev and others, 1974). These rocks are metamorphosed to greenschist facies and are intruded by small late Riphean granitoid plutons. The major volcanogenic-sedimentary mn deposit is at Porozhinskoye and the major volcanogenic Cu-Zn massive sulfide deposit is at Khariuzikhinskoye 1.

Porozhinskoye 1 Volcanogenic-Sedimentary Mn Deposit

This deposit (Golovko, Nasedkina, 1982; Gorshkov, 1994) consists of beds and lenses of rhodochrosite in Vendian chert and carbonate clastic, and pyroclastic rocks with oxidized Mn in various deposits. Host rocks vary from 25 to 85 m thick. Ore horizon contains small beds and lenses of rhodochrosite that locally comprise larger deposits. Twelve deposits, with sizes from hundreds meters to a km long along strike are known. Deposits range from 0.5 to 10 m thick with a average of 2 to 3 m. Rhodochrosite is microcrystalline, is often oolitic, and replaces pyroclastic fragmen. Siderite and dolomite are widespread along with pyrite and apatite. Carbonate ores with 8 to 29% Mn are not ecomically important. Near the surface, primary carbonate ores are oxidized sometimes up to several tens of meters depth. Oxidized ores are: manganite with up to 48% Mn and 7.9% Fe, and pyrolusite and psilomelane with uup to 29% Mn and 28% Fe. Age of oxidized ore formation is Cretaceous and Paleogene. The deposit is large with an average grade of 18.29% Mn.

Khariuzikhinskoye 1 Volcanogenic Cu-Zn Massive Sulfide Deposit

This deposit (Okhapkin and others, 1976) consists of beds of Zn-Cu sulfides and pyrite that are in late Riphean metamorphosed volcanic and sedimentary rock. Sulfide deposits occur at crest of a brachyanticline and dips 20-50° northwest together with host mafic volcanic rocks and tuff. The deposit is 15 m thick and extends about 60 m along strike. Host mafic lava and tuff are schistose and altered into chlorite-epidote-actinolite rock and pyrite. A gossan occurs at the surface. An association of lenses and layers of oxidized massive sulfide ores and schistose mineralized tuff exists. Primary ore is banded to disseminated, and medium-to fine-grained. Sulfide content ranges up to 80 to 90%. Main ore minerals are pyrite (60-80%), chalcopyrite, pyrrhotite, sphalerite, and bornite. Gangue minerals are quartz, sericite, chlorite, albite, calcite, epidote, biotite, actinolite, barite, and gypsum. The deposit is small with an average grade of 2.86% Cu, 0.38% Zn.

Origin and Tectonic Controls for Isakovsk Metallogenic Belt

The volcanogenic Cu-Zn massive sulfide deposit is hosted in metamorphosed rhyolite, andesite, and basalt that are interpreted as forming in an island-arc (Kornev and others, 1974; Kornev, 1985). Mn deposits are hosted in late Riphean and Vendian chert, clastic rock, and carbonates. Metabasalt in an associated ophiolite sequences is MORB or marginal sea type. Rb-Sr age of ophiolite sequence is about 1,260 Ma. Mn deposits are hosted in a late Riphean and Vendian siliceous, carbonate, and clastic sequence. The metallogenic belt is related to an island arc and ophiolite complex that was thrust onto the North Asian Craton Margin in the early Vendian.

REFERENCES: Kornev and others, 1974; Kornev, 1985; Golovko and Nasedkina, 1982; Cykin and Kostenko, 1984; Gorshkov, 1994.

Tatarsko-Tyradinsk Metallogenic Belt of REE-Li Pegmatite, W-Mo-Be Greisen, Stockwork, and Quartz Vein, and Ta-Nb-REE Alkaline Metasomatite Deposits (Belt TT) (Yenisei Ridge, North-Asian Craton Margin, Russia).

This Late Neoproterozoic metallogenic belt is related to veins and replacements in the Central Angara passive continental margin and Isakov island arc terranes. The belt is about 400 km length and ranges up to 150 km wide, has an irregular structure, and contains three main REE deposits, from south to north, at Sredne-Tatarsk, Enashiminsk, and Sredne-Vorogovsk. The deposits are generally small and genetically related to late Riphean and Vendian collisional, subalkalic, leucocratic granite and coeval nepheline syenite, alkali syenite, and granosyenite. The largest deposit is the Tatarskoye Nb apatite-pyrochlore carbonatite deposit that is hosted in alkali metasomatite and carbonatite. Deposits occur along intersections of sublatitudinal and northwest-trending faults with longitudinal major faults (Ishimbinsk and Tatarsk deep-faults). Granitoid-related REE deposits occur in anticlinal domes, and the alkali metasomatites occurs along deep-faults zones. Sn, W, and Mo occurrences occur in large granitoid plutons and small companion granite plutons and pegmatite bodies. The host rocks are contact metamorphosed, altered to greisen, and metasomatized (Brovkov and others, 1985).

Tatarskoye REE (±Ta, Nb, Fe) Carbonatite Deposit

This deposit (Brovkov and others, 1985) consists of phosphate and Ni minerals in carbonatite and alkali metasomatite that occur in an exocontact zone of a granitoid pluton that intrudes interbedded Proterozoic quartz-micaceous schist, marble, quartzite, amphibolite, and amphibole-chlorite schist. The district containing the deposit extends more than 20 km and ranges from 50 to 300 to 400 m wide. Twelve lensoid and sheet-like deposits occur in the district. Carbonatite is interpreted as a metasomatic unit and consists of dolomite-amphibole-biotite and calcite-amphibole-biotite carbonatite. Dolomite carbonatite has highest grade. The deposit minerals are Fe-dolomite, phlogopite, alkali amphibole, apatite, magnetite, pyrochlore, columbite, pyrrhotite. Also occurring are minor pyrite, chalcopyrite, ilmenite, molybdenite, zircon, rutile, and sphene. Deposit is interpreted as a near-fault type of alkaline metasomatite related to alkali basalt magmatism. Weathered surface rocks containg up to 5% Nb_2O_5, is widespread and contains complex Ni and phophorus minerals and vermiculite. The deposit is large.

Oleniya Gora W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Matrosov and Shaposhnikov, 1988) consists of scheelite-bearing quartz veins cutting Neoproterozoic metamorphic rock that is intruded by Tatarsk-Ayachtinsk granitoid complex. The deposit occurs along the contact of quartz-carbonate-mica and quartz-micaceous schist with quartzite. The deposit extends along strike for about 900 m long, varies from 1 to 60 m thick, and contains numerous quartz veins from 15 to 18 m long and 0.8 to 4 m thick. Quartz veins also occur concordant to quartzite and hornfels. The ore minerals occur in streaks, nests, and disseminations. The principal ore mineral is scheelite, and associated minerals are pyrrhotite, pyrite, arsenopyrite, chalcopyrite, stibnite, berthierite, native silver, and gold. Antimony and Au deposits superimposed on W deposits. Ore shoots are common. The deposit is medium size with an average grade of 0.1% WO_3. The deposit is medium-size with an average grade of 0.1% WO_3.

Enashiminskoye 3 REE-Li Pegmatite Deposit

This deposit (Brovkov and others, 1985) consists of Sn-bearing pegmatite veins in carbonate and micaceous schist adjacent to small bodies of Late-Proterozoic leucocratic granite. Veins vary from tens of meters to few hundreds of meters long and 0.2 to 4 m thick. Veins are intensely altered to albite and consist of quartz, albite, and microcline with subordinate lepidolite, zinnwaldite, fluorite, spodumene, tourmaline, spessartine, apatite, cassiterite, and magnetite. Columbite-tantalite, beryl, pyrrhotite, arsenopyrite, and pyrite occur rarely. Cassiterite is more abundant in areas of more intensely albite-altered pegmatite. The deposit is small.

Origin and Tectonic Controls for Tatarsko-Tyradinsk Metallogenic Belt

The belt and hosting magmatic occur along major fault zones separating major tectonic blocks. The host coeval granitoid and alkaline magmatic complexes interpreted as intruding during collision and local extension along major fault zones during oblique collision. The belt formed in a short time span in the late Riphean and Vendian and is hosted in leucogranite, alkali-leucogranite, alkali-granite-syenite, and nepheline syenite plutons that intruded along major fault zones. The isotopic age of the Tatarsko-Tyradinsk metallogenic belt is 675 to 620 Ma and during this time, four host magmatic complexes formed (Kornev and others, 1996): (1) the Gurakhtinsk complex of subalkali granite and leucocratic granite with aplite and pegamatite veins; (2) the Glushikhinsk complex of subalkalic leucocratic granite that is interpreted as a post-collisional intraplate granite; (3) the Srednetatarsk complex of nepheline syenite; and (4) the Srednevorogovsk alkali-granite-syenite complex that consists of A-type intraplate granite that formed in an extension regime (Kornev and others, 1996).

REFERENCES: Nozhkin, Trofimov, 1982; Brovkov and others, 1985; Lapin and others, 1987; Dacenko and others, 1994; Kornev and others, 1996.

Vorogovsko-Angarsk Metallogenic Belt of Sedimentary-Exhalative Zn, Pb (SEDEX), Carbonate-hosted Pb-Zn (Mississippi Valley type), and Fe Skarn Deposits (Belt VA) (Yenisei Ridge, North-Asian Craton Margin, Russia).

This Early Neoproterozoic metallogenic belt (also known as Yenisei Ridge polymetallic belt) occurs at the western margin of the Yenisei Ridge in the West Angara passive continental margin terrane in the Bolshepit synclinorium. The belt is about 450 km long and varies from 100 km (to the south) to 25 km (to the north) wide. The largest Pb-Zn deposits occur in the southern belt in the Priangarsk ore district. The main types of deposits in this district are: hydrothermal-sedimentary deposits with pyrite, pyrrhotite, and sphalerite that are conformable with host clastic and carbonate rocks (Gorevskoye); and galena and sphalerite streaks and disseminations that occur in algal limestone and dolomite (Moryanikhinskoye, Merkurikhinskoye, and others). To the north, in the Rassokhinskoye district (Lineinoye, Krutoye), and Bolshepitsk and Teneginsk districts are more than 300 deposits and occurrences that are mostly hosted in middle and late Riphean carbonaceous and clastic rock in a graben or syncline. Also occurring in this area are: Pb-Zn silicate and oxide deposits in carbonate rock (Teneginskoye); polymetallic vein deposits adjacent to porphyry deposits; and large Fe-skarn deposits (Enashiminskoye, Lendakhskoye, Polkan Gora) that occur near a central anticlinorium. These deposits and occurrences are related to middle and late Riphean volcanism and eruption of rhyolite and andesite-basalt, and subsequent formation of skarn along contacts with the granitoid plutons (Matrosov, Shaposhnikov, 1988). Three environment are defined for the various hydrothermal-sedimentary and polygenic stratiform Pb-Zn deposits: (1) deposition of proximal massive Pb-Zn sulfide deposits in local fault basins in clastic and carbonate sedimentary rock (Gorevskoye); 2) deposition of distal pyrite and polymetallic deposits in carbonaceous schist in deeper parts of basins (Lineynoye); and (3) deposition of carbonate-hosted Pb-Zn deposits hosted in carbonate reefs and sedimentary carbonate breccia horizons (Moryanikhinskoye, Merkurikhinskoye) (Ponomarev and others, 1991).

Gorevskoye Sedimentary Exhalative Pb-Zn (SEDEX) Deposit

This deposit (Distanov, 1985; Brovkov and others, 1985; Kuznetsov and others, 1990; Avdonin, 1997) consists of concordant lensoid masses of Pb-Zn sulfides hosted in late Riphean clastic and carbonate rock. The deposit occurs in a small synclinal fold on the limb of a larger anticline that is cut by the Main fault and associated fracture and shear zones on the northeast limb. Host rocks consist of a uniform sequence of dark-gray lenticular limestone with thin interbedded marl and shale. Host rocks are intensely deformed and metamorphosed to greenschist facies. Also occurring are numerous diabase dikes up to 10 m thick and several hundred meters long occur. Three separate deposits occur and range from 20 to 150 m wide, extend northwest for up to 1200 m, form an en-echelon system, and dip at 75 to 85°. The deposits extend to 1000 m depth at the southeastern flank of the deposit. Host rocks are siliceous siderite rocks and siderople. The ore mineral structures are lenticular, layered, streaky, massive, breccia, and disseminated. Main ore minerals are galena, pyrrhotite, and sphalerite, and lesser pyrite, marcasite, burnonite, boulangerite, jamsonite, arsenopyrite, ilmenite, rarely chalcopyrite, tennantite, argentite, pyrargirite, prustite, sternbergite, diskrasite, native silver, and lollingite. In decreasing abundance, th gangue minerals are quartz, siderite, ankerite, dolomite, calcite, biotite, muscovite, and garnet. Sphalerite occurs mainly on hanging wall of the district, whereas galena is concentrated on the footwall. Ag, Cd, Ta, and Te occur in solid solution. A model Pb isotopic age for the deposit is 834 to 852 Ma. The deposit is a large, world class deposit and has an average grade of 7.02% Pb and 1.36% Zn.

Moryanikhinskoye Carbonate-Hosted Pb-Zn (Mississippi Valley type) Deposit

This deposit (Ponomarev and others, 1991) consists of layered bodies of disseminated, streaky, disseminated, and massive Pb-Zn sulfides hosted in late Riphean dolomite and limestone. The deposit occurs in a southeastern periclinal closing of an anticline complicated by a shear zone. Host rocks are are 320 m thick and consist of dark-grey dolomite and algal ferruginous limestone with interbedded shale, marl and tuffaceous siltstone, with. single beds of schistose metabasalt porphyry and blastoporphyritic quartz-sericite schist. A spatial relation between Pb-Zn deposits and organic carbonate units exists. Five concordant layered deposits occur, and extend more than 500 m along strike and range up to 600 m deep. The thickness of deposits ranges from 3.0 to 8.7 m, occasionally up to 33 m. Boundaries of deposits are gradational, particularly for disseminated ores. Main ore minerals are galena, sphalerite, and pyrite, and rare pyrrhotite, chalcopyrite, burnonite, and fahl. The main gangue minerals are quartz and Fe-carbonate. Galena and sphalerite with a Zn:Pb ratio of 2:5 are predominant. Chalcopyrite and fahl are typical minerals in veins along with sphalerite, galena and pyrite. The deposit is interpreted as forming under polygenous hydrothermal and sedimentary conditions. A model Pb isotopic age for the deposit is 740 to 849 Ma. The deposit is medium size with an average grade of 2.5% Pb and 1.1% Zn.

Enashiminskoye 2 Fe Skarn Deposit

This deposit (Matrosov and Shaposhnikov, 1988) consists of layers and lenses deposits of magnetite in metamorphosed middle Riphean volcanic, carbonate, and clastic rocks. Host rocks and Fe-ores are intruded by Chirimbinsk granitoid pluton. The contact zone is contact metamorphosed, carbonate-altered, and silicified and contains epidote-amphibole-garnet skarn. The district containing the deposit extends up to 4.7 km along strike and contains more than 20 deposits that vary from 5 to 70 m thick, are up to 700 m long, and are up to 650 m deep. Deposit minerals are magnetite, epidote, and amphibole. Deposit contains anomalous Ti, V, Cr, and Mn, and anomously low S and P. Deposit formation was polygenetic with initial formation of primary siliceous-carbonate and ferruginous sedimentary rocks that were regionally metamorphosed, contact-metasomatized. The deposit is large with resources of 450,000,000 tonnes grading 36 to 51% Fe.

Origin and Tectonic Controls for Vorogovsko-Angarsk Metallogenic Belt

The SEDEX deposits in the belt are interpreted as forming along major fault depressions along transcrustal block in pericratonal subsidences. Carbonate-hosted Pb-Zn deposits formed in carbonate reefs. Volcanogenic-sedimentary Fe deposits are interpreted as forming during marine volcanism and sedimentation. Formation of the metallogenic belt is interpreted as forming during convergence along a middle to late Riphean continental margin (Obolenskiy and others, 1999). The principal structural control for the Gorevskoye deposit was the intersection between a system of northwest block-bounding faults and the transversal Irkeneevsk plate boundary fault. Host rocks and the coeval deposits have model Pb isotopic age of about 950 Ma. Approximate coeval units are collision-related granite plutons (Tatar-Ayakhta complex) and dolerite dikes.

REFERENCES: Matrosov, Shaposhnikov, 1988; Distanov, 1985; Ponomarev and others, 1991; Obolenskiy and others, 1999.

Central Yenisei Metallogenic Belt of Au in Black Shale, Au in Shear Zone and Quartz Vein, and Clastic-Sediment-Hosted Sb-Au Deposits (Belt CY) (Yenisei Ridge, North-Asian Craton Margin, Russia)

This Late Neoproterozoic. metallogenic belt is hosted in the passive continental margin Angara terrane and is related to regional metamorphism and granitoid magmatism. The belt extends north-northwest along the axial zone of the Yenisei Ridge for 450 km and is 40 to 80 km wide in the central anticlinorium formed Proterozoic rocks metamorphosed to amphibolite and epidote-amphibolite facies (Paleoproterozoic Teisk series), and to greenschist facies (Mesoproterozoic Sukhopit series). The metallogenic belt is bounded by the Tatarsk fault zone to the west and by the Ishimbinsk fault zone to the east. The central anticlinorium is cut by a northeast-striking transform fault that controls the regional structure, the occurrence of synorogenic and postorogenic granitoid intrusions, and the location of major districts. Au and Au-Sb deposits are predominant in the belt and occur mainly in three districts (from north to south): Severo-Yenisei (Sovetskoye, Eldorado, Ajakhta, and others); Verkhne-Enashiminsk (Olimpiada, Enashiminskoye); and Partizansk (Udereiskoye, Razdolninskoye). Host rocks are mainly carbonate and clastic rock and black shale in the middle and lower parts of the middle Riphean Sukhopit. Collisional batholithic granitoid S-type plutons of the Tataro-Ayakhtinsk complex (with an isotopic age850 Ma) are widespread (Kornev and others, 1996). The three main types of deposits are: (1) Au-quartz vein (Sovetskoye and others); (2) Au in black shale (Olimpiada and others); and (3) clastic-sediment-hosted Sb-Au (Udereiskoye, Razdolninskoye). Most deposits are polygenetic and formed during the middle to late Riphean and Vendian.

Sovetskoye Au in Shear Zone and Quartz Vein Deposit

This deposit (Bernstein and Petrovskaya, 1954; Bogdanovich, 1964; Petrovskaya, 1967; Petrov, 1974; Smirnov, 1978; Serdyuk, 1997; Simkin, 1997) consists of quartz-Au veins cutting Neoproterozoic phyllite that is intruded by small gabbro and diabase bodies and a Paleozoic syenite porphyry. Deposits occurs in a thick conformable shear zone that is complicated by small-scale folds. The district containing the deposit extends up to 8 km along strike, ranges up to 650 m wide, and extends to 390 m depth. Deposit consists of subparallel, branching veins, veinlets, and lenses. Separate veinlets and veins vary from less than a cm to 10 to 20 cm thick. Veins contain mainly coarse-grained quartz and fragments of low-grade altered host rock. Gangue minerals are carbonate, sericite, albite, and chlorite. Ore minerals constitute about 5% and are pyrite, arsenopyrite, lesser chalcopyrite, galena, sphalerite, pyrrhotite, and marcasite. Gold is fine-grained. Fineness of Au averages 940. Deposits consists mainly of quartz, quartz-pyrite, quartz-arsenopyrite, and quartz-sulfide types. Quartz-sulfide type contains the most Au. Contact zones of deposits are more productive. Two types of hydrothermal wall-rock alterations are: (1) combination of tourmaline, albite, sericite, and chlorite alteration; and (2) silica, sericite, chlorite, and sulfide alteration. Magmatic intrusive rocks occur 2 to 5 km to the northeast and consist of diabase and gabbro and diabase and dikes of mica lamprophyre, syenite porphyry, and a slightly eroded granitoid pluton. A major magmatic chamber beneath the deposit is interpreted as the source of deposit-forming solutions (Brovkov and others, 1985). The deposit is medium size with an average grade of 2.2 g/t Au.

Olympiada Au in Black Shale Deposit

This deposit (Li and others, 1990) occurs in the central part of the Central-Yenisei metallogenic belt in the Verkhne-Enashiminsk district and consists of layered and saddle-shaped bodies of disseminated Au-sulfide in metasomatite hosted in regionally-metamorphosed Neoproterozoic carboniferous and clastic rock. The deposit occurs in a roof pendant above the large Neoproterozoic Chirimbinsk granitoid pluton. Host rocks are quartz-carbonate and micaceous schist with intercalated dolomite and carboniferous and quartz-muscovite schist. Host rocks are hydrothermally altered to quartz-carbonate and mica, mica-carbonate and zoisite-quartz-mica metasomatite. Skarn locally occurs with metasomatite. Ore minerals are pyrrhotite, arsenopyrite, stibnite, berthierite, pyrite, and native Au, and rare galena, sphalerite, chalcopyrite, scheelite, fahl, and Bi-minerals. Ore minerals constitute 4 to 5% total amount of deposit. Free gold is fine-grained and disseminated and varies from 0.001 to 0.1 mm wide. Gold occurs with arsenopyrite, pyrrhotite, and granoblastic quartz. Two generations of native gold occur, an early generation with a fineness of 910 to 997, and a later generation with a finenest 647 to 757 that is associated with carbonate-hosted Sb occurrences. Weathering crust is wide-spead and contains higher-grade Au. Mining of Au-bearing crust is continuing. Weathering crust ranges to 390 m depth. The deposit is large with reserves of 700 tonnes Au grading 3-4 g/t Au.

Udereiskoye Clastic Sediment-Hosted Sb-Au Deposit

This deposit (Distanov and others, 1975; Berger, 1981; Brovkov and others, 1985) consists of quartz veins and veinlets with Au and Sb minerals hosted in Mesoproterozoic quartz-chlorite-sericite, quartz-sericite, and chlorite-sericite schist. The deposit is mainly in a steeply-dipping shear zone that is conformable with host rocks structure. Saddle-shaped reefs also occur. Deposit consists of about 12 to 15 veins that total up to 10 to 80 m thick. Commercial deposits are outlined by sampling and contain both ore veins and mineralized host rocks. Host rocks are slighly hydrothermally-altered with formation of sericite, chlorite, silica, sulfides, carbonate, and tourmaline. The main ore minerals are quartz, stibnite, berthierite, arsenopyrite, pyrite, carbonate, sericite, native gold, sphalerite, galena, chalcopyrite, argentite, and fluorite. Distribution of Au in deposits is irregular. Higher Au concentrations occur in arsenopyrite. The deposit is interpreted as forming in a complicated multistage process. Two younger mineral assemblages are quartz, arsenopyrite, and pyrite with Au, and quartz, berthierite, stibnite with sparse Au. The deposit is medium size with an average grade of 0.28 to 4.2 g/t Au.

Origin and Tectonic Controls for Central-Yenisei Metallogenic Belt

The gold deposits of the belt are interpreted as forming during collisional development of the late Riphean continental margin of the North Asian Craton. Gold initially occurring in black shale was subsequently concentrated and remobilized during collision-related metamorphism, granitoid intrusion, and hydrothermal activity (Obolenskiy and others, 1999). The belt occurs in the Sukhopit series that consists of sandstone and argillite formed in a marginal sea shelf facies. Host rocks have anomalous Au, Sb, and W and are interpreted as possibl sources of ore (Li, 1974; Shokhina, 1974; Li and others, 1979; Berger, 1981). Au-quartz vein deposits are associated with granitoid intrusions that form batholithic granitoids with deposits. Disseminated Au deposits in black shale (Olimpiada and others) are related to metasomatite hosted in carbonate and clastic rocks in a roof pendant of a large granitoid pluton (Li and others, 1984). Sb-Au clastic-sediment-hosted, hydrothermal vein deposits occur in the Partizansk ore district in the southern part of the belt and are hosted in middle Riphean carbonaceous schist of the Uderei series (Distanov and others, 1975; Li and others, 1971). K-Ar hydromica metasomatite isotopic ages for the youngest stage of deposits are 605±30 Ma (Distanov and others, 1975) and 664±36 Ma (Ovchinnikov and Voronovskiy, 1974). These ages are coeval with the Rb-Sr age of 601±9 Ma for the Tatarsk granitoid pluton (Sobachenko and others, 1986). Recent for the origin of the belt interpretations consist of multistage polygenetic sedimentary, metamorphic, and hydrothermal origin of Au and Sb-Au deposits with primary accumulation of gold in black shale and subsequent concentration and remobilization during metamorphism and granitoid-related hydrothermal activity (L, 1974; Berger, 1981; Nekludov, 1995).

REFERENCES: Li and others, 1971, 1974, 1978, 1979, 1984; Distanov and others, 1975; Brovkov and others, 1985; Kornev and others, 1996; Obolenskiy and others, 1999.

Kyllakh Metallogenic Belt of Carbonate-Hosted Pb-Zn (Mississippi Valley type) Deposits (Belt KY) (Russia, Southern Verkhoyansk fold and thrust belt)

This Vendian metallogenic belt is hosted in carbonate sedimentary rock. The belt extends longitudinally for 400 km along the North Asian Craton boundary in the southern Verkhoyansk fold and thrust belt. The belt is hosted primarily in thick Riphean through Cambrian carbonate and clastic rock. Several stratigraphic horizons of stratiform Pb-Zn and Cu deposits are recognized. The main deposits (from bottom to top) are in the: (1) middle Riphean Bik and Muskel Formations (Cu, Pb-Zn); (2) late Riphean Lakhanda Formation (Pb-Zn); (3) late Riphean Uy Formation (Cu, Pb-Zn); (4) Vendian Sardana formation (Pb-Zn); (5) Early Cambrian Pestrotsvetnaya Formation (Cu); and (6) Middle Cambrian Ust'-Maya Formation (Cu). The major horizon is the Vendian Sardana Formation that contains about 40 Pb-Zn deposits and occurrences that occur in a transition zone from the western, near-platform facies to the eastern, basin facies area. The Sardana Formation is subdivided into a lower barren sandstohe, mudstone, and carbonate unit, and an upper productive limestone and dolomite unit. Commercial deposits occur in the area of facial thinning out of saccharoidal dolomite. The major deposits are at Sardana, Urui, and Pereval'noe.

Sardana Carbonate-Hosted Pb-Zn (Mississippi Valley type) Deposit

This deposit (Ruchkin and others, 1977; Kuznetsov, 1979; Kutyrev and others, 1989; Davydov and others, 1990) consists of disseminated, banded, massive, brecciated, and stringers of ore minerals in and adjacent to a dolomite bioherm that ranges from 30 to 80 m thick and is hosted in the Neoproterozoic (Late Vendian) Yudom Formation. Lensoid deposits are concordant with dolomite in the Upper Sardana subformation that contains three members (from bottom to top): (1) light-grey fine-grained dolosparite (17 to 30 m thick); (2) dark-grey bituminous limestone and dolosparite (5 to 29 m thick); and (3) layered limestone and massive saccharoidal dolosparite (31 to 87 m thick). Several ore horizons occur, and the central area on the western limb of the Kurung anticline is the most productive. In this area, three Pb-Zn sulfides deposits extend for 150 to 1300 m and range from 9 to 70 m thick. The largest part of the deposit occurs in the third member and ranges up to 50 m thick. Galena and sphalerite are predominant and occur in masses, veinlets, and disseminations. Main ore minerals are sphalerite, galena, and pyrite, with subordinate chalcopyrite, marcasite, and arsenopyrite. Oxidized ore minerals are smithsonite, cerussite, anglesite, goethite, hydrogoethite, and aragonite. The deposit is the largest deposit in the Sardana Formation and occurs in the Selenda syncline that is complicated by the Kurung anticline and longitudinal thrusts. Low grade disseminations occur in Neoproterozoic (Upper Vendian) dolomite for many kilometers in both limbs and in the axis of a north-south-trending syncline that is 3 km wide and more than 10 km long. Deposit intruded by sparce diabase and dolerite dikes. Average combined Pb+Zn grade is 6%, with a maximum of 50%. The deposit is large with reserves of more than 1.0 million tonnes combined Pb+Zn. Drilling indicates additional sulfide bodies occur at a depth of 200 to 300 m.

Origin and Tectonoc Controls for Kyllakh Metallogenic Belt

The belt is interpreted as forming along the passive margin of the North Asian Craton. Economic deposits occur in areas of facial thinning out of dolomite

REFERENCES: Arkhipov, 1979; Davydov and others, 1990; Davydov, 1992; Parfenov and others, 1999, 2001.

Angara-Pit Metallogenic Belt of Sedimentary Siderite Fe and Volcanogenic-Sedimentary Fe Deposits (Belt AP) (Yenisei Ridge, North-Asian Craton Margin, Russia)

This Upper Riphean metallogenic belt is hosted in the North Asian Craton Margin (East Angara fold and thrust belt) and occurs in the southeastern part of Yenisei Ridge. The belt forms a band along the east wing of the Central anticlinorium from Angara River to the south to the Gorbilok River to the north, and is up to 100 km long. The belt contains three large chlorite-hematite deposits at Nizhne-Angarskoye, Ishimbinskoye, and Udorongovskoye, and numerous smaller occurrences. The deposits occur in clastic sedimentary rock of the late Riphean Nizhneangarsk. Each deposit consists of several (about 7 to 36) ore layers that vary from 2 to 16 m thick (ranging up to 30 m), have a total thickness of up to 50 m, and are 0.3 to 14 km long. All deposits exhibit similar geological structure, mineral composition, and quality of ore minerals. Ore layers and lenses hosted in clastic and clastic-chemogenous sedimentary rocks, mainly hematite gritstone and conglomerate, hematite sandstone, and sandy hematite-chlorite siltstone. Host rocks and deposits are metamorphosed to phyllite (Matrosov and Shaposhnikov, 1988). The major deposit is at Nizhne-Angarskoye.

Nizhne-Angarskoye Sedimentary Siderite Fe Deposit

This deposit (Yudin, 1968; Brovkov and others, 1985; Orlov, 1998) consists of layered hematite hosted in late Riphean argillite, siltsone, and sandstone. Fe horizon is 45 to 180 m thick and occurs in 36 separate deposits that range up to 29 m thick, extend up to 15 km along strike, and range to 650 m depth. Fe layers are intercalated with sedimentary rocks ranging up to 2 to 15 m thick. Ore layers consist of hematite, sandy-hematite, argillaceous chlorite hematite gritstone, hematite-siderite. Main ore minerals are hydrogoethite, hematite, and goethite with lesser siderite, magnetite, and pyrite. Gangue minerals are quartz, leptochlorite, clays, and sericite. Deposit contains 0.03% S and 0.08% P. The deposit is large with reserves of 1,200,000,000 tonnes grading 40.4% Fe.

Origin and Tectonic Controls for Angara-Pit Metallogenic Belt

The belt is interpreted as forming during a preorogenic stage of the Yenisei pericratonal subsidence in a back-arc (interland) sedimentary basin. Lithological-facial control of distribution of sedimentary hematite ores occurred. The paleodelta setting of formation of Fe ores is indicated by structural, mineralogical, and geochemical features of host rocks (Yudin, 1968). A possible source of clastic ore minerals was residual Fe-rich weathering crust (Brovkov and others, 1985).

REFERENCES: Yudin, 1968; Brovkov and others, 1985; Matrosov and Shaposhnikov, 1988.

Kansk Metallogenic Belt of Au in Shear Zone and Quartz Vein, REE-Li Pegmatite, amd W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposits (Belt KN) (Southern Yenisei Ridge, North-Asian Craton Margin, Russia)

This Early Neoproterozoic metallogenic belt occurs in the Kan cratonal terrane composed Archean crystalline rocks that crops out in the southern Yenisei Ridge. The western border of the belt is the Priyenisei major fault zone, the eastern border is a large fault between the Kan block anticlinorium and Angara-Taseev syncline. The northern border of the belt is the Angara-Viluy transform fault. The host are rocks are metamorphosed to amhibolite facies and are intruded by the Paleoproterozoic Taraksk gneiss and granitoid pluton with a Rb isochron age of 1850 to 1890 Ma, and a Rb-Sr isotopica age of 2.00 to 2.06 Ga). Also intruding the host rocks is the Neoproterozoic Nizhnekan granitoid pluton with a Pb isochron age of 850±50 Ma and a U-Th-Pb isochron age of 920±50 Ma (Kornev and others, 1996). Deposits are small in size and heterogenous. The major Au shear zone and quartz vein deposits, as at Kuzeevskoye and Bogunai, are predominant and occur in diaphthoresis zones in Archean rocks. Also occurring are W-Mo-Be greisen, stockwork, and quartz vein deposits, as at Kanskoye, and Li-Sn-Be and ceramic pegmatite, as at Barginskoye, that are related to granite intrusions. Ti-magnetite deposits occur in Riphean dunite, pyroxenite, and gabbro intrusions. Volcanic and sedimentary magnetite quartzite, as at Predivinskoy, is related to Riphean rhyolite and basalt. Three main districts occur in the belt: Kuzeevsk (Au), Bogunai (Au), and Predivinsk (Fe). The Sayan-Yenisei fault is the main structural control. (Brovkov and others, 1988).

Bogunai Au in Shear Zone and Quartz Vein Deposit

This deposit (Li, 1974; Bovin and Li, 1976; Serdyuk, 1997) consists of more than 40 quartz veins hosted in Archean metamorphic rock. The main host rocks are garnet and pyroxene plagiogneiss, granulite, migmatite, charnockite, and pegmatite, and diabase, diabase porphyry and gabbro dikes. Venis range up to several hundred meters length and are up to 1 km, and up to 2 m thick. Veins located in ares of greenschists facies metamorphism. Host rocks are altered to are silica, sericite, pyrite, chlorite, and carbonate. Main ore minerals are pyrite, sphalerite, and galena; and minor chalcopyrite, arsenopyrite, pyrrhotite, cubanite, magnetite, native gold, cassiterite, stannite, andmolybdenite. Gangue minerals are quartz (70 to 95%), calcite, siderite, chlorite, and sericite. Native gold is fine-grained and is associated with sulfides. Deposit is partly mined. A Pb-isotopic age of Au-sulfide deposits is 900±150 Ma. The deposit is small.

Kanskoye W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Matrosov and Shaposhnikov, 1988) consists of quartz-molybdenite veins in the Neoproterozoic Nizhnekansk granitoid pluton. Veins range up to 270 to 300 m long and are from 0.16 to 0.38 m thick. Host rock is altered to greisen. Ore minerals are molybdenite, pyrite, chalcopyrite, and ilmenorutile. Molybdenite occurs irregular grains. Sparese disseminated molybdenite occurs along with wolframite, scheelite, and cassiterite in greisen, scheelite skarn, and pegmatite. The deposit is small.

Barginskoye REE-Li Pegmatite Deposit

This deposit (Matrosov and Shaposhnikov, 1988; Serdyuk and others, 1998) consists of pegmatite veins in Archean garnet-hypersthene gneiss. Host rocks along veins are altered to mica, staurolite-mica, and amphibole gneiss. 121 pegmatite veins occur and are generally conformable to host rock schistosity. Veins are layered, extend up to 400 m, and range from 1 to 2 m thick. The Giant vein is 2 km long and 10 to 50 m thick. Also occurring are lensoid pegmatite bodies. Major pegmatite minerals are quartz, K-feldspar, muscovite, biotite, garnet, beryl, epidote, and apatite. 15 veins contain commercial muscovite. Muscovite is low grade. Deposit has been mined. Pegmatite is genetically related to a Neoproterozoic granite sequence (Brovkov and others, 1985). The deposit is small.

Origin and Tectonic Controls for Kansk Metallogenic Belt

The belt is interpreted as forming during tectonic and magmatic activation of the Angara-Kan block during orogenic development of the Riphean continental margin of the North Asian Craton. A direct relation between Au deposits and granitoid intrusions is not established. Au deposits are largely related to small mafic intrusions that intrude along the Sayan-Yenisei fault zone (Bovin and Li, 1976). W-Mo greisen and REE vein and pegmatite of presumed Late-Riphean age are interpreted as forming during early-stage intrusion of collisional granitoids (Li, 1982).

REFERENCES: Bovin and Li, 1974; Li, 1982; Brovkov and others, 1988; Kornev and others, 1996.

Tonodskiy Metallogenic Belt of Au in Black Shale Deposits (Belt Tnd) (Russia, Northern Transbaikalia)

This Riphean metallogenic belt occurs in the Paleoproterozoic Tonod greenschist terrane that comprises part of the basement of the North Asian Craton. The belt extends along a sublatitudinal trend for over 200 km is about 35 to 60 km wide. The belt occurs along the southeastern boundary of the North Asian Craton The terrane consists of quartz and quartz-feldspar metasedimentary rock (Albasinsky suite), turbidite sedimentary rock (rhythmically alternating black carbonaceous schist, quartz metasedimentary rock, chlorite-sericite and micaceous-quartz shale (Mikhailovsky suite) enclosing small bodies of metabasalt. The terrane is metamorphosed from greenschist to amphibolite facies and is deformed into linear and domal folds that are complicated by numerous thrusts. Most of the terrane consists of the accretionary Mesoproterozoic Chuya-Nechera granitoid and granite porphyry complex. The belt contains numberous Au deposits. Also occurring in the area are non-economic Fe, Sn, magnesite, U, and Ti-magnetite deposits. The major deposit is at Chertovo Koryto. Also occurring are promising large Au occurrences, as at Vostochny, Kevaktinsky, , and Osennee, that all occur on the periphery of the Kevaktinsky dome along major thrust zones in carbonaceous schist and metasedimentary rock. The belt is promising for undiscovered large Au deposits in the Kevaktinsky and Taimendinsky structures.

Chertovo Koryto Au in Black Shale Deposit

This deposit (B.V. Antonov and others wriiten commun. 1967; Ivanov and others, 1995; Kotkin, 1995) consists of three gently lying stockwork zones conformable with submeridional striking thrust. Zones contain quartz and sulphides in Paleoproterozoic carbonaceous schist and sandstone. Stockwork consists of variably-oriented veins and veinlets in fault zohes and range from 3 to 8 m thick (locally up to 300 m thick). Sulfides occur in quartz veins and enclosing rocks. Main ore minerals are arsenopyrite (0.1-0.5%), pyrrhotite, and pyrite, and lesser galena, chalcopyrite, sphalerite; ilmenite, apatite, rutile, garnet, zircon, and tourmaline. Fineness of gold is 870-904. Deposit occurs in central part of the Tonod uplift in the Patom district. The deposit is medium-size with an average grade of about 2.6 g/t Au.

Origin and Tectonic Controls for Tonodskiy Metallogenic Belt

Initial gold deposition from hydrothermal-metamorphic processes that occurred during Proterozoic regional metamorphism related to accretion and generation of Chuya-Nechera granitoids. Subsequent economic concentration during late Riphean tectonism and magmatism. Subsequent economic concentration during late Riphean tectonism and magmatism with intrusion of magmatic rocks along transform microplate boundaries and within plate (plume) environment.

REFERENCES: Kotkin, 1975; Ivanov and others, 1981; Ivanov and Ryazanov, 1992; Gusev and Khain, 1995; Ivanov and others, 1995.

Baikalo-Muiskiy Metallogenic Belt of Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu), Polymetallic (Pb, Zn, Ag) Carbonate-Hosted Metasomatite, and Serpentine-Hosted Asbestos Deposits (Belt BM) (Russia, Northern Transbaikalia)

This Neoproterozoic metallogenic belt occurs in the Baikal-Muya island arc, the Muya metamorphic terrane, and part of the Olokit accretionary wedge terrane. The major deposits are at Kholodninskoye, Lugovoye, and Molodezhnoye. The belt occurs along the northern periphery of the Vitim highland (northeastern coast of Lake Baikal) and extends from Lake Baikal to Vitim River. The belt is 500 km long and 120 km wide.

The lower part of the Baikal-Muya island arc terrane consist of tectonic slabs of ophiolite of various ages with hemipelagic sedimentary rock (Lower Kelyansky suite); and a middle Riphean island arc complex basalt, andesite, and plagiorhyolite (Verkhne Kelyansky suite), and gabbro and plagiogranite intrusions. The island arc rocks are metamorphosed to greenschist facies (Dobretsov, 1983; Bulgatov, Gordienko, 1999; Bozhko and others, 1999).

The Muya terrane consists of the metamorphic Kindikansky, Ileirsky, and Lunkutsky suites.

The Olokit-Delunuran accretionary wedge terrane consists of Riphean volcaniclastic and sedimentary rocks of the Olokit series with abundant interbedded tholeiitic basalt and rhyolite, volcanogenic siliceous sedimentary rock and tuff, and late Riphean carbonaceous, clastic, carbonate sedimentary rock of the Dovyren series. All units are metamorphosed to amphibolite facies and folded. The top displays subhorizontally lying post-accretionary sedimentary rock of intermontane basins (basalt, rhyodacite and molasse of the Padrinsky series late Riphean).

The suture complexes are collisional early Paleozoic granitoid of the Barguzin-Vitim belt.

The belt contains a group of deposits and large ore occurrences: Kholodninskoe (volcanogenic-hydrothermal-sedimentary massive Pb-Zn sulfides (±Cu), Lugovoye-polymetallic (Pb-Zn-Cu, Ba, Ag, Au) metasomatic carbonate and hosted. These deposits occur along the northern end of the Baikal-Muya island arc-in sedimentary rock of the Olokit back arc turbidite basin. There are deposits of Ni (Chaisky, Baikalsky), Mo and Fe (Tyisky, Abchadsky-ferruginous quartzite), Ti, Mn and REE. In the Baikal-Muya belt some basins (Distanov and others, 1982) contain local synclines filed with volcanogenic and siliceous-clastic rocks. As a result of metamorphism of amphibolite facies they turned to be garnet-quartz-plagioclase-micaceous schist, quartzite and marble. They host stratified pyrite-pyrrhotite-sphalerite-galena-chalcopyrite ores of banded texture (Kholodninsky deposit, occurrences Kholoysky and Kosmonavtov). Deposits are enclosed in horizons of rhythmically alternating carbonaceous aleuropelitic rock of diverse composition (Distanov and Kovalev, 1995). Deposits are multi-staged, tectonic zones have later streaky-stockwork deposits of quartz-carbonate and sphalerite, pyrite-galena-sphalerite composition.

The central part of the basin hosts the band of foliated Ni-bearing intrusions of olivinite-peridotite-troktolite composition of the Dovyren complex (Chaisky, Ioko-Dovyren, Baikalsky, Nurundukan plutons). The ultramafic varieties of the complex contain streaky-stockwork deposits of pyrrhotite, pentlandite, chalcopyrite and magnetite (Chaisky deposit of mafic-ultramafic related Cu-Ni-PGE). Ores often show increased content of cobalt, chromium and platinoids.

The late Riphean and Cambrian overlap complex of the Upper Angara sedimentary basin hosts deposits of polymetallic (Pb-Zn-Ag) metasomatic-hosted model type (Lugovoye deposit) occurring in silicified horizons of limestone. Deposits have lensoid shape and sphalerite of galena-pyrite-fluorite composition.

Bedded bodies of metasomatically altered dunite and harzburgite include commercial chrysotile-asbestos deposits with top quality commodity (Molodezhnoye, Ust-Kelyansky) that belongs to serpentine-hosted asbestos model type. The nephrite deposits (Paramskoye, Buronskoye) occur in the margins of ultramafic bodies and zones of apocarbonate metasomatism. Enclosing rocks have small occurrences of graphite (Muyskoye). The volcanic complexes of paleoophiolite composition encompass minor Au-sulfide-pyrite deposits confined to large zones of mylonitization of interblock origination (Kamennoye, Samokutskoye, Ust-Karalonskoye). Bedded lensoid sulfide ores contain pyrite, pyrrhotite, chalcopyrite, galena, sphalerite and sulfosalts of Ag with Pt and Pd.

Origin and Tectonic Controls for Baikalo-Muyskiy Metallogenic Belt

Various deposits in the belt are interpreted as forming in Baikal-Muya island arc or during Riphean accretion of terrane with Muya metamorphic terrane and Olokit-Delunuran accretionary wedge terrane.

REFERENCES: Distanov and others, 1982; Dobretsov, 1983; Bulgatov, 1983; Distanov and Kovalev, 1995; Bozhko and others, 1999; Bulgatov and Gordienko, 1999.

Bodaibinskiy Metallogenic Belt of Au in Black Shale Deposits (Belt Bod) (Russia, Northern Transbaikalia)

This Neoproterozoic to Early Carboniferous metallogenic belt occurs in the Patom fold and thrust belt in the North Asian Craton Margin. The major deposits are at Sukhoy Log, Vysochaishi, and Dogaldynskoye. The belt extends for 150 km east-west and 160 km north-south. The belt occurs in the Mesoproterozoic to early Paleozoic overlap complex of the Patom sedimentary basin that formed in a deep-water shelf along the southeastern passive continental margin of the North Asian Craton. The basin is filled with thick (8 to 10 km) carbonate and clastic sedimentary rock of the Teptorginsky, Balakhanakh, Dalnetaiginsky and Bodaibo series (Ivanov, 1995). The black shale sequences comprise an important part of the basin. The rocks are metamorphosed to kyanite-sillimanite grade and collisional granitoids of the late Riphean Yazovsky complex are coeval with metamorphism. The deposit-controlling structure is the Bodaibo synclinorium that contains the Bodaibo and Kropotkino basins (Sher, 1961). Narrow axial parts of anticlines with shear zones, intense foliation and hydrothermal-metasomatic deposits control some districts, as at Alexander-Dogaldynsky, Sukhoy Log, Verninsky, and Ksmensky. Loci of warping of major fold folds and crosscutting, diagonal ruptures are favorable for Au-quartz vein and Au-sulfide-quartz veinlet deposits (Buryak, 1982), herein termed Au in black shale. Major deposits occur at Sukhoy Log, Vysochaishy, Verninsky, and Nevsky. The largest district at Sukhoy Log extends over 2.5 km and ranges up to 200 m thick.

Sukhoy Log Au in Black Shale Deposit

This deposit (Kotkin, 1968, 1975; Inshin and Gerasimova, 1977; Konovalov, 1985) consists of two types: (1) quartz and sulfide veinlets and disseminations of (75% reserves); and (2) low-sulfide quartz-veins (25% reserves). The first type consists of layered linear stockwork consisting of veinlets and disseminations with pyrite and quartz. Sulfides range from 2 or to 5%, pyrite is abundant (95%). Rare minerals are galena, sphalerite, arsenopyrite, pyrrhotite, chalcopyrite, pentlandite, millerite, and cubanite. Au is very fine-grained (0.1-0.14 mm) and fineness is 780-820. Gold occurs in cracks in pyrite and rarely in atsenopyrite. The second type consists of 22 quartz veins with complicated morphology and occurs on the western edge of the deposit. This type consists of coarse-crystalline quartz (90-95%), pyrite (1-3%), carbonates (siderite, ankerite, dolomite, calcite), and pseudomorphs of limonite after pyrite. Also occurring are rare muscovite, chlorite, galena, sphalerite, chalcopyrite, arsenopyrite, and pyrrhotite. Gold is intergrown with pyrrhotite, chalcopyrite, and galena. Pt grade increases with sulfide content. The Sukhoy Log deposit occurs in the central part of a 3rd order anticline with sublatitudinal strike. The anticline core contains Neoproterozoic black shale alternating with limestone and quartz sandstone that are metamorphosed to greenschist facies. The deposit is large with an average Au grade of 2.8-3.6 ppm and a similar Pt grade.

Origin and Tectonic Controls for Bodaibinskiy Metallogenic Belt

The major deposits in the belt are interpreted as forming in two stages. (1) In the Riphean and early Paleozoic,Au accumulated during sedimentation with later metamorphism and hydrothermal activity (Buryak, 1982). These events formed scattered Au-sulfide deposits. (2) In the middle to late Paleozoic, post-collisional intrusion of granite and leucogranite along with hydrothermal activity formed commercial Au-quartz-sulfide deposits (Konovalov, 1985). The age of Au from deposit Sukhoy Log is about 320 Ma. A subsequent magmatic and hydrothermal event was intrusion of the middle and late Paleozoic Kadali-Butuinsky dike complex (Rundquist and others, 1992). This event formd Au-Ag-sulfosalt deposits (Znamirovsky and Malykh, 1974). The belt is promising for discovery of large Au deposits.

REFERENCES: Znamirovsky and Malykh, 1974; Buryak, 1982; Konovalov, 1985; Neumark and others, 1990, 1994; Rundquist and others, 1992; Ivanov and Livshyts, 1995.

Olokitskiy Metallogenic Belt of Volcanogenic-Hydrothermal Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposits (Belt OL) (Russia, Northern Baikal region)

This Neoproterozoic metallogenic belt occurs in the in the Olokit basin in the western part of the Olokit-Delunuran accretionary wedge terrane in the North Baikal Highland forms a narrow arc extending from Lake Baikal to the Vitim River. The belt is 400 km long and 80 km wide, The Olokit-Delunuran terrane contains the Olokit rift basin filled with turbidite (Distanov and others, 1982), and middle Riphean Olokit series that consists of volcaniclastic and sedimentary rock with interbedded basalt and liparite lava. Basalt has an isotopic age of 1000 Ma (Neumark and others, 1990, 1994) and are NMORB and EMORB types (Rytsk and others, 1999). The upper part of the section consists of volcanic, siliceous, and Fe oxide-bearing sedimentary rock and tuff the overlying Dovyren series that consists late Riphean carboniferous, clastic, and carbonate sedimentary rock. Units are strongly metamorphosed to amphibolite facies into garnet-quartz-plagoclase-micaceous schist, quartzite, and marble, and are intensely sheared and deformed into steeply-dipping isoclinal folds with axes parallel to the northeast strike of major structures of the Baikal-Patom arc. The major deposit is at Kholodninskoye.

Kholodninskoye Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposit

This deposit (Distanov, 1977; Distanov and Kovalev, 1995, 1996) consists of a series of steeply-dipping, lenticular, rhythmic, and thin-layered bodies of massive pyrite and polymetallic sulfides. The deposit extends up to 7 to 8 km. Host rocks consist of alternating beds of graphite-micaceous-carbonate-siliceous schist (tens to some hundred meters thick), porphyroblastic rock. Also occurring is skarn consisting of masses and disseminations of galena, sphalerite, and pyrite mineralization, and layered sulfides. Host rocks are alternating layers of graphite-siliceous schist. The main ore minerals are galena, sphalerite, pyrite, and pyrrhotite. Pyrite is dominant, and sphalerite and galena are widespread, and chalcopyrite and pyrrhotite occur in veins. Gangue minerals are mainly quartz and graphite. The deposit contains layered sulfide bodies during hydrothermal and sedimentary activity, recrystallized sulfides formed during prograde metamorphism to amphibolite facies, and crossing veinlets and disseminations formed during retrograde metamorphism. Also occurring are metamorphosed dikes and stocks of gabbro, diabase, and lamprophyre. Host rocks are altered to graphite and chlorite. The deposit is interpreted as forming in the Riphean at about 1000 to 740 Ma in association with bimodal volcanism. The deposit is large with an average grade of 4.0-6.3% Zn, 0.5-1.7% Pb, 0.02-0.05% Cu, 80-100 ppm Cd, 200-500 ppm As, 30-50 ppm Sb.

Origin and Tectonic Controls for Olokitskiy Metallogenic Belt

The belt is interpreted as forming in island arc or back arc sequence incorporated into an accretionary wedge.

REFERENCES: Tarasova and others, 1982; Kislov and others, 1989; Distanov and Kovalev, 1995; Rytsk and others, 1999.

Mrass Metallogenic Belt of Sedimentary Phosphate Deposits (Belt MR) (Kuznetsk Alatau Mountains, Russia, Eastern Siberia)

This Vendian to Early Cambrian metallogenic belt is hosted in the Altai-Sayan back-arc basin (Mrassu-Bateni unit) and occurs in the southern part of Kuznetsk Alatau. The belt forms the western flank of the broad Altai-Sayan phosphorite basin (Kazarinov and Krasilnikova, 1978). Two phosphorite (carbonate type) districts occur in the belt: Mrassk, to the west; and Kuznetsk-Alatau to the east. Phosphorite deposits in the Mrassk district (Belkinskoye deposit) are hosted in thick Riphean and Early Cambrian siliceous dolomite and limestone. The host Belkinsk series consists of Vendian and Early Cambrian dolomitic limestone and dolomite that ranges up to 400 to 500 m thick and is the most productive unit. Phosphorite horizons in the Kuznetsk-Alatau district (Tamalykskoye deposit) are hosted in Early Cambrian volcanic and sedimentary rock that overlaps Vendian and Early Cambrian shelf limestone. Phosphorite horizons alternate with layers of siliceous carbonate rock. Phosphorite sequences in all districts are overlapped by carbonate and clastic rock sequences.

Tamalykskoye Sedimentary Phosphate Deposit

This deposit (Mkrtychan, 1966; Kazarinov and Krasil'nikova, 1972) consists of phosphorite layers in Early Cambrian volcanic and sedimentary rock. Phosphate-bearing packet of 70 to 150 m thick extend about 8 km along strike and contains several phosphorite beds in siliceous carbonate rock. The richest beds beds extend 1.6 to 1.8 km along strike and vary from 3 to 50 m thick. Phosphorite consist of quartz microgranules (45 to 80%) and phosphate minerals (20 to 50%), along with carbonate, muscovite, and rare pyrite. Phosphorite is metamorphosed into apatite and quartz-apatite rock along contact of a diorite inrusive. In these zones, P_2O_5 ranges from 26 to 32%. Secondary phosphorite occur in weathering crust to a depth up to 250 m. P_2O_5 content in weathering crust is about 14%. Phosphate occurs in F-apatite in both primary and secondary phosphorite. The deposit is medium size with an average grade of 13% P_2O_5.

Origin and Tectonic Controls for Mrass Metallogenic Belt

The Mrass metallogenic belt is interpreted forming during shallow-water marine sedimentation in a back-arc environment along the southern marginal part of the Tomsk microcontinent. Sedimentary phosphorite formed during sedimentation in a nearshore setting in the Vendian and Cambrian (Gurevich, 1968; Mkrtychan, 1966). During the Cretaceous and Paleogene secondary phosphorite with elevated P_2O_5 formed in weathering crust.

REFERENCES: Gurevich, 1968; Mkrtychan, 1966; Kazarinov and Krasilnikova, 1978.

Bellyk Metallogenic Belt of Weathering Crust and Karst Phosphate and Bedded Barite Deposits (Belt BE) (Kuznetsk Alatau to East Sayan Ridges, Altai-Sayan folded area, Russia).

This Vendian to Early Cambrian metallogenic belt is hosted in the Altai-Sayan back-arc basin (Mrassu-Bateni unit) and occurs in the Batenevsky Range in East Sayan. The belt is an eastern extenson of the Vendian and Early Altai-Sayan phosphorite basin (Kazarinov and Krasilnikova, 1972). The belt extends east-northeast for 90 km. Phosphorite deposits are hosted in carbonate rock intercalated with carbonaceous and siliceous rock and quartzite. The deposits consist of bedded phosphorite and phosphate-bearing rock. The primary phosphates is siliceous and carbonaceous type. Phosphate-bearing occurs in weathering crust that occurs along the belt of phosphate-bearing strata and consists of beds, lenses, and irregular deposits of secondary phosphorite. The secondary phosphorite is more economically significant. The major deposit is at Seibinskoye 2. Bedded barite deposits are hosed in Vendian and Cambrian carbonate shelf rock and consist beeded carbonate and barite in alternating limestone and argillaceous shale. The large Tolcheinskoye deposit of stratiform barite ores has been developed (Matrosov and Shaposhnikov, 1988).

Seibinskoye 2 Weathering Crust and Karst Phosphate Deposit

This deposit (Kazarinov and Krasil'nikova, 1972) consists of packets of phosphate-bearing siliceous, carbonate, and argilliceous rock underlain by bituminiferous limestone and overlapped by siliceous and argillaceous shale. Host rocks are Neoproterozoic. Deposit consists of phosphorite and phosphate-bearing rocks. Main ore minerals are phosphate and chalcedony. P_2O_5 is about 15%. Primary ores reserve is about 3 million tonnes. Weathering crust is pervasive and consists of beds, lenses, and irregular bodies of secondary phosphorite. The largest deposit is about 3 km long and 40 to 90 m wide. Phosphorite occur up to 100 m at a depth. P_2O_5 content in secondary phosphorite ranges from 5 to 35%. Phosphorite reserves for weathering crust is about 13 million tonnes.

Tolcheinskoye Bedded Barite Deposit

This deposit (Mkrtychan and Vasil'ev, 1976; Archinekov, 1986; Matrosov and Shaposhnikov, 1988) consists of barite deposits in Vendian and Cambrian siliceous and carbonate rock. Two deposits are defined: (1) a lensoid deposit aboout 400 m long and up to 60 m thick that occurs in a core of syncline; and (2) a layered deposit that is about 8 to 10 m thick and 1 km long. The deposits consist of alternating barite layers, barite-rich shale, and limestone. Barite occurs in masses, bands, and disseminations. Main ore minerals are barite, witherite, calcite, dolomite, quartz, chalcedony, and epidote. Calcite veinlets are abundant. The deposit is large with an average grade of 30 to 90% BaSO4.

Origin and Tectonic Controls for Bellyk Metallogenic Belt

The Bellyk metallogenic belt is interpreted as forming during shallow-water marine sedimentation in a back-arc environment along the southern marginal part of the Tomsk microcontinent that was later overlapped by the early Paleozoic deposits. The primary phosphorite and phosphatic rocks formed during sedimentation in a Vendian and Cambrian shallow-water marine environment. The secondary phosphate deposits with elevated P_2O_5 content formed in a weathering crust zone over primary phosphorite. Both primary and secondary phosphorite are composed of F-apatite. Barite deposits formed during marine sedimentary with subsequent, superimposed hydrothermal vein deposits (Savel'ev, 1978).

REFERENCES: Kazarinov and Krasilnikova, 1972; Savel'ev, 1978; Matrosov and Shaposhnikov, 1988.

Lysansk Metallogenic Belt of Mafic-Ultramafic Related Ti-Fe (+V) Deposits (Belt LS) (Eastern Sayan Mountains, Altai-Sayan area, Russia)

This middle to late Riphean metallogenic belt is hosted in the Kuvai accretionary wedge terrane in the Eastern Sayan. Ti-magnetite and ilmenite-Ti-magnetite deposits are hosted in and related to differentiated gabbro and pyroxenite intrusions of the Riphean Lysansk complex that intrude metamorphosed Riphean volcanic and sedimentary sequences of the Kuvai rock series. A comagmatic relation between the intrusive complex and extrusive rock of the Kuvai series exists (Glazunov, 1975). Gabbro is predominant. Deposits occurs in serpentinite and pyroxenite. Resources are very large but low grade. The host gabbro and pyroxenite intrusions occur along the East-Sayan fault zone and form a group of lenses that occur in a northwest-trending band that extends more than 70 km. Gabbro pebbles of the Lysansk pluton occur in Early Cambrian conglomerate in the Balakhtisonsk suite (Glazunov, 1961). The major deposit is at Lysansk.

Lysanskoye Mafic-Ultramafic Related Ti-Fe (+V) Deposit

This deposit (Kurceraite and others, 1974; Sinyakov, 1976; Matrosov and Shaposhnikov, 1988) consists of titanomagnetite and ilmenite in gabbro and pyroxenite intrusions that intrude metamorphosed Late Proterozoic volcanic and sedimentary rocks. Intrusions are lens-shaped and range from 1 to 2 km long. Lensoid deposits occur along margins of intrusions and range from 600 to 1000 m along strike, 50 to 140 m thick, and extend to 400 to 450 m to depth. Titanomagnetite ore type contains 5 to 7% TiO_2 and 13 to 17% Fe_2O_3. Ilmenite type contains from 4 to 10% TiO_2, 3 to 6% Fe_2O_3. V_2O_5 is approximately 0.1%. The deposit is large with an average grade of 6-10% TiO_2 and 15-24% Fe. Reserves are 1,500,000 tonnes TiO_2 and 12,500,000 tonnes Fe.

Origin and Tectonic Controls for Lysansk Metallogenic Belt

The belt is interpreted as forming in a middle to late Riphean ensialic island arc that was incorporated into an accretionary wedge. Both magmatic and metasomatic models of ore genesis are suggested: (Shabalin, 1982; Glazunov, 1975). The magmatic model stresses the role of crystallizational differentiation in a magma. The metasomatic model proposes high grade ore forming mainly during transformation and concentration of primary low-grade, disseminated deposits.

REFERENCES: Glazunov, 1975, 1961; Shabalin, 1984.

Prisayanskiy Metallogenic Belt of REE (Ta, Nb, Fe) Carbonatite; Mafic-Ultramafic Related Ti-Fe (+V); Diamond-Bearing Kimberlite; and Talc (magnesite) Replacement Deposits (Belt PrS) (Russia, East Sayan)

This Late Neoproterozoic metallogenic belt is related to the following units in the Onot granite-greenstone, Sharizhalgay tonalite-trondhjemite gneiss, and Urik-Iya greenschist terranes: (1) mafic-ultramafic plutons in the Ziminsky complex; (2) upper part of Onot terrane that consists of interbedded amphibolite, and magnesite and talc layers; and (3) ultramafic alkaline plutons; and (4) sparse micaceous kimberlite dikes. The age range of metallogenic belt is interpreted as Late Neoproterozoic. The belt occurs in southwest of Irkutsk Oblast in the East Sayan Mountains and trends northwest along the junction of the North Asian Craton and Sayan Mountains. The belt is 400 km long with an average width 50 to 60 km.

The Sharyzhalgay terrane consists of Archean biotite-hornblende, biotite-hypesthene gneiss, schist, amphibolite, pyroxene plagiogneiss, sillimanite schist, ferruginous quartzite, coarse-grained marble, granulite and charnockite. The lower part of the Onot terrane consists mainly of calc-alkaline, bimodal, volcanic rock, and the upper part consist of metamorphosed sedimentary rock with interbedded amphibolite, magnesite rock and talc rock. These units are intruded by gabbro of the Arbansky complex and rapakivi granitoids of the Paleoproterozoic Shumikhinsky complex. The Urik-Iya terrane consists of Paleoproterozoic schist, phyllite, metasandstone, amphibolite, and spillite and keratophyre.

Within the belt, the deposits and ore occurrences form large districts with REE, Ti, and talc replacement deposits and small diamond occurrences. The major deposits are at Belo-Ziminskoye, Sredne-Ziminskoye; Zhidoyskoye; Ingashinskoye; Onotskoye. The diversity of deposits suggests the this is fairly promising for discovery of new large ore of REE, Ti, magnesite, and talc replacement deposits.

Beloziminskoye REE (Ta, Nb, Fe) Carbonatite Deposits

This deposit (Pozharitskaya and others, 1972; Frolov, 1975; Emelyanov and others, 1998) consists of a stockwork calcite carbonatite body that occurs in a core of an alkaline ultramafic pluton. The stockwork extends over 10 km^2, forms an northwest-trending ellipse, and extends to about 750 m depth. The stockwork is surrounded by carbonatite vein zone that is about 100 m thick and extends up to 1 km long. Carbonatite contains relics of silicate rock in the peripheral part of the stockwork. The carbonatite consists of apatite, magnetite, and phlogopite. The deposit formed in four stages and the second stage is the most economic. Outward to inward, the major mineral zones are pyroxene, forsterite, mica, and monomineral calcite. REE minerals include dizanalite, baddeleite, zirkelite, hatchettolite, and pyrochlore. Baddeleite, dizanalite, and zirkelite occur only in peripheral parts adjacent to host rock. Hatchettolite is widespread in the external zone, and pyrochlore occurs in the internal zone. The deposit is large with an average grade is 0.39%; Nb_2O_5 and 0.015-0.017% Ta_2O_5.

Onotskoe Talc (Magnesite) Replacement Deposit

This deposit (Basmanov, 1960; Korenbaum, 1967; Romanovich and others, 1982) occurs in the western part of the Onotsky graben that contains Early Proterozoic volcanic and carbonate rocks. Most of the talc is in carbonate in the Kamchadal sequence. Two productive horizons occur. (1) The lower horizon is 100-150 m thick and consists of dolomite and magnesite in lenses in limestones and various metamorphic rock. And (2) The upper horizon is 20 m thick and consists of magnesite. The deposit occurs in the lower horizon that is sheared and deformed into recumbent steeply-dipping folds. The deposit hosts seven large ore bodies of different morphology and composition. Of economic significance are veins and swells that form 32 ore bodies with thicknesses from a few to 50-80 m, lengths of tens 200-600 m, and depths of over 260 m. Ore minerals are talc, magnesite, chlorite, graphite, dolomite, serpentine, hematite, sagenite, apatite, and quartz. The origin is interpreted as an apomagnesite talc deposit with massive structure (steatites). The structure is thin to scaly. The ore quality is high, and the color varies from white to light green to light gray. Chemical composition is 59.8% SiO_2; 1.8% Al_20_3, 0.3% Fe_20_3, 1.4% FeO, 0.2% TiO_2, 33.9% MgO, 0.4% CaO. The deposit is medium size.

Ingashinskoye Diamond-Bearing Kimberlite Deposit

This deposit (Vladimirov, 1986,1989; Pechersky, 1965; Prokopchuk and Metelkina, 1985; Sekerin and others, 1993) occurs in a dike field of nine small bodies (0.08-1.0 x 50-850 m) that intrude Paleoproterozoic schist. Dikes composed mainly of olivine and phlogopite, and minor minerals are serpentine, talc, calcite, titanomagnetite, pyrope, and chrome-spinel, and rare ilmenite, apatite, diamond, chlorite, and volcanic glass, and local praiderite, armakolite, alkaline amphibole. Most abundant are chrome spinel and orange almandine, and pyrope, and rare chrome diopside and magnetite. The dike thicknesses are extremely irregular, and the dike dip subvertical. Dikes are subdivided into three types: (1) calcite-lacking with glassy bulk mass (olivine lamproites); (2) calcite with phlogopite (micaceous kimberlite); and (3) low-calcite with olivine (transitional). An isotopic age for the dikes is 1268+Ma. The small Yuzhnaya pipe at Belaya Zima is composed of kimberlite-like breccia. Diamonds are rhombododecahedral and range up to 60 mg with green spots. A single crystal of balas diamond is known. The deposit occurs on the eastern flank of the Urik-Iisk graben where cut by the Urik-Tumanshet tectonic zone along the flank of the Birusinsky block. The deposit is small and low grade.

Origin and Tectonic Controls for Prisayanskiy Metallogenic Belt

Various deposits in belt are hosted in a variety of units in the Onot granite-greenstone and Sharizhalgay tonalite-trondhjemite gneiss terranes: (1) mafic-ultramafic plutons in the Ziminsky complex; (2) upper part of Onot terrane that consists of interbedded amphibolite, and magnesite and talc layers; and (3) ultramafic alkaline plutonic rocks that intrude; and (4) sparse micaceous kimberlite dikes. Host terranes are uplifted parts of Precambrian craton crystalline basement North Asian Craton.

REFERENCES: Konev, 1970; Pozharitckaya and others, 1972; Frolov, 1975; Levitskiy, 1994; Emelianov and others, 1998; Mekhonoshin, 1999.

Pribaikalskiy Metallogenic Belt of Carbonate-Hosted Pb-Zn (Mississippi Valley Type) Deposits (Belt PrB) (Russia, Western Transbaikalia)

This Riphean metallogenic belt occurs along the juncture of Paleoproterozoic Akitkan active continental margin volcanic-plutonic belt and sedimentary rock of the Patom fold and thrust belt, North Asian Craton. The belt extends along the northwestern coast of Lake Baikal for 170 km and ranges from 30 to 50 km wide. The tectonic setting of the belt is defined by tectonic and magmatic processes associated with the Akitkan volcanic-plutonic belt along the margin of Siberian Craton. This Paleoproterozoic volcanic-plutonic belt consists of subalkaline, siliceous lava, minor basalt porphyry, and subaerial volcanic and sedimentary sedimentary rock. Also occurring are comagmatic diorite, granodiorite, and granite, and rapakivi granitoids in the Primorsky Complex with an isotopic age of 1690±40 Ma. The overlap assemblage consists of clastic and carbonate sedimentary rock of the Baikal series (Goloustenskaya and Uluntuy suites) that extend the margin of the craton for 1000 km with monoclinal northwest dips. The sedimentary rocks consist of fine-grained limestone, unequigranular micro-and coarse-crystalline limestone with oolite-like internal structure, sedimentary and diagenetic dolomite, talc rock, and talc-carbonate rock. The monoclinal dip is complicated by longitudinal S folds and higher-order folds. Deposit controls are folds and regional shear zones that consist of lenses and sublaminated bodies of talc rock, and quartz and aragonite veins. The shear zones formed during overthrusting of the deposit-enclosing sequence over the older volcanic rock. The major deposit in the belt is at Barvinskoye.

Barvinskoye Carbonate-hosted Pb-Zn (Mississippi Valley type) Deposit

This deposit consists mainly of sulfides in layers, lenses, veins, and disseminations (Tychinsky and others, 1984) that occur along concordant ruptures and shears that controll the deposit. Also occurring are crossing verins. Sphalerite, galena, fluorite ore is most productive. Host rocks exhibit widespread are metasomatic alteration. The eposit is interpreted as forming during hydrothermal activity.

Origin and Tectonic Controls for Pribaikalskiy Metallogenic Belt

The belt interpreted as forming along shear zones and faults that occur between an ancient active continental margin along the North Asian Craton.

REFERENCES: Tychinsky and others, 1984; Tychinsky and others, 1986.

Bokson-Kitoiskiy Metallogenic Belt of Sedimentary Bauxite, Magmatic Nepheline, Serpentine-hosted Asbestos, and Au in Shear Zone and Quartz Vein Deposits (Belt B-K) (Russia, East Sayan)

This Neoproterozoic through Silurian metallogenic belt is related to veins layers in plutons intruding, or in the Belaya-Kitoy metamorphic terrane, Hug accretionary wedge, and Tunka tonalite-trondhjemite-gneiss terranes, the Tannuola plutonic belt, and the Huvsgol-Bokson sedimentary overlap assemblage. The belt occurs in the central part of East Sayan Mountains in the upper parts of Irkut, Urik, and Kitoy Rivers, extends along a nearly sublatitudinal trend for 315 km, and is 150 km wide. Metallogenic belt is a composite that includes several mineral deposit types.

The Gargansky terrane consists of Archean plagio-granite-gneiss overlapped by a Riphean carbonates. The Ilchir terrane consists of a Riphean ophiolite, the Dibinsky suite of rhythmically-bedded sedimentary volcanic rock, the Sarkhoy suite of calc-alkaline and tholeiitic volcanic rock, and the middle Riphean Khugeinsky suite of clastic and volcanic rock metamorphosed at high-pressure. The Huvsgol-Bokson overlap assemblages consists of carbonate and clastic sedimentary rocks of the Vendian and Cambrian Bokson series, and clastic sedimentary rock of the Ordovian through Devonian Okinsky series.

Igneous suture complexes are the subduction-related tonalite Sumsunur complex with U-Pb and Rb-Sr ages of 790 Ma, and Devonian and Carboniferous granitoids of the Kholbinsky, Ognitsky, and Botogol complexes.

The major deposits are the Boksonskoye sedimentary bauxite, Botogolskoye magmatic nepheline, Ilchirskoye serpentinite-hosted asbestos, Bourun-Kholba Au in shear zone and quartz vein, Zun-Kholba Au in shear zone and quartz vein, and the Pionerskoye2 Au in shear zone and quartz vein deposits

Zun-Kholba Au in Shear Zone and Quartz Vein Deposit

This deposit (Feofilaktov, 1992; Zhmodik and others, 1994; Dobretsov and Ignatovich, 1989) consists of a steeply dipping zone (8000 x 200-600 m) that strikes northwest and contains over over 30 bodies of which 12 are economic. The bodies are divided into: (1) steeply-dipping quartz-polysulfide; (2) banded chalcopyrite-pyrite bodies; and (3) quartz veins. The first is economically important is hosted in talc-chlorite and carbonaceous-siliceous shales, are a combination of vein and dissemination with 20-50% sulfides. Major ore minerals are pyrite (up to 30-45%), pyrrhotite (up to 5-30%), chalcopyrite (up to 10%), galena (up to 5-8%), and sphalerite (up to 5%), and rare bornite, chalcocite, bismuthine, native silver, and Au and Ag tellurides. Gangue minerals are quartz, calcite, and talc, and rare albite, chlorite, muscovite, sericite, and graphite. Wall rocks contains zones of beresite, talc, graphitie, and listvinite alterations. Sulfide body dimensions are 150-300 by 0.2 by 0.4 m and occur in limestone. Sulfide grade ranges up to 50-80% and sulfides are mainly pyrite, sphalerite, galena, chalcopyrite, and pyrrhotite. Small quartz-sulfide veins 1-2% and rarely 5% sulfides with an average grade of 9.8 ppm Au and 13 ppm Ag. The deposit occurs in the central part of the Samarta-Kholba shear zone along the northern boundary of the Gargansky terrane. The deposit is medium size with an average grade of 26 ppm Au, 24-37 ppm Ag, and 1.7ppm Pt.

Boksonskoye Sedimentary Bauxite Deposit

This deposit (Il'ina, 1958; Orlova, 1958) consists of bauxite layers that occur over different dolomites (spotty, reef-generating, algae, banded, pink and red) in part of the thick Bokson suite in Archean and Proterozoic metamorphic and mafic igneous rock. Thickness of the bauxite beds average 5 m, locally up to 30 m. Bauxite occurs in contain dense, banded, thin-banded, and breccia varieties, locally as a sandy bauxites. The deposit contains 35 minerals and the primary minerals are bemite, kaolinite and dikkite, leptochlorite, and gallauzite, and rare dafite, montmorillonite, pyrophyllite, Fe oxides and hydroxide. Secondary minerals are sericite, muscovite, talc, serpentine, zeolite, hydrargillite, diaspore, chlorite, crysotile, quartz, calcite, and gypsum. The ore minerals are hematite, goethite, pyrite, magnetite. Terrigenous minerals are tourmaline, olivine, feldspar, quartz, rutile, leucoxene, and alunite. Varities of mineral assemblages are red-brown diaspore-hematite, gray-green diaspore chlorite, and intermediate diaspore-chlorite-hematite. The bauxite formed from coastal marine and lagoon sediments. The age of the deposit 540-600 Ma. This is the oldest bauxite deposit in Russia. The deposit is large with an average grade of 40% Al_20_3.

Botogolskoe Magmatic Nepheline Deposit

This deposit (Solonenko, 1950) occurs in the Botogol alkaline nepheline syenite massif that forms an elongated oval that is 6 x 2 km and intrudes Proterozoic schist and carbonate rock. The massif formed in three stages: normal pyroxene and quartz syenite; alkaline pyroxene and nepheline syenite; and leucocratic nepheline syenite. Two deposit bodies occur, the Severny body of 0.6 km^2 size and the Yuzhny body of 0.2 km^2 size. The bodies are separated by a kilometer-wide zone of a low-grade deposit. The Severny body is mainly leucocratic nepheline syenite with local biotite and pyroxene. The Yuzhny body is mainly a pyroxene nepheline syenite. The deposit is interpreted as forming in a back-arc rift. The deposit is medium size with an average grade of 21% Al_20_3.

Ilchirskoye Serpentinite-Hosted Asbestos Deposit

This deposit (Shamansky, 1945; Krutsko, 1964) occurs in the Ilchir lens-shaped massif (2.5 x 1 km) composed of Vendian peridotite and serpentinite. The deposit is an irregular lens with dimensions of 1700 by 100-380 by 150-550 m. The deposit has a concentric structure: a central part of asbestos-bearing serpentinite with a core of unaltered harzburgite; outward, serpentinite devoid of asbestos; and serpentinite-talc-carbonate rock. High-grade asbestos occurs in two tectonic zones of that cut the massif and vary from 100 to 400 m thick. Asbestos is a large network type with veinlets ranging from 20-30 mm thick (locally up to 70 mm), cutting in various directions, and occurring about 1-2 m apart. The ore mineral minerals are chrysotile-asbestos, bastite, serpentine, ophite, magnetite, talc, chromite, brucite, atagorite, carbonates, pyroxene, and olivine. Asbestos is silky, durable, useful for technological purposes. The deposit is small with an average grade of 2.5% asbestos fibre and from 0.08-0.25% textile grade asbestos.

Origin and Tectonic Controls for Bokson-Kitoiskiy Metallogenic Belt

This belt is hosted in metamorphic, oceanic, accretionary wedge, and accretionary wedge, and tonalite-trondhjemite-gneiss terranes that underwent Cambrian through Silurian metamorphism, hydrothermal alteration, and plutonic intrusion. A younger suture complex is the subduction-related Sumsunur complex tonalite with a U-Pb and Rb-Sr isotopic age of 790 Ma. The deposits in the belt are interpreted as forming in multiple events.

REFERENCES: Solonenko, 1950; Orlova, 1958; Vinogradov, 1958; Il'ina, 1958; Krutsko., 1962; Krutsko, 1964; Levitsky, 1966; Dobretsov and Ignatovich, 1989; Feofilaktov, 1992; Mironov and others, 1995.

Lake Metallogenic Belt of Volcanogenic Cu-Zn Massive Sulfide (Urals type, Volcanogenic-sedimentary Fe, Podiform Cr, Mafic-Ultramafic Related Ti-Fe, Cu (± Au, Ag, Fe) Skarn, Fe Skarn, Granitoid-related Au Vein, Cyprus Cu-Zn Massive Sulfide, and Mafic-Ultramafic Related Cu-Ni-PGE Deposits (Belt LA) (Western Mongolia)

This Late Neoproterozoic (Vendian to Late Cambrian) metallogenic belt is hosted in the Lake island arc terrane (Tomurtogoo and others, 1999). The metallogenic belt was defined by Dejidmaa and others (1996) as a complex metallogenic belt with different type deposits and occurrences The northern part of thebelt trends north-south and the southern part trends southeast to east. The belt is approximately 30 to 100 km in the southern part, varies from

200 to 250 km wide in northern part, and is approximately 1000 km long. A large part of the belt is covered by Cenozoic surficial deposits and large lakes. Cu sulfide deposits and volcanogenic-sedimentary Fe deposits and occurrences are related to the Vendian to Early Cambrian Khantaishir ophiolite complex in basalt, andesite, dacite, and rhyolite volcanic rock in the Early Cambrian Tsol uul, Icheet, Daagandel, Ulaanshand, and Khanhohii Formations. Mafic-ultramafic related podiform Cr and zoned mafic-ultramafic related Fe-Te occurrences occur in ultramafic rock in the Vendian to Early Cambrian Khataishir ophiolite complex, and in ultramafic intrusions in the Khanhohii area. Cu skarn, Fe skarn, and granitoid-related vein, stockwork, replacement Au deposits are related to the Middle and Late Cambrian Togtohiin shil igneous complex that consists of gabbro, tonalite, and granite. Gabbroic Ni-Cu occurrences are related to the Middle Cambrian Khyargas nuur igneous complex that consists of layered pyroxenite, gabbro, norite, and troctolite (Izoh and others, 1990).

The major deposits in the belt are: (1) major disseminated Cu sulfide deposits at Borts uul, Mendeeheindavaa, Narandavaa, and Suvraagiin; (2) Au massive sulfide deposits at Gozgor, Khurendosh uul and Suvraa; (3) volcanogenic-sedimentary type Fe occurrence at Bayanhudag; (3) mafic-ultramafic related podiform Cr occurrences at Nogoontolgoi and Bideriingol; (4) mafic-ultramafic related Fe-Ti occurrences at Turgengol and Dumberel uul; (5) Cu skarn occurrences at Togloin khudag, Alag uul, and Jargalant nuruu; (6) Fe skarn occurrence at Arvangurav; (7) granitoid-related stockwork and replacement type Au occurrence at Khyargas; and (8) a layered gabbroic type Ni-Cu(± PGE) occurrences at Bust khairhan and Altan khudag.

Bideriingol Podiform Chromite Deposit

This deposit (A. Rauzer and others, written commun.,1987) consists of lenses of massive chromite and pockets of disseminated chromite in ultramafics of the Khantaishir ophiolite Complex of Vendian to Early Cambrian age. Lenses are 0.2 m x 3.0 m. Disseminated chromite mineralization forms pockets 5.0 m by 3.0 m in melanged serpentenite. Chromite impregnation occupies from 20-30% to 50-70% the pockets. Grab samples from weakly disseminated ore contained Cr-0.3-0.5%, Ni-0.2-0.5%, Co-0.02% and Cu-0.01%.

Borts Uul Volcanogenic Cu-Zn Massive Sulfide (Urals type) Deposit

This deposit (D. Baatar and others, written commun., 1979; Baadai and others, 1982; Podkolzin and others, 1990) consists of sulfide rich lenses and tabular bodies in volcanic rock at the intersection of the Khangai and Zavkhan major faults. The deposit contains three parts. In Northern part is hosted in faulted horizons and lenses of andesite, dacite, basalt tuff and volcanic breccia. The three main bodies are tabular and conformable with host volcanic rocks. Sulfide bodies and host rocks are folded together. Sulfide bodies ranges from 1 m to 17 m thick and extend up to 1.4 km long. Ore minerals occur in irregular masses, disseminations, stringers, and nests. A gradation contact between host rock and sulfides. Grade varies widely up to 4.0% Cu and the average grade sulfide bodies is 0.5-0.6% Cu, up to 60.0 g/t Ag and up to 0.4 g/t Au. Ore minerals are chalcopyrite, chalcocite, bornite, cuprite, covellite, and copper oxides. Host rock is altered and white. Chlorite and epidotie alternation is widely developed. The Central part consists of sheets and lenses of andesite, basalt, dacite tuff, tuff, and tuff-breccia, strikes northwest, and estends for 0.5 km. Two main zones range from 2.0 m to 15.0 m thick and contain sulfide lenses or tabular bodies that range from 0.2 m to 2.0 m thick and dip steeply. Other features are similar to Northern part. Average grades are 1.3% Cu and 5.0 g/t Ag. The third or Pyrite part occurs 1.5 km east of the Central part and is hosted in dacite porphyry and tuff. Finely disseminated pyrite occurs in a zone 100.0 m by 250.0 m. Pyrite is intensively oxidized and limonite is well developed. Cu minerals are rare. Grades are is up to 0.1% Cu, up to 0.4 g/t Au, and up to 5.9 g/t Ag. The deposit is large with an average grade of 0.5-0.6-1.3% Cu with a cutoff grade of 0.1% Cu. Resource in the Northern part is 28,200 tonnes Cu with average grade of 1.0-1.5% Cu to a depth of 100.0 m.

Khyargas Granitoid-Related Au Vein Deposit

This deposit (B.A. Samozvantsev and others, written commun.,1982) consists of a sublatitudinal-trending listvenite zone in serpentinite. The zone ranges from 50.0 m to 100.0 m wide, and is up to 500.0 m long and occurs in a melange zone. The ore minerals are pyrite and chalcopyrite, malachite, and Fe oxides. Abundant ore minerals occur in the northwest part in an area up to 16.0 m thick, and in the northwest part in an area up to 8.0 m thick. Channel samples grade up to 1.6% Cu, up to 3.0 g/t Au (in 1 sample 6.0 g/t), up to 20.0 g/t Ag, up to 0.3% Ni, and up to 0.6% As. To the southwest, the zone is surrounded by small outcrops of amphibole-garnet skarn with hematite and malachite. The skarn contains 0.01-0.09% Zn and Cu, 0.2 g/t Au and 1.0 g/t Ag. For the deposit, the average grade is 0.01-0.09% Zn+Cu, 0.2 g/t Au, 1.0 g/t Ag.

Naran Davaa Cyprus Cu-Zn Massive Sulfide Deposit

This deposit (A.A. Rauzer, and others, written commun., 1987) consists of northwest-trending zone with chlorite, epidotie, quartz-sulfide stringers, and disseminated pyrite, chalcopyrite, hematite. Zone occurs in an area 0.7 km wide and 2.5 km long in Vendian age mafic-ultramafic bodies, and Vendian to Lower Cambrian chlorite and chlorite-sericite schist that are overlain by Middle Devonian carbonate rock. Zone ranges up to 10.0 m thick and up to a few hundred meters long. Rock chip and grab samples contain 0.01% to 1.0-2.0% Cu, 0.001% to 0.2% Ni, 0.001-0.01% Co, up to 0.2% Cr, up to 15.0 g/t Ag, 0.001% Mo, and up to 0.01 g/t Au. Abundant sulfides (chalcopyrite, malachite, and azurite) occur in areas of disseminated sulfides. The average grade in abundant sulfide bodies ranges up to 10.0% Cu. Similar zones occur to the east and west.

Tsagdaltyn Davaa Mafic-Ultramafic Related Cu-Ni-PGE Deposit

This deposit (Togtokh and others, 1977; B.N. Podkolzin and others, written commun.,1990) occurs in 3.5 km^2 serpentinite massif. The ore minerals are magnetite, a black Ni mineral, chromite and martite. Other minerals are ilmenite, limonite, chalcopyrite, pyrite, and pentlandite. The massif strikes northeast for 5.0 km, and ranges up to 0.7 km wide. Chrisotile-asbestos stringers range up to 0.5 cm thick. Grab samples contain 0.016-0.24% Ni (average of 0.175%); 0.003-0.023% Co (average of 0.008-0.013%), and up to 0.02% Cu. In the central part of the serpentinite massif pyroxenite us replaced by amphibole. Pyroxenite contains up to 0.4%, Cr, 0.02-0.06% Ni, 0.01-0.02% Co, and 0.02-0.1% Cu. One sample contains 0.003 g/t Au. Gold occurs in pan concentrates of stream sediment samples from small valleys in the massif.

Origin and Tectonic Controls for Lake Metallogenic Belt

The various types of deposits in belt are interpreted as forming during sea floor spreading volcanism and related mafic-ultramafic magmatism, and in subduction-related island arc volcanism and mafic plutonism, and and multiple-phase granitic magmatism.

REFERENCES: Izokh and others, 1990; Dejidmaa and others, 1996; Tomurtogoo and others, 1999.

Tsagaanolom Metallogenic Belt of Sedimentary Phosphate and Volcanogenic-sedimentary Mn Deposits (Belt TO) (Central Mongolia)

This Vendian through Early Cambrian metallogenic belt is related to sedimentary units in the Huvsgol-Bokson sedimentary overlap assemblage. The major deposits are at Baruun Arts, Zuun Arts, Alagiin davaa, and Tsahir uul, and Hag nuur. The belt was first defined as the Zavhan phosphate-bearing through (Dorjnamjaa and others, 1987) or the Zavhan phosphate bearing basin (Dorjmamjaa, 1999a). The belt is extends over approximately 24.000 km^2. Phosphorite deposits and occurrences are mostly in the Vendian Tsagaanolom Formation, and rare in Early Cambrian Bayangol Formation (Dorjnamjaa and Ochir, 1984; Dorjnamjaa and others, 1987; Dorjnamjaa and others, 1995; Dorjnamjaa and others, 1999; Dorjnamjaa and others, 1999). Volcanogenic-sedimentary Mn occurrences occur locally in clastic rocks of the Bayangol Formation in the northern part of the belt.

Zuun-Arts Sedimentary Phosphate Deposit

This deposit (Z. Zorzhnamzhaa, K. Kepezhinskas, and L.Ochir, written commun., 1987) consists of phosphorite in Vendian and Early Cambrian sedimentary rock. The phosphorite beds occur along strike for 15 km and range from 5 to 10 m thick. The phosphorite alternates with dolomite, chert, sandstones, aleurolite, and argillaceous shale. The phosphorite are silicic and occur in layers, lenses, and in clastic rock. The deposit is small with an average grade of 7.1-26.0% P_2O_5.

Khagnuur Volcanogenic-Sedimentary Mn Occurrence

The occurrence (B. Samozvantsev and others, written commun., 1982) consists of Mn sandstone beds that occur between a Vendian lower carbonate and an upper terrigenous sedimentary rock. The Mn sandstone crops over a 1.4

km^2 area, is 0.3 km to 2.0 km wide, and 2.0 km long. The Mn beds range from 2.0 m up to 7.0 m thick (average of 4.0 m). Grades are 10.26-36.98% Mn in channel and core samples, 3.4-4.8% Mn in Mn beds, and from 1.55-5.23% Mn in host rocks. Samples also contain 0.01-0.06 g/t Au, 0.3-1.0 g/t Ag, up to 0.015% Mo, up to 0.02% Zn, up to 0.03% La, up to 0.015% Ce. The deposit is small with a resource of 3.4 million tonnes Mn grading 30.53% Mn.

Origin and Tectonic Controls for Tsagaanolom Metallogenic Belt

The belt is interpreted as forming during sedimentation in carbonate-dominated basin along a Vendian through Early Cambrian continental shelf.

REFERENCES: Dorjnamjaa and Ochir, 1984; Dorjnamjaa and others, 1987; Dorjnamjaa and Eganov, 1995; Dorjnamjaa and others, 1999a, b; Tomurtogoo and others, 1999.

Hugiingol Metallogenic Belt of Sedimentary Exhalative Pb-Zn (SEDEX), Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu), and Volcanogenic-Sedimentary Fe Deposits (Belt HG) (Northern Mongolia)

This middle Neoproterozoic (middle to upper Riphean) metallogenic belt is related to stratiform units in the hosted in the Hug accretionary wedge terrane. Isotopic ages for deposits range are 718± 30 Ma and 752 Ma. The Hug accretionary wedge terrane (Tomurtogoo and others, 1999) is dominated oceanic rocks. Sedimentary-exhalative Pb-Zn and volcanogenic-sedimentary Tsaanuul and other occurrences are mainly hosted in black and green shale of the middle Riphean Hug group, and volcanogenic Zn-Pb-Cu massive sulfide (Kuroko, Altai types) occurrences are closely related to subvolcanic basalt, andesite, and dacite bodies in the upper Riphean Darhad Group. The belt trends north-south, it is approximately 200 km long, and ranges up to 50 km wide. Middle Riphean age green and black shale of the Hug Group is interpreted as a back-arc basin, and the sedimentary and volcanic units of the Darhad Group are interpreted as an island arc. The Darhad Group is correlated with the Sarhoi Group in southern Siberia (Konnikov and others, 1994). A Rb-Sr isochron age for volcanic rock in the Sarhoi Group is 718± 30 Ma (Buyakaite and others, 1989). The isotopic age of granite coeval with volcanic rocks is 752 Ma (Ulyn, 1983). The major deposit is at Tsagaan-Uul.

Tsagaan-Uul Sedimentary Exhalative Pb-Zn (SEDEX) Deposit

The deposit (D. Dorjgotov, written commun., 1990) consists of disseminated sulfides layered zones that are interbedded with Proterozoic metamorphic rock including dark schist and marble. Zones range up to 950 m long and several tens of meters wide. Ore are pyrite, sphalerite, galena, pyrrhotite and oxide. The average grade is 0.1-1.0% Pb, 0.1-1.0% Zn.

Origin and Tectonic Controls for Hugiingol Metallogenic Belt

The belt is interpreted as forming during rifting in backarc basin that was associated with a subduction-related island arc.

REFERENCES: Ilyn, 1983; Buyakaite and others, 1989, Konnikov and others, 1994, Tomurtogoo and others, 1999.

Hovsgol Metallogenic Belt of Sedimentary Phosphate, Volcanogenic-Sedimentary Mn, and Sedimentary Fe-V Deposits (Belt HO) (Northern Mongolia)

This Vendian through Early Cambrian metallogenic belt occurs in the Huvsgol-Bokson sedimentary overlap assemblage. Sedimentary phosphate deposits and occurrences are mostly in the Vendian to Early Cambrian lower siliceous dolomite member of the Doodnuur or Kheseen Formations. Sedimentary Fe, volcanogenic-sedimentary Mn, and sedimentary U-V occurrences are mainly above of the productive phosphate deposition in the Kheseen Formation, and also in clastic horizons of the Early Cambrian Khordil Formation (Ilyn, 1973). The metallogenic belt was first defined as a zone Ilyn (1973), and as the Chubsugul phosphate basin. Dejidmaa and others (1996) defined the belt as a complex metallogenic belt with sedimentary phosphorite, volcanogenic-sedimentary Mn, Fe, Fe-Mn, and U-V deposits. The basin comprises approximately 30,000 km^2, trends generally north-south, is approximately 300 km long, and ranges from a few tens to 120 km wide (Ilyn, 1973). The major deposits are the Urandosh, Uhaagol, Janhai, Ongilog nuur, Manhan uul, Burenhaan phosphorite deposits; the Ikh-Baga Tsagaangol and other Mn occurrences, and the Hatigiin gol, Tsahir uul, and other U-V occurrences.

Hubsugul Sedimentary Phosphate Deposit

This deposit (Muzalevskii, 1970; I'lin, 1973; Byamba, 1996) consists of up to five phosphorite beds that alternate with dolomite, limestone, chert, aleurolite, and argillite in a phosphorite-bearing zone. The phosphorite beds range from 5 to 50 m thick, generally occur with carbonate rock, and form mainly aphanite and granular types. The deposit occurs in the Hubsugul basin that occurs on the western coast of Lake Hubsugul. The basin extends 25 km stretching from south to north. The deposit occurs on both edges of the Hesen syncline in the lower part of the Vendian and Middle Cambrian Hubsugul series that consists of terrigenous and carbonate rock deformed in the late Riphean. The phosphorite deposit overlies Vendian sedimentary rock is overlain by Late Cambrian limestone with archaeocyathids. The deposit is large with an average grade of 20-40% P_2O_5. The deposit has produced 632.9 million tonnes.

Hitagiin gol Sedimentary Fe-V Deposit

The deposit (S. Tseveennamjil and others, written commun., 1983) occurs in Early Cambrian carbonate and terrigenous units in the Horidol Formation of the Hovsgol Group. Three horizons with V minerals occur, two hosted in siliceous carbonaceous slate, and one in chert. The host rocks are intercalated carbonaceous slate, siltstone, chert , and limestone, and quartzite. Deposit occurs in Northern, Central and Southern that range from 600 to 2700 m long, and from 20 110 m thick. The resources are 11,039 million tonnes V_2O_5. Grades range from 0.05-0.235% V, up to 0.05% Mo, 0.002-0.034% Cu, and up 1.0% Pb, and 0.2-1.0% Ba.

Saihangol Volcanogenic-Sedimentary Mn Deposit

The deposit (C.A. Kiselov and others, written commun., 1959) consists of pyrolusite and minor hematite in siliceous layers in carbonate of the Early Cambrian Khoridol Formation. Main ore mineral is pyrolusite with minor hematite. The host rock containing the pyrolusite siliceous beds ranges from 10-20 m thick. The pyrolusite beds are 300 m long and 1.5-2.0 m thick. The beds dips steeply to north. The deposit is large with an average grade of 4.0-36.72% MnO, 3.2-21.88% Fe_2O_3. Resources are 293 million tonnes ore with 65 million tonnes Mn, and 43 million tonnes Fe.

Origin and Tectonic Controls for Hovsgol Metallogenic Belt

The belt is interpreted as forming during sedimentation in a carbonate-dominated basin along a continental shelf.

REFERENCES: Dejidmaa and others, 1966; Ilyn, 1973; Tomurtogoo and others, 1999.

Jixi Metallogenic Belt of Banded Iron Formation (BIF, Algoma Fe), Homestake Au, Metamorphic Graphite, and Metamorphic Sillimanite Deposits (Belt JX) (Northeastern China)

This Neoproterozoic to Cambrian metallogenic belt occurs in the eastern Heilongjiang Province and is hosted in the Jiamusi metamorphic terrane and the Paleozoic Zhangguangcailing continental margin arc superterrane. The belt trends north-south, is about 400 km long, and about 100 km wide. Most of the BIF, graphite, sillimanite deposits are related to the Al-rich clastic rock and carbonate of the Mashan and Xingdong Groups that are regionally metamorphosed to granulite or amphibolite facies. Some deposits, such as the Dongfengshan BIF and Homestake Au vein deposits, are related to volcaniclastic rock and carbonate in the Dongfengshan Group that is regionally metamorphosed to lower greenschist or amphibolite facies. The Mashan Group was interpreted as Late Archean or Paleoproterozoic, but recent isotopic ages suggest a Neoproterozoic age (Nilde and others, 1999). The main deposits are at Shuangyashan, Liumao, and Dongfengshan.

Shuangyashan Banded Iron Formation (BIF, Algoma Fe) Iron Deposit

This deposit (Deng, Xianyuan, 1980; Cao, Jingxian, 1993b) consists of bedded and stratiform BIF deposits that occur concordant to the host rocks. The main deposit is 2,169 m long, 8 m thick, and extends 520 m down dip. The host rocks are sillimanite schist and gneiss, and marble of the Xingdong Group. The ores vary from banded to massive, and consist of magnetite, hematite, scheelite, pyrite, quartz, augite, and diopside. The deposit is large with an average grade of 30% Fe.

Liumao Metamorphic Graphite Deposit

This deposit (Xiao, Changsheng and others, 1994) consists of bedded, stratiform and lensoid graphite in Al-rich gneiss, and is hosted in sillimanite gneiss, graphite schist and gneiss, and marble in the the Jiamusi terrane. The deposit consists of graphite schist (13 to 16% C) and graphite gneiss (3 to 8% C) The main minerals are feldspar, quartz, mica, calcite, dolomite and varied metamorphic minerals, including more than 30 associated minerals. Single deposit layers range from 15 to 17 m thick and extend from several hundred to a thousand meters. Graphite schist, the main part of the deposit, comprises up 80% ores. The host rocks are interpreted as forming in a near shore and lagoon volcanic and sedimentary basin. A group of large graphite deposits occur in adjacent areas. The deposit is superlarge with reserves of 28.25 million tonnes graphite.

Dongfengshan Homestake Au Deposit

This deposit (Xu, Enshou and others, 1994) consists of stratiform Au deposits in BIF in the Proterozoic Dongfengshan Group. The BIF deposit occurs at the core of a anticline, varies fropm 40 m to 120 m thick, and contains 0.01 to 100.41 g/t Au. Four mineral facies occur in the BIF: a sulfide layer (5 m thick); a carbonate layer (5 m thick); a silicate layer (about 20 m thick); and an oxide layer (about 10 m thick). Stratiform Au occurs mainly in sulfide layers and has complicated mineral assemblage including spessartine, dannemorite, eulite, biotite, quartz, tourmaline, flouroapatite, rutile, pyrrhotite, arsenopyrite, danaite, cobaltite, gersdorffite, niine, chalcopyrite, sphalerite, magnetite, rutile, ilmenite, native Au, electrum, and graphite. Averaged fineness is 933. The deposit occurs at the intersection of Jilin-Heilongjiang Variscian orogenic belt and the Jiamusi fault zone. The deposit is small with an average grade of 19 g/t Au.

Origin and Tectonic Controls for Jixi Neoproterozoic Metallogenic Belt

The belt is hosted in a khondalite that is interpreted as derived from Al-rich mudstone and carbonate deposited in isolated oceanic basin and lagoon in a shallow sea (Lu Liangzhao, 1996). Part of the belt is hosted in the Jiamusi metamorphic terrane thatconsists of: (1) sillimanite schist, quartz schist, felsic gneiss, graphitic schist, and marble of the Mashan Group; and (2) migmatite, gneiss, quartz schist, graphite schist, banded iron formation, and marble of the Xindong Group. Part of the metallogenic belt is also hosted in the Zhangguangcailing continental margin terrane that consists of slate, schist, quartzite, marble, and metasandstone. The sedimentation probably occurred in the Neoproterozoic. The isotopic age of metamorphism is 500 Ma was (Nilde and others, 1999). The region including the Jixi Neoproterozoic-Cambrian metallogenic belt may have been part of the Gondwanaland passive continental margin.

REFERENCES: Lu Liangzhao, 1996; Nilde and others, 1999; Sun Jiapeng and others, 2000; Sun Jiapeng this study.

Damiao Metallogenic Belt of Mafic-Ultramafic Related Ti-Fe (V) and Zoned Mafic-Ultramafic Cr-PGE Deposits (Belt DM) (North China)

This Neoproterozoic metallogenic belt is hosted in mafic-ultramafic plutons intruding the West Liaoning-Hebei-Shanxi granulite-orthogneiss terrane in the Sino-Korean Craton. The belt occurs in Mount Yanshan in the Damiao area of the eastern Hebei Province. The belt trends east-west, is about 130 km long, and 50 km wide. The significant deposit is at Damiao.

Damiao Mafic-Ultramafic Related Ti-Fe (V) Deposit

This deposit (Cheng Yuqi and others, 1994) consists of a number of lenses and veins. The larger deposits extend along strike up to 300 to 500 m, extend downdip to 500 m and range from several tens to a hundred meters thick. The deposits occur at the contact zone between anorthosite and gabbro, or in the dikes of anorthosite and gabbro. The ores are mainly massive Ti-magnetite, minor ilmenite, and sparse pyrite and chalcopyrite. Gangue minerals are chlorite, amphibole, plagioclase, and minor apatite. P_2O_5 content is 0.07%. Also occurring is stockwork mainly in the gabbro adjacent to the contacts with anorthosite. The ore minerals are disseminated and are mainly Ti magnetite, ilmenite, plagioclase, augite, hypersthene, actinolite, chlorite, apatite, rutile, and sulphides. P_2O_5 content is 0.59 to 0.93% and Fe content is less than 20%. The host mafic intrusion intrudes Early Precambrian units along the northern margin of the Sino-Korea Craton, and is controlled by east-west-trending ional faults. K-Ar isotopic ages for the anorthosite range from 604 to 992 Ma. The deposit is large with reserves of 130 thousand tonnes V_2O_5, grading 0.16-0.39% V_2O_5, reserves of 58 thousand tonnes TiO_2, grading 7.17% TiO_2, and 32-34% Fe.

Gaositai Zoned Mafic-Ultramafic Related Cr-PGE Deposit

This deposit (Cheng, Yunchung and others, 1996) consists of a number of chromite bodies hosted in serpentinizied dunite and diopside pyroxenite that form part of an untramafic intrusion that is 9 km long and 1 km wide. The intrusion intrudes Early Precambrian metamorphic rock. The chromite bodies occur in veinlets and disseminations, and rare masses. The ore minerals grade into host rocks. The deposit occurs in the northern margin of the North China Platform in the Yanshan Mountains. Nearby are a number of similar small chromite deposits that occur along an east-west trend. The deposit is small with reserves of 170 thousand tonnes grading 14.12% Cr_2O_3 and locally up to 40% Cr_2O_3.

Origin and Tectonic Controls for Damiao Metallogenic Belt

The belt hosted in Neoproterozoic mafic-ultramafic plutons that intrude Archean gneiss that intrude Archean crystalline rocks of West Liaoning-Hebei-Shanxi terrane. The plutons occur along northwest-trending major major faults along the northern margin of the Sino-Korean Platform. The mafic and ultramafic intrusions have isotopic ages of 604.4 to 992 Ma. The plutons and deposits are interpreted as forming during interplate magmatism. The plutons and deposits are interpreted as forming during interplate magmatism related to an Neoproterozoic active continental margin along the north margin of the Sino-Korean Craton**.**

REFERENCES: Cheng Yuqi and others, 1994.

CAMBRIAN THROUGH SILURIAN METALLOGENIC BELTS (540 to 410 Ma)

Tuora-Sis Metallogenic Belt of Carbonate-hosted Pb-Zn (Mississippi Valley type) Deposits (Belt Tuo) (Russia, northern Verkhoyansk fold and thrust belt)

This Early Cambrian metallogenic belt is hosted in clastic and carbonate sedimentary rocks of the Verkhoyansk fold and thrust belt in the North Asian Craton Margin that constitutes a major passive continental margin. The belt is hosted in Riphean clastic and carbonate rocks (1700 m thick), Vendian dolomite and sandstone (400 to 450 m thick), and Aldanian clastic and carbonate rocks (Early Cambrian). The major deposit is at Mengeniler.

Mengeniler Carbonate-hosted Pb-Zn (Mississippi Valley type) Deposit

This deposit (Natapov, 1981; Davydov and others, 1988) consists of three lensoid stratiform deposits that range from 70 to 135 m long and 0.4 to 3.6 m thick. The principal ore minerals are sphalerite and galena. Sphalerite is predominant and consists of honey-yellow and colourless cleiophane. Pb and Zn average 0.04 to 0.6% and 0.2 to 6.7%, respectively. Ore minerals are disseminated, and locally grade to massive. The deposit is well-bedded and consists of alternating rich-and poor-sulfide beds. The belt contains some stratiform Pb-Zn sulfide occurrences that are hosted in dark-brown bituminous silty dolomite (about 30 m thick) that occurs at the bottom of the Aldanian stage.The deposit is medium size with aerage Pb and Zn grades of 0.04-0.6% and 0.2-6.7%, respectively.

Origin and Tectonic Controls for Tuora-Sis Metallogenic Belt

The belt interpreted as forming during sedimentation after Neoproterozoic rifting along the passive continental margin of North Asian Craton. Economic deposits occur in areas of facial thinning of dolomite.

REFERENCES: Natapov, 1981; Parfenov and others, 1999, 2001.

Bedobinsk Metallogenic Belt of Sediment-Hosted Cu Deposits (Belt BD) (Russia, Eastern Siberia, Yenisey Ridge area)

This Middle to Late Cambrian metallogenic belt occurs along the southwest margin of the North Asian Craton along the margin of the Middle to Late Cambrian Priangarsk sedimentary basin. The belt contains the productive southern Priyenisei metallogenic district that extends from Angara to Podkamennaya Tunguska Rivers. The belt is 200 km long and 150 km wide (Bogdanov and others, 1973). The major Cu deposits occur in the middle and upper parts of carbonate and clastic rock in the Yeniseisk and Turamsk Series that contains mottled anhydrite limestone and dolomite. More than 200 Cu ore occurrences occur in mottled carbonate and clastic rocks that contain the Cu-bearing Middle to Late Cambrian limestone, dolomite, siltstone, and sandstone of the Yeniseisk series. Eight Cu-bearing horizons ranging from 0.3 to 10 m thick are identified. The most significant deposit at Bedobinsk occurs in a horizon that is 2.1 m thick and consists of sandstone and mudstone with covellite, chalcocite, bornite, fahl, and up to 1% in total cuprite, and up to 0.5% malachite and azurite (Borzenko and Sklyarov, 1970). The major deposits are at Bedobinskoye and Kurishskoye.

Bedobinskoye Sediment-Hosted Cu Deposit

This deposit (Narkelyun and others, 1977) consists of stratiform Cu sulfides in the Middle to Late Cambrian argillaceous, clastic, and carbonaceous rock of the Evenkiisk suite. The Cu sulfide horizon is 2 to 3 m thick. Host lithologies are red aleurolite and siltstone. Host rocks are dolomitic sandstone, limestone, and marl. Ore minerals are chalcocite, pyrite, hematite, chalcopyrite, bornite, arsenopyrite, fahl, sphalerite, and native silver. Ore minerals occur marinly in cement of sedimentary rocks in disseminations, concretions, and thin laminae. The deposit is medium size with an average grade of 0.1 to 0.6% Cu.

Kurishskoye Sediment-Hosted Cu Deposit

This deposit (Malich and others, 1987) consists of stratiform Cu minerals in Upper Riphean terrigenous red molasse. The most abundant Cu minerals occur in variegated sedimentary rocks formed in a coastal-marine and deltaic facies. Four Cu horizons range from 0.5 to 4.5 m thick and display features of high stability over a large area. The ore minerals are chalcocite and bornite, and rare chalcopyrite, covellite, malachite, and azurite. Fractured Cu-bearing rock is along the southern margin of the Siberian Platform may have been the source of copper. The deposit is medium size with an average grade of 1% Cu.

Origin and Tectonic Controls for Bedobinsk Metallogenic Belt

The belt interpreted as forming in an inland-sea basin in a post-saline stage of rock deposition. Main source of Cu is interpreted as weathered Riphean rocks and lode deposits in the Yenisei Ridge, and from hydrothermal activity along deep-fault zones related to rifting. The mottled and red-bed carbonate and clastic Cu-bearing strata accumulated under arid conditions in a shallow-sea platform basin.

REFERENCES: Sklyarov, 1970; Bogdanov and others, 1973; Narkelun and others, 1977; Borzenko, Miroshnikov, 1981; Miroshnikov and others, 1981, 1988.

Taidon-Kondomsk Metallogenic Belt of Fe Skarn and Volcanogenic-Sedimentary Mn Deposits (Belt TK) (Russia, Eastern Siberia)

This Early Cambrian to Ordovician metallogenic belt is hosted in as a narrow band along the eastern and southeastern folded framing of the Kuznetsk basin. The Fe skarn deposits occur in the Telbes-Kitat island-arc terrane and the volcanogenic-sedimentary Mn deposits occur in Altai-Sayan back-arc basin (Mrassu-Bateni unit). The belt is about 600 km long and ranges from 30 to 90 km wdie. The main part of the belt occurs along the Kuznetsk-Alatau fault zone. The northern flank of the belt is overlapped by Cenozoic sedimentary rock. The eastern part of the belt splits and partly coincides with the Au Martaiginskiy metallogenic belt. Fe-skarn deposits predominate in the belt and are hosted in late Riphean through Ordovician volcanic and sedimentary rock that is intruded by gabbro, diorite, gabbro and plagiogranite (albitite), granodiorite, granosyenite, and syenite (Polyakov, 1971). Some skarn deposits may be related to younger Devonian porphyry Cu (±Au) and Cu-Mo deposits that are related to calc-alkalic diorite, granosyenite, and granite porphyries in the Sorsk metallogenic belt. The Mn deposits are related to Early Cambrian volcanogenic and carbonate formation. The main Fe skarn deposit is at Sheregesh and the main volcanogenic-sedimentary Mn deposit is at Usinskoye.

Sheregesh Fe Skarn Deposit

This skarn (Kalugin and others, 1981; Kuznetsov, 1982; Orlov, 1998) is a magnetite skarn deposit hosted in Middle Cambrian volcanic and sedimentary rock including limestone, tufaceous sandstone, siltstnone, and porphyritic trachite tuff that are intruded by gabbro, syenite, and granite. The skarn consists of pyroxene and garnet and occur along exocontact zones of syenite that is the youngest granite intrusion. Pyroxene-phlogopite and pyroxene-spinel skarn occurs in gabbro dolomite host rocks. The skarns consist of complicated lenses, stocks, nests, pipes, and veins. The ore structures are mainly brecciated and rarely massive. At depths of 500 to 700 m, the structures are veinlets and disseminations that contain low-grade ores. Distal deposits are concordant with host rock bedding and consist of layers and lenses of banded ore. The principal ore minerals are magnetite, mushketovite, hematite, minor pyrite, pyrrhotite, sphalerite, chalcopyrite, galena, and arsenopyrite. Recrystallization of ores and skarns occurred during younger granite inrusion. The deposit is large with reserves of 184,700,000 tonnes grading 35.83% Fe and production of greater than 50 million tonnes ore.

Usinskoye Volcanogenic-sedimentary Mn Deposit

This deposit (Kuznetsov, 1982; Bych and Batyrev, 1998) consists of bedded Mn ores that occur in the upper part of an Early Cambrian sedimentary sequence of dark Mn limestone and interlayered mafic pyroclastic rock. The host strata ranges from 450 to 600 m thick, extends up to 4.5 km along strike, and is divided into underlying and deposit-bearing parts. The lower part of the deposit contains five low-grade beds that are 2 to 3 m thick containing 10 to 14% Mn. The principal ore mineral is rodochrosite. The upper part of the deposit is more than 100 m thick and contains 10 ore beds. Thickness of individual ore beds ranges from 2.5 to 14 m. Primary ores consist of rodochrosite (more than 20% Mn), limestone-rodochrosite (0 to 20% Mn), and chlorite-rodochrosite (17 to 22% Mn). Also present are minor silicate metasomatic ores containing bustamite, rodonite, ekmanite, rodochrosite, calcite, quartz, axinite, and sulfides that occur along exocontacts of dikes and fractures. The deposit was party metamorphosed during intrusion of early Paleozoic gabbros and granitoids. Weathering crust occurs over all areas of Mn rock outcrop. Oxidized ore minerals are psilomelane, vernadite, and pyrolusite. The deposit is large with reserves of 98,500,000 tonnes of ore, rsources of 276,500,000 tonnes ore, and an average grade of 19.12% Mn for carbonate ore, and 27% Mn for oxide ores. Reserves of 11 million tonnes Mn occur in oxidized ore.

Origin and Tectonic Controls for Taidon-Kondomsk Metallogenic Belt

The belt is interpreted as forming in a back-arc environment island-arc for the stratiform Mn deposits and during subsequent accretion for the Fe skarn deposits (Berzin and Kungurtsev, 1996; Alabin and Kalinin, 1999). They occur in the oceanic and island arc-collisional complexes. The most important economic Fe-skarn deposits occur in the oceanic sedimentary and volcanic rock. Where this metallogenic belt overlaps the Martaiginskiy Au metallogenic belt, the Fe skarn deposits also contain Au. The sources of Fe for some Fe-skarn deposits is interpreted as the older volcanogenic-sedimentary Fe deposits (Kalugin and others, 1981). The Usinskoye Mn deposit occurs in volcanic and sedimentary rock of the Early Cambrian Usinskaya Suite in a transitional zone between volcanic and sedimentary and sedimentary rock. The host strata consist of limestone with interlayers of calcareous-siliceous-micaceous Mn shale that contain rhodochrosite and manganocalcite.

REFERENCES: Polyakov, 1971; Kalugin and others, 1981; Berzin, Kungurtsev, 1996; Alabin and Kalinin, 1999.

Martaiginsk Metallogenic Belt of Granitoid-related Au Vein and Au Skarn Deposits (Belt MT) (Kuznetsk Alatau to Gorny Altai Mountains, Russia, Eastern Siberia)

This Late Ordovician and Early Silurian metallogenic belt is related to the Tannuola plutonic belt that intrudes the Kozhukhov, Kanim and Uimen-Lebed island-arc terranes, and the Altai-Sayan back-arc basin. The belt extends along the eastern slope of the Kuznetsk Alatau Ridge for up to 500 km with breaks and ranges from 30 to 60 km wide. The belt is 250 km wide in the Kuznetsk Alatau. Most of the Au deposits occur along the Kuznetsk Alatau branch of the belt. The belt occurs along the hanging wall of the Kuznetsk Alatau fault zone that exhibits complex relations between Precambrian and early Paleozoic sedimentary, extrusive, and intrusive rocks. The granitoid-related Au deposits occur in early Paleozoic granitoid batholiths, in relatively older gabbro and norite intrusions, in andesite, basalt, and andesite porphyry, and in complexly deformed volcanic and sedimentary rock (Alabin and Kalinin, 1999). Au skarn deposits occur along contact between the early Paleozoic granitoid plutons and companion stocks and consist of magnesium-silicate and calc-silicate skarn. The most abundant Au deposits occur in brecciated and recrystallized skarn. Au-rich wollastonite skarn at the Sinyukhinskoye deposit extends to 500 m depth. Also occurring are Au-sulfide-quartz veins in some Au skarn deposits. This relation is links the two types of Au deposits in the belt. The majority of Au skarn deposits occur at the western part of the Martaiginskiy metallogenic belt where it overlaps with the Taidon-Kondomsk Fe-Mn metallogenic belt. Lode Au deposits are the sources of numerous Au placers that have been mined during last 150 years. The major deposits are at Sarala, Natal'evskoye, Komsomolskoye, and Sinyukhinskoye.

Komsomolskoye Granitoid-Related Au Vein Deposit

This deposit (Denisov, 1968) Consists of quartz-sulfide veins hosted in Ordovician-Silurian gabbro and diorite stock that intrudes Cambrian carbonaceous and volcanic rock. Stock intrusive is oval with dimensions of 5x3,5 km. Multiple xenoliths of contact metamorphosed and skarn-altered host rock occur in gabbro and diorite massif. About 150 quartz veins occur in the five districts. Single veins range up to 1.5 km long and 5 m thick. Wallrock alterations are beresite alteration, silica alteration and sulfide alteration. Deposit minerals pyrite, pyrrhotite, sphalerite, arsenopyrite, galena, chalcopyrite, scheelite, native gold. Native gold is associated with arsenopyrite and galena. The deposit is small.

Sarala Granitoid-Related Au Vein Deposit

This deposit (Miroshnikov and Prochorov, 1974; Sazonov and others, 1997; Shirokich and others, 1998) consists of a group of quartz-carbonate and sulfide veins hosted in Early to Middle Cambrian volcanic and sedimentary rock that is metamorphosed and hydrothermally altered. The veins are related to early Paleozoic gabbro, diorite and granite intrusives of age occur. More than 250 veins occur in seven districts. Two types of veins are defined according to size: (1) single veins that are up to 3 km long, 1.5 to 2 m thick (up to 4 to 5 m in swells) are the most economically important and comprise the bulk of Au reserves; (2) a more common type of veins that are several hundred meters long (rarely up to 1 km), are 0.2 to 0.6 m thick, and occur in berezite, silica, sericite and listvenite alteration zones. Grade of Au in altered wall rock vary from minor to 57 g/t Au. Ore minerals assemblages are: quartz, pyrite, and scheelite; quartz, pyrite, and arsenopyrite; amd quartz, pyrite, sphalerite, galena, and calcite. Average sulfide content is 4.75%. Native Au occurs mainly with arsenopyrite, sphalerite, and galena. Fineness of Au ranges from 483 to 911 (mainly 680 to 790). The deposit is medium size with an average grade of 8.4 g/t Au.

Natal'evskoye Au Skarn Deposit

This deposit (Alabin and Kalinin, 1999) consists of a group of Au skarn bodies with a complicated mineral assemblage that occur along the contact of the Ordovician and Silurian Natal'evsk granitoid stock that intrudes Vendian and Cambrian andesite and basalt porphyry and tuff that are interbedded with chlorite and carbonaceous-siliceous schist, limestone, and dolomite. The skarn contains an older assemblage of magnesium-silicate minerals (diopside, spinel, phlogopite, and serpentine), and a younger assemblage of calcsilicate minerals (garnet, pyroxene, wollastonite, tremolite, and vesuvianite). Ore minerals are mainly magnetite, chalcopyrite, cubanite, and bornite, and lesser pyrite, pyrrhotite, sphalerite, galena, native Au, molybdenite, and native bismuth. Fineness of Au is of 760 to 820 pm. Sulfides comprise from 3 to 8% skarn. The main Au-minerals are chalcopyrite and bornite. Skarn that is brecciated, recrystallized and slightly hydrothermally altered (albite, actinolite, and silica alteration) are most enriched in Au. The deposit is small.

Sinyukhinskoye Au Skarn Deposit

This deposit (Nikolaev, Neverovicn, 1958; Luzgin, 1974; Korobeynikov and others, 1997; Sharov and others, 1998) consists of quartz-carbonate and Au-Cu-sulfide skarns that occur in a contact zone of an Ordovician and Silurian granitoid pluton intruding Middle Cambrian volcanic and sedimentary rock. Varikous wollastonite, pyroxene, and garnet skarn occurs along contact of volcanic rock and rare dikes with carbonates. Various age dike complexes are widespread. The oldest diabase and spesartite dikes intrude skarn ande also metasomatized. Younger quartz diorite porphyrye and felsite dikes are not metasomatized, but contain Au-sulfide deposits that contain economic Au connected that formed during post-skarn hydrothermal metasomatism that resulted in silica alteration and sulfide replacement. The Au skarn deposits are occur in irregular masses, nest, lenses, and stockworks. Individual skarn bodies range from ten to several hundred meters long. Thickness of ore veins is 2 to 6 m and occur mainlyi in skarn and to a lesser extent in magnetite masses and wall rocks. A gold-chalcocite-bornite assemblage is typical for upper part of deposit, and Au-chalcopyrite is typical in deeper levels. The deposit is medium size with reserves of 20 tonnes Au.

Origin and Tectonic Controls for Martaiginsk Metallogenic Belt

The belt is interpreted as forming during accretion and collision and generation of mantle and crustal granitoids. Deposit clusters occur along fault and shear zones that are branches of the Kuznetsk Alatau fault and along intersections with transversal sublatitudinal faults. The belt occurs in a terrane collage of fragments of an island arc system and an active continental margin (Berzin and Kungurtsev, 1996; Alabin and Kalinin, 1999). The granitoids consist of an older gabbro sequence and a younger granitoid sequence. The origin of Au-sulfide-quartz vein deposits (Centralnoye, Berikul, Komsomolskoye, Kommunar, Sarala) and Au skarn deposits (Natalevskoye, Sinyukhinskoye) are related to early Paleozoic collisional granitoid of the Martaiginsk and Lebed complexes (Berzin and Kungurtsev, 1996) that are interpreted as derived from calc-alkaline andesite mantle melt. The initial $^{87}Sr/^{86}Sr$ ratio in accessory apatite from granite ranges from 0.7043 to 0.7044 (Sotnikov and others, 1999). The $^{40}Ar/^{39}Ar$ isotopic age for granitoid of the Martaiginsk complex is 480 to 460 Ma (Sotnikov and others, 1995). Similar data occur for granite in the Lebed complex with a K-Ar isotopic age age of 445 to 427 Ma. Rb-Sr isotopic ages for gangue minerals and metasomatite are 472±10 Ma at Gavrilovskoye; 458±4 Ma at Centralnoye; 444±4 Ma for Komsomolskoye; and 433±17 Ma for Sarala. Some studies suggest the Au deposits may be related to dike complexes superimposed on the Martaiginsk and Lebed granitoids (Shirokich and others, 1998).

REFERENCES: Bulynnikov, 1948; Sotnikov and others, 1995, 1999; Berzin, Kungurtsev, 1996; Sharov and others, 1998; Shirokich and others, 1998; Alabin and Kalinin, 1999.

Kiyalykh-Uzen Metallogenic Belt of Cu (±Fe, Au, Ag, Mo) Skarn, W±Mo± Be Skarn, Fe Skarn, and W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposits (Belt Kiy) (Kuznetsk Alatau, Russia, Eastern Siberia)

This Early Ordovician to Early Silurian metallogenic belt is related to the Tannuola plutonic belt located in the Altai-Sayan back-arc basin (Mrassu-Bateni unit) and occurs along the southeastern slopes of the Kuznetsk Alatau Ridge. The belt is oval and trends sublongitudinally for 150 km and ranges from 50 to 80 km wide. Deposits are concentrated in early Paleozoic granitoids that intrude Vendian and Cambrian carbonate and clastic shelf rocks, and rarely in Cambrian volcaniclastic and carbonate sedimentary rock. Deposits occur in: (1) contact zones of granitoid intrusions and as skarn in large xenoliths of host rocks; and (2) endocontact zones and cupolas of granitoid plutons in greisens and veins. Deposits are controlled by zones of intersection of northwest-and northeast-trending faults. Cu skarn deposits are predominant. Most deposits are small. The Kiyalykh-Uzen, Juliya Mednaya Cu (±Fe, Au, Ag, Mo) skarn and the Tuim W (±Mo±Be) skarn deposits are mined.

Kiyalykh-Uzen Cu (±Fe, Au, Ag, Mo) Skarn Deposit

This deposit (Kuznetsov and others, 1971; Levchenko, 1975) consists of a lensoid body that occurs along the contact of the Tuim granitoid pluton and intruded-Cambrian carbonate rock. Garnet, pyroxene-garnet, and magnetite skarn, and hornfels and quartzite occur along the contact zone. The deposit occurs in a district that is 900 m long and ranges from 1 to 50 to 80 m thick. Some economic deposits occur. The major lens like deposit is 550 m long and ranges from 4 to 76 m thick. The ore minerals are: magnetite, chalcopyrite, pyrite, arsenopyrite, pentlandite, sphalerite, pyrrhotite, molybdenite, fahl, galena, enargite, and scheelite. The ore minerals occur in veinlets, masses, and disseminations in skarn. Also occurring are quartz-sulfide veinlets. Molybdenite occurs in zones in silicified granitoid in quartz veinlets containing disseminated molybdenite, chalcopyrite, and other sulfides. The deposit has been mined. The deposit is small.

Tuim W±Mo±W±Mo±Be Skarn Deposit

This deposit (Kuznetsov and others, 1971; Levchenko, 1975) is hosted in pyroxene-garnet and garnet skarn that occurs along the margine of large roof pendants of Cambrian limestone that are intruded by the early Paleozoic Tuim granitoid pluton. The ore minerals are scheelite, pyrite, chalcopyrite, molybdenite, pyrrhotite, and galena. Scheelite occurs both in skarn and quartz veinlets in disseminations and masses. Sulfides, including molybdenite, occur in quartz veinlets. In the district containing the Tuim deposit are numerous quartz veins (that vary from0.3 to 0.4 m thick) with disseminated scheelite and wolframite. These veinlets are related to a small granite pluton. The deposit is small.

Verhne-Askizskoye W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Amshinskiy and Sotnikov, 1976) consists of quartz-scheelite veins that occur in a fracture zone cutting an an Early Cambrian syenite and diorite pluton that contains numerous Vendian and Cambrian xenoliths. The veins occur in a 100-m-wide band. Five main sublongitudinally-trending, steeply-dipping quartz veins range from 80 to 440 m long and from 0.4 to 1.4 m thick. The major vein mineral is quartz. Also occurring are carbonate, albite, epidote, muscovite, and chlorite. Ore minerals are pyrite, scheelite, chalcopyrite, sphalerite, pyrrhotite, galena, and argentite. The deposit is small.

Turtek W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (V.I. Sotnikov, this study) consists of numerous quartz veins and veinlets in Cambrian and Ordovician granitoids that are altered to greisen. The deposit is 150 to 200 m thick and extends up to several km with interruptions. The deposit contains veins and veinlets that range from 5 to 50 cm wide. Individual veins range up to 300 to 500 m wide. Ore minerals occur in greisen zones in host rocks. The ore minerals are scheelite, molybdenite, pyrite, and galena, and rare chalcopyrite, bismuthine, and gold. The deposit is small.

Samson Fe Skarn Deposit

This deposit (Kuznetsov and others, 1971; Kalugin and others, 1981) consists of six steeply-dipping lensoid skarn-magnetite deposits that occur along a contact zone between a Paleozoicgranitoid and Early Carboniferous marble. The deposits range from 100 to 600 m long, and extend from 320 to 610 m depth, and range ukp to 5 to 30 m thick. Ore assemblages are magnetite, magnetite-silicate, and magnetite-sulfide. Associated minerals are: pyrite, pyrrhotite, chalcopyrite, and arsenopyrite. Gangue minerals are garnet, pyroxene, amphibole, calcite, epidote, and minor scapolite. Average grade is 44.28% Fe, 0.15% P_2O_5, 0.83% S, and minor Co, Cu, As. The deposit is medium size with reserves of 23,300,000 tonnes ore.

Origin and Tectonic Controls for Kiyalykh-Uzen Metallogenic Belt

This metallogenic belt is related to early Paleozoic collisional granitoids (Berzin and Kungurtsev, 1996). Granitoid plutons are interpreted as intruding during dextral-slip movement along the Kuznetsk Alatau fault (Alabin and Kalinin, 2000). Host rocks were intensely altered during both prograde and retrograde stages of intrusion of granitoid plutons. Two age groups of granitoid plutons with different suites of deposits are recognized. An older suite of mainly skarn deposits is hosted in Martaiga complex granitoid batholith that contains diorite, granodiorite, syenite, and diorite (Kuznetsov and others, 1971). An $^{40}Ar/^{39}Ar$ age is 480 to 460 Ma and initial $^{87}Sr/^{86}Sr$ ratio is 0.70430 to 0.70436 (Sotnikov and others, 1995, 1999). A younger suite of REE and vein and stockwork deposits is hosted in a granite and leucogranite sequence that has a $^{40}Ar/^{39}Ar$ age of 440 to 420 Ma.

REFERENCES: Kuznetsov and others, 1971; Sotnikov and others, 1995, 1999; Berzin and Kungurtsev, 1996; Alabin, Kalinin, 1999.

Kizir-Kazyr Metallogenic Belt of Fe Skarn, Volcanogenic-Sedimentary Fe, and Granitoid-related Au Vein Deposits (Belt KK) (Eastern Sayan Ridge, Altai-Sayan folded area, Russia)

This Middle Silurian metallogenic belt is related to Tannuola plutonic belt and occurs in the Altai-Sayan back-arc basin (Mrassu-Bateni unit) in the East Sayan Mountains. The belt extends northwest for and is about 90 km wide. The belt occurs in Ordovician gabbro, diorite, and granodiorite plutons (Polyakov, 1971). Host rocks in the Fe –deposits are mainly Early to Middle Cambrian volcanic and sedimentary rocks with abundant basalt. Fe-skarn deposits occur along the exocontact zones of gabbro, diorite, granodiorite plutons, and replace large xenoliths of host rocks. Granitoid-related Au Vein deposits occurs along the contacts of granitoid intrusions that metasomatize and contact metamorphose Cambrian rocks. Granitoids are mainly multistage gabbro, diorite, and granodiorite intrusives. Fe and Au deposits occasionally occur in clusters. The major deposits are at Irbinskoye, Belokitatskoye, and Olkhovskoye.

Irbinskoye Fe Skarn Deposit

This deposit (Dymkin and others, 1975; Kalugin and others, 1981; Sinyakov, 1988) consists of lensoid and layered magnetite in garnet and pyroxene-garnet skarn and aposkarn. Gangue minerals are amphibole, epidote, and chlorite. Skarn occurs in the contact zone of Ordovician gabbro, diorite, and granodiorite plutons that intrude Early Carboniferous volcanic and sedimentary rock and in xenoliths. The main district containing the deposit is 5 km long, ranges from 300 to 400 m thick, and contain 50 deposits. Average size of individual deposit is about 650 m along strike, 350 m depth and 60 m wide. Pyroxene-garnet-magnetite, garnet-epidot-magnetit,e and epidote-chlorite-magnetite skarns occur. Ores have high SiO_2 and CaO low MgO and P_2O_5. The principal ore mineral is magnetite. Also occurring are minor hematite, various sulfides: pyrite, chalcopyrite, pyrrhotite, sphalerite, galena, pentlandite, and arsenopyrite. The deposit has reserves of 95,000,000 tonnes.grading 38.8% Fe.

Belokitatskoye Volcanogenic-sedimentary Fe Deposit

This deposit (Andreev and Kurceraite, 1977; Kalugin and others, 1981) consists of lenticular and layered deposits of hematite and magnetite in Early Cambrian volcanic and sedimentary rock consisting mainly of interbedded tuff, sandstone, phyllite, and by jasperite. The deposit occurs in the-Western and Eastern districts. The Western district is 1.5 km long and contains 10 deposits that vary from 0.75 to 9 m thick. The Eastern district contains ore layers that vary from 4.5 to 11.3 m thick and extend for 4 km. Deposits consist of alternating ore minerals layers and and jasperite. Ore layers contain magnetite, hematite, quartz, vermiculite, chamosite, and siderite, along with pyrite, pyrrhotite, and chalcopyrite. Deposits are interpreted as derived from metamorphosed volcanic and sedimentary units. Average grade is 0.2 to 1.5% P_2O_5, and up to 5.2% MnO. The deposit is has reserves of 200,000,000 tonnes grading 36 to 88.6% Fe.

Olkhovskoye Granitoid-related Au Vein Deposit

This deposit (Bulinnikov, 1968; Chazagorov, 1963, 1968; Smirnov, 1978) occurs along the contact zone of the Ordovician Olchovsk granitoid pluton that intrudes Early and Middle Cambrian sedimentary and volcanic rock that is contact metamorphosed and metasomatized. Lenses and columns sulfide deposits commonly occur in carbonate rock. Quartz and quartz-sulfide veins and dense networks of stockwork veinlets occur in hornfels contact zones adjacent to granitoids. Also occurring in the pluton is disseminated Au. Wall rock are altered to berezite, silica, sericite and chlorite. Main ore minerals are pyrrhotite, pyrite, chalcopyrite, marcasite, sphalerite, galena, arsenopyrite, fahl, Bi-minerals, and native Au. Gold deposits are mainly associated with polymetallic sulfide deposits. The size of free Au grains ranges from 0.05 to 3 mm. Fineness of Au ranges from 688 to 358. The deposit is small.

Origin and Tectonic Controls for Kizir-Kazyr Metallogenic Belt

The belt is related to early Paleozoic collisional granitoids that intrude Vendian and Cambrian shelf carbonate and carbonate rock along the margins of the East Sayanian and Minusa Basins and associated structures. Deposits are related to Ordovician gabbro, diorite, and odiorite intrusions(Berzin and Kungurtsev, 1996). The composition of host rocks played an important role in ore genesis. The Early Cambrian volcanic and sedimentary rock of the some districts were both favorable for formation of Fe skarn and also the source of Fe. Syngenetic Fe deposits are related to Early Cambrian volcanic rocks as at the Belokitatskoye volcanogenic-sedimentary Fe deposit (Andreev and Kurceraite, 1977). The host Cambrian black shale may be a source of Au. The K-Ar age for deposit-hosting gabbro, diorite, and granodiorite intrusions in the Irbinskoye Fe district is 430 Ma (Dymkin and others, 1975). The younger, post-ore, Devonian granite and syenite intrusions crosscut the and modify the deposits.

REFERENCES: Polyakov, 1971; Andreev and Kurceraite, 1977; Dymkin and others, 1975; Berzin and Kungurtsev, 1996.

North-Sayanian Metallogenic Belt of Fe Skarn and Cyprus Cu-Zn Massive Sulfide Deposits (Belt NS) (West Sayan Mountains, Russia, Eastern Siberia)

This Early to Middle Cambrian metallogenic belt is related to replacements in the North Sayan island arc terrane. The belt occurs along the north margin of West Sayan, extendssouth from the Sayan-Minusinsk fault zone, and extends up to 300 km long and ranges up to 30 km wide. The belt occurs in a band of volcaniclastic rock in the Early Cambrian Nizhnemonoksk Suite in the Mainsk synclinorium that is interpreted as forming in a back-arc basin (Bogatskiy and Kurceraite, 1966). Volcanic rocks in the belt are mainly calc-alkaline diabase, andesite and dacite porphyry, and quartz albitophyre. Widespread sedimentary rocks are argillaceous carbonaceous shale, siltstone, and sandstone. Host rocks are intruded by the Early Cambrian Mainsk gabbro and plagiogranitic complex, the Middle Cambrian Anzassk gabbro and albitophyre complex, and ultramafic rock along the Early to Middle Cambrian Kandat fault. The deposits are also intruded by youngerDevonian porphyric K granite and syenite of the Dzhoisk magmatic complex. The belt contains both Fe-skarn deposits (Abakanskoye, Anzass) and volcanovolcanogenic-sedimentary deposits (Mainskoye Cu-pyrite Cyprus deposit) that provide the main metallogenic character of the belt (Belous and Novozhilov, 1969; Distanov, 1977).

Abakanskoye Fe Skarn Deposit

This deposit (Bogatskiy and Kurceraite, 1966; Kalugin and others, 1981; Orlov, 1998; Sinyakov, 1988) consists of large lenses and layers of magnetite that are hosted in Early Cambrian extrusive and tuffaceous rock, andesite and basalt extrusives, tufaceous sandstone, and aleurolite intercalated with conglomerate and limestone. The magnetite deposits about 3 km from a plagiogranite and pyroxene diorite intrusive. Wall rock exhibit albite, chlorite, and amphibole alterations. Deposits are concordant to bedding of host rocks. Four deep-steeping deposits occur and extend from 550 to 1000 m along strike, reach to 430 to 1150 m deep, and range from 14 to 60 m thick. Ores are mottled, massive, laminated, brecciated and disseminated. The main mineral ore assemblages are: amphibole-magnetite, amphibole-chlorite-magnetite, chlorite-calcite-magnetite, and epidote-chlorite-magnetite. The principal ore mineral is magnetite. Associated minerals are chlorite, gastingsite, albite, carbonate, quartz, anhydrite, pyrite, pyrrhotite, and chalcopyrite. Garnet and pyroxene are rare. The deposits exhibit two main relations: (1) close temporal and spatial relation with Early Cambrian volcanic and sedimentary rock; and (2) occurrence of hydrosilicate skarn minerals as the result of contact-metasomatism related to Cambrian or younger intrusions (Bogatskiy and Kurceraite, 1966; Orlov, 1998). The deposit is large with reserves of 172,500,000 tonnes grading 38% Fe.

Mainskoye Cyprus-Type Cyprus Cu-Zn Massive Sulfide Deposit

This deposit (Belous and Novozhilov, 1969; Distanov, 1977) consists of layers and lenses of Cu-pyrite and Fe-oxide in Early Cambrian volcaniclastic and and sedimentary rock. The deposit occurs near the regional Sayan-Minusinsk fault zone. Host greenschist consists interbedded black schist and sandstone along with layers of conglomerate, jasperite, and volcanic rock (porphyry, quartz albitophyre, and diabase). The deposit occurs along the south exocontact of the Early Cambrian Mainsk plagiogranite-granodiorite intrusive. Fe-oxide and Cu-pyritie ores occur along two stratified horizons. Layers and lenses in the major ore horizon extend up to 1 km along strike. Mineral zonation consists of hematite and hematite-magnetite ores along the flanks to magnetite-sulfide, and sulfides in the central part of the deposit. Main ore minerals are hematite, magnetite, maghemite, mushketovite, pyrite, chalcopyrite, sphalerite, and pyrrhotite, and rare marcasite. Gangue minerals are quartz, carbonate, chlorite and hydrohematite. Garnet, epidote, biotite occur in the contact metamorphic zone. Layered and banded structures of ores are typical for both Fe-oxide and oxide-sulfide deposits along with pisolitic structure (2 to 4 mm wide). Sulfide chalcopyrite-pyrrhotite deposits are mainly massive. Sulfide-magnetite in the contact zone of the granitoid pluton is locally metasomatically altered, recrystallized, and cut by veins and masses of Cu and Pb-Zn sulfides. The deposit is small with average grade of 0.3 to 4.5% Cu; 0.2 to 4.9% Zn.

Origin of and Tectonic Controls for North-Sayanian Metallogenic Belt

The belt is interpreted as forming in volcanic basins along an island-arc. The host Early Cambrian volcanic belt contains Fe and Cu-Zn pyritie deposits. The Cu pyrite Mainskoye deposit occurs in volcaniclastic rocks and is associated with with stratiform Fe-oxide deposits. The metasomatized and conformable Abakanskoye Fe skarn deposit occurs in Early Cambrian volcanic and sedimentary rock. The primary bedded Fe deposits were metasomatized along the contacts of Cambrian granitoid and gabbro and albitite (Orlov, 1999). The Anzass Fe-skarn deposit and others are spatially and genetically related to gabbro and albitite intrusions that intruded along the major Shamansk fault. Explosive and hydrothermal-explosive breccias, enriched in magnetite in fragments and matrix, are related to gabbro and albitite intrusions. The most abundant deposits occur along zones of albite alteration and cataclasis that crosscut both host and intrusive rocks. The metallogenic belt is interpreted as formaing in the Early and Middle Cambrian in the North Sayan island arc and associated back-arc basin with prevalent oceanic crust with abundant basalt and andesite and dacite extrusives. Major faults played a significant role and controlled sedimentary, volcanic, and intrusive processes as well as the general linear structure of the belt.

REFERENCES: Bogatskiy and Kurceraite, 1966; Belous and Novozhilov, 1969; Distanov 1977; Zaikov, 1991; Orlov, 1999.

Khemchik-Kurtushibinsk Metalloginic Belt of Serpentinite-Hosted Asbestos Deposits (Belt KhK) (Western Siberia, Tuva, Russia)

This Vendian to Early Cambrian metallogenic belt is related to the West-Tuvinian and West-Sayanian ophiolitic belts in the early Paleozoic Kurtushiba accretionary wedge terrane. The belt extends more than 500 km. The large large chrysotile-asbestos deposits (Actovrak, Sayanskoye, and others) are occur in dunite and harzburgite plutons that form a chain of ultramafic bodies and serpentinite lenses hosted in Early Cambrian volcanic and sedimentary rock consisting of diabase, augite and plagioclase porphyry, pyroclastic rock, reef limestone, sandstone, and shale. Tectonic melange zones occur along the contacts of serpentinite bodies (Pinus and others, 1958; Tatarinov, Eremeev, 1967).

Actovrak Serpentinite-Hosted Asbestos Deposit

This deposit (Tatarinov and Eremeev, 1967; Sibilev, 1980) consists of chrysotile-asbestos deposits in the Actovrak ultramafic pluton. The pluton is a steeply-dipping body that is 3.5 km long, 0.2 to 0.5 km wide, and is emplaced conformable with Vendian and Early Cambrian extrusive and sedimentary rock. The pluton consists of apoharzburgite serpentinite and rare apodunite serpentinite with relicts of harzburgite. Serpentine-chlorite-amphibole rock occurs at the pluton exocontacts. The chrysotile-asbestos deposits is developed over the entire pluton and forms a single, concentrically zoned deposit. Asbestos veins occur in the central part of the deposit whereas small veinlets occur at the periphery. The veined zone containing the main ore reserves is 1.75 km long and 128 m thick. The deposit is large.

Origin and Tectonic Controls for Khemchik-Kurtushinsk Metallogenic Belt

The belt is interpreted as forming during accretion of Kurtushiba ophiolite belt along the major Tuva-Sayanian fault in the Kurtushiba accretionary wedge terrane that contains mainly oceanic rocks. The West-Tuvinian branch of the ophiolite belt consists of ultramafic plutons elongated east-northeast along the major Syan-Tuva fault zone that extends for 250 km. The large Actovrak chrysotile-asbestos deposit occurs at the western margin of the belt (Khemchik zone). Host rocks are serpentinized harzburgite, and rare websterite and diallagite. Slightly altered rock occurs only in the central parts of the large plutons (Matrosov and Shaposhnikov, 1988). The large Sayanskoye chrysotile-asbestos deposit occurs in the endocontact zone of the Idzhinsk harzburgite pluton that comprises a 180 km^2 area. Economic deposits occur in a narrow district that ranges from 35 to 260 m wide, extends up to 4 km along strike, and extends down to 650 m depth (Sibilev, 1980).

REFERENCES: Pinus and others, 1958; Tatarinov, Eremeev, 1967; Sibilev, 1980; Matrosov and Shaposhnikov, 1988.

Ondumsk Metallogenic Belt of Au Skarn and Granitoid-related Au Vein Deposits (Belt ON) (Tuva, Russia, Eastern Siberia)

This Late Cambrian to Ordovician metallogenic belt consists of replacements related to Tannuola plutonic belt that intrudes Early Cambrian volcanic and sedimentary rock. The plutonic belt consists of the large Kaakhemsk diorite, tonalite, and granodiorite pluton. The host Early Cambrian sedimentary rocks are alternating siliceous and intermediate extrusive rock with interlayered limestone and argillaceous slate that are overlapped by carbonate and clastic rock. The volcanic rocks constitute a rhyolite and dacite plateau with calderas and domes (Zaikov, 1991). The major deposit is at Tardan.

Tardan Au Skarn Deposit

This deposit (Vakhrushev, 1972; Zaikov and others, 1981) consists of an Au skarn that occurs along the contact zone of a Late Cambrian gabbro, diorite and tonalite pluton that intrudes Early Cambrian carbonaceous and volcanic rocks. Magnesium-silicate and calc-silicate skarn replaces te carbonate and aluminosilicate rock. Skarn is hydrothermally altered to calcite, quartz, dolomite, magnesite, chlorite, serpentine, talc, and pyrite. Granitoid is locally altered to berizite. Au occurs in skarn, quartz veins, and quartz-stockwork. The ore minerals are chalcopyrite, barnite, pyrite, galena, pyrrhotite, and native Au. Au grains are less than 0.3 mm. Au fineness is 940 to 960 and locally decreases to 840 to 860 p.m. A direct correlation exists between Au and chalcopyrite in ore. Pt and Pd admixture occurs. Altered skarn contains from 0.5-33 ppm Pt. The deposit is small.

Proezdnoye Granitoid-Related Au Vein Deposit

This deposit (V.I. Sotnikov, this study) consists of gold-bearing quartz veins and stockwork zones in Cambrian and Ordovician granitoids. The veins to 100-350 m along strike and average 0.3-0.4 m thick (up to 1.5 m in swells). Quartz is the predominant vein mineral along with lesser sericite, epidote, feldspar, and carbonate. Ore minerals are pyrite, galena, and chalcopyrite, and rare sphalerite, bismuthine, tetradimite, and native gold. Total sulfides range up to 1-2%. Sulfides are concentrated along veins selvages. Visible gold occurs with quartz and pyrite, and rarely with other sulfides. The gold ranges from 0.001 to 1.5-2.0 mm diameter and occurs in fine-grains, flakes, and dendritic forms. Gold is irregularly disseminated in veins and sometimes occurs in shoots. Wall rocks are altered to beresite adjacent to veins. The stockwork predominates the granitoid and consists of a close network of quartz veinlets that are about 2-5 mm thick and contain pyrite and native gold. The deposit is small.

Origin and Tectonic Controls for Ondumsk Metallogenic Belt

The belt is hosted in granitoid intrusions of the collisional Late Cambrian and Ordovician Tannuola complex that intrudes Early Cambrian carbonate and volcanic rock in the Ondum ensialic island arc terrane (Vakhrushev, 1972; Kilchichakov and Tokunov, 1971). Along with Au skarn deposits (Tardan), hydrothermal Au also occur in widespread veins, silica alteration zones, and stockworks. Au in quartz, quartz-sulfide, carbonate, and quartz veins occurs along the contacts of granitoid plutons (Proezdnoye, Tardan-2). Host silicified zones occur along breccia zones in metamorphic schist, have a lensoid shape, and range up to 25 m thick. Aucontent in relatively low. Au stockwork occurs in silicified plagiogranite of the Kopto pluton, ranges up 800 m long and 60 m thick. The Ondumsk terrane is an ensialic volcanic arc that is interpreted as forming along the southern end of the Kaakhem rift (Zaikov, 1991). The Ondumsk metallogenic belt is directly related to collisional granitoid magmatism and intrusion of the Late Cambrian and Ordovician Tannuola complex. On a small-scale, Au and Ag occur with chalcopyrite, sphalerite, and barite in volcanic structures of the alkali Early Cambrian basalt and rhyolite (Zaikov and others, 1981; Zaikov, 1991).

REFERENCES: Kilchichakov and Tokunov, 1971; Vakhrushev, 1972; Zaikov and others, 1981; Zaikov, 1991.

Ulugoisk Metallogenic Belt of Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu) Deposits (Belt UO) (Eastern Tuva, West Siberia, Russia)

This Early Cambrian metallogenic belt occurs in the Ulugo island arc subterrane in Eastern Tuva. The belt extends sublatitudinally up to 150 km and ranges up to 40 to 50 km wide. The companion major Kaakhem fault bordering ultramafic plutons forms the southern boundary of the belt. The basement of the island arc complex consists of sodic Vendian basalt. Overlying are Early Cambrian deposit host rocks that consist of bimodal tholeitic rhyolite and basalt. The upper part of the Early Cambrian section consists of pyroclastic rock associated with basalt, andesite, and dacite (Zaikov, 1991; Shiray and others, 1999).

Kyzyl-Tashtygskoye Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu) Deposit

This deposit (Distanov, 1977 ; Zaikov and others, 1981) consists of lenses, stocks, and ribbons of pyrite and polymetallic sulfides that are hosted in an Early Cambrian rhyolite and dacite and basalt complex. The deposit occurs in a paleovolcanic structure containing mafic and siliceous extrusiveand pyroclastic rock, diatremes, and subvolcanic and hypabyssal rock. The deposit extends east-wests for about 1200 m. Pyrite and polymetallic sulfides are conformable and and occur mainly along contacts of subvolcanic intrusions. The upper part of the main deposit is stock-shaped and consists of pyrite that extends down to a depth 70 to 100 m. Most of the deposit formed during hydrothermal-metasomatic alteration. In the upper parts of deposit are minor syngenetic sedimentary breccias. Wall-rock alterations consist of quartz-sericite metasomatite, Mg-chlorite alteration, and formation of talc and dolomite.

The ore assemblages are pyrite, Cu pyrite, barite and Cu-Pb-Zn –sulfides, and quartz-carbonate and sulfide. Ore minerals occur in masses, breccia, and disseminations. Main ore minerals are pyrite, sphalerite, chalcopyrite, galena, and tennantite. Gangue minerals are quartz, chlorite, dolomite, barite, talc, and sericite. The deposit is large with an average grade of 10.5% Zn; 1.5% Pb; 0.7% Cu.

Kyzyl-Tashskoye Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposit

This deposit (Distanov, 1977; Zaikov and others, 1981) consists of two pyrite lensoid deposits with superimposed magnetite that are hosted in Vendian and Early Cambrian volcanic rock. The deposit occurs close to a fault zone that borders the Ulugoi Basin that contains Devonian sedimentary rock. Deposit host rocks are andesite and basalt porphyritic lavas and tuff, siliceous tuff, tufaceous sandstone, and breccia. These rocks are intruded by subvolcanic rhyolite and dacite porphyry, gabbro, diabase, and hypabyssal plagiogranite porphyry. Deposits are conformable with host rocks and are related to fracture and shear and zones that range up to several tens of meters wide. The deposit contains two districts. The first district is 700 m long and 15 to 20 m thick. The second district extends down to 230 m deep and ranges from from 1.5 to 32 m thick. Deposit consists mainly of pyrite composition and sparse chalcopyrite and sphalerite. Ores occur in masses and rare disseminations. Main ore minerals are pyrite and magnetite, and lesser chalcopyrite, sphalerite, pyrrhotite, arsenopyrite, and native Au. Gangue minerals are quartz, chlorite, carbonates, and epidote. Talc typically forms a selvage. Magnetite was superimposed on pyrite during contact metamorphism. Wall rock alterations are chlorite, talc, sericite, and silica alterations. The deposit is small.

Origin and Tectonic Controls for Ulugoisk Metallogenic Belt

The belt is interpreted as forming in an island-arc. Within the metallogenic belt, the pyrite and polymetallic sulfides deposits occur in three ore clusters at Kyzyl-Tashtygskoye, Kyzyl-Tash, and Taskyl. The largest Kyzyl-Tashtygskoye Zn-Pb-Cu massive sulfide deposit occurs at the rim of a volcanic-tectonic basin that contains rhyolite and basalt volcanic and subvolcanic rock. The deposit is interpreted as forming during moderate-temperature hydrothermal and metasomatic processes with minor influence of syngenetic hydrothermal-sedimentary processes. Evidences of a submarine hydrothermal-sedimentary environment consists of ore hills, weak pyrite alteration of host rock, and ore fragments in overlying sedimentary rock (Distanov, 1977; Kuzebny, 1989; Zaikov, 1991). The most productive, eastern part of the metallogenic belt is related to an ensialic volcanic range that formed at the margin of the Tuva-Mongolian microcontinent.

REFERENCES: Distanov, 1977; Kuzebny, 1989; Zaikov, 1991; Shiray and others, 1999.

Iiskiy Metallogenic Belt of Mafic-Ultramafic-Related Fe-Ti (±V) Deposits (Belt Iy) (Russia, East Sayan)

This Cambrian to Silurian metallogenic belt is related to mafic-ultramafic plutons of Haaktigoi complex (too small to show at 10 M scale) that intrude the Birusa paragneiss terrane and Derba passive continental margin terranes. Mafic-ultramafic-related Fe-Ti (+V) deposits are related to early Paleozoic layered intrusions. The belt occurs in the northwest part of East Sayan Mountains in the Utkhumsky synclinorium. The belt strikes northwest for 235 km and ranges ukp to 70 km wide. Position and structure of the belt are defined by the major East Sayan Mountains fault and regional sublatitudinal strike-slip faults (Kandatsky and Kholbinsky faults) that controlled Cambrian thorugh Silurian magmatic and hydrothermal activity in the region. In the Oka River basin at the junction of the major Sayan fault and Utkhumsky Basin is the Paleoproterozoic Khoito-Oka complex (gabbro, gabbro, diorite and melanocratic diorite that hosts Ti-magnetite deposits. The complex is interpreted as intruding during active movement of the Kandatsky and Kholbinsky faults (Berzin, 1967). The most significant in the belt is the Verkhne-Iiskoye Ti deposit that occurs in the early Paleozoic stratified Khaaktygoy gabbro pluton that varies from anorthosite to deposit-hosting ultramafic rock (Bognibov and others, 1990; Baryschev, 1981). The deposit extends for 12.5 km and ranges up to1.3 km wide as interpreted from magnetic anomalies (Shabalin, 1977). Ore minerals occur in masses and disseminations and consist of Ti magnetite, ilmenite, magnetite, apatite, and pyrrhotite, amd traces of chalcopyrite and pyrite (Shmakin and others, 1969). The belt is promising for discovery of new of Ti deposits.

Verkhne-Iiskoye Mafic-Ultramafic Related Ti-Fe (V) Deposit

This deposit (Shabalin, 1977; Baryshev, 1981; Bognibov and Mekhonoshin, 1990) occurs in the Early Paleozoic Khaaktygoy layered massif that contains anorthosite, olivine and titano-magnetite gabbro, olivine pyroxenite, and plagioperidotite (kanzaskites). The gabbros are melanocratic and vary from anorthosites to ultramafic with sulfides. The deposit is defined by a magnetic anomaly that extends for 12.5 km andvaries from 1.2 to 3 km wide. A 3 km^2 contains six lens-shaped sulfide bodies that range from 30-60 m thick and 350-800 m long with gradational contacts. Ore minerals occur in disseminations and masses and consist of titano-magnetite, ilmenite, magnetite, apatite, and pyrrhotite with rare pyrite and chalcopyrite. The deposit is large with an average grade of 9.71% TiO_2, 21-34% F, 0.47% P_2O_5.

Origin and Tectonic Controls for Iiskiy Metallogenic Belt

The belt is interpreted as forming during intrusion of rift-related mafic-ultramafic plutons into a passive continental margin.

REFERENCES: Berzin, 1967; Shmakin and others, 1969; Shabalin, 1977; Baryshev, 1981; Bognibov and Mekhonoshin, 1990; Bognibov and others, 1990.

Ozerninsky Metallogenic Belt of Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb, Zn (Cu), Sediment-Hosted Cu, and Volcanogenic-Sedimentary Fe Deposits (Belt OZ) (Russia, Western Transbaikalia)

This Cambrian to Silurian metallogenic belt is hosted in the Eravna island arc terrane that is overlapped by the Barguzin-Vitim and Transbaikalia sedimentary and volcanic-plutonic belts. The belt occurs in the central part of Vitim Lowland in the upper drainages of the Uda and Vitim Rivers. The belt extends for over 150 km and ranges up to 75 km wide. The Eravna island arc terrane consists of volcanic and sedimentary rocks the Vendian and Cambrian Oldynda Suite (Belichenko, 1969, 1977). The volcanic part dominated is mainly rhyolite, dacite, andesite, and rhyolite, with minor diabase and basalt porphyry. Pyroclastic units predominating over flows. Also occurring are widespread subvolcanic stocks and sills of lava breccias and minor diabase and andesite porphyry dikes and sills. The sedimentary rocks are mainly limestone and minor carbonaceous and carbonataceous shale, siltstone, and sandstone. The carbonaceous rocks contain reefs, bioherms, and biostromes. Sedimentary rock of the Eravna terrane occur only as scattered, variable-size roof pendants in plutons in the large Barguzin-Vitim batholith with an isotopic age of 320 to 400 Ma (Yarmolyuk and others, 1997). The Ozerninsky roof pendant covers 200 km^2 and hosts the Ozerninsky metallogenic belt that contains over twenty stratiform pyrite, polymetallic sulfide, and ferric Fe deposits and ore occurrences. The main deposits are the Ozernoye, Zvezdnoye, Ulzutuyiskoye, and Nazarovskoye volcanogenic hydrothermal-sedimentary Pb, Zn, Cu deposits, the Gundui and Turkul sediment-hosted Cu deposits The major deposits are at Ozernoye, Ulzutuyskoye, and Gundui.

Gundui Sediment-Hosted Cu Deposit

This deposit (Tsarev and Firsov, 1988; Kovalev and Buslenko, 1992; Tsarev, 1995) occurs in an outlier of Early Cambrian carbonate and pyroclastic rocs along a contact with quartz-plagioclase porphyry. The deposit contains two large steeply-dipping occurrences that range from 300-1000 m long, are 600 m deep, and vary from 8 to 105 m thick. Also occurring are three small occurrences along a major fault that also controls five Fe and Cu deposits. The ores minerals are chalcopyrite, barite, and magnetite. Lenses and layers of barite, chalcopyrite-barite, magnetite, apatite-magnetite, Cu-pyrite also occur and contain magnetite, chalcopyrite, pyrite, hematite, barite, siderite, pyrrhotite, sphalelite, galena, bornite, and apatite. Gangue minerals are ankerite, calcite, quartz, chlorite, epidote, and kalispar. Chalcopyrite occurs as disseminations in and in masses with magnetite. Metamorphism formed chalcopyrite and barite nests and veins. Local siliceous and quartz-albite-chlorite metasomatite occur. The deposit is medium with an average grade of 0.92% Cu, 22-31% Fe, and 27-46% barite.

Origin and Tectonic Controls for Ozerninsky Metallogenic Belt

The belt is interpreted as forming in an island arc that was subsequently intruded by the Barguzin-Vitim batholith (Distanov, 1977; Kovalev, 1986; Distanov, Kovalev, 1996). The belt occurs in the northwestern margin of the Vendian and Cambrian Eravna island arc terrane that formed on the margin of the Paleo-Asian Ocean and Siberian continent (Gordienko, 1987; Dobretsov and Bulgatov, 1991; Belichenko and others, 1994). Deposits occur in basins along northeast-striking fault zones.

Sulfides exhibit a fairly simple composition, even distribution in basins, and deep stratigraphic differentiation. Occurring are either pyrite beds, or galena and sphalerite beds, or siderite beds. Cu-pyrite ores primarily consist of chalcopyrite, magnetite, and barite, and Fe ores consist of magnetite, martitized magnetite, and hematite. Host rocks are well persevered and regionally metamorphosed to low greenschist facies. Metamorphism resulted in skarn formation, silica-alkaline metasomatism, barite alteration, and siderite alteration, metamorphism of ore minerals.

Majority of deposits formed during marine hydrothermal and sedimentary sedimentation activity. Host rocks and sulfide minerals exhibit gradational rhythmic turbidite structure (Pettijohn, 1981). Gradational rhythmic layers exhibit all elements of Bowme cycle. The coarse-grained part consists of greywacke or coarser sedimentary clastic material derived from volcanic rock. Bedded ore horizons occur near top of gradational beds. , and southeastern margins of the Ozerninsky roof pendant. Alternating, rhythmically-bedded Fe oxides and sulfides occur in interlayered volcanic and sedimentary rocks. Multistage ore mineral occurrence is correlated with rhythmic structure of host rocks and with pulses of volcanic, seismic-tectonic, sedimentation, and hydrothermal activity (Tarasova and others, 1972).

REFERENCES: Belichenko, 1969, 1977; Tarasova and others, 1972; Distanov, 1977; Pettijohn, 1981; Gordienko, 1987; Dobretsov and Bulgatov, 1991; Distanov, Kovalev, 1996; Kovalev, 1986; Nefediev, 1986; Belichenko and others, 1994; Tsarev, 1995; Yarmolyuk and others, 1997.

Kruchininskiy Metallogenic Belt of Mafic-Ultramafic Related Ti-Fe (± V) Deposits (Belt Krh) (Russia, Northeastern Transbaikalia)

This Cambrian to Silurian metallogenic belt is related to mafic-ultramafic plutons in the Bargusin-Vitim granitoid belt that intrudes the West Stanovoy terrane. The belt extends for 225 km along a latitudinal trend from Chita and varies from 25 to 90 km wide. The intrusive part of volcanic arc consists of laminated mafic and ultramafic rock of Kruchininsky complex and granitoid intrusions of the Krestovsky complex of Cambrian to Silurian age. The major deposit is at Kruchininskoye.

Kruchininskoye Mafic-Ultramafic Related Ti-Fe (V) Deposit

This deposit (Vakhromeev, 1959; Demin, 1964; Lebedev, 1965; Balykin and Shabalin, 1984) occurs in the differentiated Variscian Angashansky gabbro-anorthosite massif that forms a large xenolith in younger granitoids. The massif has an irregular oval shape and extends east-west. The massif consists of two complexes: sulfide-bearing gabbro and pyroxenite, and anorthosite. The sulfide complex comprises the central and northern parts of the massif and has dimensions of 2.7 by 1.0 km and has a vertical thickness of 200-350 m. The gabbro and pyroxenite part of the massif consists of medium-grained gabbro with low-grade, disseminated ilmenite, magnetite, and titanium-magnetite (average grade of 3.5% Ti02). Medium-grained gabbro contain numerous zones and lenses of olivine gabbro, sulfide gabbro, coarse-and gigantic-grained gabbro, and sulfide-pyroxene deposits. Thickness of the largest bodies range from 10-200 m and are 1000-1500 m long. Disseminated sulfides are most widespread and include ilmenite (6-16%), titatanium-magnetite and magnetite (up to 20%), monoclinal pyroxene (20-28%), olivine (up to 8%), hornblende (1.5%), apatite (3%), iddingsite (2%), and small amounts of chlorite, pyrite, chalcopyrite, pyrrhotite, and pentlandite. Massive sulfides are composed of ilmenite (25-35%), titanium-magnetite (40-50%), apatite (30%), and minor pyrite and chalcopyrite. The deposit has an average grade of 6% TiO_2 in grey and 15% Fe in disseminated ores, an average grade of 6-15% Ti02 and 15-35% Fe in compact ore, and an average grade of 1.43-3.93% P_2O_5, 0.09% V_2O_5.

Origin and Tectonic Controls for Kruchininskiy Metallogenic Belt

The differentiated mafic and ultramafic plutons in the early Paleozoic Kruchininsky complex host mafic-ultramafic related Ti-Fe ± V deposits. The plutons consist of two complexes, the deposit-hosting gabbro and pyroxenite complex, and an anorthosite complex. Ore minerals occur in layers and disseminations. Main minerals ores are ilmenite, Ti magnetite, magnetite, apatite, and pyrite (Balykin and Shabalin, 1984). The belt is interpreted as forming in a volcanic arc during intraplate magmatism.

REFERENCES: Balykin and Shabalin, 1984.

Shimanovsk-Gar Metallogenic Belt of Fe Skarn, Volcanogenic-Sedimentary Fe, and Volcanogenic Cu-Zn Massive Sulfide (Urals type) Deposits (Belt ShG) (Russia, Far East)

This Late Cambrian or older metallogenic belt is related to: (1) replacements associated with granitic rocks of the Kiviliysk Granite Complex that intrudes the margins of the Gar accretionary wedge and Manyn passive continental margin terranes (too small to show at 10 M scale); or (2) stratiform deposits in oceanic sedimentary rocks that were structurally incorporated into Galam accretionary wedge terrane.. The belt occurs at the boundary between Gar accretionary wedge terrane (unit GR) and Mamyn passive continental margin terrane (unit MM). The extensive Paleozoic granitoids of the Kiviliysk complex of the Khanka-Bureya igneous arc have a minimum K-Ar isotopic age of 495 Ma. The major deposits are at Gar and Kamenushinskoe.

Gar Fe Skarn Deposit

This deposit (Zimin, 1985; Zimin and Konoplev, 1989) consists of sheeted Fe deposits that occur in metamorphosed Early Cambrian(?) felsic and mafic volcanic rock interlayered with limestone lenses in the Gar terrane. Magnetite is the dominant ore mineral. The Fe beds occur chiefly in an upper Early Cambrian(?) section composed mainly of mafic volcanic rock. The Fe minerals occurs in 220 to 250 m thick section, but mainly in an interval ranging from 156 to 184 m. The deposit extends 4 km along strike. The deposit has estimated reserves of 389.1 million tonnes, grading 41.7% Fe. Total inferred reserves in the metallogenic belt are 4 billion tonnes. The deposit is intruded by early Paleozoic gabbro, diabase, and plagiogranite and is locally metamorphosed to skarn. Similar volcanogenic Fe deposits occur north of the Gar deposit. The deposit has not been mined and needs further exploration. The deposit is large, and has resources of 389.1 million tonnes grading of 41.7% Fe and.

Kamenushinskoe Volcanogenic Cu-Zn Massive Sulfide (Urals type) Deposit

This deposit (P.N. Radchevsky, written commun., 1956 , V.V. Ratkin in Nokleberg and others, 1997) consists of sulfide lenses that range from 100 to 800 m long and 2 to 12 m thick that occur conformable to bedding. Eleven lenses occur to depths of up to 300 m. Pyrite is the main ore mineral along with lesser hematite, magnetite, and pyrite, and rare chalcopyrite. The deposit is locally contact-metasomatized into skarn that formed during intrusion of Paleozoic granite. The deposit is interpreted as forming during exhalation associated with felsic seafloor volcanism. The deposit occurs in Cambrian rhyolite of the Mamyn terrane. The rhyolite underlies a basalt and limestone sequence that contains the volcanogenic Gar deposit. The deposit is small.

Origin and Tectonic Controls for Shimanovsk-Gar Metallogenic Belt

Fe skarn deposits in the belt are interpreted as forming during intrusion of Kiviliysk Granitic Complex. The volcanogenic-sedimentary Fe and volcanogenic Cyprus Cu-Zn massive sulfide deposits in the belt are interpreted as forming during seafloor hydrothermal activity and associated with basalt volcanism that was accompanied by chert deposition in marine basins.

REFERENCES: P.N. Rabchevsky, written commun., 1956; Zimin, 1985; Zimin and Konoplev, 1989; Nokleberg and others, 2000, 2003.

Uda-Shantar Metallogenic Belt of Volcanogenic-Sedimentary Fe, Volcanogenic-Sedimentary Mn, and Sedimentary Phosphate Deposits (Belt Ud-S) (Russia, Far East)

This early Paleozoic metallogenic belt occurs in the Galam accretionary wedge terrane that consists chiefly of Paleozoic rocks in an imbricate stack of thrust sheets. The terrane consists of three rock sequences: (1) coherently bedded turbidite, (2) basalt, ribbon chert, and siliceous shale, and (3) olistostrome. Each rock sequence occurs in independent tectonic slices and sheets that are separated by ductile faults that occur parallel to bedding in the sheets. Internal parts of the sheets are comparatively weakly deformed. The significant deposit is the Gerbikanskoe volcanogenic-sedimentary Fe deposit. Other significant deposits are the North-Shantarskoe, Nelkanskoe, Ir-Nimiiskoe-2, and Lagapskoe sedimentary P deposits, and the Ir-Nimiiskoe-1, Milkanskoe, Galamskoe, Kurumskoe, and Itmatinskoe volcanogenic-sedimentary Fe and Mn deposits. The major deposits are at Gerbikanskoe, North-Shantarskoe , Ir-Nimiiskoe 1 and 2, Lagapsko, and Nelkanskoe.

Gerbikanskoe Volcanogenic-Sedimentary Fe Deposit

This deposit (Shkolnik, 1973) consists of two zones separated by a sequence of sandstone and siltstone. The zones consist of approximately 30 steeply-dipping, sheeted and lenticular bodies of magnetite and hematite. Individual bodies range from several tens of m to 5 to 7 km long and are sometimes closely spaced in an en-echelon pattern. Thickness varies from 5 to 50 m and is commonly 8 to 28 m. Fe mineral layers vary from banded to thinly-banded, lenticular, and bedded, and consist of finely-dispersed hematite, magnetite, and rare pyrite and chalcopyrite. The deposit is large with an average grade of 42 to 43% Fe (soluble Fe 33 to 53%); 1.8% Mn, and 9.6% P.

North-Shantarskoe Sedimentary Phosphate Deposit

This deposit (Shkolnik, 1973) consists of phosphorite deposits that occur in a sedimentary breccia with indistinct borders. Deposit ranges up to 15 to 16 m thick and is hosted in carbonate rock in a sequence of chert and volcanic rock that are partially altered to quartz-carbonate rock. Sequence occurs for approximately 8 to 10 km at the northeast end of Bolshoi Shantar Island. The deposit is small with average grade of less than 6 to 8% P_2O_5.

Nelkanskoe Sedimentary Phosphate Deposit

This deposit (Shkolnik, 1973) consists of a phosphorite sedimentary breccia that occurs in a steeply-dipping sequence of jasper and volcanic rock that are exposed in an erosional windows below gently-dipping Jurassic sedimentary rock. Host rocks are silicified dolomite and limestone. Phosphorite beds range up to 1.8 km long; however, some are only several tens of meters long. Thickness varies from 2 to 41 m. Deposit drilled to almost 300 m. In addition to fragments of primary phosphorite, deposit contains fragments of silicified carbonate rocks that range from 0.5 to 2 cm wide, and are cemented by phosphate and hydromica. Phosphates are radioactive. The deposit is small. Grade ranges from 4 to 30% P_2O_5 and averages 7 to 11%.

Ir-Nimiiskoe-2 Sedimentary Phosphate Deposit

This deposit (S.G. Kostan'yuan and others, written commun., 1973.) consists of numerous and unusual phosphorite bodies that occurs in a sedimentary breccia formed in atoll fans and seamounts. Deposits occurs in an area 25 to 30 km long and 6 to 8 km wide, and are hosted in complex, steeply-dipping, and folded rocks that comprise a reef edifice. Some carbonate is silicified. Boundaries of deposits are gradational due to variable amount of fragments of primary phosphorite in dominant host limestone, dolomite, and siliceous carbonate, and in rare jasper, volcanic rock, and siliceous claystone fragments. Primary phosphorite seldom occur occurs mainly in thin beds and small lenses of coquina formed predominantly of inarticulate brachiopods with phosphate shells and some Cambrian trilobites. Phosphorite breccia occurs at various stratigraphic levels with no clear boundaries. Margin determined by sampling. Approximately 30 phosphorite layers are identified. Layers range from several tens of m to several km long and are commonly discontinuous. Deposit generally has simple mineral composition. In addition to phosphorite, contain quartz, dolomite, calcite, rare pyrite, chert, and volcanic rock fragments. Thickness of the phosphorite ranges from 0.5 to 24 m, but varies greatly over short distances. The deposit is medium size. Phosphorus anhydrite ranges from 3 to 12% and averages 7 to 8%.

Lagapskoe Sedimentary Phosphate Deposit

This deposit (Zagorodnykh, 1984) consists of carbonate beds that contain phosphorite breccia with Cambrian fossils. Beds locally range up to 30 m thick, but generally range from several tens of cm to 20 m thick. Phosphorite breccia contains fragments of primary phosphorite, dolomite, limestone, and rare jasper, schist, and shale. carbonate is commonly completely altered to quartz. carbonate bed intercalated with jasper, shale, schist, siltstone, spilite, basalt, and basalt tuff. The deposit is medium size and contains rom 4 to 30% anhydrous phosphorous and averages 5 to 7%.

Ir-Nimiiskoe-1 Volcanogenic-sedimentary Mn Deposit

This deposit (Shkolnik, 1973) consists of partly metamorphosed, steeply-dipping, lenticular and sheeted, bedded Mn bodies that occur in a diverse Early Cambrian sequence of jasper, shale, spilite, basalt, and basaltic tuff that overlay a carbonate reef complex and seamounts. Mn bodies range from several tens to several hundred m long, and vary from 1.5 to 120 m thick. Bodies vary from massive and banded to thinly-banded. Mn bodies consist of oxidized braunite, hausmannite-rhodochrosite, and rhodochrosite, and rhodonite-rhodochrosite. Bodies also contain quartz and minor magnetite, hematite, manganite, sulfides, piedmontite, manganophyllite, tordite, viridine, amphiboles, muscovite, and plagioclase. Mn content varies greatly, extending up to 50 to 56% Mn in oxidized ore, and 47% Mn in carbonate ore, along with 0.01 to 0.12% P, up to 3% Fe, and 9 to 70% SiO_2. The deposit is small. Average grade is about 22.4% Mn.

Origin and Tectonic Controls for Uda-Shantar Metallogenic Belt

The belt is interpreted as forming during sea floor hydrothermal activity associated with basaltic volcanism that was accompanied by chert deposition in basins. The volcanogenic-sedimentary Fe deposits in the belt consist of numerous lenticular and sheeted magnetite bodies that consist of conformable, steeply-dipping bodies of complex composition. The volcanogenic-sedimentary Mn deposits consist of partly metamorphosed, steeply-dipping, lenticular and sheeted, bedded Mn bodies that occur in a diverse Early Cambrian sequence of jasper, shale, schist, spilite, basalt, and basalt tuff that overlays a carbonate reef complex with seamounts. The sedimentary P deposits are interpreted as formed in limestone caps that formed in two stages on accreted seamounts, atolls, and guyots.

The deposits are interpreted as being subsequently deformed and metamorphosed during subsequent accretion of the Galam that is interpreted as tectonically linked to the Uda volcanic-plutonic belt that formed along the Stanovoy block of the North Asian Craton and is overlain by the Jurassic and Early Cretaceous Torom sedimentary basin. Right-lateral strike-slip displacement occured along the Uligdan fault that bounds Galam terrane to the north.

REFERENCES: Shkolnik, 1973; Nokleberg and others 1997, 1998, 2000, 2003; Khanchuk, 1993.

Uzuurtolgoi Metallogenic Belt of Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai type) and Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu) Deposits (Belt Uzu) (Western Mongolia)

This Cambrian(?) metallogenic belt occurs in the island arc Ulgii terrane. The belt is approximately 700 km long and 30 km wide. The belt contains massive to disseminated Pb-Zn sulfide deposits, including the Khoh Adar deposit and Uzuurtolgoi occurrence, and massive to disseminated Cu sulfide deposits, including the Toshimt uul occurrence. Deposits and occurrences are metamorphosed into blueschist and greenschist in the Early Cambrian Uzuurtolgoi and Zamtyn Formations (Storojenko and others, 1991) in the Uzuurtolgoi island arc terrane. The northwest-striking belt is bounded by the Tolbonuur fault to the northeast and by an unnamed fault to the southwest. The major deposits and occurrences are at Khoh Adar, Uzuurtulgoi, and Toshint uul.

Malachite Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai type) Deposit

This deposit (A.V. Bobrovskii and others, written commun., 1991) consists of a sulfide bearing carbonate-quartz replacement zone in a northwest-trending fault in the Early Cambrian Uzuurtolgoi Formation. The zone is 1800 m long, 5-8 m wide, dips steeply, and strikes longitudinaly. Three areas occur with irregular distribution of native Cu, cuprite, pyrite, and chalcopyrite, and rare pyrrhotite and cinnabar. Main textures are disseminations, stringers, and breccia. Malachite chips and stringers range up to 3-5 mm. The average grade is 1.0% Cu, 0.8 g/t Au.

Khukh-Adar Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu) Deposit

This deposit (Demin and others, 1990; D. Dorjgotov, written commun., 1990; B.N. Podkolzin and others, written commun.,1990) consists of sulfide bearing mineralized zones in Cambrian slate, sandstone, and siltstone that are intruded by a diabase dike. Wall rocks are hydrothermally altered to silica, sericite, and limonite. Zones contain quartz-sulfide veins that range up up to 7.5 km long and several hundred meters wide. Ore minerals are pyrite, sphalerite, chalcopyrite, galena, arsenopyrite, and oxides. Gangue minerals are quartz, sericite, and chlorite. The diabase varies from 1.0-2.0 m wide and 1300 m long and occurs in the southern part of the deposit with argillite and limonite alterations hosted in carbonaceous siltstone and calcareous sandstone. The zone is 7500 m long and 50-420 m wide.The Northeastern part or zone No 1 strikes northwest, dips northeast, is 1300 long m and 70-140 m wide. Ore minerals are malachite and azurite. The Central part or northwestern part is cut by sublongitudinal fault and contains disseminations and nests of pyrite, chalcopyrite, chalcocite, galena, sphalerite, arsenopyrite, malachite, covellite, and iron oxides. The Southern sublatitudinal part or zone No 3 consists of two sulfide that are1000.0 m long, 50.0-80.0 m wide, and dip north. The deposit contains resources of 405,000 tonnes Pb, 202,500 tonnes Zn, 1,878,000 tonnes Cu. Average grades are 0.1-15% Cu, 0,2-6.9% Zn, 0.8% Pb.

Origin and Tectonic Controls for Uzuurtolgoi Metallogenic Belt

The belt is interpreted as forming during subduction-related island arc basalt, andesite, dacite volcanism.

REFERENCES: Storojenco and others, 1991; Byamba and Dejidmaa, 1999.

Hovd Metallogenic Belt of Granitoid-related Au Vein, Au Skarn, and Cu (±Fe, Au, Ag, Mo) Skarn Deposits (Belt HO) (Western Mongolia)

This Ordovician to Late Silurian metallogenic belt contains granitoid-related Au vein, Au skarn, and Cu and Fe occurrences related to the Khovd and Turgen granitoid complex that intrudes an Ordovician sedimentary-volcanic-plutonic overlap assemblage in the Hovd continental-margin turbidite terrane and a Silurian sedimentary-volcanic-plutonic overlap assemblage (too small to depict on map at 5 M scale) (Tomurtogoo and others, 1999). The granitoid complex consists of gabbro, diorite, granodiorite and and biotite-amphibole granite. The metallogenic belt was first defined by Tcherbakov and Dejidmaa (1984) as the Harhiraa Au belt. The major deposits and occurrences are at Hovd, Sharhooloi, Tsetsegnuur, Tsagaantolgoi, Hagshirbulag, Yolochka, and Antsavyn

Yolochka Cu (±Fe, Au, Ag, Mo) Skarn Deposit

This occurrence (L. B. Chistoedov and others, written commun., 1990) occurs along the major Tsagaan Shiveet fault zone in the western margin of the Nuuryn terrane. The occurrence is hosted in the Vendian to Early Cambrian Tsol Uul Formation, Early Silurian Khutsbulag Formation, and Lower Devonian Makdor intrusive complex. The Tsol Uul Formation consists of andesite, basalt, andesite porphyry, tuff, volcanic breccia, spilite, and limestone. The Khutsbulag Formation consists of sandstone, siltstone and greywacke. The Makdor complex is a small intrusive and consists of a first phase of fine-grained diorite and a second phase of miedium-grained granodiorite. Also occurring are abundant dikes of granodiorite porphyry, syenite porphyry, and diabase porphyry, and two fault zones that vary from 20.0-200.0 m wide, and small fracture zones that vary from 0.1-1.0 m wide. Quartz and siderite veins occur in the fault zones and contain chalcopyrite, chalcocite, malachite, and azurite. Hydrothermal replacements consist of skarn, and alteration to epidote and silica. The skarns vary from .4-2.5 m wide and 20.0-100.0 m long. Some skarns contain pyrite and chalcopyrite. Gangue minerals are epidote, quartz, calcite, and garnet. The average grades in skarn are 0.4-1.0 g/t Au, 0.1-0.5% Cu, up to 0.06% Zn, up to 0.2% Pb, up to 2.5 g/t Ag.

Origin and Tectonic Controls for Hovd Metallogenic Belt

The belt is interpreted as forming during subduction related granitic magmatism that occurred along a continental-margin arc. Other workers interpret the host Khovd terrane as an island arc (Dergunov, 1989), or a turbidite terrane (Tomortogoo and others, 1999), or a a continental margin arc (Byamba and others, 1999). The Hovd terrane is part of the Ordovician Tsagaanshiveet continental marin arc that is built on the Vendian to Cambrian Lake island arc terrane and is linked to the Late Ordovician, subduction-related Turgen Complex consisting of gabbro, diorite, granodiorite and biotitic, biotite-amphibolic granite.

REFERENCES: Tcherbakov and Dejidmaa, 1984; Dergunov, 1989; Byamba and Dejidmaa, 1999a, b; Tomurtogoo and others, 1999.

Tastyg Metallogenic Belt of REE-Li Pegmatite Deposits (Belt TG) (Southern Tuva, West Siberia, Russia)

This Middle to Late Silurian metallogenic belt is related to the South Siberian volcanic-plutonic belt (plutonic part) and occurs in southwestern Tuva in the Sangilen Uplift. The belt extends latitudinally along for 100 km long and ranges up to 30 km width. The belt coincides with the Kachinsk anticlinorium in the Sangilen terrane and occurs in two structural levels. The lower level consists of intensely-deformed Early and Mesoproterozoic schist, quartz-mica gneiss, amphibolite, and graphite marble. The large Tastygskoye spodumene-pegmatite district occurs in Mesoproterozoic marble. The upper level consists of Riphean volcaniclastic and carbonate sedimentary rock. Ordovician and Silurian granite-gneiss domes contain allochtonous biotite and two-mica, Li granite (Bluman, 1983). Host rocks are zonally metamorphosed and vary from phyllite, to slate to sillimanite gneiss around granite-gneiss domes. Among numerous pegmatite veins are four pegmatite districts with economic Li (spodumene) and Ta-Be deposits. The most important deposits is at Tastygskoye Li-.

Tastygskoye REE-Li Pegmatite Deposit

This deposit (Matrosov and Shaposhnikov, 1988) consists of a pegmatite veins field that contains thick veins that exhibit persistent lateral and vertical trends. The field is more than 1000 m long, and varies from 180 m thick in the northern part to 375 m in the southern part. Pegmatite veins trend sublongitudinally and extend to a depth of 700 m. In the main district the veins extend to 500 m depth. The host rocks consist of Mesoproterozoic marble. The most intense vein zone occurs in the crest of an anticline in the central part of the deposit. Genetically and spatially, the spodumene pegmatite is related to a Paleozoic porphyritic biotite alkaline granite. The length of individual veins is 250 to 300 m, thickness ranges from 5 to 10 to 100 m in swells. Veins dip at high angles. The main rock-forming minerals are albite, oligoclase, spodumene, quartz, and microcline. Accessory minerals are biotite, muscovite, graphite, fluorite, calcite, garnet, tourmaline, cassiterite, cyrtolite, pyrite, galena, molybdenite, helvite, microlite, and fergusonite. Some pegmatite bodies exhibit a zonal structure. The deposit is favourable for mining by open pit methods. The deposit is medium size with reserves of 450,000 tonnes Li.

Origin of and Tectonic Controls for Tastyg Metallogenic Belt

The belt is hosted in a polymetamorphic complex and related to a post-collisional, anorogenic complex of granite and leucogranite-pegmatite (Lebedev and others, 1993; Vladimirov and others, 2000). Spodumene pegmatite deposits are genetically and spatially related to biotite and bimicaceous porphyry granite. A U-Th age of Li granite and spodumene pegmatite is 420 to 436 Ma (Bluman, 1983). Li granite intrudes Late Cambrian and Ordovician tonalite and granodiorite plutons of the Tannuola complex and are cut by nepheline syenite of the Devonian and Early Carboniferous Sangilen Complex (Matrosov and Shaposhnikov, 1988). The belt is related to magmatism of transpression zones related to transform micro plate boundaries and within plate (plume) environment.

REFERENCES: Bluman, 1983; Matrosov, Shaposhnikov, 1988; Lebedev and others, 1993; Vladimirov and others, 2000.

Telmen Metallogenic Belt of Mafic-ultramafic Related Cu-Ni-PGE, Fe Skarn, and Cu (±Fe, Au, Ag, Mo) Skarn Deposits (Belt TL) (North Mongolia)

This Middle Cambrian through Middle Silurian metallogenic belt is related to plutons and replacements in the Telmen volcanic-plutonic belt. The metallogenic belt extends east-west along the major Khangai fault, is approximately 450 km long, and varies from 50 to 100 km wide. Most of the belt is intensely intruded and covered by younger magmatic, sedimentary and volcanic rock. The belt contains a small Ni-Cu deposit and several occurrences, including Oyut deposit, Onts uul and Tahilgat uul occurrences; several Fe skarn occurrences at Jinsen gol and Khanjargalant uul, and several Cu skarn occurrences at Minjuurtolgoi and elsewhere. Most of the deposits and occurrences are in the northern early Proterozoic Baydrag cratonal terrane where intruded by the Telmen collisional granite Gabbroic Ni-Cu deposit and occurrences are related to the Middle Cambrian Ider complex (Izoh and others, 1990) that consists of layered gabbro. Fe skarn and Cu skarn occurrences are related to granitoids in the Middle and Late Cambrian Telmen volcanic-plutonic belt. The significant deposits are at Oyut tolgoi 2 and Solongot.

Oyut tolgoi 2 Mafic-Ultramafic Related Cu-Ni-PGE Deposit

This deposit (Garamjav and others, 1978, B.N. Podkolzin and others, written commun.,1990) consists of Cu sulfides in a Middle Cambrian gabbro and hornblendite stocks that occur along the Khangai fault system for 6.0 km and ranges up to 1.5 km wide. The igneous rocks intrude Paleoproterozoic gneiss, schist, and amphibolite. The sulfides occur around of amphibole grains, and and in rare small nests and disseminations in quartz and quartz-feldspar veins in outer contact zone of some small stocks. Main ore minerals are chalcopyrite, pyrite, ilmenite, magnetite, bornite, and millerite, and rare sphalerite, arsenopyrite, chalcocite, pentlandite, and native gold. Four sulfide bodies occur. Part 1 is located in western part of the deposit and occurs in a hornblendite stock that crops out over an area 350.0 m by 250.0 m. Ore minerals occur the upper part of the stock in subhorizontal lenses and layers that dip gently east. The average grade is 0.36% Cu, 0.039% Ni, and 0.04% Co. The length is 212.0 m, and the average thickness is 38.0 m of the ore body. Part 2 1 km east Part 1 in asmall stock dipping steeply in south. The average grade is 0.52% Cu, 05% Ni, and 0.006% Co. Two samples contain 0. 16 g/t Pd and 0.4 g/t Au. The length is 220.0 m, downdip extension is 200 m, and the average thickness is 50.0 m. Part 3 occurs 800.0 m east of Part 2 and is a small gabbro body with a surface area of 120.0 m by 30.0 m. Average grade is 0.27% Cu and 0.031% Ni. Part 4 occurs east Part 3, is 1.8 km long and 0.6 km wide. There are 15 small bodies with pyrite and chalcopyrite disseminations, and malachite and azurite coatings. The bodies vary from 30.0 m to 100.0 m long, and up to 25.0 m wide. Average grade varies from 0.38-0.78% Cu. The entire deposit is large with reserves of 50,000 tonnes Cu grading 0.36% Cu.

Solongot Cu (±Fe, Au, Ag, Mo) Skarn Deposit

This deposit (G. Jamsranjav and others, written commun., 1984) is hosted in a xenolith of Paleoproteozoic limestone and gneiss in a Late Permian granite. The xenolith is altered to skarn minerals, silica, and llimonite, and extends sub-longitudinally for 2.0 km and ranges up to 1.5 km wide. The ore minerals are hematite and magnetite, and rare chalcopyrite and pyrite. 65 channel samples contain 0.001-0.1% Cu, up to 0.3% W, 0.002-0.02% Zn, and 0.001% Mo. One sample contains 0.1 g/t Au and 4.0 g/t Ag. For the entire deposit, average grades are0.001-0.1% Cu, up to 0.3% W, 0.1 g/t Au, and 4.0 g/t Ag.

Origin and Tectonic Controls for Telmen Metallogenic Belt

The belt is interpreted as forming during subduction-related gabbroic magmatism, and during subsequent collision-related granitic magmatism. The Telmen volcanic-plutonic belt is interpreted as collisional origin by Tomurtogoo and others (1999), and consists of gabbro, granodiorite, and granite. However, herein, the Telmen complex is interpreted as a subduction-related complex emplaced in a continental margin arc.

REFERENCES: Izokh and others, 1990; Tomurtogoo and others, 1999.

Zavhanmandal-Jargalant Metallogenic Belt of Mafic-Ultramafic Related Ti-Fe (+V) and Granitoid-Related Au Vein Deposits (Belt ZJ) (Central Mongolia)

This Early to Middle Cambrian(?) metallogenic belt is related to the Telmen volcanic-plutonic belt that intrudes the Baydrag cratonal terrane. The age of the belt is interpreted as Middle Cambrian to Late Cambrian. The belt extends in north-south trend, and it is approximately 250 km long and at average 50 km wide. The metallogenic belt is overprinted on Riphean Zavhan continental margin arc and Archean and Proterozoic Baydrag cratonal terranes (Tomurtogoo and others, 1999). The belt contains zoned mafic-ultramafic related Fe-Ti occurrence at Uet-Ondor (Togtoh, 1995), and a granitoid-related Au vein and stockwork type occurrences at Shuvuun Har uul and Zuun Shuvuu uul (Samozvantsev, 1982). These occurrences are closely related to the Middle Cambrian(?) layered gabbro, and the Middle and Late Cambrian Telmen granitoid complex that consists of gabbro, granodiorite, and granite. The major deposits are the Uet-Ondor, Shuvuun Har uul, and Zuun Shuvuu uul occurrences.

Uet Ondor Mafic-Ultramafic Related Ti-Fe (V) Occurrence

This occurrence (D. Togtoh and others, written commun., 1995) consists of 40 magnetite and titanium-magnetite lenses that occur in a 1 km long zone in a late Riphean layered gabbro stock. The stock has a surface area of approximately 10 km^2. The lenses range from 0.2-1.0 m wide, are up to 120 m in length, and contain small amounts of pyrite, pyrrotite, chalcopyrite, and apatite in masses and disseminations. The lenses dip gently to east. The average grade is 15-50% Fe, 1-14% Ti,-0.03-0.15 g/t Au.

Origin and Tectonic Controls for Zavhanmandal-Jargalant Metallogenic Belt

The belt is interpreted as forming during subduction-related gabbroic magmatism, and during subsequent collision-related granitic magmatism.

REFERENCES: Samozvantsev and others, 1982; Togtoh and others, 1995; Tomurtogoo and others, 1999.

Khachim-gol Metallogenic Belt of Mafic-Ultramafic Related Ti-Fe (±V) Deposits (Belt Kch) (Northern Mongolia)

This Early to Middle Cambrian metallogenic belt is hosted the Telmen volcanic-plutonic belt that intrudes the Gargan and Darhad terranes. The age of the belt is interpreted as Middle to Late Cambrian. The Khachimgol belt extends in northwest approximately 80 km and northeast approximately 30 km. The belt contains several zoned mafic-ultramafic related Fe-Ti occurrences, including the Khachim gol occurrence (Filippova and others, 1977) and the related Cambrian layered mafic-ultramafic pluton (Izoh and others, 1990). Several gabbro plutons occur also in the southern and southwestern margin of the adjacent Gargan cratonal terrane.

Khachim gol Mafic-Ultramafic Related Ti-Fe (V) Occurrence

This deposit (Filippova and Vydrin, 1977) consists of titanium-magnetite in a Middle Cambrian zoned gabbro and pyroxenite intrusion that is 5.5 m wide and contains sulfide and oxide lenses, masses, and disseminations in zones about 3.0 km long. The deposit is large with resources of 10 million tonnes ore grading 41.57% Fe; 5.54% TiO_2, 0.43% V.

Origin and Tectonic Controls for Khachim-gol Metallogenic Belt

The belt is interpreted as forming during subduction-related gabbroic magmatism.

REFERENCES: Fillippova and Vydrin, 1977; Izokh and others, 1990; Tomurtogoo and others, 1999.

Egiingol Metallogenic Belt of Talc (Magnesite) Replacement and Serpentine-Hosted Asbestos Deposits (Belt EG) (Central Mongolia)

This Ordovician(?) metallogenic belt is related to replacements in regionally metamorphosed rocks in the Dzhida island arc terrane as defined by Tomurtogoo and others (1999). The Dzid terrane consists of a Late Riphean ophiolite complex, the Vendian to Early Cambrian Group Eguur and Badargol Formations, and Early to Late Cambrian Burgastain Formation. The Dzid terrane is interpreted as a series of several seamounts and island arcs (Tomorhuu, 1999; Purevsuren and others, 2000). The Riphean ophiolite complex consists of serpentinite melange, metamorphosed peridotite, serpentinite, layered ultramafic and mafic rock, gabbro, sheeted dikes, and pillow basalt. The ophiolite complex occurs in in thrust faults between the various subterranes, and along the fault between the Dzid terrane and the Hamardavaa metamorphic terrane. The Vendian to Early Cambrian formations are form two different sequences. The Vendian to Early Cambrian Eguur Formation consists of subalkaline basalt, pyroxene basalt and forms the Uurgol seamount subterrane. The Vendian to Early Cambrian Badargol Formation consists of calc-alkaline volcanic rock, including basalt, andesite, and tuff, siliceous lava, limestone, dolomite, and quartzite. Also occurring are Early to Middle Cambrian chert and carbonate, and Late Cambrian to Early Ordovician carbonate and flysh (Tomorhuu, 1999). Middle to Late Cambrian small gabbro, gabbrodiorite, diorite and plagiogranite intrusions occur in the Dzhida island arc terrane and have an isotopic age of 540 Ma (Ilyn, 1982). Middle Ordovician collisional granitoid intrusions occur extensively along the faults bounding subterranes and terranes. The major deposits are the Zalaat asbestos deposit, and the Baganuur talc, and Bayanondor talc occurrences.

Zalaat Serpentine-hosted Asbestos Deposit

This deposit (Kleiner and others, 1977; Pinus and others, 1984; Kuznetsov and others, 1986; Jargalsaihan and others, 1996) and other similar occurrences are hosted in serpentine melange in dunite and peridotite. The deposit consists of chrysotile-asbestos in variably serpentinized alpine ultramafic rock. The deposit occurs in the central part of the intrusive in a lens extends northeast. In the ultramafic massif are two generations of asbestos. One generation occurs in an area approximately 300 long by 40 m wide. The second generation consists of a network of crosscutting, thin (1-8mm), chrysolite-asbestos veins that range up to 6 m long. The size of major asbestos-bearing bed is 265m by 40 m. The bed is cut by an asbestos network forming boxes of size approximately 7 by 7 cm, and rarely up to 50 by 50 cm. The length of asbestos fibers varies from 3 to 10 mm. The deposit age is interpeted as Neoproterozoic and Early Cambrian. The deposit is controlled by a northwest-southeast-trending thrust fault that contains ultramafic intrusions and Ordovician collisional granitoids. The deposit is medium size with reserves of 91.2 tonnes grading 3.8% asbestos.

Baganuur and Bayanondor Talc Metasomatite Occurrences

The Baganuur occurrence (Pinus and others, 1984; Kuznetsov and others, 1986; Jargalsaihan and others, 1996) is hosted in ultramafic rock in an ophiolite complex. The related Bayanondor occurrence hosted in chert and carbonate and occurs along the contact zone of an Ordovician collisional granite. The distribution of the talc, and associated asbestos and nephrite deposits and occurrences is controlled by northwest-southeastern trending thrust faults that contain ultramafic intrusions and Ordovician collisional granitoids. Talc replacement deposits are hosted in ultramafic and in carbonate rock that occur along a northeast-striking fault zone between the Hamardavaa metamorphic and the Dzid island arc terranes.

The Baganuur talc metasomatite deposit (Enhbat and others, 1995) is hosted in ultramafic rock in an ophiolite complex. The deposit is 10 m thick and consists of 90% talc and 10% of carbonate minerals. The Bayanondor talc metasomatite deposit (Enhbat and others, 1995) is hosted in chert and carbonate rock. The deposit ranges from 40 to 100 m thick and consists of dolomite with talc and amphibole. The grade ranges from 30% to 60% talc. These occurrences are along a northeast-striking fault zone between an Ordovician collisional granite and the Hamardavaa metamorphic and Dzid island arc terranes.

Origin and Tectonic Controls for Egiingol Metallogenic Belt

The belt occurs in the Dzid terrane that is closely related to Ordovician collisional granite. Belt interpreted as forming during collision-related regional metamorphism.

REFERENCES: Ilyn, 1982; Enhbat and others 1995; Dondovyn Tomorhuu, 1999; Tomurtogoo and others, 1999; Purevsuren and others, 2000.

Bayangol Metallogenic Belt of Mafic-Ultramafic Related Ti-Fe (+V), Mafic-Ultramafic Related Cu-Ni-PGE, Fe Skarn, and Cu (±Fe, Au, Ag, Mo) Skarn Deposits (Belt Bgl) (Central Mongolia)

This Middle to Late Cambrian metallogenic belt is related to replacements and plutons in, and related to the Telmen granite belt. The belt is approximately 700 km long and ranges from a few km to 70 km wide. The metallogenic belt occurs mostly in the Orhon passive marginal terrane (Tomurtogoo and others, 1999) that is intruded by the Middle and Late Cambrian the Telmen collisional granite belt. The metallogenic belt contains: (1) several large and medium-size Fe skarn deposits including the Tomortei, Bayangol, and Tomortolgoi deposits; (2) several mafic-ultramafic related Ti-Fe (+V) occurrences including the Songino uul-Olont-Ust Angal uul group, Monostoi, and Khanan occurrences; (3) layered gabbroic Ni-Cu occurrences including the Serten-Nomgon, Khotol, and other occurrences; and (3) Cu skarn occurrences including the Solongot and Darhan group occurrences. The western part of the belt occurs in the eastern part of northern Baydrag cratonal terrane. This area contains most of the Fe skarn deposits of Mongolia with large reserves. This part of the belt occurs in the Baydrag cratonal terrane. The central part of the belt is extensively intruded and covered by younger magmatic, sedimentary, and volcanic rocks, and occurs in two main parts. The major deposits in the metallogenic belt are the Songino uul-Olont-Ust Angal uul group, Monostoi, the Khanan occurrences, the Serten-Nomgon and Khotol occurrences, the Tomortolgoi, Bayangol, and Tomortolgoi deposits, and the Solongot and Darhan occurrences.

Bayangol 3 Fe Skarn Deposit

This deposit (Filippova and others, 1977; N.A. Chebotarev and others, written commun.,1990) consists of a magnetite skarn in the late Riphean Darkhan Group that contains metasandstone, shale, and limestone. The deposit occurs along northwestern and southeastern branches of northeast-trending Bayangol fault zone. Host rocks are locally, intensively replaced by an epidote-albite-actinolite assemblage in a zone that ranges from 9.0-10.0 km long. In the south, ten steeply-dipping magnetite skarns extend at least to a depth of 200 m. The East1 body is 1900 by 20 by 66 m and consists of massive sulfide-magnetite, and the East 2 body is 1200 by 4.0 by 42 m and consists of stringers, disseminations, and masses of sulfide and magnetite. Eight ore bodies occur in the northwestern part of the deposit and consist mostly sulfide and magnetite in massive lenses. Grade is more 50% Fe in masses, approximately 34% Fe in stringers and disseminations, and more 55% Fe in oxidized martite and magnetite. Stringers and disseminations are developed mostly in microdiorite and diorite dikes. Ore minerals are mainly magnetite, and rare pyrite, pyrrhotite, and chalcopyrite. Also occurring is 0.13% to 4.0% S and up to 0.07% to 0.31% P. The deposit is large with reserves of 110 tonnes ore grading 34.6-57.1% Fe.

Serten-Nomgon Mafic-Ultramafic Related Cu-Ni-PGE Deposit

This deposit (Ts. Gundsambuu and others, written commun., 1992) consists of lenses of chalcopyrite, magnetite and ilmenite in a Middle Cambrian bedded gabbro stock. The stock consists of gabbro-norite, troctolite, olivine gabbro, anorthosite, gabbro, and diorite. Chalcopyrite, magnetite and ilmenite disseminations occur in gabbro and norite in four lenses gabbro-norite horizons. The main ore minerals are chalcopyrite, bornite, pentlandite, and pyrrhotite, and malachite, azurite and iron oxide coatings. Average grade is 0.275% Cu, 0.54 g/t Pt+Pd.

Serten Cu (±Fe, Au, Ag, Mo) Skarn Deposit

This deposit (B. Batroom and others, written commun., 1992) consists of lenses of skarn that occur along a contact between Neoproterozoic limestone xenoliths of the Darkhan series that is intruded by Cambrian gabbro and peridotite. The skarn lenses occur from 50 m to 200 m apart in an area 700 by 20 by 40 m. The lenses vary from 5 to 20 m long and 2-5 m wide. The ore minerals are pyrite, chalcopyrite, bornite, chalcocite, bismuthite, and covellite. Rock samples contain 0.02-0.2% Cu, 0.02-1% Zn, 0.02-1.0% Pb, 0.005-0.1% Bi, 0.02% Co, 0.03% As, 0.01% Sn, 10.0-50.0 g/t Ag, and 0.005 g/t Au. The average grade is 0.02-0.2% Cu, 10.0-50.0 g/t Ag.

Tomortolgoi Banded Iron Formation (BIF, Superior Fe) Deposit

This deposit (T. Semeihan and others, written commun., 1970; Filipova and others, 1977; Geology and mineral resources of Mongolia, 1999) consists of hematite-magnetite lenses in sandstone of the Carboniferous Khangai Group. The length of body is hundreds of m and the thickness ranges up to 55-60 m. The size of massive hematite-magnetite lenses is 15 by 30 m. Major deposit mineral is hematite, with minor magnetite. The grade of Fe ranges from 50% to 55% in magnetite masses and from 30% to 40% in hematite masses. The deposit is medium size, has an average grade of 36-56% Fe, and reserves of 25 million tonnes.

Origin and Tectonic Controls for Bayangol Metallogenic Belt

The belt interpreted as forming during subduction-related gabbroic magmatism. Gabbroic Ni-Cu and zoned mafic-ultramafic related Fe-Ti type deposits are related to the Middle Cambrian layered gabbro Ider complex (Izoh and others, 1990). Fe and Cu skarn occurrences are related to the Middle and Late Cambrian Bayangol complex that consists of gabbro, granodiorite, and granite. The Middle Cambrian Ider layered gabbroic complex and Middle and Late Cambrian Telmen and (or) Bayangol complex, consisting of gabbro, granodiorite, and granite, are herein interpreted as forming in a Middle or Late Cambrian continental margin arc that was developed and overprinted on a passive continental margin containing the Orhon and adjacent terranes.

REFERENCES: Fillippova and Vydrin, 1977; Izokh others, 1990; Tomurtogoo and others, 1999.

Zaamar-Bugant Metallogenic Belt of Au in Shear Zone and Quartz Vein and Granitoid-Related Au vein Deposits (Belt Zaa) (Central Mongolia)

This Ordovician(?) metallogenic belt is related to veins in the Haraa part of the Zag-Haraa turbidite basin overlap assemblage (Tomurtogoo and others, 1999) in the Hentii Mountain Range. The significant deposits occur in the Zaamar and the Yorogol districts and are hosted in the lower sequence of Middle Cambrian to Early Ordovician Haraa Group that consists of intercalated greenschist, metasandstone, and metasiltstone with amphibolite and quartzite horizons and lenses. The lower sequence is metamorphosed from greenschist to amphibolite facies occurs in the core of the Zaamar anticline. The quartz-carbonate vein deposits occur along the northeastern and southwestern hinges of the Zaamar anticline axis. Quartz veins are conformable with host metasedimentary rock, and are interpreted to have been emplaced during faulting. The anticline axis occurs close to the Late Ordovician Boroogol complex that consists of collisional gabbro, granodiorite, and granite. The period of regional metamorphism is interpreted as occurring immediatel;y before granitic pluton intrusion because regionally metamorphosed host units are contact metamorphosed along pluton contacts (Dejidmaa and others, 1993; Enkhbaatar, 1998). Quartz-carbonate Au vein deposits and occurrences in the Zaamar district are the primary sources for famous and extensive Au placer deposits of the district. A primary source of some placer Au deposits occur along the Tolgoit and Bugant Rivers consist of Au quartz vein deposits that occur in the northern part of the Salbartai anticline axis. The major deposits are at Bumbat, Baruunshand, Khailaast, Arnaimgan, and Nariin-gol.

Bumbat Au in Shear Zone and Quartz Vein Deposit

This deposit (Jargalsaihan and others, 1996; D. Terra and others, written commun., 1996; Enkhbaatar, 1998) consists of quartz veins in schist, amphibolite, and quartzite of the Zaamar Formation. The main vein strikes northeast, dips steeply southeast, is approximately 1.0 km long, ranges from 0.91 m to 8.26 m wide, and extends to 300 m below depth. Ore minerals are pyrite, chalcopyrite, galena, sphalerite, tetrahedrite, gold, malachite, and azurite. Sulfides comprise approximately 2% the vein. Main gangue minerals are quartz, sericite, and carbonate. The vein has a coarse banded texture. Grade ranges from 0.1-720.1 g/t Au and of 0.7-23.1 g/t Ag. A 400 m long bonanza occurs in the southwestern and the central parts of the vein. The vein is surrounded by alteration halos that range from 5.0-20.0 m thick. The deposit is small and contains a probable resource of 16 tonnes Au. Grade ranges from 0.1-50.9 g/t Au, and 0.5-8.9 g/t Ag.

Narantolgoi Granitoid-related Au vein Deposit)

This deposit (B.R. Khennel and others, written commun., 1970; Khenel and others, 1970; Lagonravov and Shabalovskii, 1977) consists of parallel quartz veins in the Lower Paleozoic sandstone and shale of the Kharaa Group is intruded by an early Mesozoic granodiorite stock. Deposit contains the Main and the Parallel veins and lesser veins that strike sub-longitudinally. The Main vein is 1800 m long, and ranges from 0.4 to 1.05 m, dips steeply west, and averages 5.7 g/t Au. The Parallel vein occurs 200 m in west of the Main vein, is 1250 m long, and ranges from 0.14-0.31 m wide with an average grade of 8.4-35.8 g/t Au. Veins formed in following stages: (1) quartz I, arsenopyrite and pyrite I, and gold l (2) quartz II, pyrite II, enargite, sphalerite, chalcopyrite, tennantite, galena, petcite and gold II; and (3) quartz III and carbonate. Host rocks are altered to minor beresite that increases with depth. The deposit is explored by trenches, by underground workings, and drill holes. The deposit is large with reserves of 177,343 tonnes, and resources of 440,000 tonnes. Average grade is 8.2 g/t Au.

Origin and Tectonic Controls for North Hentii 1 Metallogenic Belt

The belt is interpreted as forming during collision-related deformation and related regional metamorphism in the Late Ordovician and Silurian during collision of the correlated Zag-Haraa and Orhon terranes.

REFERENCES: Dejidmaa and others, 1993; Enkhbaatar, 1998; Tomurtogoo and others, 1999.

Chagoyan Metallogenic Belt of Sedimentary Exhalative Pb-Zn (SEDEX) Deposits (Belt Chn) (Russia, Far East)

This Cambrian(?) metallogenic belt occurs in the Bureya metamorphic terrane that is bounded by strike-slip faults. The terrane consists mainly of an early Paleozoic metamorphic core complex that contains two units. The lower unit consists of gneiss, schist, marble, quartzite, and amphibolite that are metamorphosed to amphibolite facies. The upper unit consists of marble, quartzite, and metasandstone that are metamorphosed at greenschist facies. Weakly metamorphosed deposits are (1) silicic and intermediate volcanic rock, sandstone, and siltstone; (2) Neoproterozoic limestone; (3) Cambrian clastic rock and limestone. Younger overlap units are Middle and Late Devonian clastic marine rocks. Widespread early Paleozoic and Mesozoic granitoids intrude the terrane. The major deposit is at Chagoyan.

Chagoyan Sedimentary Exhalative Pb-Zn (SEDEX) Deposit

This deposit (I.G. Khel'vas, written commun., 1963; Nokleberg and others, 2000) consists of a galena-sphalerite aggregate that occurs as cement between grains in sandstone. Veinlets are also common. The deposit is about 270 m long and one m thick, and is hosted in quartz-feldspar sandstone that underlies Cambrian(?) limestone and dolomite. Galena and sphalerite are the dominant ore minerals, with subordinate pyrite, pyrrhotite, and chalcopyrite. Post-ore dikes and stocks of Early Cretaceous diorite and granodiorite cut the deposits. The Mesozoic igneous rocks intrude the stratiform deposit locally exhibit hydrothermal silica, sericite, and tourmaline alterations. The deposit occurs on the northern bank of the Zeya River and is small. Average grades are 1.42% Pb, 5.16% Zn, and up to 3,000 g/t Ag. The deposit contains estimated reserves of 65,000 tonnes Zn.

Origin and Tectonic Controls for Chagoyan Metallogenic Belt

The belt interpreted as forming during generation of hydrothermal fluids during rifting and intrusion of intermediate composition dikes, and chemical marine sedimentation.

REFERENCES: I.G. Khei'vas, written commun., 1963; Nokleberg and others, 2000, 2003; V.A. Stepanov, this study.

South Khingan Metallogenic Belt of Banded Iron Formation (BIF, Superior Fe) Deposits (Belt S-Kh) (Russia, Far East)

This Neoproterozoic and Cambrian metallogenic belt occurs in the Malokhingansk accretionary wedge terrane that consists of an early Paleozoic metamorphic core complexe that is metamorphosed to greenschist to amphibolite facies. Primary rocks are Neoproterozoic and Early Cambrian that form an ophiolite sequence and overlying shale, siliceous shale, phyllite, and limestone.This Neoproterozoic and Cambrian sequence is intruded by granitoids with K-Ar ages of 604 and 301 Ma. The major deposits are at Yuzhno-Khingan, Kimkanskoe, and Kostenginskoe.

Yuzhno-Khingan Banded Iron Formation (BIF, Superior Fe) Deposit

The Yuzhno Khingan deposit (V.A. Yarmolyuk and A.P. Glushkov, written commun., 1966) consists of Fe-and Mn-bearing beds of magnetite-, hematite-, and magnetite-hematite-quartzite. Beds range from 18 to 26 m thick and are interlayered with chlorite dolomite breccia Underlying sedimentary rock contains of braunite, haussmanite, and rhodochrosite that range from 2 to 9 m thick. The Fe-and Mn-bearing layers are overlain by a dolomite sequence that is overlain by shale, limestone, and dolomite. The deposit has not been developed because of difficulties with ore concentration and steeply-dipping beds. The largest deposits at Kimkanskoe, Kostenginskoe, and Yuzhno Khingan contain approximately 3 billion tonnes ore. Mineralogic and geochemical studies suggest a sedimentary-exhalative origin. The deposit is medium size.

Origin and Tectonic Controls for South Khingan Metallogenic Belt

The metallogenic belt is interpreted as forming in volcanic and sedimentation basin along an unstable proto-continental margin, or in a fragment of Archean craton that was incorporated into an accretionary wedge terrane.

REFERENCES: Krasny, 1966; Kozlovsky, 1988; Martynyuk, 1983; Kazansky, 1973; Nokleberg and others, 1994, 1997, 2003.

Bayanhongor-1 Metallogenic Belt of Au in Shear Zone and Quartz Vein, Granitoid-Related Au vein, Cu (±Fe, Au, Ag, Mo) Skarn and Cu-Ag Vein Deposits (Belt BH-1) (Central Mongolia)

This Late Ordovician metallogenic belt is related to veins cutting the Hangay-Dauria accretionary wedge and Orhon-Ikatsky continental margin arc terranes, and the Zag-Haraa turbidite basin. The occurs in southwestern wing of the Hangay Mountain Range. The major Au deposits are at Bor khairhan, Khan Uul, and Dovont, and the major Cu deposits are at Jargalant, Bayantsagaan 1, and Burdiingol.

Cu-Ag Vein Occurrences

Cu-Ag vein occurrences are related to regional metamorphism andoccur in the Bayanhongor ophiolite complex (Zabotkin and others, 1988). The occurrences consist of a quartz and quartz-carbonate linear stockwork composed of pyrite and chalcopyrite that is developed in Vendian to Early Cambrian gabbro, spillite, diabase, basalt, andesite porphyry, and chlorite-silica and silica-chlorite schist. Pyrite and chalcopyrite occur in the center of the stockwork whereas pyrrhotite, galena, and sphalerite occur in the marginal parts. The stockwork is conformable with host rocks that are intensely foliated, silicified, and altered to carbonate and pyrite. The average thickness of quartz stringers is approximately 1 to 2 cm. Locally quartz veins range up to 1.5 to 2 m thick. Average Cu grade is mainly 0.001 to 0.1% Cu, but 1 to 2 m thick intervals contain from 0.6% to 0.8% Cu. Average Ag grade is mainly 3 to 10 g/t Ag. Stockwork dimensions are 200 by 500 m..

Au in Shear Zone and Quartz Vein Occurrences

Gold occurrences (Zabotkin and others, 1988) consist of quartz-carbonate vein and stockwork occurrences that are conformable with host greenschist in the Zag-Haraa turbidite and the Orhon continental margin arc terranes. Au grade is variable and ranges from 0.1 g/t to several tens g/t Au. Veins and stringers and host rocks are multiply folded and faulted so that surface and down dip extensions are difficult to determine. Metamorphic age of a foliated metamorphosed Vendian to Early Cambrian mudstone in the Olziitgol Formation in the Orhon terrane has K-Ar isotopic ages 447 and 453.9 Ma (Kurimoto and others, 1998). Placer Au deposits are closely related spatially to quartz-carbonate vein and stockwork type Au deposits.

Khokhbulgiin khondii Cu (±Fe, Au, Ag, Mo) Skarn Deposit

This deposit (D. Andreas and others, written commun., 1970; Watanabe and others, 1999) occurs adjacent to a late Paleozoic quartz diorite and granite stock with a K-Ar isotopic age of 252 Ma that intrudes Late Proterozoic Burdgol Formation consisting of intercalated limestone, calcic sandstone, calcic shale, and sandstone. The skarn consists of five bodies along the lower and the upper contacts of a metadiabase sill. Bodies range from 2040 m wide and 140-160 m long. Ore minerals are chalcopyrite and bornite and minor native gold. Gold ranges up to 0.5 mm diameter. The bodies layers of skarn, skarn-like formation, and hornfels. Layers in bodies range from 0.01 m to 0.4 m in skarn, up to 0.8 m in hornfels, and up to 2.8 m in skarn-like formation. Skarn layers contain more ore minerals. Skarn consists of grossular-andradite and minor clinopyroxene and calcite, and rare vesuvianite in nests and amphibole in narrow stringers. Skarn-like formation consists mostly of feldspar, scapolite, or epidote. Hornfels consists of masses of quartz, albite, and biotite. Primary ore minerals are native bismuth, bismuthine, arsenopyrite, pyrite, sphalerite, enargite, bornite, tetrademite, chalcopyrite, cubanite, vittihenite, pyrrhotite, and gold. Most gold occurs in gangue minerals and forms rounded, irregular, or stringers, and varies from less than 1 to 160 microns. Gold is also intergrown with with chalcopyrite and bornite, and rare arsenopyrite. Fineness of gold varies from 800 to 900%. Oxide ore minerals are chalcocite, covellite, malachite, azurite, and Fe oxides. The deposit is medium size with resources of 8.8 tonnes Au, 10700 tonnes Cu and an average grade of 5.6 g/t Au and 0.685% Cu.

Tsagaantsakhir Uul Granitoid-Related Au Vein Deposit

This deposit (D. Andreas and others, written commun., 1970; Jargalan and Fujimaki, 2000) is hosted in Middle to Late Cambrian granodiorite and granite intruding early and middle Riphean schist of the Burd-gol Group. Also occurring is a late Paleozoic diorite stock, and widely distributed diotite porphyry, gabbro porphyry and quartz porphyry dikes. Quartz veins contain economical Au in groups of veins in four sites. Ore minerals are pyrite, arsenopyrite, sphalerite, chalcopyrite, tetrahedrite, galena, bournonite, native gold, altaite, gessite, tellutium-busmuthine. The average Au fineness is 900, maximum grade in some veins is 645 g/t Au. The average grade of Au was approximately 1.0 g/t in other veins. The deposit is medium size.

Origin and Tectonic Controls for Bayanhongor Metallogenic Belt

The belt is interpreted as forming during regional metamorphism associated with accretion of Bayanhongor and Baytag terranes.

REFERENCES: Zabotkin and others, 1988; Chikao and others, 1998; Tomurtogoo and others, 1999.

Govi-Altai Metallogenic Belt of Volcanogenic-Sedimentary Fe and Mn Deposits (Belt GAl) (Southwestern Mongolia)

This Middle Cambrian to Early Ordovician metallogenic belt is hosted in the western Gobi-Altay continental-margin turbidite terrane (Tomurtogoo and others, 1999). The belt is 40 km wide and 150 km long. The metallogenic belt consists of amphibole schist in the Early anbd Middle Cambrian Togrog Formation, and in intercalated quartzite, phyllite, tuffaceous siltstone, and sericite-chloritic schist of Middle Cambrian to Early Ordovician Uhin Ovoo Formation. Both formation contain Fe-and Mn-bearing quartzite horizons that range up to several meters thick and extend up to several kilometers long. The Fe, Fe-Mn and Mn occurrences of the belt were discovered by

1:200,000 scale geological mapping and general prospecting (A.A. Rauzer and others, 1987). The major Fe deposit is at Uhin Ovoo, and the major Mn deposits are at Tahilgat Uul and Sharturuutiin gol.

Tahilgat uul Volcanogenic-Sedimentary Mn Deposit

This deposit (A. Rauzer and others, written commun., 1987) consists of pyrolusite, magnetite, and martite in a quartzite bed in amphibolite and schist of the Early to Middle Cambrian Togrog Formation. The bed is 0.5-1.0 m thick and extends for 2000 m. Grade ranges from 3-20% Mn. Grab samples contain up to 0.015% Co, up to 0.02% Mo, and up to 0.01-0.25% Cu. The deposit is medium size and contains a resource of 2 million tonnes Mn and 3 million tonnes Fe

Uhiin ovoo Volcanogenic-Sedimentary Fe Deposit

This deposit (A. Rauzer and others, written commun., 1987; Jargalsaihan and others, 1996) consists of magnetite and hematite bearing beds hosted in Middle Cambrian to Early Ordovician chlorite-sericite slate. Beds are 5.0-10.0 m by 50.0-70.0 m thick and extend up to 4000 m long. Analyses of three grab samples yields 20.5-48.4% Fe, 1.5% Mn, up to 0.08% V, and up to 0.01% Cu.

Origin and Tectonic Control for Govi-Altai Metallogenic Belt

The belt is interpreted as forming during sedimentation along an early Paleozoic continental slope.

REFERENCES: Rauzer and others, 1987; Tomurtogoo and others, 1999.

Ikh Bogd Metallogenic Belt of Serpentine-hosted Asbestos, Talc (magnesite) Replacement and, Podiform Chromite Deposits (Belt IB) (Central Mongolia)

This Ordovician metallogenic belt is related to replacements in Ih Bogd oceanic and Lake island arc terranes. The Ih Bogd oceanic terrane consists of a small fragment of Vendian and Early Cambrian ultramafic rock and volcanic rock that are overthrust onto the Idermeg passive margin terrane (Tomurtogoo and others, 1999). Asbestos deposit and occurrences occur in serpentinized ultramafic rock in allochthon and occur along a gabbro contact for up to 8 km. Asbestos and talc replacement deposit and occurrences also are hosted in ultramafic rock in an area that extends west-northwest for approximately 400 km and ranges from 20 km to 45 km wide. Most of the deposits in the metallogenic belt are related to ultramafic rock intrusions in the Ih Bogd ultramafic rock belt (Kleiner and others, 1977). The major deposits are the Ih hajuu (or Ih Hajuu) asbestos deposit, the Yamaan us asbestos occurrence, and theTsagaan gol talc occurrence.

Tsagaan gol Talc (magnesite) Replacement Deposit

This deposit (P. Shaandar and others, written commun., 1992; Jargalsaihan and others, 1996) consists of carbonate talc replacement occurring in presumed Vendian to Early Cambrian serpentinized dunite and harzburgite, presumably. Deposit consists of a talc-breunnerite lens approximately 700 m long and 50-200 m wide and occurs along a northwest-trending fault. The a verage grade is 20-80% talc.

Origin and Tectonic Controls for Ih Bogd Metallogenic Belt

The belt is interpreted as forming during collision during amalgamation of subterranes of the Lake island arc terrane into a superterrane, and also during amalgamation of Lake terrane with Baidrag and Idermeg terranes.

REFERENCES: Kleiner and others, 1977; Tomurtogoo and others, 1999.

Tamirgol-Yoroogol Metallogenic Belt of Volcanogenic-Sedimentary Fe Deposits (Belt TY) (Central Mongolia)

This Middle Cambrian to Early Ordovician metallogenic belt is hosted in the Zag-Haraa turbidite terrane Middle Cambrian to Early Ordovician quartzite, sandstone, shale, and intercalated rocks of the Haraa Formation that is deformed into steep-dipping, linear monoclinal folds. The deposit and occurrences consist of quartzite-hosted magnetite and hematite (as at the Tamirgol deposit) and (or) hematite (as at the Sognogor occurrence). Gangue minerals are quartz, muscovite, chlorite, and dolomite. Deposits contains high Mn and P. The western Tamirgol part of the belt occurs in individual tectonic blocks of the Haraa Formation. The eastern Yorogol part extends along the major northeast-striking The belt and bounding faults are intensely studied (Filippova and Vydrin, 1977; Bahteev and Chijova; 1984). The Tamirgol and the Yorogol zones are herein combined into a single belt with similar type and coeval Fe deposits and occurrences. The major deposits and occurrences at at Tamirgol and Sognogor.

Tamirgol Volcanogenic-Sedimentary Fe Deposit

This deposit (Filippova and Vydrin, 1977) consists of of 20 bodies of thin layers of magnetite and hematite with quartzite. Host rocks are Riphean schist and quartzite deformed into a northwest-trending, steeply dipping isocline folds. Quartz-chlorite, quartz-biotite-chlorite, quartz-carbonate-chlorite and sericite schist are dominant. Deposit is mostly concordant with host rocks, is steeply dipping, is 300-1100 m long and 30-60 m thick. Gangue minerals are quartz, muscovite, chlorite, and dolomite. Main ore minerals are magnetite and hematite. Deposit contains from 0.07% to 0.4% P. The deposit is medium size with an average grade of 48% Fe, 1.18-5.86% Mn and a resource of 220-280 million tonnes.

Origin and Tectonic Control for Tamirgol-Yoroogol Metallogenic Belt

The belt is interpreted as forming during sedimentation along an early Paleozoic continental slope.

REFERENCES: Filippova and Vydrin, 1977; Bahteev and Chijova, 1984; Tomurtogoo and others, 1999.

Xilin Metallogenic Belt of Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu) Deposits (Belt XL) (Northeastern China)

This Early Cambrian metallogenic belt is hosted in the Zhangguangcailing continental margin arc superterrane and occurs in the eastern Heilongjiang Province, Northeastern China. The belt is 50 km long, over 25 km wide and strikes northwest. The deposits are hosted in mainly Early Cambrian volcaniclastic and carbonate rock (Xilin Group) that is metamorphosed to greenschist and lower amphibolite facies. The Xilin Group contains numerous fossils including trilobites (Kootenia Sp., Inouyina Sp.and *Neocobbodia?*Sp.), *Brachiopodous* (*Obolus* Sp.and *Linggulenlla* Sp) and *Hyolithes* (Wuxingzhen Formation). The significant deposit is at Xiaoxilin. This metallogenic belt occurs in the eastern part of Zhangguangcailing superterrane (continental margin arc) that consists chiefly of (1) Paleoproterozoic schist, quartzite, marble, and gneiss (Xinhuadukou Group); (2) Neoproterozoic tuff, rhyolite dacite, slate, schist, quartzite, marble and metamorphic sandstone (Yimianpe and Dongfenshan Groups); (3) local Neoproterozoic and Early Cambrian siliceous slate, limestone, marble, carbonaceous slate, and siltstone (Xilin Group), local Ordovician sedinentary rock and intermediate-mafic volcanic rock, and local Silurian volcanic and sedimentary rock metamorphosed to amphibolite, biotite fine-grain gneiss, diopside marble, garnet-biotite gneiss, and biotite schist.

Xiaoxilin Volcanogenic Hydrtothermal-Sedimentary Pb-Zn Massive Sulfide Deposit

This deposit (Yan, Hongquan and others, 1994) occurs in a fault-controlled epicontinental aulacogen. Host rocks are mainly Early Cambrian dolomite marble (with oolitic texture) and tremolite marble, and interlayered with metavolcanic rock and carbonaceous slate. Ore minerals are mainly pyrrhotite, sphalerite, galena, magnetite, siderite, pyrite, and marcasite. Minor ore minerals are chalcopyrite and arsenopyrite. Layered and massive ore minerals occur in large lenticular body that are recrystallizatized. The deposits are para-stratiform.Wallrock alteration is not visible adjacent to the main deposit. Tremolite alteration in the wallrocks above deposit is not closely related to deposits. Carbonate, silica, and wallrock bleaching are associated with minor veinlets and disseminations. Thin layers of Mn siderite occur above the deposit layer, and younger, diabase porphyry dikes occur beneath. Also occurring are syntectonic Caledonian granite and hornnfels. The deposit is large with reserves of 260,000 tonnes Pb, 326,500 tonnes Zn, and an average grade of 4.09% Pb, 1.61% Zn.

Origin and Tectonic Controls for Xilin Metallogenic Belt

The belt is interpreted as forming during volcanic, clastic, and carbonate sedimentation in an aulacogen that closed in the Silurian and underwent greenschist facies metamorphism, multiple faulting, and intrusion by syntectonic granitic stocks (Yan Hongquan and others, 1994). A three stage ore model for Xilin metallogenic belt consists of: (1) initial of volcanogenic hydrothermal-sedimentary deposits in the Early Cambrian or possibly the late Neoproterozoic(?); (2) recrystallization of deposit during metamorphism and deformation of the deposit and host rocks, and intrusion of syntectonic granitoid in the Ordovician and Silurian; and (3) formation of superposed skarn and hydrothermal Fe (Pb-Zn) in the late Triassic and Early Jurassic (Yan Hongquan and others, 1994). The metamorphism, deformation of the host Xilin Group and syntectonic granitoid intrusion are interpreted as related to the amalgatiom of Zhangguancailing Superterrane during the Ordovician and Silurian.

REFERENCES: Yan Hongquan and others, 1994.

Tadong Metallogenic Belt of Volcanogenic-Sedimentary Fe Deposits (Belt TD) (Northeastern China)

This Silurian metallogenic belt is hosted in the Zhangguangcailing continental margin arc superterrane and occurs in the northern Jilin Province, Northeastern China. The belt is 80 km long, over 20 km wide, and trends northwest. The deposits in the belt are mainly hosted in the Silurian volcaniclastic rock metamorphosed in greenschist and lower amphibolite facies (the Hongguang Formation). The significant deposit is at Tadong.

Tadong Volcanogenic-Sedimentary Fe Deposit

This deposit (Cao, Jingxian, 1993c) is hosted in the Silurian Hongguang Formation in a well-defined horizon. The footwall and hanging wall units are diopside marble, diopside-, biotite-lepitynite, and biotite-plagioclase gneiss, amphibolite, and and migmatite. The deposits occur concordant to host rocks, and are mainly stratiform or laminated with minor lenses. A single deposit ranges from 50 to 300 m long, and 1.29 to 10.89 m thick. The ore minerals are mainly V magnetite and Co pyrite. Also occurring are pyrrhotite, chalcopyrite, molybdenite, galena, sphalerite, and skutterudite. Gangue minerals are mainly hornblende, plagioclas,e and F apatite. Minor gangue minerals are biotite, chlorite, diopside, tremolite, epidote, and clinoepidote. Two main types of economic deposits occur, P and V magnetite, and hematite. The main ore structure is banded. Other ore structures are veinlets and disseminations, laminations, and masses. Alteration minerals are pyrite, biotite, chlorite, and epidote, and local actinolite and carbonate. The deposit is generally interpreted as a metamorphosed marine volcanogenic-sedmentary deposit; however some researchers favor an origin as a metamorphosed sedimentary deposit. The deposit is large with reserves of 177 million tonnes and an average grade of 25.24% Fe, 1.72% P_2O_5, 0.25% V_2O_5, 2.74% S, 0.007% Co, 0.002-0.004% Ga.

Origin and Tectonic Controls for Tadong Metallogenic Belt

This belt is hosted in pre-accretionary volcanic and sedimentary rocks that were metamorposed and folded during the accretion of Zhangguangcailing superterrane. The metallogenic belt is hosted in the metamorphosed Silurian volcanic and sedimentary rocks in the upper part of the Zhangguangcailing superterrane.

REFERENCES: Cao Jingxian, 1993.

Kabarga Metallogenic Belt of Banded Iron Formation (BIF, Superior Fe) Occurrences (Belt Kb) (Russia, Far East)

This Cambrian(?) metallogenic belt is related to sedimentary units in the Kabarga accretionary wedge terrane. The belt contains mainly ironstone occurences of beds of magnetite-and hematite-magnetite-bearing chert that occur in Early Cambrian clastic and carbonate rock that overlies Early Cambrian dolomite. The older units of the Kabarga terrane are highly metamorphosed and deformed marble, calc-schist, gneiss, and quartzite that are metamorphosed to granulite and amphibolite facies, and exhibit a Rb-Sr whole-rock isotopic age of greater than 1,517 Ma. Younger units consist of Silurian sandstone and limestone, and Silurian collisional-related granitoid plutons, Permian basalt, andesite, and rhyolite, and Early Triassic sandstone. The significant deposit is at Ussuri.

Ussuri Banded Iron Formation (BIF, Superior Fe)

This deposit (Denisova, 1990) is hosted in Cambrian siliceous limestone, limestone, graphitic politic shale, Fe-Mn and phosphate layers, and dolomite. The rocks are intensely deformed. The stratigraphic thickness ranges up to 1 km. Magnetite and hematite layers occur along the layering planes between chert and intercalated with quartz-sericite-chlorite and quartz-sericite schist and dolomite. The upper part of the Fe occurrences is oxidized, and contains Mn deposits, mainly pyrolusite that occurs in addition to the Fe deposits. Mineralogic and geochemical studies suggest an exhalative-sedimentary origin. The occurrences are generally small, with 24 to 39% Fe.

Origin and Tectonic Controls for Kabarga Metallogenic Belt

The belt is related to marine sedimentary rocks that were structurally included into the highly metamorphosed Kabarga accretionary wedge terrane.

REFERENCES: Nokleberg and others, 1994, 1997, 1998, 2000, 2003; Denisova, 1990.

Voznesenka Metallogenic Belt of Korean Pb-Zn Massive Sulfide Deposits (Belt VZ) (Russia, Far East)

This Cambrian through Permian metallogenic belt occurs in layers in marine sedimentatry units in the Voznesenka passive continental terrane of the Khanka superterrane that is a fragment of a Paleozoic active continental-margin arc. The Voznesenka terrane consists of two major units. (1) Cambrian sandstone, pelitic schist, rhyolite, felsic tuff, and limestone and dolomite that range up to several thousand meters thick, are intensely deformed, and are intruded by Ordovician collision biotite and Li-F protolithionite granitoids with Rb-Sr and Sm-Nd isotopic ages of 450 Ma. And (2) Ordovician to Early Silurian conglomerate and sandstone. Overlapping assemblages range from Early Devonian through Late Permian. The massive sulfide deposits generally occur conformable to organic-rich, bituminous limestone near a contact with overlying marl. Banded magnetite associated with algae bioherms is a peculiar association with stratiform sulfide deposits of the Voznesenka metallogenic belt. The significant deposits are at Voznesenka-I and Chemyshevskoe.

Voznesenka-I Korean Pb-Zn Massive Sulfide Deposit

This deposit (Androsov and Ratkin, 1990) consists of massive and thick-banded sphalerite and magnetite-sphalerite layers in Early Cambrian bedded limestone turbidite. The deposits are lenticular, 1 to 2 m thick, 20 to 100 m long, and occur in dolomitic limestone and marl. The sulfide bodies and host rocks are folded and regionally metamorphosed. The sulfide bodies were locally altered to skarn and greisen during emplacement of a Silurian granitic stock that intrudes the-carbonate unit. The deposit is medium size with an average grade of 4% Zn.

Chernyshevskoe Korean Pb-Zn Massive Sulfide Deposit

This deposit (Bazhanov, 1988) consists of layered assemblage of pyrrhotite, arsenopyrite, pyrite, galena, and sphalerite that occurs at the contact of a limestone sequence with overlying Early Cambrian siltstone. Rare conformable zones of disseminated sulfide occur in the limestone away from the contact. The sulfide bodies are 1 to 2 m thick and have a surface exposure of 100 by 200 m. The deposit was drilled to a depth of about 100 m. The deposit is small with an average grade of 1.5 to 6.5% Pb and 0.7 to 2.5% Zn.

Origin and Tectonic Controls for Voznesenka Metallogenic Belt

The belt is hosted in Voznesenka terrane that is interpreted as part of the passive continental margin of Gondwanaland. The limestone turbidite hosting the Voznesenka-I and Chernyshevskoe Korean Zn-Pb massive sulfide deposits are interpreted as forming on the upper part of an Early Cambrian continental slope. The limestone turbidite and other Cambrian sedimentary and volcanic units of the Voznesenka terrane are interpreted as a fragment of a Late a passive continental margin of Gondwanaland.

REFERENCES: Androsov and Ratkin, 1990; Nokleberg and others, 1994, 1997, 2003; Khanchuk and others, 1997, 1998; Bazhanov, 1988;Ryazantseva, 1988; Belyatsky and others, 1999.

Bainaimiao Metallogenic Belt of Porphyry Cu-Mo (±Au, Ag) Deposits (Belt BN) (North-Central China)

This Cambrian and Early Ordovician metallogenic belt is related to granitoids in the small Bainaimiao complex (too small to show on 10 M scale map) that intrude the early Paleozoic Wundurmiao accretionary wedge terrane. The belt occurs in eastern Inner Mongolia. The belt extends east-west, and is more than 80 km long and 20 km wide. The significant deposit is Bainaimiao.

Bainaimiao Porphyry Cu (±Au)-Mo Deposit

This deposit (Chen Qi and others, 1994) consists of several parallel veins in a early Paleozoic granodiorite porphyry in a northern belt, and in greenschist at the contact of a porphyry the southern belt. Ore minerals occur in disseminations and veinlets and consist mainly of pyrite, chalcopyrite, molybdenite, quartz, and 30 other minerals. The host rocks are altered mainly to K feldspar, biotite, and quartz. Alteration to sericite, chlorite, epidote and carbonate minerals also occurs. In the northern belt, alteration zones around the porphyry intrusion outwards is K feldspar (biotite zone), silica, chlorite, and epidote. In the southern belt, alteration zones are K feldspar, silica, biotite, chlorite, and epidote. The deposits are closely related to the silica alteration. The host granodiorite porphyry has a U-Pb zircon isotopic age of 466 to 694 Ma. The host metamorphic rock (of the Bainaimiao Group) is intruded by porphyry and consists of Mesoproterozoic island arc volcanic and sedimentary rock with a U-Pb zircon isotopic age of 1,130 Ma. These metamorphic rocks underwent Late Silurian intense shearing. The host granodiorite porphyry is controlled by east-west-trending ductile shear zones. The deposit is medium size with reserves of 73,200 tonnes Cu and an average grade of 0.91% Cu.

Origin and Tectonic Controls for Bainaimiao Metallogenic Belt

The granodiorite porphyry stock that hosts the metallogenic belt is related to accretion of the Wenduermiao terrane to the Sino-Korean Craton in the early Paleozoic. Some authors suggest some stratified deposits in the Bainaimiao Greenstone Group that formed during Mesoproterozoic volcanism were the original source of metals for the porphyry Cu deposits in this metallogenic belt (Shi Lindao,1994).

REFERENCES: Chen Qi and others, 1994; Shi Lindao,1994.

Fangniugou Metallogenic Belt of Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu) Deposits (Belt FN) (Northeastern China)

This Ordovician to Silurian metallogenic belt is related to the Laoling island arc terrane and occurs in eastern Jilin Province, Northeastern China. The belt is 40 km long, over 20 km wide, and strikes northwest. The deposits in the belt are mainly hosted in the Late Ordovician volcanic rock of the Laoling island arc terrane. The significant deposit is at Fangniugou.

Fangniugou Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu) Deposit

This deposit (Zhang Hongtao and Ne Fengjun, 1994) consists of upper stratiform and lensoid deposits, and lower lenticular and fine veined deposits. The upper deposits occur concordant to andesite, andesite tuff, shale, and marble. The deposit is intruded by granite. The ore minerals are massive and disseminated. The three ore mineral assemblages are: (1) magnetite, arsenopyrite, pyrite, and scheelite; (2) grunerite, pyrrhotite, pyrite, chalcopyrite, and molybdenite; and (3) galena, sphalerite, chalcopyrite, and pyrite. Alteration minerals are pyrite, chlorite, grahite, and silica. Along the contact of the granite intrusion is garnet and diopside skarn. The Late Ordovician host rocks are metamorphosed andesite, rhyolite, sericite schist, and marble. A Rb-Sr isotopic age for the volcanic rock is 445 Ma. The volcanic rocks are calc-alkaline and are interpreted as part of an island arc sequence. The Rb-Sr isotopic age of the granite is 352 Ma. Some researchers interpret the deposit as a massive sulphide deposit related to tectonism and magmatism in the rear of an island arc (Zhang Hongtao and Nie Fengjun, 1994). Others interpret the deposit as a magmatic hydrothermal deposit (Feng Shouzhong, 2000). The deposit is medium size with reserves of 357,000 tonnes Zn grading 3.30% Zn.

Origin and Tectonic Controls for Fangniugou Metallogenic Belt

The belt is interpreted as forming during subduction-related volcanism in Late Ordovician volcaniclastic rock of Laoling island arc terrane. The terrane consists chiefly of: (1) metamorphosed Late Ordovician marine sedimentary rock, siliceous volcanic and volcaniclastic rock (quartz schist, mica schist, metamorphosed intermediate and siliceous volcanic rock, marble, slate, and sandstone of the Shifen Formation); (2) metamorphosed Early Silurian volcaniclastic and sedimentary rock (slate, siltstone, phyllite, tuff, siliceous lava, and sandstone of the Taoshan Formation); and (3) Middle Silurian sandstone, siltstone, and tuff of the Zhangjiatun Formation), and Late Silurian shale, siltstone, graywacke, and limestone of the Erdaogou Formation); This terrane is intruded by Silurian and Hercynian plutons with a K-Ar isotopic age of 408 Ma. The Laoling terrane is strongly deformed along east-west trend, and is locally intruded by mainly Hercynian plutons.

REFERENCES: Zhang Hongtao and Ne Fengjun, 1994.

Hunjiang-Taizihe Metallogenic Belt of Evaporate Sedimentary Gypsum Deposits (Belt HT) (Northeastern China)

This Cambrian to Ordovician metallogenic belt is hosted in the Sino-Korea platform sedimentary cover and occurs in the East Liaoning and East Jilin Provinces, Northeastern China. The occurs in the Hunjiang River, East Jilin Province and in Taizihe River, East Liaoning Province. The belt is hosted in the Cambrian and Ordovician overlap sedimentary assemblages of the Jilin-Liaoning-East Shandong terrane. The evaporate sedimentary gypsum deposits occur in the Early Cambrian Mantou Formation in dolomite mudstone, dolomite, and limestone. The metallogenic belt is 300 km long and 20 to 30 km wide. The significant deposits is at Rouguan.

Rongguan Evaporate Sedimentary Gypsum Deposit

This deposit (Ren, Caohong, and Cai, Jingming, 1989) consists of thin, concordant gypsum beds in Early Cambrian carbonate in the Mantou Formation. Four horizons occur and the main horizon is 2,800 m long and 5.5 m thick. The ores are carbonate and sulphate type with a simple mineralogy. Main minerals are gypsum, karstenite, dolomite, calcite, quartz, illite, and minor montmorillonite. The sedimentary environments is interpreted as a super-tidal vaporizing Sabha or high saline basin. The deposit is medium size.

Origin and Tectonic Controls for Hunjiang-Taizihe Metallogenic Belt

Gypsum deposits in the belt are interpreted as forming in a super-tidal sabkha sedimentary environment (Ren Caohong and Cai Jingming, 1989). The host Cambrian and Ordovician sedimentary rock are part of the overlap sedimentary assemblages on the Archean Jilin-Liaoning-East Shandong terrane and consist mainly of very thick carbonates and clastic clastic rock. During the Early Cambrian period, the limited Hunjiang-Taizihe basins formed along a northeast trend.

REFERENCES: Ren Caohong and Cai Jingming, 1989.

Jinzhong Metallogenic Belt of Evaporate Sedimentary Gypsum (Belt JZ) (North China)

This Cambrian through Silurian metallogenic belt is hosted in sedimentary units in the the Sino-Korea platform sedimentary cover and occurs in the central part of southeast Shanxi Province, Northern China. The belt is hosted in an overlap sedimentary assemblage deposited on the Archean West Liaoning-Hebei-Shanxi terrane. The belt trends north-south, is over 600 km long, and ranges from 20 to 30 km wide. The gypsum deposits are hosted in limestone horizons in Early and Middle Ordovician strata. The most significant deposit is at Taiyuan.

Taiyuan Evaporate Sedimentary Gypsum Deposit

This deposit (Yuan, Jianqi, and Cai, Keqin, 1994) consists of gypsum-bearing strata in evaporate rocks in the Early Ordovician Majiagou Formation. The gypsum-bearing strata range from 118 to 207 m thick. The strata are divided into the following members: (1) lower limestone; (2) lower gypsum; (3) middle limestone; (4) upper gypsum; (5) interbedded dolomite and limestone; and (6) upper limestone. Ten layers of gypsum occur, with nine in the upper gypsum member and one in the lower gypsum member. The average thickness of each layer is 1.0 to 2.49 m. Generally, where the gypsum member is thicker, the thickness of gypsum layer is correspondingly larger. The gypsum layers occur continuously along strike for several thousand meters and extend downdip to more than 1000 meters. Some laminated and banded gypsum layers frequently contain halite pseudomorphs and mud cracks. However, most gypsum layers consist of crystalloblastic, coarse-grained gypsum replacing anhydrite. The deposit is interpreted as evaporate layers that formed in a tidal zone. The deposit is large.

Origin and Controls for Jinzhong Metallogenic Belt

The gypsum deposits in the belt are interpreted as forming in a large epicontinental marine basin that comprises the most extensive sedimentary cover on the North China Platform. The metallogenic belt is the most significant in the North China Platform is hosted in Middle Ordovician limestone and gypsum formations that contain multiple cycles with a group of large gypsum deposits (Tao Weiping and others, 1994; Wang Hongzhen, 1985).

REFERENCES: Wang Hongzhen, 1985; Tao Weiping and others, 1994.

East Liaoning Metallogenic Belt of Diamond-Bearing Kimberlite (Belt EL) (Northeastern China).

This Ordovician(?) metallogenic belt is related to kimberlite intruding Sino-Korean Craton-Jilin-Liaoning-East Shandong terrane, and occurs in the East Liaoning Peninsula in Northeastern China. The kimberlite intrudes Archean crystalline rocks, trends northeast, and is about 80 km long and 30 km wide. The significant deposit is at Fuxian.

Fuxian Deposit of Diamond-bearing Kimberlite

This deposit (Deng, Chujun and others, 1994) occurs in the Fuzhou basin in Eastern Liaoning uplift of North China Platform. The basement rocks consist of Archean granite and gneiss that is overlain by Paleozoic and Mesozoic sedimentary rock that occur in a north-northeast-trendingsynclinorium. Kimberlite occurs along east-west striking faults in the basement and the northeast-striking faults in overlying rocks. The major Tanlu fault zone is the main structure. Eighteen kimberlite pipes and 58 kimberlite dikes occur in an area of 28 km (east-west)and 18 km wide (north-south). Kimberlite pipes are complicated, irregular, and are exposed in areas from 200 m^2 to 41200 m^2. Eight pipes are economic with an average grade is 50 mg/m^3. A maximum grade of 308 mg/m^3 occurs in pipe no. 50. Kimberlite dikes occur along fractures that strike north-northeast and dip at 70 to 80°. The dikes are parallel to each other, and 8 intensely-carbonate-altered dikes contain diamonds. Dike no.69 is the richest, with a grade of 327 mg/m^3. Kimberlite contains 33.78% SiO_2, 27.96% MgO, 1.04% K_2O, 0.13% Na_2O, 33.91% Al_2O_3 and 1.61% TiO_2.

The main rock-forming minerals are olivine, phlogopite, garnet, chromite, moissanite, and ilmenite. The accessory minerals in kimberlite with relatively high diamond grade are rather complex and include rutile, anatase, pyrope, chrome, and spinel. The diamond hardness is more thon 88,000 kg/mm^2. Most diamonds are transparent and with a strong adamantine luster. The deposit is small.

Origin and Tectonic Controls for East Liaoning Metallogenic Belt

This metallogenic belt is hosted in kimberlite pipes and dikes including gabbro, amphibolite, serpentinite, peridotite, websterite, and peridotite. The dikes occur in swarms. The kimberlites and associated intrusions occur along the northeast-trending regional Tanlu fault at northern margin of the Sino-Korean Platform. The age of intrusion of kimberlite is well defined. Inclusions of Cambrian limestone occur in kimberlite pipes. The isotopic age of kimberlite is about 340 to 455 Ma and the isotopic age of kimberlite at the Shandong Peninsula is 460 to 490 Ma. Possibly the age of kimberlite intrusion in those area may be Late Ordovician (Deng Chujun and others, 1994). The kimberlite and other intrusions are mainly controlled by the major northeast-trending major Tanlu fault that cuts the the northern margin of the Sino-Korean Platform.

REFERENCES: Deng Chujun and others, 1994.

DEVONIAN THROUGH EARLY CARBONIFERROUS (MISSISSIPPIAN) METALLOGENIC BELTS (410 to 320 Ma)

Udzha Metallogenic Belt of REE (±Ta, Nb, Fe) Carbonatite Deposits (Belt UD) (Russia, Northeastern Siberian Craton)

This Devonian(?) metallogenic belt is hosted in carbonatite intruding late Precambrian sedimentary rock in the northern part of the North Asian Craton. The belt age is interpreted as Devonian. Host rocks have Rb-Sr and K-Ar ages of 810 to 240 Ma. The belt occurs in the Udzha uplift that contains the Riphean Udzha aulacogen, is 30 km wide, and extends longitudinally for 200 km. Several plutons of alkalic ultramafic rock and carbonatite occur in the belt, and the largest Tomtor pluton contains the a deposit with uniquely large Nb and REE resource. The Tomtor pluton is about 20 km in diameter, is almost circular in plan view, and is concentrically zoned. The central part consists of carbonatite surrounded by ultramafites and foidolites. The outer part contains alkalic nepheline syenite. The alkali ultramafic rock and carbonatite are interpreted as related to Devonian rifting. The major deposit is at Tomtor.

Tomtor REE (±Ta, Nb, Fe) Carbonatite Deposit

This consists (Orlov, 1994; Tolstov and others, 1995) of a volcanic-plutonic assemblage comprised three groups of rocks. (1) Carbonatite II comprise the bulk of the carbonatite core of the pluton with P_2O_5, Nb_2O_5, TR_2O_3 values of 0.7 to 11.4, 0.1 to 0.78, and 0.45%, respectively. The carbonatite comprises the substratum for a weathering crust that constitutes a hypergene ore complex that forms a phosphorus-REE deposit. The weathering crust consists of alternating subhorizontal goethite-siderite, francolite, francolite-goethite-siderite, hematite, and groutite. The francolite horizon consists of francolite (>60%), siderite, rhodochrosite, and goethite in varying proportions (up to 40%). Nb_2O_5 ranges from 0.2 to 2.4%, TR_2O_3 to from 0.8 to 4.5%, P_2O_5 to from 10 to 35%, Sc_2O_3 ranges up to 0.011%, Y_2O_3 to 0.09%, and V_2O_3 to 0.22%. The goethite horizon contains goethite and hydrogoethite (70 to 80%), francolite (5 to 15%), siderite (up to 10%), and chlorite, francolite, siderite, hematite, and rhodochrosite. Nb_2O_5 varies from 0.1 to 3.0%, TR_2O_3 varies from 1.3 to 5.4%, P_2O_5 varies from 0.2 to 8%, Sc_2O_3 ranges up to 0.006%. The siderite horizon is made of siderite (50 to 80%), alumophosphates of the crandallite group (20 to 30%), goethite (up to 10%), chlorite or kaolinite (up to 10%). Nb_2O_5 ranges from 0.3 to 0.8%, TR_2O_3 to from 0.8 to 1.3%, Sc_2O_3 to from 0.009 to 0.01%, P_2O_5 is as high as 12%, and Y_2O_3 to 0.09%. The main upper ore horizon of the Tomtor deposit consists of thin-bedded alumophosphate pyrochlore monazite, alnoite, tinguaite, and carbonatite, and varies from a few meters to 12 to 15 m thick. Carbonate and ore breccia occur. The upper ore horizon is a weathering crust for the carbonanite III metasomatite substratum that is rich in REE and phosphates. Economic metals occur mainly in monazite and rhabdophanite (REE, Y, Sc), pyrochlore (Nb), and alumo-and ferro-alumophosphates (P_2O_5, Al_2O_3). The deposit is large with estimated reserves of 500 million tonnes to a depth of 500 m. No commercial concentrations of P_2O_5 and Nb_2O_5 are known.

Origin and Tectonic Controls for Udzha Metallogenic Belt

The alkalic ultramafic rock and carbonatite that host the deposits are interpreted as forming in Devonian rifting.

REFERENCES: Entin and others, 1991; Orlov, 1994; Tolstov and others, 1995; Parfenov and others, 1999, 2001.

Daldyn-Olenyok Metallogenic Belt of Diamond-Bearing Kimberlite Deposits (Belt DO) (Russia, Northeastern Siberian Craton)

This Devonian metallogenic belt is hosted in kimberlite intruding Phanerozoic sedimentary rock in the North Asian Craton. The belt extends 800 km southwest-northeast and occurs north of the Botuobiya-Markha belt. The belt contains several diamond-bearing kimberlite pipes (Aikhal, Udachnaya, Ubileinaya, Sytykanskaya, and others) that intrude Cambrian through Silurian carbonate sedimentary rock of the North Asian Craton. The major deposits are at the Aikhal, Udachnaya, Ubileinaya, and Sytykanskaya pipes.

Aikhal Diamond-Bearing Kimberlite Deposit

This deposit (Brakhfogel' and others, 1997) consists of a kimberlite pipe hosted in Lower annd Middle Ordovician and Lower Silurian argillaceous carbonate sedimentaryh rock. The pipe is elongated to the northeast, and has irregular outlines in plan view at different levels and in cross-section. The pipe narrows at depth and grades into a dike that is 2-3 m thick with swells.Also occurring are numerous kimberlite dikes that crop out at the surface (four dikes) and at various depths. The amount of deep-level, associated minerals is minor. The minerals are rare picroilmente, and more abundant chrome-spinel, pyrope, and olivine. In breccia in the southwestern ore shoot and in tuff, the concentration of chrome-spinel is higher than pyrope, whereas in the central part of the pipe their occur in equal amount. Olivine only occurs in a third phase breccia, up to 5-9%. The deposit is large

Udachnaya Diamond-Bearing Kimberlite Deposit

This pipe (Brakhfogel' and others, 1997) consists of two conjugate western and eastern bodies that are shaped like a distorted figure eight in plan view. The pipe extends downward to 1400 m. In the upper levels, to a depth of about 250 to 270 m, the western and eastern bodies merge, but separate at deeper levels. At a depth of 280 m, both bodies are isometric and almost round in plan view. The pipe is Devonian The host rocks are Early Ordovician, Late and Middle Cambrian massive dolomite, dolomitized limestone, marl, mudstone, silstone, sandstone, and calcareous conglomerate.

The kimberlites consist mainly of serpentine pseudomorphs after olivine and local fresh olivine. Pyrope and picroilmenite are relatively rare. The amount of sedimentary rock xenoliths is smaller in the eastern body than in the western body where deep rock xenoliths are more abundant. The content of autoliths ranges from 10-15 to 35-40%.

Xenoliths of sedimentary rocks consist of limestone, dolomite limestone, dolomite with admixture of clay and sand, and marl and siltstone. The size of xenoliths ranges from fractions of a millimeter to 100 m. Most reseachers believe that the western body predated the eastern one. The bodies differ in the composition of their constituent kimberlite rocks.

Several independent phases of a kimberlite magma were emplaced in the western body. Kimberlite breccia in varous phases differ in the picroilmenite/pyrope ratio, morphological characteristics of diamonds, and chemical composition of the rocks. Late kimberlite phases occur at deeper pipe levels. Kimberlite breccias at deep levels are characterized by higher concentrations of pseudomorphs after olivine (15-30%), autoliths (up to 25%), and xenoliths of sedimentary rock (10-25%). The western body is strongly serpentinized throughout (to a depth of 1400 m). Concentration of fresh olivine relics is somewhat higher at levels deeper than 400 m. The amount of hydrothermal formations of geodes and veinlets of calcite, celestite, barite, and other minerals decreases with depth.

The pipe contains a large amount of xenoliths of the basement metamorphic rock. Their maximum concentration occurs in the central part of the body. Both bodies of Udachnaya pipe contain a high content of deep rock xenoliths. In the western body, upto 0.1-0.3%. Most common are undulose garnet serpentinite (apolherzolite) that range up to 57.1%. Less frequent are equigranular garnet serpentinite (31.1%), including apodunite, apoharzburgite, and apolherzolite.

The eastern body is unique with relatively abundant deep rock xenoliths (0.3-0.6%), their variety, and the presence of nodules. The xenoliths are irregularly distributed and tend to occur in central areas of the body. They include both small clasts and giant blocks weighing more than 100 kg. Morphology of diamonds crystals does not regularly change with depth. The deposit is large.

Origin and Tectonic Controls for Daldyn-Olenyok Metallogenic Belt

The tectonic environment for the origin of the belt is unknown. Devonian kimberlite pipes intrude mainly Cambrian to Silurian carbonate sedimentary rocks of North Asian Craton.

REFERENCES: Khar'kiv and others, 1997; Brakhfogel' and others, 1997; Parfenov and others, 1999, 2001.

Orulgan Metallogenic Belt of Sediment-Hosted Cu Deposits (Belt OR) (Russia, Northern Verkhoyansk fold and thrust belt)

This Late Devonian(?) to Early Carboniferous(?) metallogenic belt is hosted in clastic and carbonate sedimentary rock in the Verkhoyansk fold and thrust belt that constitutes a passive continental margin for the North Asian Craton Margin. The deposits are hosted in shallow marine rocks in the Late Devonian and Early Carboniferous Artygan and Agakukan Formations. The Artygan Formation consists of red calcareous siltstone and green sandstone with thin beds and lenses of Cu-bearing shale. Deposits occurs as disseminations of malachite, azurite, covellite, and chalcopyrite. The major deposit is at Aga-Kukan.

Aga-Kukan Sediment-hosted Cu Deposit

This deposit (Melnikov and Izrailev, 1975) consists of disseminated galena, sphalerite, and chalcopyrite that occurs in a layer in lower part of Early Carboniferous (Tournaisian) limestone of the Agakukan Formation that consists of limestone in the lower and upper parts separated by sandstone. Sulfide layer is 40 cm thick; host limestone is 20 m. thick. Limestone unconformably overlies cross-bedded, green sandstone and red siltstone that contains disseminated malachite, azurite, covellite, chalcopyrite, and Cu-hydrocarbonate films. Cu-bearing sandstone and shale contains up to 3% Cu. Sulfides are gently folded and extend along strike for long distances. To the north and south, the sulfide layers thins and grades into small (0.1x1.5 m) lenses. The deposit is small and grades up to 1-3% Cu, 0.15 ppm Au, 400 ppm Ag.

Origin and Tectonic Controls for Orulgan Metallogenic Belt

The belt is interpreted as forming during sedimentation during Devonian to Early Mississippian rifting along passive margin of the North Asian Craton. Belt hosted in shallow marine clastic and carbonate sedimentary rocks of the Artygan and Agakukan formations.

REFERENCES: Mel'nikov and Izrailev, 1975; Parfenov and others, 1999, 2001.

Botuobiya-Markha Metallogenic Belt of Diamond-Bearing Kimberlite Deposits (Belt Bot) (Russia, Central part of the Siberian platform)

This Devonian metallogenic belt is hosted in kimberlite intruding manly early Paleozoic carbonate sedimentary rock in the North Asian Craton. The belt extends 300 km in southwest-northeast trend and contains several diamond-bearing kimberlite pipes of Devonian age. The major deposits are the Mir and Internatsional'naya pipes that intrude Cambrian and Ordovician carbonate and clastic rocks. The Mir pipe was mined from the 1950's until recently. The major deposits are at Mir and Internatsional'naya pipes.

Internatsional'naya Diamond-Bearing Kimberlite Deposit

This deposit (Khar'kiv and others, 1997) consists of well-defined funnel shaped pipe in the upper part and changes at depth into an almost cylindrical diatreme with subvertical contacts. The size of the pipe is contstant to a depth of 1000 m. The pipe intrudes horizontal Early Ordovician and Cambrian clastic and carbonate rock and is overlain by Early Jurassic deposits that range from 2,200 to 9,200 m thick. A characteristic feature of the pipe rocks are sparse Ti minerals (picroilmenite, orange pyrope) and abundant Cr minerals (chrome spinel, chrome diopside, chrome pyrope). The deposit is large.

Mir Diamond-Bearing Kimberlite Deposit

This deposit (Khar'kiv and others,1997) consists of a pipe intruding Ordovician and Cambrian carbonate, terrigenous, and halogen-bearing rocks. The pipe is associated with two Late Devonian sills and a diabase dike. From the surface to a depth of 200 m, the pipe is funnel-shaped and at greater depth, down to 900 m, is cylindrical shaped. At greater depths, the pipe grades into a feeding dike. Diamond forms are octahedra (61.2%), rhombododecahedra (9.7%), combined habit crystals (28.8%), and cubes (0.6%). Most common colors are colourless (75.4%), brown (7.2%), bluish-green (0.6%), lilac (2%) and smoky-grey (13.9%). Secondary minerals are serpentine, carbonate, and chlorite comprise most of the kimberlite throughout the pipe. The deposit is large.

Origin and Tectonic Controls for Botuobiya-Markha Metallogenic Belt

The tectonic environment for the origin of the belt is unknown. Devonian kimberlite pipes intrude mostly Cambrian to Silurian carbonate sedimentary rocks of North Asian Craton.

REFERENCES: Khar'kiv and others, 1997; Brakhfogel' and others, 1997; Parfenov and others, 1999, 2001.

Sette-Daban metallogenic belt of Sediment-Hosted Cu, Basaltic Native Cu, REE (±Ta, Nb, Fe) Carbonatite, and Carbonate-Hosted Pb-Zn (Mississippi Valley type) Deposits (Belt SD) (Russia, Southern Verkhoyansk fold and thrust belt)

This Middle Devonian to Early Carboniferous metallogenic belt is hosted in Middle and Late Devonian to Early Carboniferous clastic and carbonate sedimentary rock, alkalic basalt lava and tuff, and coarse clastic rock of the Verkhoyansk fold and thrust belt of the North Asian Craton Margin. The belt occurs in the central part of the Southern Verkhoyansk fold and thrust belt in a thick (up to 10,000 m) Vendian to middle Paleozoic sequence. The metallogenic belt contains two districts, the Dzhalkan-Menkyule district to the north, and the Sakhara district to the south. The Dzhalkan-Menkyule district contains several deposits and occurrences of stratiform Cu deposits at Kurpandzha, Dzhalkan, Kemyus-Yuryakh, Segenyakh, and Allakh-Yun'. Cu deposits in sandstone and shale tend to occur at the top of the section of the carbonate and clastic rock unit along with Middle Devonian and Early Carboniferous trachybasalt sheets. The basalt lava flows contain native copper occurrences. In the Sakhara ore district Ta, Nb, REE, and apatite deposits occurs in alkalic ultramafic and carbonatite plutons that are interpreted as forming during Devonian rifting. A discontinuous chain (about 100 km long) of small plutons and dikes of alkalic ultramafic rock, carbonatite, and alkalic syenite intrudes early Paleozoic carbonate rock. Rb-Sr isotopic ages for the plutonic rocks range from 480 to 146 Ma. Most of the age determinations of carbonatite and alkalic syenite are Middle to Late Devonian and are supported by geological data. The major deposits are at Kurpandzha (sediment-hosted Cu), Dzhalkan and Rossomakha (basalt native copper), Gornoye Ozero, and Povorotnoye (REE (±Ta, Nb, Fe) carbonatite).

Dzhalkan Sediment-Hosted Cu Deposit

This deposit (Kutyrev and others, 1988) consists of disseminated Cu in Famennian basalt flows that are 180 m thick. The flows were erupted into a shallow marine to subaerial environment. Deposit occurs in horizons from 0.5 to 2.0 m thick in breccia and amygdaloidal basalt at the top of flows. Ore minerals are native copper and cuprite with lesser bornite, chalcocite, and chalcopyrite. Epidote and quartz wallrock alteration occurs locally. Deposits range from 0.3 to 1.0 m thick and up to 100 m long. Areas of Cu deposits are separated by unmineralized areas that range up to several kilometers wide. Host basalt are folded and fold limbs generally dip 40 to 60°. Average grade is 0.3 to 4.5% Cu.

Gornoye Ozero REE (±Ta, Nb, Fe) Carbonatite Deposit

This deposit (Samoilov, 1991; Entin and others, 1991; Tolstov and others, 1995) occurs in two carbonatite stages, early-and late. The early stage occurs in steep veins up to 25 m thick and to 150 m long. The veins are composed of augite, diopside, calcite, forsterite, calcite, and pyrochlore-betafite. Late stage consists of a small stock with an area of 1 km^2 that is composed of aegirine, dolomite, and ankerite along with bastnaesite, parisite, monazite, pyrochlore, and columbite. K-Ar isotopic ages range from 280 to 350 Ma. The stock is concentrically zoned and composed of 90% carbonatite along with pyroxenite, ijolite, and nepheline and alkalic syenite. The complex covers an area of 10.3 km^2. Age of deposits interpreted as probably 290 Ma. Depoist has no visible boundary is defined by concentrations of Nb_2O_5 and Ta_2O_5. The deposit is large with resources to a depth of 200 m of 5,423,000 tonnes of Nb_2O_5 (grading 0.10-0.12%), 246,500 tonnes Ta_2O_5 (grading 0.01-0.011%); 223,446,491 tonnes REE. Range of 2.04-5.38% P_2O_5 in carbonatite with average of 4%. Resources to a depth of 200 m are 24 million tonnes P_2O_5. Average grade is 0.35% REE oxides; 0.09 to 0.36% Nb_2O_5; 0.011% Ta_2O_5.

Segenyakh Carbonate-Hosted Pb-Zn (Mississippi Valley type) Deposit

This deposit (Kutyrev, 1984) consists of concordant horizons of disseminations, stringers, and bedded breccia of sphalerite and fluorite that are hosted in Late Silurian (Ludlovian) dolomite and limestone that is overlain by Prjidolian marl. Deposit horizons consist of dolomite, calcite, fluorite, sphalerite, and lesser galena, and common metasomatic quartz, microcline, hyalophane, and pyrite. Bedded breccia contains up to 20% sphalerite and 15% fluorite. Also occurring is cross-cutting breccia veins, that contain up to 70% fluorite and up to 8% sphalerite. The two known deposit horizons trend north-south for 10 km and dipping eastward from 40 to 60°. Distribution and concentration of sulfides is irregular.

Origin and Tectonic Controls for Sette-Daban Metallogenic Belt

The stratiform Cu deposits in the belt are interpreted as forming during Devonian rifting. The REE and apatite deposits hosted in alkalic ultramafic and carbonatite plutons are also interpreted as forming during Devonian rifting.

REFERENCES: Elyanov and Moralov, 1973; Arkhipov, 1979; Ioganson, 1988; Kutyrev and others, 1988; Entin and others, 1991; Parfenov and others, 1999, 2001.

Mamsko-Chuiskiy Metallogenic Belt of Muscovite Pegmatite Deposits (Belt MCh) (Russia, Northern Transbaikalia)

This Devonian to Early Carboniferous metallogenic belt is related to veins and dikes in the Mamsky and Konkudero-Mamakansky complexes (too small to show at 10 M scale) that intrudes the Chuja paragneiss terrane that is overlapped by the Patom fold and thrust belt of theNorth Asian Craton Margin. The belt occurs in the North Baikalian Highland near north end of Lake Baikal, extends northeastern for 375 km, and is 85 km wide. The Chuja paragneiss terrane forms part of the Baikal-Patom fold and thrust belt that occurs along a passive continental margin. The Chuja terrane consists of hypersthene-diopside-plagioclase-amphibole schist, gneiss, and amphibolite

(Braminsky Complex), plagiogneiss with horizons of quartzite, limestone, biotite-amphibole gneiss and amphibolite (Chuja Series), and biotite and biotite-amphibole gneiss, and cordierite, sillimanite-and andalusite schist. The two are dated as Archean (Neelov and Podkovyrov, 1983).

Occurring in this metallogenic belt are a large number of muscovite pegmatite deposits that are related to the final stages of intrusion of the alkaline granitoids of the middle Paleozoic Mamsky and middle Paleozoic to late Paleozoic Konkudero-Mamakan Complexes. The largest deposits (mica-bearing fields) are at Vitimsky, Lugovka, Bolshoe Severnoye, Komsomolskoye, Sogdiondon, and Chuysky. Part of the metallogenic belt is controlled by the northeastern zone of regional metamorphism and granitization. The commercial mica pegmatite bodies occur in local domes that contain widespread features of migmatization, granitization and pegmatite formation (Vasilieva, 1983). Both synkinematic and late synkinematic pegmatites are recognized (Velikoslavsky and others, 1963). The former formed in situ during folding and progressive metamorphism jointly with formation of metasomatic zones and mica. The latter pegmatite veins are related to retrogressive metamorphism and plastic deformations and are the most economic. The mica-bearing pegmatite contains plagioclase-microcline and plagioclase types that occur primarily in mica gneiss and clinopyroxene schist. The shape of bodies is most diverse and consists of veins, lenses, stocks, and pipes. Mica occurs in quartz-muscovite nests and is associated with beryl. In addition to muscovite, the belt is promising for granitoid-related Au vein deposits as at the Mukodek occurrence. The major deposits are at Vitimskoye, Lugovka, Kolotovka, Bolshoye Severnoye, Komsomolsko-Molodezhnoye, Sogdiondonskoye, and Chuyskoye.

Lugovka Muscovite Pegmatite Deposit

This deposit (Verkhozin and Kochnev, 1979; Kochnev,1966, 1968, 1971; Rudenk and others, 1980.) consists of two pegmatite fields and a series of veins that occur along a sublatitudinal tectonic zone and associated shear folds. Vein dimensions vary from small (920-50 x 1-5 m) to very large (200-500 x 10-30 m), at a depth of 115 m. The vein forms are concordant, plate-like, crosscutting, and pipe. Locally, the veins occur in clusters of extensive veins. Petrologic types are plagioclase-microcline pegmatite, quartz-muscovite and pegmatite, plagioclase pegmatite, and fractured biotite-muscovite (pegmatite). Host rocks are. Mesoproterozoic two mica gneiss and schist. Veins are associated with Mesoproterozoic to early Paleozoic granites. The deposit occurs in the central part of the Mamsky muscovite province. Twenty-two veins have been mined. Reserves are 150 kg/m^3 of large-scale muscovite with a raw muscovite content of 100-300 kg/m^3. The deposit is large and contains up 14% total mica in Mamsky mica-bearing province.

Sogdiondonskoye Muscovite pegmatite deposit

This deposit (Chesnokov, 1966; Tyurin, 1966, 1967; Galkin, 1969) consists of a series of veins (20-300 x 1-25 x 150 m) of various shapes with predominant cross-cutting veins and dikes controlled by sublatitudinal fractures zones and flexures. Deposit consists of plagioclase-microcline pegmatite and quartz-muscovite pegmatite. Host rock is Mesoproterozoic mica schist and gneiss, and Mesoproterozoic-early Paleozoic pegmatite-bearing granitoids. The deposit is controlled by the Chuya-Sludianka structural zone and occurs along intersection of fault with granite and migmatite dome in the northwest and central parts of the Mamsky muscovite province. The deposit contains rare large veins.

Origin and Tectonic Controls for Mamsko-Chuiskiy Metallogenic Belt

The belt is interpreted as forming during intrusion of alkaline granitoid of the Mamsky and Konkudero-Mamakansky Complexes into the Chuja paragneiss terrane that formed part of a passive margin. The host granitoids are interpreted as forming during post-accretionary magmatism in transpression zones related to transform micro plate boundaries and within plate (plume) environment.

REFERENCES: Velikoslavsky, 1963; Sryvtsev and others, 1980; Neelov and Podkovyrov, 1983; Vasilieva, 1983, Gusev and Khain, 1995; Ivanov and others, 1995; Makrygina and others, 1993; Bulgatov, 1999.

Synnyrskiy Metallogenic Belt of Magmatic and Metasomatic Apatite Deposits (Belt Sn) (Russia, Northern Transbaikalia)

This Devonian to Early Carboniferous metallogenic belt is related to replacements associated with the Synnyrsky alkaline magmatic complex in the Synnyrskyky plutonic belt (too small to show at 5 M scale) that intrudes the Baikal-Muya terrane and Barguzin-Vitim granitoid belt. The belt obliquely crosses the northern flank of the Baikal-Muya island arc terrane, the western wing of the Olokit accretionary wedge terrance, and extends beyond the southern Chuya paragneiss terrane. The belt occurs along the northwestern margin of the Vitim Highland (northeastern Lake Baikal), and forms anarrow linear zone (350 long and 30 to 55 km wide). The belt is controlled by the major Abchada fault. The deposits occur in metasomatically altered synnyrite. The apatite melanocratic metasomatite consists of pyroxene, biotite, and apatite with local orthoclase, nepheline, plagioclase, magnetite (sometimes to 10 to 20%), and sphene (Zak and others, 1969). Melanocratic metasomatite consist of faialite and micaceous shonkinite (Sharakshinov, 1974). The apatite zones range from 0.2 to 10 to 12 m wide and extend up to several hundred meters long, and apatite content ranges from 5 to 10% to 80% (Zhidkov, 1968; Panina, 1972). Apatite in metasomatic zones occurs in isolated lenses and nests. Reserves are low. Synnyrite plutons are economically important. with K, Al, and Fe that occur primarily in leucocratic metasomatite-aposynnyrites. The plutons have plan dimensions from 0.5 to 18 km^2. The average grades are are about 18.3% K_2O (reserves 123 million tonnes and resources 331 million tonnes), and 22.9% Al_2O_3 (152 and 414 million tonnes) (Andreev and Ushakov, 1995). The REE deposits (predominantly Ce and Ni) contain abundant disseminations of loparite, chevkinite, torite, eudialite, and zircon and occur in metasomatically altered nepheline syenite (albitite) and nepheline-syenite pegmatite as at the Burpalinsky pluton (Salop, 1967). The major deposit is at Synnyrskoye. The belt is promising for aluminiferous and potassium commodities and REE.

Synnyrskoye Magmatic and Metasomatic Apatite Deposit

This deposit (Arkhangelskaya, 1964) occurs in the Synnyrsky zoned massif of alkaline and nepheline syenite and in an associated large zone of metasomatite. The deposit consists of two types of apatite-rich areas. (1) one type of area is melanocratic metasomatite composed of combinations of ijolite, faiyialite, and micaceous shonkinites. Individual areas vary from a few cm to several hundred m wide. The second type of area is leucocratic, simplektite synnyrite metasomatite that ranges up to tens of m^2. The mirmektite structure of synnyrite consists of intergrowths of K-feldspar, kaliophilite, K nepheline, and biotite that replaces host rock. Apatite-rich areas in melanocratic metasomatites consist of pyroxene, biotite, and apatite with traces of orthoclase, nepheline, plagioclase, magnetite (locally up to 10-20%), and sphene. High-grade areas contains up to 80% apatite and low-grade areas contain about 5-10% apatite. Apatite-rich areas in synnyrite are manly apatite composition with orthoclase, biotite, pyroxene, and magnetite. Grade is 70-80% apatite. The deposit is interpreted as forming during rifting. The deposit is large with an average grade ranging from 5 to 10 to 80% apatite.

Origin and Tectonic Controls for Synnyrskiy Metallogenic Belt

The belt is interpreted as forming during formation of the middle Paleozoic North Baikal rift that contains an axial zone with ten concentrically-zoned plutons of alkaline and nepheline syenite in the Devonian and Early Carboniferous Synnyrsky complex. The North Baikal rift is interpreted as a post-collisional, extension structure that formed in continental crust. From west to east the major plutons are the Goudzhekit, Gorbyloksky, Akitsky, Burpalinsky, Synnyrsky, Yakshinsky, Monjukansky, Khorobsky, Gilindrinsky, and Ovsakovsky. The Synnyrsky pluton (with a plan view area of 570 km^2) occurs in the central part of the belt and is largest. The dimensions of plutons noticeably decrease to 0.25 km^2 on the flanks of alkaline belt, their composition is less alkaline, and to the northeast, the composition is primarily alkaline. The Synnyrsky belt contains intrusions in a structural-tectonic zone, has a unizue petrographic composition, similar type and age of deposits. Plutons occur at the junction of the axial zone of the rift with northwestern-striking transverse faults. The central parts of intrusions contain trachytoid alkaline syenite sequentially surrounded by zones of pseudoleucite syenite, allotriamorphic ditroite, and ditroite (Andreev, 1965; Andreev and Ushakov, 1995). Along the pluton contacts, host Cambrian carbonate and extrusive and sedimentary rock are altered to skarn and phenite. Numerous xenoliths of these rocks (often to 1 km in diameter) occur in the plutons. Synnyrite (ultrapotassic porphyry composed of pseudoleucite syenite, with up to 80 to 99% pseudoleucite) form linear to concentric bodies with plate shape in the fields of pseudoleucite syenite. In the Synnyrsky pluton, synnyrite bodies with diameters of 0.5 to 3.0 km extend for 40 km. The largest ones host deposits and occurrences as at Kalyminsky, Trekhglavoye, and Verkhneushmunsky. Within the Synnyrsky metallogenic belt, dolomite contains small Hg occurrences with cinnabar, barite, and metacinnabarite as at Monjukanskoye and Mamskoye (Znamirovsky and Malykh, 1974). These occurrence are along interblock faults in the Abchada tectonic zone.

REFERENCES: Andreev, 1965; Salop, 1967; Zhidkov, 1968; Zak and others, 1969; Panina, 1972; Sharakshinov, 1974; Znamirovsky and Malykh, 1974; Andreev and Ushakov, 1995.

Muiskiy Metallogenic Belt of Granitoid-Related Au Vein, Au in Shear Zone and Quartz Vein, Carbonate-Hosted Hg-Sb-Sb, and Porphyry Sn Deposits (Belt MS) (Russia, Northwestern Transbaikalia)

This Devonian to Early Carboniferous metallogenic belt occurs in the granitoid complexes of the Barguzin-Vitim granitoid belt that forms a major suture complex. The belt occurs in the central part of the Vitim Highland, extends northwest along Muysky Range that is a watershed for Lake Baikal and the Vitim River. The belt is about 250 km long and 75 km wide. The granitoid belt intrudes the Baikal-Muya island arc, Olokit-Delunurian accretionary wedge terranes, Aldan cratonal, and Muysky terranes. The metallogenic belt contains various large metalliferous and non-metalliferous deposits, and small occurrences of various deposit types. The belt occurs in in two large districts, the North Muysky and South Muysky districts that occur in the Muya terrane. The major deposits are at Irokindinskoye, Verkhne-Sakukanskoye, Mokhovoye, and Kelyanskoye. The belt is promising for undiscovered Au, Sn, and Hg deposits.

The granitoid-related Au Vein deposits are hosted in Archean and Proterozoic basement as at Irokindinskoye and Kedrovskoye. The characteristics of the deposits are: (1) occurrence of deposits in garnet-pyroxene, amphibole-pyroxene, and amphibole gneiss along the major Kelyano-Irokinda fault zone (Rubanov and others, 1970); (2) quartz-rich and sulfide-poor composition, with major sulfide minerals being pyrite, galena, sphalerite, pyrrhotite, and arsenopyrite; (3) sulfides comprising about 0.5 to 1.5%; and (4) abundant quartz vein generations (Dzasokhov, 1985); (5) occurrence of deposits along gently-dipping thrusts; (6) a close age of deposits; (7) vein shape of deposits; and (8) interblock position of veins.

The major Au in shear zone and quartz deposits are at Verkhne-Sakukansky and Yubileynoye (Zhilyaeva and Naumov, 2000), Irbinskoye and Vitimkonskoye and occur in Precambrian sulfide-bearing schist and amphibolite in the Olokit-Delunuran accretionary wedge terrane. The deposits occur in thick hydrothermal zones of diaphtorites that occur along along oblique-thrust-strike-slip faults. Common features are elevated Ag content, and occurrence of galena, pyrite, chalcopyrite, and sphalerite.

The carbonate-hosted Sb-Hg deposits are hosted in Vendian and Cambrian clastic and carbonate rocks and in Middle Carbonaceous jasperoid dolomite in the Yangudsky Suite (Berger and Murina, 1972; Znamerovsky and Malykh, 1974). The deposits consist of layered zones (to 300 m thick) of intense silica alteration, and brecciation that occur along thrusts (Obolensky, 1985). The deposits contain Au, Sb, pyrite, fluorite and potassic hydromica. Major deposits are at Kelyanskoye, Sosnovskoye, and Anomalnoye.

The porphyry Sn deposits occur in Paleoproterozoic to Mesoproterozoic granitoid that is hosted in tectonically reworked blocks containing hematite-magnetite-feldspar metasomatite (Mitrofanova, 1979) and cassiterite-sulfide deposits. Examples are the Mokhovoye deposit and occurrences at Korotkoye and Goltsovoye. In addition to chalcopyrite, bornite, pyrite, and arsenopyrite, also occurring are REE deposits with beryl and molybdenite.

Kelyanskoye Carbonate-Hosted Hg-Sb Deposit

This deposit (Kiselev, 1968; Demidova, 1976) consists of a series of steeply-dipping zones that occur along a major thrust fault that cuts Early Cambrian dolomite. The zones consist of layers and lenses with dimensions of 160-450 x 2.8-4.0 m. The extend for a few tens of kilometers and consist of of quartz dolomite breccia that is cemented by veins containing cinnabar. The vein minerals are quartz, calcite, and dolomite, and rare fluorite and barite. The ore minerals are cinnabar, antimonite, pyrite, galena, sphalerite, and chalcopyrite. Cinnabar is also disseminated in dolomites and in veins occurs irregularly Cinnabar nests occur in areas of disseminations, crossing zones, and fractures. The deposit is large with an average grade of 0.01-25.1% Hg, 0.1-0.78 Sb.

Irokindinskoye Au in Shear Zone and Quartz Vein Deposit

This deposit (Namolov, 1980; Rubanov, 1980; Dzasokhov, 1985; Dzasokhov, 1987; Shelkovnikov, written commun., 1986) consists of 36 varibly-oriented and gently-lying quartz veins that occur to a depth of 480 m. The average length is 150-180 m and thickness is 0.5-0.9 m. Veins contain about 0.2-0.5% sulfides that consist of pyrite (up to 78%), and galena (up to 15%), and sphalerite, chalcopyrite, pyrrhotite, arsenopyrite, hessite, argentite, and scheelite.Gangue minerals are quartz and carbonate (to 2-4% veins). Gold has high fineness and locally occurs nests that range to 1-5 mm thick. In veins gold locally occurs in pillars with dimensions of 50 400 x 10-60 m. The most productive veins cut garnet-pyroxene gneiss that is altered to quartz, pyrite, sericite, and chorite in a band that varies from 3-4 to 30-40 m wide. The deposit occurs within a tectonic block with an area 75 km^2 that consists of Paleoproterozoic gneiss, limestone, and amphibolites. The deposit occurs in the central part of the Archean-Proterozoic southern Muya terrane where cut by the submeridional, major Kilyaro-Irokindinsky fault. The deposit is medium size with an average grade of 0.7-133.8 ppm Au.

Mokhovoye Porphyry Sn Deposit

This deposit (Khrustalev and Yatsenko, 1977; Mitrofanova, 1979, 1981; Khrenov and others, 1983; Ignatovich, 1986; Skurskiy, 1996) consists of 23 lenses that range from 3-15 m thick and extend to 110 m depth. The lenses occur in pillars metasomatically altered cataclastic zones. The deposit assemblages are: (1) cassiterite-hematite; (2) magnetite-feldspar metasomatite with chalcopyrite and rare bornite, pyrite, and scheelite; (3) micaceous-hematite-quartz in low grade metasomatite (about 0.004% Sn); (4) arsenopyrite-carbonate-sericite in greisen; and (5) molybdenum with rare beryl in quartz vein. The first assemblage is more economically important and the second and third assemblages are secondary and occur along the edges of the deposit. The deposit occurs in a paleocaldera with surface dimensions of 30 x 50 km that consists of Riphean metavolcanic rocks, including basalt and rhyolite that are intercalated with with Vendian terrigenous calcareous sedimentary rock. The caldera is hosted in intensely deformed Mesoproterozoic granitoids that are alterted to K-feldspar and hematite. Metasomatism is most intense along northwest fracture zones, and less intense along northeast-trending zones. The deposit contains traces of Cu, Co, Zn, and Mn. The deposit is medium size with an average grade of 1.0-2.0% Sn, rarely to 8% Sn, up to 0.4% Cu.

Origin and Tectonic Controls for Muiskiy Metallogenic Belt

The belt is interpreted as forming in granitoids and veins in the Barguzin-Vitim granitoid belt that was generated during Riphean collision of Baikal-Muya terrane with Muysky terrane.

REFERENCES: Berger and Murina, 1972; Rubanov and others, 1970;Bulgatov, 1983; Dzasokhov, 1985; Dobretsov and others, 1989; Znamirovsky and Malykh, 1974; Mitrofanova, 1979; Mitrofanov and others, 1983; Obolensky, 1985; Rytsk, 1999; Zhulyaeva and Naumov, 2000.

Berdsko-Maisk Metallogenic Belt of Sedimentary Bauxite and Bauxite (karst type) Deposits (Belt Ber) (Salair Range, Russia, Eastern Siberia)

This Early Devonian metallogenic belt is hosted in the Khmelev back-arc basin and occurs in the northwestern Salair Range. The belt extends north-south for 100 km and ranges from 25 to 30 km wide. The bauxite occurs in the Eifelian reef clastic limestone (Sukharina, 1973; Kuznetsov, 1982; Sviridov and Roslyakov, 1998), is underlain by the Late Silurian limestone, and is bounded by metamorphosed Cambrian and Silurian sandstone and argillite. The deposit contains from one to five bauxite horizons that occur along disconformities. Average thickness of bauxite horizons is 1.5 to 2.5 m and thickness of interbedded limestone is 100 to 300 m. Bauxite horizons are grade omtp argillaceous shale and sandstone along strike and downdip. The major deposits are at Berdsko-Maiskoye and Oktyabrskoye 4.

Berdsko-Maiskoye Sedimentary Bauxite Deposit

This deposit (Sukharina, 1973; Kuznetsov, 1982) consists of bauxite horizons that occur at the boundary between Middle and Early Devonian limestone that is intruded by Paleozoic granitoid dikes. The bauxite horizon ranges up to 20 m thick. The deposits and host rocks are folded. Higher-grade ores occur in the central part of deposit. Both leptochlorite-diaspore and chlorite-diaspore assemblages occur. Leptochlorite-diaspore assemblage contains 61.2 to 63.4% Al_2O_3; 8.3 to 11.2% SiO_2; 2.2 to 2.4% TiO_2; 9% Fe_2O_3; 4.0 to 16.6% FeO. Chlorite-diaspore assemblage contains 45.3 to 51.0% Al_2O_3; 15.8 to 19.0% SiO_2; 0.7 to 1.8% TiO_2; 2.7 –17.0% Fe_2O_3. The deposit is medium size.

Oktyabrskoye 4 Bauxite (karst type) Deposit

This deposit (Ageenko, 1970; Kuznetsov, 1982; Roslyakov, Sviridov, 1998) consists of diaspore bauxite that occurs at the base of dark-grey Early Devonian (Emsian) limestone. The deposit has an irregular average thickness of 2 m. The deposit horizon morphology is a fundtion of surface irregularities in underlying Early Devonian (Praghian) limestone. The top of the horizon grades into overlying limestone. Along the strike and downdip, bauxite grades into shale and sandstone. The deposit consists of argillo-leptochlorite shale with minor diaspore (33.23% Al_2O_3); diaspore-chlorite bauxite (45.31% Al_2O_3;); diaspore-bauxite (53.44% Al_2O_3); and calcareous bauxite with diaspore (36.62% Al_2O_3). Diaspore-chlorite bauxite is dominant. Diaspore bauxite contains up to 0.36% sulfur. The deposit extends 600 m along the strike and to a depth of 250 m. The deposit is large with reserves of 1,090,000 tonnes grading 33.23-53.44% Al_2O_3.

Origin and Tectonic Controls for Berdsko-Maisk Metallogenic Belt

This belt is interpreted as forming in near-shore marine sedimentary rocks that were deposited in submarine basins (Sukharina, 1973; Kuznetsov, 1982). Host sedimentary rocks are Eifelian reef clastic limestone. Bauxite formed in a shallow reef environment. The interpreted source of alumina is neighbouring early Paleozoic blocks of alumosilicate rocks. During metamorphism, the primary ores recrystallized to leptochlorite, chloritoid, and diaspore. At the Obukhovskoye deposit, bauxite recrystallized to mica-corundum rock during intrusion of Permian granitoid (Kuznetsov, 1982). Formation of bauxite deposits is interpreted as occurring during development in a middle Paleozoic Khmelev back-arc basin that overlapped the Vendian-early Paleozoic Salair and Alambai terranes (N. Berzin, this study).

REFERENCES: Sukharina, 1973; Kuznetsov, 1982; Sviridov and Roslyakov, 1998; N. Berzin, this study

Salair Metallogenic Belt of Polymetallic (Pb, Zn, Cu) Metasomatic Volcanic-Hosted and Porphyry Cu-Mo (±Au, Ag) Deposits (Belt SL) (Russia, Eastern Siberia)

This Middle Devonian(?) to Early Carboniferous(?) metallogenic belt is hosted in porphyry intrusions and associated replacements that arerelated to the Altai volcanic-plutonic belt that overlies and intrudes the early Paleozoic Salair island arc terrane. The belt occurs on the northeastern side of the Salair Range along the tectonic boundary between Salair terrane and the Kuznetsk basin. The belt extends northwest, is about 75 km long, and is 2.5 km wide. The age of a deposit-related quartz-porphyry intrusion is interpreted age as Middle Devonian to Early Carboniferous. The polymetallic deposits are hosted in volcanogenic and volcanic and sedimentary rock of the Early to Middle Cambrian Pechorkinskaya Suite. Host rocks are underlain by Early Cambrian limestone, overlain by Middle Cambrian volcaniclastic rock, and are intruded by Cambrian subvolcanic diabase and dacite porphyries, and by small middle Paleozoic, Permian, and Triassic siliceous and mafic intrusions. Middle Devonian to Early Carboniferous rhyolite and dacite porphyry, Early Carboniferous gabbro and diabase and diabase porphyry, and Permian and Triassic diabase and diabase porphyry dike swarms are widespread in the metallogenic belt (Distanov, 1977; Lapukhov, 1966). The Cambrian sedimentary rock are deformed into isoclinal northwest-overturned folds and cut by lengthwise faults that contain fissure and schistose zones that host diabase porphyry dike swarms that controlled hydrothermal activity. Large deposits in the Salair district have been explored and mined. The large deposits of the Urskoye district are explored in detail. The major varities of deposits are: (1) barite-polymetallic

(Salair district); (2) pyrite-polymetallic (Urskoye district, Uskandinskoye deposit); and (3) porphyry Cu (Kamenushinskoye deposit). Numerous small Au placer deposits also occur.

Salairskoye Polymetallic (Pb, Zn, Cu) Metasomatic Volcanic-Hosted Deposit

This deposit (Distanov, 1964, 1977, 1983; Lapukhov, 1966; Sharov and others, 1998) occurs in the southeastern part of metallogenic belt and consists of massive, streaky, and disseminated barite-polymetallic metasomatite that is hosted in intensely schistose Early to Middle Cambrian volcanic rock. The deposit occurs in the Salair district in a large lens (4 by 1.5 km) of volcanogenic and subvolcanic porphyry that intrude Early Cambrian limestone. Deposits are hosted in rhyolite and dacite lava and tuff, porphyry, and argillaceous and carbonaceous shale. Stratified rocks are intruded by Devonian and Early Carboniferous rhyolite and dacite quartz porphyries that in the central and western parts of the district deep. Numerous of diabase porphyry dikes occur in the district. The deposits occur in steeply-dipping, sublongitudinal shear zones. The deposits consist of complex lenses with masses, streaks, and disseminations. The major deposits occur in quartz porphyry intrusions economic ores occur to a depth of 400 to 450 m. The ore minerals are barite and polymetallic sulfide with low Fe-sulfides. The main ore minerals are pyrite, sphalerite, galena, chalcopyrite, and fahl. Minerals are argentite, magnetite, and hematite. Gangue minerals are barite, quartz, carbonate, albite, sericite, chlorite, and rare fluorite. The deposits are mainly massive banded quartz, barite, and sulfide that grade into spots, bands, and disseminations. Zone of oxidation is 25 to 170 m deep. An age of Middle Devonian to Early Carboniferous is interpreted for the quartz porphyry intrusion. The deposit has been mined, is large and has reserves of 72,400 tonnes Pb, 545,700 tonnes Zn, 219 tonnes Ag, 2,812,000 tonnes BaSO4. Average grade of 0.13% Pb, 2.42% Zn, 8.5 g/t Ag, 11.22% BaSO4.

Kamenushinskoye Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit consists of bodies of disseminated and streaky-disseminated copper sulfides in shear zones in a dacite quartz-porphyry that intrudes tuff and tuff breccia. Host rocks are altered to silica, sericite, argillite, and propylite. Host and altered rock are cut by diabase and gabbro dikes that range from 0.5 to 45 m thick. The deposit dimensions are 100, by 300 by 500 m. The deposit contains some parallel and echelon-like lenses and ore layers that are concordant with host rocks and deip steeply. Individual deposit bodies extend from 40 to 420 m along strike. Ore minerals are pyrite and chalcopyrite and lesser tennantite, sphalerite, galena, pyrrhotite, and molybdenite. Gangue minerals are quartz and lesser chlorite, sericite, dolomite, calcite, ankerite, barite, and fluorite. A gossan occurs to 70-80 m depth. A weak zone of secondary enrichment slightly occurs, is 1-3 m thick, and consists of bornite, chalcocite, and covellite. The deposit is small with reserves of 110,000 tonnes Cu grading 1.71% Cu.

Origin and Tectonic Controls for Salair Metallogenic Belt

This belt is interpreted as forming along an active continental margin in which mafic dike swarms and small siliceous porphyries intruded. The belt occurs in a complicated nappe area that was deformed in several stages. The early Paleozoic Salair island arc was deformed and intruded in the middle Paleozoic during Hercynian development of an active continental margin that resulted in intrusion of mafic dike swarms and small and siliceous porphyry, and formation of deposits. These deposits include Au-barite-polymetallic deposits of the Salair district, pyrite-polymetallic deposits of the Urskoye district, and associated Au quartz deposits (Distanov, 1977; 1983). Strike-slip zones and transverse faults controlled distribution of deposits.

Two interpretations exist about the origin of the Salair metallogenic belt. (1) A relationship exists between ore deposition and Cambrian volcanism and a direct relation between ores and volcanic vents and subvolcanic quartz keratophyre intrusions (Distanov, 1964; 1983). And (2) the interpretation of this study that the majority of the deposits younger and are related to Middle Devonian to Early Carboniferous rhyolite and dacite quartz porphyry, and small gabbro and diabase and diabase intrusions that are controlled by the post-orogenic fissures and schistose zones (G.S. Labasin, G.L. Pospelov, E.G. Distanov, A.S. Lapukhov, written commun., 2000). The age the Salair metallogenic belt is interpreted as coeval with the Rudny Altai island arc and associated polymetallic metallogenic belt that occurs southwest (Distanov, 1983; Obolenskiy and others, 1999).

REFERENCES: Distanov, 1964; 1983; Lapukhov, 1966; Gladkov and others, 1969; Obolenskiy and others, 1999.

Kiya-Shaltyr Metallogenic Belt of Magmatic Nepheline Deposits (Belt Ksh) (Kuznetsk Alatau Mountains, Russia, Eastern Siberia)

This Middle Devonian metallogenic belt is related to intrusions in the South Siberan volcanic-plutonic belt and occurs in the northern part of Kuznetsk Alatau. The belt is isometric and and ranges up to 60 km wide. The belt is hosted in small alkaline nepheline gabbroid plutons that range from 1 to 3 to 10 km^2 in diameter, and are composed of urtite, ijolite, nepheline gabbro (teralite), nepheline monzonite, and nepheline syenite (Luchitskiy, 1959; Klushkina and others, 1963). The most abundant is nepheline syenite with locally up to 80% nepheline (juvite). Nepheline syenite is highly oversaturated in alumina and undersaturated in alkalie (commonly, Na prevails over K). The alkaline intrusives intrude mainly a Cambrian carbonate and volcanoclastic rocks. The magmatic nepheline deposits of the belt are main source of raw material for the Achinsk alumina plant in the Krasnoyarsk region. The major deposit is the large Kiya-Shaltyr deposit that has been mined since 1970 (Smirnov, 1974).

Kiya-Shaltyr Magmatic Nepheline Deposit

This deposit (Luchitskii, 1959; Klyushkina and others, 1963; Smirnov, 1974; Dancig, 1988) consists of a large urtite dike that occurs along the contact between alkaline gabbro and Cambrian carbonate, volcanic, and sedimentary rock. The alkaline gabbroid pluton is 2.1 km^2 in area. The urtite dike is 2.3 km long and 20 to 200 m wide. The deposit gradually pinches out downward. The urtite contain 75 to 90% nepheline and 10 to 25% titanaugite. The dike contains 27 to 27.5% Al_2O_3, 40 to 40.6% SiO_2, 4.5 to 5% Fe_2O_3, and 13 to 13.5% Na_2O+K_2O. The main sulfide is pyrrhotite with lesser chalcopyrite, pentlandite, pyrite, sphalerite, galena, arsenopyrite, cobaltite, niine, sperrylite, gersdorfite, native silver, and gold. The deposit has been mined since 1970. The deposit is large with an average grade of 27.75% Al_2O_3.

Origin and Tectonic Controls for Kiya-Shaltyr Metallogenic Belt

The belt is interpreted as forming during rift-related magmatism above a hot spot. A $^{87}Sr/^{86}Sr_o$ ratio of 0.7053 for gabbros and urtite of the Kiya-Shaltyr pluton indicates a deep-mantle origin (Alabin and Kalinin, 1999. The host nepheline plutons occur along major fault zones. Formation of alkaline gabbroid intrusives was companion by high-temperature metasomatism, including formation of fenitie and nepheline and subsequent albite alteration of primary magmatic and host rocks (Luchitskiy, 1959; Klushkina and others, 1969). Nepheline-bearing rocks intrude all pre-Devonian rocks and Early Devonian strata and are coeval with Early Devonian extrusive rock of the Bereshsk Suite in the Byskarsk Series. These igneous rocks exhibit a Rb-Sr isochron age of 383±39 Ma and a $^{87}Sr/^{86}Sr_o$ value of 0.7036 (Zubkov and others, 1990).

REFERENCES: Luchitskiy, 1959; Klushkina and others, 1963; Smirnov, 1974; Alabin, Kalinin, 1999; Zubkov and others, 1990.

Sorsk Metallogenic Belt of Porphyry Mo (±W, Bi), Polymetallic (Pb, Zn, Ag) Carbonate-Hosted Metasomatite, and Zn-Pb (±Ag, Cu) Skarn Deposits (Belt SO) (Kuznetsk Alatau Mountains, Eastern Siberia, Russia)

This Early and Middle Devonian metallogenic belt is hosted in granitoids and associated replacements related to the South Siberian volcanic-plutonic belt and occurs on the eastern slope of Kuznetsk Alatau Ridge. The belt extends sublongitudinally for about 200 km and ranges from 30 to 60 km wide. The belt is controlled by the north-northwest-striking major Kuznetsk-Altaisk fault and by northeast fractures. Porphyry Mo (±W, Bi) deposits are dominant. The largest deposit is the Sorskoye porphyry Mo (±W, Bi) deposit (Amshinskiy, Sotnikov, 1976; Pokalov, 1992, 1996) that has been discovered in 1937. The Agaskyrskoye and Ipchulskoye porphyry Mo (±W, Bi) deposits are also explored. These deposits are closely related to Devonian subalkalic porphyry stocks and dikes. The porphyry intrusions and related metasomatic rocks are hosted in older, early Paleozoic granitoid plutons and wall rocks. Skarn and polymetallic metasomatic deposits are hosted in Vendian and Cambrian carbonate shelf rocks along intrusive contacts of tgranitoid plutons. Other types of deposits are: (1) large porphyty Mo deposits at Sorskoye, Agaskyrskoye, and Ipchulskoye; (2) small Pb-Zn skarn deposit at Yulia Svintsovaya; (3) small polymetallic (Pb, Zn, Ag) carbonate-hosted metasomatite deposits at Karasuk and others; and (4) a small Ag-Sb vein deposit at Tibik.

Sorskoye Porphyry Mo (±W, Bi) Deposit

This deposit (Amshinskiy and Sotnikov, 1976; Pokalov, 1992; Sotnikov and others, 1993, 1995, 1998) consists of disseminations, streaks, and breccia that occur in intensely hydrothermally-altered gabbro and granitoid in the Cambrian and Ordovician Uibat pluton. The ore minerals are associated with numerous stocks and dikes of subalkalic granite porphyry. Host rocks extensively hydrothermally altered to K-feldsdpar, quartz-biotite-K-feldspar, albite, sericite, and silica. Mafic rock is altered to chlorite. Dissemination and streaks are the most economic, and consist of quartz-molybdenite veins and veinlets that range from less thian 1 cm to 0.5 to 1.0 m thick. The associated stockwork in the central part of deposit extends to a depth of about 1 km, and decreases along the flanks to 300 to 500 m. Stockwork ores consists of molybdenite, pyrite, chalcopyrite, bornite, quartz, feldspar, and sericite. Average grade is 0.04 to 0.7% Mo and 0.2 to 0.3% Cu. The rich Cu contents are typical for the central part of deposit. Cu decreases along theflanks, and Mo is relatively constant. At depth, Cu/Mo ratio decreases. Breccia ores also contains fluorite, galena, sphalerite, and fahl, and grade locally ranges from 0.5 to 1% Mo. $^{40}Ar/^{39}Ar$ isotopic age is 385 to 400 Ma. The deposit is large with an average grade of 0.04 to 0.07% Mo and 0.2 to 0.3% Cu.

Julia Svintsovaya Zn-Pb (±Ag, Cu) Skarn Deposit

This deposit (Bulynnikov, 1960; Levchenko, 1975) consists of Pb-Zn metasomatic layers and nests in the Cambrian limestone. Host limestone grades upward into intercalating limestone, shale, and tuff. Limestone is intruded by Devonian syenite, granosyenite, and granite. Garnet-diopside skarn occur along the intrusive contact and consists of layers,, veins, and pipes that are concordant to host limestone. The major ore minerals are galena, sphalerite, and pyrite, along with lesser chalcopyrite, pyrrhotite, tennantite, burnonite and molybdenite. Gangue minerals are siderite, quartz, ankerite, sericite, and calcite, and rare fluorite and barite. A well-defined oxidation zone occurs. Ores contain up to 1% Bi and up to 0.6 ppm Au. The deposit is small.

Karasuk Polymetallic (Pb, Zn, Ag) Carbonate-Hosted Metasomatite Deposit

This deposit (Bulynnikov, 1960; Levchenko, 1975) consists of Pb-Zn lenses and pipes in Cambrian limestone. The deposit occurs in a syncline formed in crystalline, microlaminated limestone interbedded with bituminous limestone and siltstone. Limestone is intruded by small granosyenite bodies surrounded by a wide zone of intrusive breccia. Quartz porphyry dikes cut the granosyenite. All intrusive rocks are interpreted as Devonian. The deposit occurs along the dike contact, and ranges from 0.4 to 0.8 m thick. The major ore minerals are galena, and sphalerite, pyrite, and minor minerals are arsenopyrite, chalcopyrite, tetrahedrite, and marcasite, and native Au. Gangue minerals are calcite, quartz, ankerite, siderite, chlorite, sericite, and adularia. Ore minerals occur in masses, layers, and disseminations. Wall rocks display sideritie, silica, and pyrite alteration. A weak oxidation zone occurs. The deposit has been mined and is small.

Tibik Ag-Sb Vein Deposit

This deposit (Amshinskiy and Sotnikov, 1976) consists of quartz veins and quartz zones that occur in propyliticaIly-altered Cambrian extrusive rock. Separate zones range from 50 to 800 m long and 1.5 to 12 m thick. Zones are irregularly saturated with quartz veins and veinlets. The veins do not persist along strike or at depth. Deposits in veins and zones consist of disseminations and nests of ore minerals. Ore minerals are stibinite, allemontite, pyrite, marcasite, chalcopyrite, berthierite, and realgar. The deposit is small.

Origin and Tectonic Controls for Sorsk Metallogenic Belt

The belt is interpreted as forming during Devonian subalkalic porphyry magmatism related to interplate rifting. Deposit-related porphyry intrusions intrude older, early Paleozoic granitoid plutons. Skarn and metasomatic polymetallic deposits are hosted in Vendian and Cambrian shallow-water marine carbonate rocks. The Devonian sedimentary and extrusive rock occurs in superimposed sedimentary basins and grabens. Volcanic rock consist of basalt, andesite, and trachyandesite porphyry, and tuffs along with rare dacite, rhyolite, and trachyte porphyry. K-Ar isotopic age is 396 Ma, a Rb-Sr isotopic age is 416 ±13 Ma, and the initial $^{87}Sr/^{86}Sr$ ratio is 0.7043 (Rikhvanov and others, 1987). Also occurring is Early to Middle Devonian granite and syenite intrusions along with widespread dikes. The K-Ar isotopic age for porphyry at the Sorskoye deposit and associated K-feldspar and albite metasomatite is 400 to 380 Ma (Sotnikov and others, 1996). Based on the initial $^{87}Sr/^{86}S$ ratio of 0.70460 (Sotnikov and others, 1999), a mantle source is interpreted for the Sorsk ore-magmatic system.

REFERENCES: Amshinskiy and Sotnikov, 1976; Rikhvanov and others, 1987; Pokalov, 1992, 1996; Sotnikov and others, 1993, 1995, 1996, 1998, 1999.

Teisk Metallogenic Belt of Fe Skarn, Volcanogenic-sedimentary Fe, and Mafic-Ultramafic Related Ti-Fe (±V) Deposits (Belt TE) (Kuznetsk Alatau Mountains, Eastern Siberia, Russia)

This Early Devonian metallogenic belt is related to plutonic rocks in the South Siberian volcanic-plutonic belt and occurs in the eastern part of Kuznetsk Alatau. The sickle-shaped belt is about 120 km long, ranges up to 50 km wide, and occurs at the intersection of geological structures of Kuznetsk Alatau and the Devonian Minusa basin. The structure of the metallogenic belt is complex and heterogeneous. The belt is hoted in: Neoproterozoic limestone and quartzite; Early to Middle Cambrian tuffaceous shale, and clastic and carbonate rocks; and Devonian trachyandesite, rhyolite, basalt, andesite extrusive rock, and sedimentary rock. Intrusive rocks are widespread in the Fe districts consist of early Paleozoic gabbro and granitoids, and Devonian gabbro and syenite and granosyenite (Polyakov, 1971). Fe skarn deposits occur along contact zones of gabbro and albitite and granosyenite intrusions (Dolgushin and others, 1979; Mazurov, 1985; Orlov, 1998). Mafic-ultramafic related Ti-Fe deposits occur in layered syenite, gabbro, and pyroxenite plutons (Kuznetsov and others, 1982) often are concentrically zoned. Main ore minerals are titanomagnetite and ilmenite, occur in mafic layers, and comprise up to 5.5 to 15 wt.% the rock. The major deposits are Fe-skarns at Teiskoye and Khaileolovskoye,and zoned mafic-ultramafic Fe-Ti deposits at Patynskoye and Kul-Taiga.

Teiskoye Fe Skarn Deposit

This deposit (Kalugin and others, 1981; Mazurov, 1985; Sinyzkov, 1988; Orlov, 1998) consists of magnesium-silicate skarn and occurs in pipes of explosive breccia in Early Cambrian dolomite and limestone. The deposits types are magnesium-silicate skarn, calc-silicate skarn, and aposkarn metasomatite. Magnesium-silicate skarn consists of forsterite, spinel, and composition. Calc-silicate skarn is younger, replaces magnetite skarn, and contains a complex mineral assemblage. The deposit forms a lens in plan view, extends more than 1,500 m along the strike, is 1,400 m deep, and about 300 m thick. Mineral assemblages are serpentine and magnetite (60%), carbonate and magnetite (25%), magnetite (5%), gematite and magnetite (8%), and carbonate, serpentine, phlogopite, and magnetite (2%). Ore minerals occur in masses, disseminations, breccia, rhythmic layers, and colloform masses. The principal ore mineral is magnetite with lesser hematite. From 1966 to 1977 total production was 39.2 million tonnes of ore, with an average grade of 28.8% Fe. The deposit is large with reserves of 136,400,000 tonnes grading 29.9% Fe.

Patynskoye Mafic-Ultramafic Related Ti-Fe (+V) Deposit

This deposit (Kuznetsov, 1982; Orlov, 1998) consists of titanomagnetite layers in the differentiated Patynsk gabbro pluton that intrudes and metamorphoses Proterozoic and Cambrian carbonaceous and volcanic rock. The pluton forms a lopolith that extends over 100 km^2. The pluton contains layers that are rich in pyroxene, amphibole, titanomagnetite, olivine, and titanaugite. In upper part of the pluton are twelve layers of titanomagnetite-gabbro. The layers vary from 1 to 100 m wide, extend for 100 m to 10 km along strike, and extend to a depth of 600 m. Titanomagnetite content in ranges from 5 to 20%. Ore minerals are mostly disseminated. Small lenses (100x10 cm) of massive ore also occur. Associated minerals are olivine, sphene, apatite, actinolite, biotite, hornblende, epidote, and chlorite. Gabbro contains of 2.5 to 12.8% Fe; 0.5 to 7.8% TiO_2; 0.01 to 0.12% V_2O_5. The deposit is large with an average grade of 2.5-12.8% Fe, 0.5-7.8% TiO_2.

Chilanskoye Volcanogenic-Sedimentary Fe Deposit

This deposit (Belous and Klyarovskiy, 1959; Levchenko, 1975) consists of hematite layers hosted in Eifelian and Givetian sedimentary, volcanic, and tuff. Low-grade layers contains about 27% Fe in a horizon up to 43 m thick. Horizon contains layers grading 30-48% Fe, 130-420 m long, and 4-10 m thick. The ore minerals are hematite, lepidocrocite, hydrogoethite, and limonite that formes a breccia cement. Hematite is concentrated in breccia zone that cuts Devonian host rock. Veinlets and nests of recrystallized, colloform hematite occur in fracture zones. A dense network of hematite veinslets occurs in overlapping sandstone and locally form a stockwork. The deposit is large with resources of 5,000,000 tonnes. Average grade is 27-48% Fe.

Origin and Tectonic Controls for Teisk Metallogenic Belt

This belt is interpreted as forming during interplate rifting associated with the South Minusa volcanic basin that is part of the South Siberian volcanic-plutonic belt. The deposit-related Early Devonian granosyenite plutons occur along marginal faults of Devonian basins. Two interpretations exist for the age of mafic-ultramafic intrusions hosting Fe-Ti deposits in the belt, either Ordovician and Silurian, or Early Devonian. K-Ar isotopic ages for syenite and diorite of the Malaya Kul-Taiga pluton are 411 and 438 Ma (Polyakov, 1971). Fe skarn deposits of the belt are polygenetic and polychronous. In the Teisk district that occurs along in the sublongitudinal major Teisk fault, Fe skarn deposits are related to Late Cambrian gabbro and granitoid, and Early Devonian granosyenite. Small plutons of Early Devonian granosyenite occur along the faults bounding Devonian basins and are associated with Devonian volcanic rock bordering the basins. Subvolcanic granite and syenite intrusions are interpreted as comagmatic with trachyandesite and rhyolite volcanic rock (Polyakov, 1971). Explosive breccia is widespread in Fe skarn districts. The final stage in formation of these deposits is related to the development of the South-Minusa rift volcanic basin. A K-Ar isotopic age for volcanic rock is 396 Ma, a Rb-Sr isotopic age is 416±3 Ma; the initial $^{87}Sr/^{86}Sr$ ratio is 0.7043 (Rikhvanov and others, 1987).

REFERENCES: Polyakov, 1971; Dolgushin and others, 1979; Rikhvanov and others, 1987;Mazurov, 1985; Orlov, 1998.

Chapsordag Metallogenic Belt of Barite Vein and Polymetallic Pb-Zn± Cu (±Ag, Au) Vein and Stockwork, and Carbonate-Hosted Fluorspar Deposits (Belt ChD) (Minusa Basin, Southern Siberia, Russia)

This Devonian metallogenic belt is related to granitoids in the South Siberian volcanic-plutonic belt and occurs in the southern Minusa Basin. Numerous occurrences and economic deposits are in the belt. Widespread host rocks are Devonian volcanic and sedimentary rock, and older, early Paleozoic metamorphic and intrusive rock. Barite veins, that extend up to 1 km, and ranges up to 1.5 m thick, occurs in both Devonian intrusive rock and in Devonian volcanic and sedimentary rock (Matrosov and Shaposhnikov, 1988). The most significant veins occur in intrusives and thick extrusive rocks. Barite is the most abundant vein mineral with lesser quartz and calcite. Some significant Cu sulfide deposits occur at deeper levels and are interpreted as the transitional to Bazik type, Cu-barite vein deposits (Levchenko, 1975). The Bazikskoye and Chapsordag barite deposits are partly mined.

Chapsordag Barite Vein Deposit

This deposit (Savel'ev, 1978) consists of about twenty barite veins in Devonian labradorite and augite porphyry that range from 30 to 1050 m long and 0.2 to 1.5 m thick. Ore minerals occur in masses and local breccia. Gangue minerals are quartz and calcite. Wall rocks adjacent to veins are slightly altered to argillite. The deposit is medium size with an average grade of 62 to 98% $BaSO_4$. The deposit is small.

Bazikskoye Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This Cu-rich deposit (Levchenko, 1975) consists of quartz-sulfide veins in Early Cambrian limestone. The veins occur in fault zones in Early Devonian sedimentary and volcanic rock and in porphyry dikes. Five bodies occur, are from 55 to 500 m long, range from about 3 to 5.5 m thick, and extend to a depth of 20 to 120 m. Ore minerals are bornite, chalcocite, chalcopyrite, and pyrite. Gangue mineral is carbonate that is more abundant in limestone host rock. The deposit is small.

Zhurskoye Carbonate-Hosted Fluorspar Deposit

This deposit (Kachalo and Vasil'ev, 1976) consists of two conformable lenses of fluorite bodies in the lower part of Tournaisian limestone age. The lenses extend 350 and 370 m along the strike, are 0.2-0.4 m thick, and pinchout rapidly at depth. Lenses contain from 5-10 to 85% fluorite. The deposit is medium size with reserves of 3,100 tonnes CaF_2 grading 76-85% CaF_2.

Origin and Tectonic Controls for Chapsordag Metallogenic Belt

The belt interpreted as forming during hydrothermal activity related to rift-related magmatism that formed that the South Siberian volcanic-plutonic belt (Savel'ev, 1978; Zonenshain and others, 1990). Local remobilization of stratiform barite deposits may have occurred during hydrothermal activity.

REFERENCES: Levchenko, 1975; Savel'ev, 1978; Matrosov and Shaposhnikov, 1988; Zonenshain and others, 1990.

Agulsk Metallogenic Belt of Porphyry Cu-Mo (±Au, Ag) Deposits (Belt AG) (Eastern Sayan, Southern Siberia, Russia)

This Early and Middle Devonian metallogenic belt is related to granitoids in the South Siberian volcanic-plutonic belt and occurs in the northwestern and northeastern Derba terrane. The belt contains two districts of porphyry Cu-Mo (±Au, Ag) deposits. Deposits consisting of streaks and disseminations are spatially related to the small stocks of Devonian granitoids that intrude older, early Paleozoic granitoids, Cambrian and Devonian volcanic and sedimentary rock (Petrov and Mkrtychan, 1976). Leucogranite, alaskite, and leucogranite granosyenite comprise most of the Devonian intrusives (Shneider and others, 1969; Matrosov and Shaposhnikov, 1988). Deposits occur in zones of K-feldspar, ilica, and sericite alteration. Deposits are large and low grade. Mo the main metal in most deposits and occurrences whereas only a few Cu occurrences exist as at Kuzhebazskoye. Molybdenum deposits are associated with low-grade Au and W scheelite deposits. Small occurrences of molybdenite, scheelite, and chalcopyrite, and galena and sphalerite also ocurr in the belt. Sparse Mo deposits are associated in early Paleozoic Fe deposits (Dymkin and others, 1975). The large Agulskoye Cu-Mo and medium-size Djotskoye deposit are major deposits in the belt.

Agulskoye Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Petrov and Mkrtychan, 1976) consists of a Cu-Mo stockwork hosted in Proterozoic schist and gneiss intruded by a Paleozoic granitoid stock. The host rocks are altered to K-feldspar, silica, and sericite. A hydrothermal alteration zone contains some intensely brecciated and silicified areas. Ore minerals are molybdenite, chalcopyrite, pyrite, sphalerite, pyrrhotite, magnetite, abd scheelite. Gangue minerals are quartz, feldspar, sericite, and carbonate. The deposit is large with an average grade of 0.07% Mo.

Dzhetskoye Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Petrov and Mkrtychan, 1976) consists of a quartz-molybdenite stockwork hosted in Neoproterozoic sandstone and shale that are intruded by small stocks of early Paleozoic granite and granodiorite. The deposit occurs both in granitoid and in adjacent host rocks. Wall rocks are altered to K-feldspar, silica, and sericite. Ore minerals are molybdenite, pyrite, pyrrhotite, scheelite, chalcopyrite, sphalerite,and magnetite. Gangue minerals are quartz, feldspar, sericite, and carbonate. Grade varies from 0.02 to 0.16% Mo. Two areas with an average grade of 0.069% Mo and 0.032% WO_3 occur. The deposit is medium size with an average grade of 0.069% Mo and 0.032% WO_3.

Origin and Tectonic Controls for Agulsk Metallogenic Belt

The belt interpreted as forming during rift-related granitoid magmatism of South Siberian volcanic-plutonic belt. The deposit-hosting granitoids occur in Devonian basins near the major East-Sayanian and Principal Sayanian faults. The intrusives are associated with an Early Devonian a basalt, andesite, and rhyolite volcanic complex (Matrosov and Shaposhnikov, 1988). K-Ar isotopic ages of biotite granite associated with the Irbinskoye Fe-skarn deposit are 398 to 418 Ma (Dymkin and others, 1975). The geologic, genetic, and geochemical features of the Mo-Cu deposits of the Agulsk metallogenic belt are similar to those of the the Sorsk metallogenic belt and contained Sorsk porphyry Cu-Mo (±Au, Ag) deposit that is related to Devonian porphyry and volcanic magmatism with $^{40}Ar/^{39}Ar$ isotopic ages of 400 to 380 Ma (Sotnikov and others, 1996).

REFERENCES: Shneider and others, 1969; Dymkin and others, 1975; Petrov and Mkrtychan, 1976; Matrosov, Shaposhnikov, 1988; Sotnikov and others, 1996.

Kizhi-Khem Metallogenic Belt of W-Mo-Be Greisen, Stockwork, and Quartz Vein, Porphyry Cu-Mo (±Au, Ag), Porphyry Mo (±W, Bi) (±W, Bi), Ta-Nb-REE Alkaline Metasomatite, and Granitoid-Related Au Vein Deposits (Belt KZ) (northeast Tuva, Southern Siberia, Russia)

This Devonian through Pennsylvanian metallogenic belt is related to replacements and granitoids in the South-Siberian volcanic-plutonic belt that overlies and intrudes the Khamsara island-arc terrane. The belt occurs in northeast Tuva and extends from east-west for about 300 km and ranges from 40 to 60 km wide. The metallogenic belt occurs in the Ordovician through Carboniferou Kandat granitoid belt that extends latitudinally along the major Kandat fault for more than 500 km. The granitoids intrude mainly Vendian and Early Cambrian basalt, andesite, and dacite and Devonian volcanic and sedimentary rock. Porphyry Cu-Mo (±Au, Ag) and porphyry Mo (±W, Bi) deposits occurring in the eastern part of the metallogenic belt, often along margins of Devonian basins. The host porphyry complexes consist of stocks of diorite, tonalite, and plagiogranite, and dikes of diorite and tonalite porphyry, and granodiorite porphyry (Popov and others, 1988; Dobryanskiy and others, 1992). The deposits consists of streaks and disseminations in both Early Devonian porphyry stocks and granitoids. W-Mo-Be greisen, stockwork, and quartz vein deposits are related to small subalkalic leucogranite stocks and dikes (Danilin, 1968) and occur mainly in exocontact zones. The Okunevskoye deposit with the rare leucophane mineral is part of this group. More significant is the Aksug porphyry Cu-Mo (±Au, Ag) deposit. The Aryskanskoye Ta-Nb-REE alkaline metasomatite deposit also occurs in the metallogenic belt, but is older with a recently-determined Late Ordovician isotopic age (454.6±1.4 Ma) (Kosticyn and others, 1998).

Aksug Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Popov and others, 1988; Dobrjanskiy and others, 1992; Sotnikov and Berzina, 1993, 2000) consists of a stockwork with streaks and disseminations of Cu-Mo minerals in intensely-sheeted and hydrothermally-altered Early Cambrian volcanic rock that is intruded by the Aksug stock. The stock varies from gabbro and diorite in periphyry to granodiorite and granite porphyry in the core. The dominant rocks are tonalite and Na-rich plagiogranite. Deposis occurs in outer zone of the porphyry intrusive around the quartz core. Two circular deposits occur. Host rocks are altered to K-feldspar, silicia and propylite. Cu deposits occurs in hydrothermally alteration of quartz and sericite. Locally, Mo occurs in quartz-K-feldspar metasomatite. The ore minerals are chalcopyrite, pyrite, bornite, molybdenite, fahl, enargite, and magnetite. The deposit is medium size with an average grade of 0.5 to 1.0% Cu and 0.02% Mo.

Dashkhemskoye Porphyry Mo (±W, Bi) (±W, Bi) Deposit

This deposit (V.I. Sotnikov, this study) consists of a Mo stockwork hosted in early Paleozoic silicified biotite granodiorite. Porphyry dikes occur in the district. The deposit occurs in seven areas that range from 1 to10 m wide and up to 30 m long. The total area of Mo deposits is 400 m^2. Deposits consist of quartz-sulfide veins, veinlets (up to 1 cm thick), and fine molybdenite disseminations. Also occurring is pyrite. Grade ranges up to 0.3 to 0.4% Mo. The deposit is small.

Okunevskoye W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This Be and fluorite deposit (Kachalo and others, 1976a, b; Serdyuk and others, 1998) consists of masses and lenses of fluorite-altered rock with beryl in the exocontact zone of the alkalic Seibinsk granitoid pluton. The steeply dipping intrusive extends northeast for 2.5 km and is altered to albite and fluorite. Host rocks are marble, chert, and metamorphosed extrusive rock that locally are altered to skarn. Both host rocks and granite are altered to fluorite in the exocontact zone. Beryl deposits are closely associated with fluorite that contain leucophane and danalite. Deposits range from 1 to 3 m thick and extend along strike up to tens of meters. The deposit is small, has fluorite resources of 800,000 tonnes with an average grade of 30% fluorite.

Aryskanskoye 1 Ta-Nb-REE Alkaline Metasomatite Deposit

This deposit (Kudrin and Kudrina, 1959) of albite metasomatite with zircon (malacon) and Ti-Ta-Nb minerals that occur along a northwest-striking fault zone in the apical part of a middle Paleozoic granitoid massif. The deposit is 375 m long, varies from 15 to 70 m thick, and increases to 110 m thick at a depth 250 m. Albite formed during intrusion of aegirine-riebeckite granite and granosyenite with an isotopic age of 390-400 Ma. Three stages of formation of albite metasomatite are recognized. The first stage is albite-zircon (malacon) metasomatic veins with riebeckite. The second stage is priorite, and fergusonite that are closely associated with albitite metasomatite. The largest vein is 170 m long and 0.45 m thick. And the third stage is quartz veinlets with ilmenite, sulfides, native As, Ta-Nb minerals, and thorite. Ore minerals are priorite, fergusonite, pyrochlore, zircon (malacon), thorite, gadolinite, astrophyllite, xenotime, apatite, gagarinite, fluorite, bastnaesite, native As. The deposit is small with an average grade of 0.2-0.5% REE.

Origin and Tectonic Controls for Kizhi-Khem Metallogenic Belt

This belt is interpreted as forming during granitoid magmatism associated with the South Siberian volcanic plutonic belt. Deposit-related plutons intrude Early Cambrian volcanic rock of the Khamsara island-arc terrane and early Paleozoic granite of Tannuola plutonic belt. The belt contains a broad variety of deposits that formed over a long time. The belt occurs along the major Kandatsk fault mainly in a large, early Paleozoic granitoid pluton that intrudes Vendian and Early Cambrian basalt of the Tuva ensimatic island arc, and is overlapped by Early Devonian extrusive rock that forms part of the continental margin South-Siberian volcanic-plutonic belt (Berzin and Kungurtsev, 1996). The formation of deposit-hosting granitoid complexes is followed by rift magmatism that formed trachybasalt and trachyrhyolite volcanic rock and subalkalic-leucogranite intrusions. The deposit-hosting porphyry intrusions structurally occur along edges of grabens that contain Early to Middle Devonian red-bed molasse. The $^{40}Ar/^{39}Ar$ isotopic age for the Aksug porphyry Cu-Mo (±Au, Ag) deposit is 400 to 380 Ma. Alaskite and alkalic granite hosting W-Mo-Be deposits cut the Silurian and Devonian granite and have a K-Ar isotopic age of 305 to 280 Ma (Danilin, 1968).

REFERENCES: Danilin, 1968; Popov and others, 1988; Dobryanskiy and others, 1992; Berzin and Kungurtsev, 1996; Kosticyn and others, 1998.

Rudny Altai Metallogenic Belt of Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) and Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Deposits (Belt RA) (South-Russia, Eastern Siberia).

This Middle to Late Devonian metallogenic belt occurs in volcanic and sedimentary rocks of the Rudny Altai island arc terrane that is interpreted as forming on the sialic basement of the Ordovician and Silurian passive continental margin of the Siberian paleocontinent (Rotarash and others, 1982; Berzin and Kungurtsev, 1996; Distanov and Gaskov, 1999). The belt extends southeast-northwest for about 500 km and ranges up to 100 km wide. The belt contains about 50 economic deposits, 20 of which occur in the northwestern belt in Russia. Most of the base-metal deposits are hosted in Devonian volcanic and sedimentary rock, including basalt and rhyolite, and siliceous and clastic rock. Siliceous volcanic rock prevails. Subvolcanic porphyry intrusions, diabase porphyry (Devonian and Early Carboniferous), gabbro and diabase, and granitoid intrusions of various ages (Middle Devonian, Carboniferous, Permian, and Early Triassic) are widespread. Two principal mineral types of base-metal deposits are occur: (1) pyrite and polymetallic sulfide (Korbalichinskoye, Stepnoye, Talovskoye, Rubtsovskoye, Zakharovskoye, Jubileinoye and others); and (2) Au, Ag, barite, and polymetallic sulfide (Zarechenskoye, Zmeinogorskoye). The deposits occur in the Zmeinogorsk, Korbalihinskoye, Zolotushinsk, and Rubtsovsk districts.

Korbalihinskoye Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposit

This deposit (Chekalin, 1985; Gaskov and others, 1991; Sharov and others, 1998) consists of lenses of pyrite and polymetallic sulfides that are hosted in Middle to Late Devonian volcanic and sedimentary rock. Host rocks are mainly basalt, and rhyolite, siltstone, and sandstone. Numerous subvolcanic quartz porphyry, amigdaloidal diabase porphyry, and gabbro and diabase dikes occur. The deposit occur in conformable lenses and ribbons, extend for 1000 m along strike, and to a depth of 750 m. Six zones contain 90% total reserves. Mineral zonation occurs with: (1) small barite and polymetallic sufides occurring in the hanging wall; (2) massive pyrite and polymetallic sulfides in a central part; and (3) Cu-sulfide pyrite occurring in the footwall. Host rock is exhibits chlorite, carbonate, talc, and sericite alteration. Main ore minerals are pyrite, sphalerite, galena, and chalcopyrite with lesser marcasite, fahl, and hematite. Gangue minerals are quartz, calcite, barite, and chlorite. Ore minerals occur in masses, breccias, disseminations, and layers. The Pb:Cu:Zn ratio is 1:0.6:3.6. Admixture elements are Au, Ag, Cd, Se, Te, Bi, Ga, In, Ta, and Ge. The deposit is large with reserves of 497,800 tonnes Pb, 2,403,200 tonnes Zn, 360,100 tonnes Cu, 1,360 tonnes Ag. Average grades are 2.01% Pb; 9.8% Zn; 1.46% Cu and 54.2 g/t Ag.

Zarechenskoye Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposit

This deposit (Kuznetsov, 1982; Gaskov and others, 1991; Sharov and others, 1998) consists of lenses and stockwork with masses, streaks, and disseminations of barite and sulfides that are hosted in Eifelian volcanic and sedimentary rock. The deposit occurs in a narrow basin zone steeply dipping bedding. The bordering sublatitudinal fault zones control subvolcanic quartz albitophyre, and gabbro and diabase dikes that range from 0.5 to 5 m thick. The host rock for the deposit is an argillite horizon that ranges from 50 to 80 m thick and is underlain by felsic tuff. The main deposit occur along the contact between shale and limestone. The deposit extends more than 1 km along strike and ranges from 30 to 100 m wide. Individual lenses in the deposit are 40 to 180 m long, 1 to 1.5 m thick, and extend to a depth of 30 to 200 m. The ore mineral assemblages are barite, Au-Ag minerals and barite, and barite and polymemetallic sulfides. Barite occurs in the hanging wall of the large lenses of barite and polymetallic sulfides. Commonly, massive sulfides in the hanging wall. Streaks and dissemination occur in breccia in fissuires in the footwall. Wall-rock exhibits silica, chlorite, hematite, and pyrite hydrothermal alteration. Altered rocks generally occur in the footwall. Main ore minerals are sphalerite, galena, fahl, chalcopyrite, bornite, chalcocite, native Au and Ag, electrum, argentite, silvanite, stromeyerite, jalpaite, pyrite, marcasite, and hematite. Gangue minerals are barite, quartz, calcite, dolomite, chlorite, and sericite. Ore minerals occur in masses, nests, breccia, streaks, and disseminations. The Cu:Pb:Zn ratio is 1:3.3:4.6. The deposit is mined, is medium size, and has reserves of 11,2900 tonnes Pb, 44200 tonnes Zn, 10,000 tonnes Cu, 650,000 tonnes $BaSO_4$, and 432 tonnes Ag. Average grades are 2.89% Pb, 3.91% Zn, 0.89% Cu, 46.4% $BaSO_4$, and 343 g/t Ag.

Origin and Tectonic Controls for Rudny Altai Metallogenic Belt

The belt is interpreted as forming in the Rudny Altai island arc in shallow marine volcanic rock on a shelf. Regularities in distribution of deposits and districts reveal a genetic relation between pyrite and polymetallic sulfide deposits and Devonian volcanism, and formation in volcanic centers wit bimodal basalt and rhyolite with (Shcherba and others, 1984; Gaskov and others, 1991; Distanov, Gaskov, 1999). The position of major volcanic centers is controlled by sublatitudinal-striking transform faults as at the Orlovsk-Karaguzhikha, Alei-Tigirek, and Varshavskiy deposits. The main ore districts, as at Zmeinogorskiy, Zolotushinskiy, and Rubtsovskiy, are associated with the largest volcanic structures. In each district, deposits occurs at two or three startigraphic levels and are related to the final stage of volcanic activity. Metasomatic ore deposition and filling of cavities of weakly lithified sedimentary rock occurred. The deposits with Au, Ag, barite, and polymetallic sulfides formed early, essentially siliceous volcanism in the Eifelian and Jivetian. The widespread pyrite and polymetallic sulfides are hosted mainly in Jivetian and Frasnian rhyolite, dacite, basalt, and andesite volcanism.

REFERENCES: Rotarash and others, 1982; Shcherba and others, 1984; Gaskov and others, 1991; Berzin and Kungurtsev, 1996; Distanov and Gaskov, 1999.

Korgon-Kholzun Metallogenic Belt of Volcanogenic-Sedimentary Fe, Fe Skarn, Mafic-Ultramafic Related Ti-Fe (+V), and Polymetallic (Pb, Zn, Ag) Carbonate-Hosted Metasomatite Deposits (Belt KKh) (Gorny Altai, Russia, Eastern Siberia)

This Devonian to Carboniferous metallogenic belt is related to the Altai volcanic-plutonic belt that overlaps and intrudes the Altai and Charysh continental margin turbidite terranes. The belt occurs in the northwest part of Gorny Altai and is related to a Hercynian volcanic-plutonic belt that formed along an active continental margin. The host Devonian volcanic and sedimentary rock and intrusions overlap the Altai and Charysh terranes. The belt extends northwest for 275 km and ranges 60 to 70 km wide. The major Charysh-Terekta fault zone forms the northeast boundary of the belt. The southwest boundary of the belt is the Northeastern shear zone that contains a group of Permian through Jurassic granite intrusions (Vladimirov and others, 1997; Gaskov and others, 1999). Volcanogenic-sedimentary Fe-deposits, as at Kholzunskoye, Inskoye, and Beloretskoye, and associated Mn and polymetallic vein deposits are dominant in the belt. Small metasomatic Ag and polymetallic sulfide occurrences are hosted in Silurian carbonate and clastic rock (Charyshskoye). Low-sulfide Au quartz occurrences are hosted in skarn, and the large Kharlovskoye Fe-Ti deposit is hosted in a stratified gabbroid pluton in the northern part of the belt (Charysh-Inskaya).

Kholzunskoye Volcanogenic-Sedimentary Fe Deposit

The deposit is the largest in metallogenic belt (Popov, 1967; Kalugin, 1976; Kalugin, 1985; Orlov, 1988) and consists of layered volcanogenic-sedimentary magnetite hosted in intensely deformed Middle Devonian rock. Host rocks are limestone and tuff, dacite, and interbedded trachydacite porphyry and quartz albitophyre. The deposit ranges from 300 to 600 m thick and extends for 25 km. Devonian host rocks are intruded by aPermian biotite granite pluton in the southwest part of the deposit. Host rocks contact metamorphosed to quartz-muscovite-feldspar hornfels adjacent to the intrusive. Individual masses occur from 0.5 to 1 km from granite massive. Pegmatoid granite dikes of cut the magnetite ore. The ore horizon consists closely-spaced layers and lenses. Individual masses extend more than 700 m along strike and depth, and range up to 70 to 100 m thick. The ore minerals alternate with schistose and recrystallized sedimentary and volcanic rock. Ore minerals occur in plications, layers, lenses, and in rare streaks and nests. Ore minerals are hydrosilicate-magnetite with high grade of apatite (prevale), actinolite, biotite, carbonate, and sulfides. Secondary minerals are: epidote, quartz, dolomite, zeolite, anhydrite, barite, pyrite, and chalcopyrite. The deposit is high silica and low Mg. Extensive superimposed metasomatism modified stratiform Fe layers and host rocks. The deposit is large with reserves of 600,000,000 tonnes grading 29.7% Fe. Average grades are 0.10% V_2O_5, 1.77-3.49% S, 0.25-0.34% P_2O_5.

Inskoye Fe Skarn Deposit

This deposit (Chekalin and Polovnikova, 1997; Orlov, 1998) consists of magntite layers hosted in an Eifelian volcanic and sedimentary sequence. The host rocks are intruded by the Permian of Tigerek granitoid pluton. Along the contact with the granitoid, host rocks are recrystallized to hornfels and skarn. The deposit occurs in an economic deposit that extends for 4.7 km long and ranges from 100 to 400 m wide. The district contain four main deposits that each range from 180 to 1000 m long, extend from 150 to 640 m deep, and have an average thickness of 8 to 40 m. Ore minerals occur in masses and bands, and rarely in disseminations, spots, breccias, and streaks. The main ore assemblage is amphibole, pyroxene, and magnetite ore. Locally occurring are garnet, chlorite, epidote, carbonate, quartz, and scapolite. Associated ore minerals are pyrite, pyrrhotite, minor chalcopyrite, and sphalerite. Genesis of deposit is discussed. One interpretation is formation during volcanism and sedimentation with subsequent regional and contact metamorphism (Kalugin, 1985). Another interpretation is formation during contact-metasomatism. The deposit is large with reserves of 250,000,000 tonnes and an average grade of 45.2% Fe, and 0.06% P_2O_5.

Kharlovskoye Mafic-Ultramafic Related Ti-Fe (+V) Deposit

This deposit (Shabalin, 1976, 1982; Kalugin and others, 1981; Kuznetsov, 1982) consists of layers of titanomagnetite in a gabbroic lopolith pluton that covers about 10 km^2 (Shokalskiy, 1990). The pluton contains alternating melanocratic olivine gabbro, and non-mineralized leucocratic gabbro, norite, and anorthosite. Thickness of igneous layers ranges up to several tens of meters thick. Ten ore layers occur, range from 425 to 3700 m long, extend to a depth of 225 to 2250 m, and are 16 to 140 m thick. Ore minerals are rarely disseminated. The main ore minerals are: titanomagnetite (23 to 31%), ilmenite (1.5 to 5.2%), olivine (1.6 to 31.5%), pyroxene (18 to 25%), plagioclase(14 to 28%), and calcite (up to 0.9%). Lesser minerals are serpentine, garnet, biotite, chlorite, apatite, hornblende,and epidote. Ores exhibit high V (0.08% V). The deposit is large with reserves of 1,700,000,000 tonnes and resources of 4 000,000,000 tonnes. Average grade is 15.3% Fe and 5.9% TiO_2.

Origin and Tectonic Controls for Korgon-Kholzum Metallogenic Belt

The belt is interpreted as forming along an active Hercynian-age continental margin arc in the northwestern Gorny Altai during the Devonian and Carboniferous. The volcanic-plutonic belt had features similar to a cordillera type active continental margin (Kovalev, 1978). The belt contains widespread subalkalic basalt, andesite, and rhyolite sequence with siliceous volcanic rock being the most abundant. Subaeral and shallow water volcanic and sedimentary rock is typical. Metallogeny related to volcanism and formation of Fe deposits (Popov, 1967; Kalugin, 1985; Gaskov and others, 1999). The main Fe deposits formed nearly tectonic sutures, as at Kholzunskoye and Timofeevskoye. Some large deposits (Inskoye, Beloretskoye) were later metasomatized during intrusion of collisional granitoids. The belt contains numerous small volcanogenic-sedimentary deposits (Korgonskoye, Kedrovskoye), magmatic-related deposits, and hydrothermal occurrences. Many deposits are Mn rich. Geodynamically, the Charysh terrane is interpreted as a fragment of an Ordovician and Silurian passive continental margin that was weakly reactivated during the Devonian with formation of interfault basins and minor volcanism. The Eifelian and Jivetian volcanic rock consist of andesite, basalt, rhyolite, and dacite as in the Kur'ya and Novo-Firsovo Basins. Cutting the Ordovician and Silurian clastic and clastic and carbonate rocks are Middle Devonian(?) numerous subvolcanic andesite porphyry dikes and sills, small rhyolite and dacite stocks, granodiorite poprhyries, and layered intrusions of gabbro and anortosite (Shokalskiy, 1990).

REFERENCES: Popov, 1967; Kalugin, 1985; Shokalskiy, 1990; Vladimirov and others, 1997; Gaskov and others, 1999.

Shirgaita Metallogenic Belt of Sedimentary Exhalative Pb-Zn (SEDEX) and Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposits (Belt SH) (Gorny Altai Mountains, Southern Siberia, Russia)

This Early to Middle Devonian metallogenic belt is related to sedimentary and volcanic rocks in the Altai volcanic-plutonic belt in the Gorny Altai region. The belt trends northwest, ranges up to 150 km long, and ranges from 30 to 40 km wide. Host rocks are clastic and carbonate rock, and andesite and diabase porphyry, tuff, tuff-breccia, felsite, felsite porphyry, albitophyre, and siliceous tuff. Sedimentary rock prevail. Subvolcanic intrusive quartz porphyry and albitophyre also occur. These Devonian rocks are underlain by a thick sequence of Ordovician and Silurian sandstone, argillite, and clastic and carbonate rock that host rare polymetallic veins and disseminations. Devonian host rocks are folded and intruded by the Permian and Triassic Yalomansk granodiorite and adamellite complex (Kononov, 1969). Polymetallic sulfide deposits in the metallogenic belt are small and occur in districts, the Shirgaitinsk to the north, and the Ursulsk to the south (Kuznetsov, 1966). The main types of deposits are: (1) concordant layers and lenses of streaks and disseminations of Zn-Pb-Cu sulfides (Shirgaita); (2) quartz and polymetallic Pb-Zn sulfide veins (Il'inskoye); and (3) complex combinations of streaks, disseminations, and layers of sulfides in siliceous and intermediate volcanic rock (Ursul). These types of deposits differ in geological position and structures, but are similar in coeval age and genetic association with Devonian volcanic rock. At the contacts with granitoid intrusions, the deposits are locally metasomatized and contain superimposed REE (Mo+W) deposits (Shirgaita). The major deposits are at Shirgaita and Ursulskoye.

Shirgaita Sedimentary Exhalative Pb-Zn (SEDEX) Deposit

This deposit (Dmitriev, 1958; Kuznetsov and others, 1966’ Kuznetsov , 1982) consists of conformable layers and lenses deposits of polymetallic sulfides hosted in sedimentary part of a Middle Devonian volcanic and sedimentary sequence. The deposit occurs at the central part of the Anui-Chuisk synclinorium in alternating limestone and calcareous shale underlying a quartz albitophyre sill. The major part of the deposit is 580 m long and 1.5 km wide. The minerals are Cu-Pb-Zn sulfides. Ore minerals are sphalerite, galena, and chalcopyrite, and lesser molybdenite, scheelite, pyrrhotite, and marcasite; and rare bornite, fahl, burnonite, pyrite, arsenopyrite, and axinite. Gangue minerals are quartz, epidote, and calcite. Ores exhibit high values of Mo and W. The Cu:Pb:Zn ratio is 1:1.1:2.9. Wall rocks exhibit silica, epidotie, and actinolite alteration, and rare chlorite, sericite, and carbonate alteration. Ores are slightly contact metamorphosed. Two views exist for the origin of the Shirgaita deposit: (1) hydrothermal and contact metasomatic (skarn) origin related to granitoids (Dmitriev, 1958; Kononov, 1969); or (2) a volcanic, hydrothermal, sedimentary origin. The deposit is small scale with an average grade of 1.57% Pb; 1.25% Cu; 3.77% Zn.

Ursulskoye Volcanogenic Zn-Pb-Cu massive sulfide (Kuroko, Altai type) Deposit

This deposit (Tychinskiy, 1963; Kuznetsov, 1982) consists of layers, lenses, disseminations, and nests of Pb-Zn sulfides in Middle Devonian volcanic and sedimentary rock. The deposit occurs at the crest of a brachyanticline in adjacent to a fault. Host rocks are siliceous and local andesite flows and tuff and intercalated with shale and sandstone. Also occurring are diabase, diorite porphyry, and gabbro dikes. The sulfide bodies are irregular plates and lenses and are conformable to bedding. Disseminations occur in gently to steeply dipping layers of tuffs and tuff breccia. Sulfide bodies are 120-200 m long and 1.1-2.5 m thick and are intercalated with chlorite-sericite-quartz and sericite-chlorite-stilpnomelane schist and quartzite. The main ore minerals are sphalerite, galena; fahlore, pyrite, pyrrhotite, chalcopyrite, and marcasite with lesser aikinite, arsenopyrite, and berthierite. The deposit is small.

Origin and Tectonic Controls for Shirgaita Metalloginic Belt

The belt is interpreted as forming along back-arc region of an island arc. Belt hosted in clastic and carbonate rocks, andesite and diabase porphyries, tuff, tuff breccia, felsicporphyries, and siliceous tuff. This belt, also known as the Anui-Chuya polymetallic belt, occurs in the central part of the Anui-Chuya synclinorium that contain Early to Middle Devonian clastic, clastic and carbonate, and volcanogenic sedimentary rock. For a long time, it was a basin that developed as a sedimentary basin under continuously changing geodynamic conditions. The more ancient Cambrian and Ordovician rocks of the Gorno-Altaisk sequence consist of flysch deposits of the early Paleozoic fore-arc basin. They are overlapped by thick Ordovician and Silurian sandstone and schist and limestone sequence of the passive continental margin. Since Emsian, the Anui-Chuya terrane has developed as a marginal-sea back-arc basin (Elkin and others, 1994). During Devonian it was and endogenous-active basin with andesitic and siliceous volcanism widespread. Volcanic rock are abundant at the Emsian and Jivetian levels. Within districts, concordant sills and cutting bodies of quartz porphyries and albitophyres occur. The elongated areas of development of dikes and sills of mafic composition point to the extension conditions in back-arc marginal-sea environments. The formation of the local volcanic island arcs companion by pyrite-bearing polymetallic Kuroko-type deposits of Rudny Altai is not excepted. Numerous polymetallic ore occurrences in the areas of development of Devonian volcanic rock, in spite of their smalls, may be indicative of possible further finding larger base-metal deposits in the belt.

REFERENCES: Dmitriev, 1958; Nekhoroshev, 1958; Tychinskiy, 1963; Kuznetsov, 1966; Kononov, 1969; Yolkin and others, 1994.

Deluun-Sagsai Metallogenic Belt of Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite, Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork, Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai type), Sediment-Hosted Cu, Ag-Pb Epithermal Vein, and Granitoid-Related Au Vein Deposits (Belt DS) (Western Mongolia)

This Early Devonian(?) to Early Carboniferous(?) metallogenic belt is related to granitoids and replacements in the Deluun sedimentary-volcanic-plutonic belt. The metallogenic belt occurs in the Mongol Altai area and is interpreted as one of two belts that occur in a large metallogenic aureole related around Devonian calc-alkaline igneous rocks that were part of an Andean type active continental margin in north and northwestern Mongolia (Kovalenko and others, 1990). The metallogenic aureole contains two large metallogenic belts. The metallogenic belt and host Deluun overlap assemblage are intruded by Middle and Late Devonian calc-alkaline granitoids. The Deluun overlap assemblage (Tomurtogoo and others, 1999) is interpreted as forming along an active Andean-type continental margin arc (Berzin and others, 1994). This overlap assemblage (Byamba and Dejidmaa, 1999) stitches the Mongol Altai and Hovd terranes. An alternative interpretation is that the Deluun-Sagsai metallogenic belt formed during accretion (Dandar and others, 2001). The major deposits are the Dulaan khar uul Ag-Pb-Zn deposit, the Burged Cu-Pb-Zn occurrence, the Khatuugiin gol Cu occurrence, and the Nominy Am occurrences.

Dulaan khar uul Ag-Pb Epithermal Vein Deposit

This deposit (Shubin and others, 1985; V. Filonenko and others, written commun.,1991) occurs in margin of volcano tectonic caldera containing the Early to Middle Devonian Dulaankhar Formation that consists of rhyolite tuff, flows, tuffaceous sandstone, rhyolite and dacite porphyry subvolcanic bodies and dikes, and diabase dikes. The deposit occurs in layers and sheets layers of siliceous tuff breccia. Four bodies occur and vary from 200.0 to 700.0 m long and 10.0 to 40.0 m wide. Primary ore minerals are sphalerite, galena, chalcopyrite, and gold. Sulfides occur in altered chlorite-sericite-quartz tuff and at the intersection of the Dulaankhar fault with a dike swarm that is 600 m wide. The sulfide bodies vary form 0.7 m to 20.0 m thick, and occur in layers, lenses, and veins, and extend over 100.0 m on surface and downdip to a depth of 400.0 500.0 m. A large SP anomaly in the northeast part of the deposit that has potential for new sulfide bodies. Oxidized parts of the deposit contain cerussite, calamine, galena, wulfenite, barite, fluorite, calcite, and malachite. Grades are 1.0% Pb, 1.0 10.0% Zn, 0.5 1.0% Cu, up to 2000.0 g/t Ag, and up to 0.2% Ba, from 0.2 to 4.0 g/t Au. A silica cap 700 m by 10-20 m occurs in the southwest part of the deposit and contains Cu oxides and hematite. The easter and central parts of the deposit are hosted in tuff breccia. These areas contain anomalous Pb, Zn, Cu, Mo, and Co. Anomaly aureoles also occur in the western part. The deposit is large with resources of 665,000 tonnes Zn, 430,000 tonnes Pb, 16.0 tonnes Au. Average grade is 2.05% Zn, 0.1-1.76% Pb, 1.1 g/t Au, 1.0-45.0 g/t Ag, 0.1-0.3% Cu.

Burgedtas Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Deposit

This deposit (D. Dorjgotov, written commun.,1990) consists of zones in Devonian felsic volcanic and sedimentary rock (altered sandstone and siltstone). Wall rocks are hydrothermally altered to silica, sericite, and limonite. Sulfide zones are up to 3.2 km long and several hundreds meters wide. Ore minerals are pyrite, sphalerite, chalcopyrite, galena, arsenopyrite and oxide. Major gangue minerals are quartz, sericite, kaolinite, and chlorite. Average grade is 0.1-1.0% Cu, 0.2% Zn, and 0.2-1% Pb.

Khatuugiin gol Sediment-Hosted Cu Deposit

This deposit (Demin and others, 1990; B.N. Podkolzin and others, written commun., 1990) consists of sulfides in lenses and horizons in a zone that estends for 25 km black shale of the Middle to Late Devonian Khatuu gol Formation along the eastern branch of the Khatuugiin gol River. Sulfides are pyrite, pyrrhotite, and chalcopyrite in disseminations, small nests, and stringers. A unit of carbonaceous siltstone and sandstone with disseminated chalcopyrite extends 12 km from the Tsagaan gol River to the Asysan gol River. The unit varies from 1.0 m to 7.0 m thick and contains up to 1.0% Cu, 0.1% As, 0.3% Sb, and 0.1% Ba. Quartz-biotite-chlorite veins with chalcopyrite and pyrrotite occur in carbonaceous shale and contain up to 2.88% Cu, 0.07% Zn, up to 30.0 g/t Ag, and 0.01 g/t. Au. The deposit has an average grade of 1.0% Cu.

Nominy Am Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (Demin and others, 1990; B.N. Podkolzin and others, written commun.,1990) consists of sulfides in quartz and quartz-barite veinlets in a breccia zone hosted in the Early to Middle Devonian Otogiin Formation that consists of dacite, and andesite, tuff, tuff breccia, and quartz-calcite sandstone. The breccia zone strikes northwest and occurs at the intersection of northwest-and northeast-striking faults at the contact between volcanic and terrigenous rock. The breccia zone is 60-100 m wide and the 300-350 m wide. Cataclastic host rock is intensely altered to silica and limonite. The quartz and quartz-barite veins varies from 0.1 m to 1.5 m thick extend for 60-70 m along strike. Ore minerals are chalcopyrite, pyrite, galena, arsenopyrite, malachite, and azurite. Largest vein is 1-1.5 m by 70 m wide and grades from 0.3% to 1.0% Cu, 0.0015-0.7% Pb, 0.007-0.5% Zn, up to 1% As, up to 1% Ba, 0.003-0.015 g/t Au, and 1.5 g/t to 500 g/t Ag. Average grade is 1.0% Cu.

Origin and Tectonic Controls for Deluun-Sagsai Metallogenic Belt

This belt is interpreted as forming along an active Andean-type active continental margin arc. The polymetallic volcanic-hosted metasomatite deposits, as at Dulaanhar and Burgedtas, are related to Early to Middle Devonian basalt, andesite, and rhyolite. The sediment-hosted Cu deposits are hosted in Middle to Late Devonian black shale, siltstone and sandstone of the Sagsai Formation. Granitoid-related vein, stockwork, and replacement occurrences occur at Sagsai, Dert tolgoi, and others are hosted in volcanic and sedimentary rocks that are probably spatially and genetically related to small Late Devonian calc-alkaline granodiorite and granite stocks that occur along fault zones that control this collisional stitching complex.

REFERENCES: Kovalenko and others, 1990; Berzin, and others, 1994; Byamba and Dejidmaa, 1999; Dandar and others, 2001.

Khalzanburged Metallogenic Belt of Peralkaline Granitoid-related Nb-Zr-REE and Ta-Nb-REE Alkaline Metasomatite Deposits (Belt KhZ) (Western Mongolia)

This Early Devonian(?) metallogenic belt is related to alkaline granitoid plutons in the Altai volcanic-plutonic belt. The metallogenic belt occurs in the Mongol Altai area and is interpreted as one of two belts that occur in a large metallogenic aureole related around Devonian calc-alkaline igneous rocks that were part of an Andean type active continental margin in north and northwestern Mongolia (Kovalenko and others, 1990). The metallogenic belt, also called the Khan Hohii-Khovsgal REE metallogenic belt, occurs in the northern Lake terrane in the western Khovsgol area. The belt is closely related to: (1) Early Devonian alkaline gabbro and nepheline syenite that occurs in the Ujigiin gol Complex in the Khovsgol area; and (2) Devonian alkaline syeniteand granite in the Halzan Complex. The Khalzanburged metallogenic belt is superposed overprinted on an early Paleozoic metallogenic belt in the Lake terrane (Dandar and others, 1999). The major deposits are at Ulaantolgoi and Shartolgoi.

Ulaantolgoi Peralkaline Granitoid-Related Nb-Zr-REE Deposit

This deposit (Jargalsaihan and others, 1996) consists of Zr-REE minerals in a hypabyssal late Paleozoic(?) stock of alkaline ribeckite syenite that intrudes Middle and Late Cambrian granodiorite. The northern part of the stock (with an area of 0.12 km^2) is altered into biotite-quartz-albite and riebeckite-microcline-albite rock with REE. Along the northern contactof alkaline syenite stock, the host granodiorite is are strongly brecciated and altered to albite metasomatite along northwest-and northeast-trending faults. The metasomatic rock contains small disseminations of zircon, fluorite, chlorite, muscovite, apatite, xenotite, cassiterite, monazite, columbite, fergusonite, chevkinite, orthite, Ce-bearing thorite, sphene, braite, and Cu-Pb-Fe sulfides. Deposit grades 0.005-0.028% Ta_2O_5, 0.060-3.0% Nb_2O_5, 0.011-0.8% Y_2O_3, and 0.015-10% ZrO_2. In tenths and hundredths per cent are Ce, La, Cu, Mo, Zn, Pb, Be, Sn, Bi, and Ag. The deposit is medium size with resources of 10,000-12,000 tonnes Ta, 100,000-120,000 tonnes Nb, 20,000-25 000 tonnes Y, and a few hundred thousand tonnes Zr.

Shartolgoi Ta-Nb-REE Alkaline Metasomatite Deposit

This deposit (Kovalenko and others, 1977; Jargalsaihan and others, 1996) consists of Nb-Ta-REE minerals in late Paleozoic alkaline subvolcanic rock that intrude a Cambrian granodiorite pluton. The alkaline rocks comprise a volcanic-plutonic structure 2 km^2 in area, and are intensely altered along with the host Cambrian granodiorite pluton to muscovite, K-feldspar, fluorite, albite, sulfides, and silica. Albite alteration also occurs along faults. Ore minerals are zircon, pyrochlore, and niobirutile, and rare cassiterite, xenotime, thorite, monzite, sphalerite, molybdenite, and chalcopyrite. Gangue minerals are albite (80-90%), microcline (10%), and muscovite and sericite (3-8%), and sparse fluorite, sphene, apatite, and calcite. Two main deposit stages are recognized: a REE stage with Ta, Ni, Zr, Hf, S, and Y, Ce, and La yttrium; and superimposed Cu, Pb, Zn, Mo and Ag sulfides. The deposit is small with an average grade of 0.01-0.08% Ta_2O_5, 0.05-0.63% Nb_2O_3, 0.1-4.0% ZrO_2, 0.02-5.68% Y_2O_3.

Origin and Tectonic Controls for Khalzanburged Metallogenic Belt

The belt is interpreted as forming along an active Andean-type active continental margin. The Halzanburged, Tsahiryn, and other occurrences and deposits occur along the Tsagaanshiveet fault zone between the Lake island arc and the Hovd continental margin arc terranes. These occurrences are closely related to the Halzan syenite-alkaline granite complex. Isotopic age of the complex ranges from Late Silurian to Carboniferous, but a Devonian age is assessed as more reliable. Similar occurrences (Ulaantolgoi, Shartolgoi and others) occur north and northeast of Halzanburged district in the early Paleozoic Lake island arc terrane and are closely related to overlaping, anorogenic alkaline granite stocks.

REFERENCES: Kovalenko and others, 1985; Kovalenko and others, 1990; Dandar and others, 1999.

Bayan-Kol Metallogenic Belt of Magmatic Nepheline Deposits (Belt BK) (Tuva, Southern Siberia, Russia, Northern Mongolia)

This Late Mississippian and Pennsylvanian metallogenic belt is related to granitoids in the middle Paleozoic South Siberian volcanic-plutonic belt that intrudes the Salair terrane. The igneous units consist of widespread, small Early Devonian stocks of the Sangilin Complex that contains alkaline gabbro and nepheline syenite. The belt extends northwest-southeast along a regional fault, is about 200 km long, and ranges up to 60 km wide. The belt is a part of a large middle Paleozoic metallogenic aureole related to Devonian magmatic rocks of an Andean type active continental margin arc that formed in northern and northwestern Mongolia and adjacent part of Russia (Kovalenko and others, 1990). The belt is hosted in more than 20 alkaline plutons that vary from 0.2 to 6 km^2 in diameter. The plutons comprise an urtite-melteigite assemblage, including foyaite, urtite, ijolite, juvite, alkali and nepheline syenite, essexite, gabbro, and granosyenite. The plutons intrude Riphean and Vendian limestone and marble, and rare dolomite and carbonaceous shale. The metallogenic belt consists of two large metallogenic groups. One is a REE group that oocurs in the northern Lake terrane in the western Khovsgol area (Mongolia). The other group occurs in Russia and contains magmatic nepheline deposits. The large nepheline deposits at Bayan-Kol, Chikskoye, and Dahu-Nurskoye are hosted mainly in early stage alkalic urtite, ijolite-urtite, and juvite. The most significant deposit is the Bayan-Kol nepheline deposit (Matrosov and Shaposhnikov, 1988; Yashina, 1982). The other high-grade nepheline deposits are not well studied.

Bayan-Kol Magmatic Nepheline Deposit

This deposit (Kononova, 1961, 1962; Matrosov and Shaposhnikov, 1988; Dancig and others, 1988) is hosted mainly in nepheline-bearing igneous rock (ijolite-urtite to juvite) of the Silurian and Devonian Bayan-Kol alkaline pluton. The pluton is conformable with folded Proterozoic marble and is highly eroded. Nepheline content varies from 65 to 84%. Associated minerals are microcline, pertite, Na-hedenbergite, titanomagnetite, calcite, apatite, and sphene. Al_2O_3 content in the most abundant juvite ranges up to 26.5%. The host rocks extend more than 5 km and vary from 150 to 200 m to 1 km wide. The deposit is Fe poor (<3% Fe_2O_3) and high-alkaline (13 to 18% K_2O+Na_2O). The deposit is large with an average grade of 26.5% Al_2O_3.

Korgere-Daba Magmatic Nepheline Deposit

This deposit (Yashina, 1965) consists of nepheline-bearing igneous rock in the Carboniferous Korgere-Daba alkaline pluton that intrudes Neoproterozoic marble. Thie pluton consists of hornblende-nepheline syenite and aegirine-arfvedsonite foyaite. The pluton extends over an area of 30 km^2. Nepheline content varies from 15 to 32%,. Feldspar content varies from 51 to 64%. The deposit is medium size with an average grade of 23.5% Al_2O_3.

Origin and Tectonic Controls for Bayan-Kol Metallogenic Belt

The belt is interpreted as forming during middle Paleozoic intraplate rifting. Two main types of plutons occur: (1) differentiated plutons of syenite, nepheline syenite, and gabbro; and (2) and desilicified and contaminated plutons. Rare peralkaline rocks occur in contaminated plutons and include urtite, juvite, ijolite-urtite, melteigite, and malignite (Chik, Dahu-Nur, and Bayan-Kol plutons) (Kononova, 1961, 1962). According age, two groups of alkalic igneous rock occurs in the Sangilen Upland: (1) an older ijolite-gabbro and foyaite-syenite sequence (Late

Devonian to Early Carboniferous); and (2) younger alkalic granite, syenite, and nepheline syenite with a K-Ar biotite isotopic age of 310 Ma (296 Ma for the Korgere-Daba pluton, 313 Ma for the Ulan-Erginsk pluton, and 323 Ma for the Pichekol pluton) (Yashina, 1982). The many nepheline-bearing plutons of the Sangilen Complex contain large resources of alumina. Two types of economic deposits occur: (1) deposits hosted in nepheline-bearing rock (ijolite-urtite, urtite, juvite) that formed at the contacts between nepheline syenite intrusions and marble during the early stage of intrusion, and (2) deposits hosted in leucocratic nepheline syenite that formed in alkaline magma during the second magmatic stage. The alkalic rocks of the metallogenic belt are interpreted as the products of crystallization of mantle-derived nepheline syenite magma (Yashina and Kononova, 1960).

REFERENCES: Yashina and Kononova, 1960; Kononova, 1961, 1962; Yashina, 1982; Matrosov and Shaposhnikov, 1988; Kovalenko and others, 1990.

Bugseingol-Ovormaraat Metallogenic Belt of Magmatic Nepheline, Ta-Nb-REE Alkaline Metasomatite, and Peralkaline Granitoid-related Nb-Zr-REE Deposits (Belt BOM) (Northern Mongolia)

This Early Devonian(?) to Permian(?) metallogenic belt is related to anorogenic Early Devonian, Carboniferous and Permian alkaline granite plutons of the Tes volcanic-plutonic belt. The belt occurs west and south of Hovsgol Lake. This alkaline complex is part of an alkaline magmatic aureole that extends into the eastern Tuva and eastern Sayan areas of Russia (Luvsandansan and others, 1990). The Early Devonian the Ujigiin gol Complex, with isotopic ages of 400 to 396± 10 Ma, consists of subalkaline and alkaline gabbro and nepheline syenite, and a Carboniferous alkaline igneous complex, with an isotopic age of 325 to 300 Ma, that consists of alkaline nepheline syenite and REE pegmatite vein (Andreeva and others, 1990; Yashina, 1990). A Permian intrusive complex, with isotopic ages of 276 to 240 Ma, consists of alkaline syenite and granite that is coeval with trachyte, trachyrhyolite, and komendite (Yashina, 1990). The various-age alkaline complexes are closely spatially related, but differ in petrochemical and metallogenic features (Yashina, 1990). Anomalous Fe, Ti, and P is related to the early gabbro phase, and magmatic nepheline is related to the nepheline syenite phase of the Ujigiin gol Complex. Alkaline metasomatitic Nb-Zr-REE deposits are related to a Carboniferous nepheline syenite sequence that occurs in pegmatite and alkaline albite metasomatite. Th-Nb-Zr-REE occurrences are related to Permian alkaline syenite and granite intrusives, and occur in albite metasomatite hosted in carbonatite that occurs in the outer periphery. The composition of alkaline metasomatite Th-Nb-Zr-REE occurrences is complicated with occurrence of anomalous U, Th, Zr, Ta, Nb, La, Ce, Hf, Gd, Y, and Yb. Major northwest-southeast-trending faults control the various alkaline intrusive complexes in Bugseingol-Ovormaraat metallogenic belt. The northwest-trending Sumber, Ujigiin gol, Shivleg-Baruun Harigiin faults control the more interesting and prospective deposits and occurrences. The major deposits are: the Ovormaraat, Doshiin gol, and Beltesiin gol magmatic nepheline deposits; the Altanboom Ta-Nb-REE occurrence; the Uranhem, Arsaan, Shignuul gol, and Ust gol Nb-Zr-REE occurrences; and the Ar gol, and Yarhis gol Th (U)-Nb-Zr-REE occurrences.

Duchin gol Magmatic Nepheline Deposit

This deposit (Yashina, 1975; Yakovlev and Il'in, 1977, Andreeva and others, 1990) is hosted in Early Devonian nepheline-bearing igneous rocks, including urtites, rare ijolite-urtites, and subalkaline trachyte gabbro and theralites. The igneous rocks form two stocks with a surface area of 0.9 by 0.6 and 0.6 by 0.3 km. The predominant urite consist of nepheline (60-90%) and Ti-augite (10-40%), and accessory hornblende, diopside, sphene, apatite and magnetite. Host rocks are Precambrian marble and limestone. Igneous rock grades from 24.20 to 30.45% Al_2O_3 and 12.63 to 16.48% total alkalies. The deposit is suitable for smelting without preliminary enrichment. The deposit is medium size with resources of 58.3 million tonnes Al_2O_3 grading 28.8% Al_2O_3.

Altanboom Ta-Nb-REE Alkaline Metasomatite Deposit

This deposit (Jargalsaihan and others, 1996) is hosted in a late Paleozoic leucocratic muscovite granite stock (with surface dimensions of 200-290 by 250-350 m) and in several granite dikes altered to greisen and silica. That contains Ta minerals. The greisen superposed on Mo minerals. The Ta minerals are tantalite and microlite that occur in very fine disseminations and range up to tenths of mm. Cassiterite forms grains that range from 0.02-0.03 mm. Mo minerals are powellite, molybdenite, and wulfenite. The deposit is medium size with resources of 1,700 tonnes Ta_2O_5, 1,610 tonnes Nb_2O_5, and 1,100 tonnes Mo. Average grades is 0.01-0.05% Ta_2O_5, 0.0002-0.03% Nb_2O_5, 0.0001-0.03% REE, and 0.002-0.289% Mo.

Origin and Tectonic Controls for Bugseingol-Ovormaraat Metallogenic Belt

The belt is interpreted as forming during middle Paleozoic interplate rifting related to an Andean-type continental margin. Deposits hosted in anorogenic alkaline gabbro, nepheline syenite, alkaline syenite, and alkaline granite. The belt is interpreted as forming during middle Paleozoic interplate rifting related to an Andean-type active continental margin.

REFERENCES: Andreeva and others, 1990; Luvsandanzan and others, 1990; Yashina, 1990.

Tomurtein Nuruu Metallogenic Belt of Clastic-Sediment-Hosted Sb-Au Deposits Belt TN (Southern Mongolia)

This Early to Middle Carboniferous metallogenic belt is hosted in the Beitianshan-Atasbogd island arc terrane (Ruzhentsev and others, 1990; Tomurtogoo and others, 1999). The belt consists of clastic-sediment-hosted Sb-Au deposits that are related to regionally metamorphosed rocks. The metallogenic belt was defined first by Dejidmaa and others (1996). Potential exists for undiscovered deposits in the Talyn meltes-Hatansuudal Au ore-district (Dejidmaa, 1996). The Beitianshan-Atasbogd terrane contains early Palaeozoic(?) marble and quartzite overlain by thick Silurian oligomictic turbidite and Early Devonian differentiated mafic, intermediate, and siliceous volcanic rocks that are, intruded by the Atasbogd granitoid batolith. Unconformably overlying are Middle Devonian volcanic and terrigenous molasses that consists of limestone, conglomerate, and trachybasalt that were deposited in small basins. The terrane is intruded by Carboniferous and Permian granite.

Au occurrences consist of concordant banded or layered quartz-carbonate veins or ladder veins that are concordant to altered host rock zones (Suprunov and others, 1990). The quartz veins occur over a large area. Most veins are composed mainly of quartz, but more productive Au veins contain quartz and carbonate that occurs along vein contacts. Host greenschist exihibits silica, carbon, sericite, and local pyrite alteration. Quartz-carbonate veins are mostly low-sulfide, with variable amounts of sulfides. Major ore minerals are pyrite, arsenopyrite, chalcopyrite, sphalerite, antimonite, and gold. Major gangue minerals are quartz and carbonate. Gold grades correlate well with sulfide and Sb content. Quartz veins and ladder vein zones occur mainly along minor fault zones, and form large districts. The major deposits are at Talynmeltes and Hatansuudal.

Talynmeltes Clastic-Sediment-Hosted Sb-Au Deposit

This deposit (Sanjaadorj and others, 1998; Podkolzin and others, 1990; G. Dejidmaa, E. Sato, and S. Jargalan, written commun., 1994) is hosted in Middle Devonian intercalated siliceous siltstone and fine-grained sandstone that are metamorphosed to greenschist facies, and are intruded by syn-orogenic, concordant Devonian gabbro, tonalite, granodiorite, and granite intrusives. Extensive ladder and concordant quartz veins occur in metamorphosed volcanic and terrigenous rock. Veins were intensively mined out from surface by openpit. The veins occur in three major zones 3 zones, KhB-I, KhB-II and KhB-III (Sanjaadorj and others, 1998). As an example, the KhB-I zone contains west-northeast striking, steeply-sipping quartz veins that are parallel to bedding in host rock. The echelon-like veins range up to 1.5 m thick and 3.0 m long zone and occur in shear zones. Host rock is weakly to strongly altered to silica, pyrite, and argillite. Grab sample of veins contain 2.44-2.91 g/t Au, 0.79 g/t Ag, 0.005% Cu, 0.0002% Pb, 0.002% Zn, and 0.0001% As. Argillic replacement samples contain 0.1-0.15 g/t Au, 0.64 g/t Ag, 0.002% Cu, 0.00035 Pb, 0.007% Zn, and 0.0002% As. Grab sample of pyrite and sericite-altered limestone contain 7.7 to 10.35 g/t Au, 1.58 g/t Ag, 0.003% Cu, 0.001% Pb, 0.003% Zn, and 0.0002% As. Quartz-pyrite alterations contain 9.52-10.82 g/t Au, 1.92 g/t Ag, 0.05% Cu, 0.0002% Pb, 0.002% Zn, and 0.0003% As. The zone may extend to up 275 m wide with good Au grade. For the entire deposit, the average grade is 0.91 g/t Au, 0.79 g/t Ag, 0.005% Cu, 0.0002% Pb, 0.002% Zn, 0.0001% As.

Origin and Tectonic Controls for Tomortein Nuruu Metallogenic Belt

The belt is interpreted as forming during egional metamorphism and vein emplacement associated with accretion of Beitianshan-Atasbogd and Zhongtianshan terranes.

REFERENCES: Dejidmaa, 1996; Dejidmaa and others, 1996; Rujentsev, Badarch,G., Voznesenckaya, and Markova, 1990; Suprunov, Podkolzin, Dobrolyubov, and Levintov, M.E.; 1990; Tomurtogoo and others, 1999.

Bidzhan Metallogenic Belt of Sn-W Greisen, Stockwork, and Quartz Vein, and Fluorite Greisen Deposits (Belt Bdz) (Russia, Far East)

This Devonian(?) metallogenic belt is related to granitoids in the Khanka-Bureya granitic belt that intrudes the Malokhingansk accretionary wedge terrane. The belt is partly overlain by the Mesozoic and Cenozoic Sanjiang sedimentary basin and Yishu graben. The major deposit is at Preobrazhenovskoye.

Preobrazhenovskoye Fluorite Greisen Deposit

This deposit (Onikhimovskiy and Belomestnykh, 1996) occurs in a Devonian(?) biotite-hornblende granodiorite pluton. The central part of the pluton is intersected by A fracture zone that is 1.5 km long and from 250 to 300 m wide. The fracture zone contains seven lenses of quartz-muscovite greisen with REE-fluorite veinlets and disseminations. Greisen zones range from 130 to 740 m long, from 7.5 to 57.0 m wide, and extend to 100 to 150 m downdip. Greisen is composed of quartz, muscovite, and fluorite with disseminated wolframite, cassiterite, molybdenite, arsenopyrite, pyrrhotite, chalcopyrite, monazite, xenotime, and Be minerals. The deposit is large with resources of 927,700 tonnes grading 6.22% fluorite.

Origin and Tectonic Controls for Bidzhan Metallogenic Belt

The belt is interpreted as forming in the final stage of intrusion of the Khanka-Bureya granitic belt that formed in a subduction-related continental-margin arc.

REFERENCES: Krasny, 1966; Kozlovsky, 1988; Martynyuk, 1983; Onikhimovkiy and Belomestnykh, 1996.

Baruunhuurai Metallogenic Belt of Au in Shear Zone and Quartz Vein Deposits (Belt BAH) (Southwestern Mongolia)

This Early to Middle Carboniferous metallogenic belt is related to replacements in the Waizunger-Baaran island arc terrane (Tomurtogoo and others, 1999) in the Baytag, Havtag, Nariin har nuruu Mountain Ranges in southwestern Mongolia adjacent to China. Au occurrences are associated with Au-Pb-Zn Nuhnii nuruu deposit, and the Haltar Uul I and Haltar Uul II occurrences (Ajipa, 1957; Gridasova and others, 1960). These deposits and occurrences are part of the Baruunhuurai Cu-polymetallic metallogenic belt (Yakovlev, 1977; Blagonravov and others, 1977). The metallogenic belt was defined by Dejidmaa and others (1996) as an Au metallogenic belt with potential for undiscovered deposits in the large Uherchuluut, Khaltar Uul, Nariin har Au districts. The host Waizunger-Baaran terrane consists of serpentine melange, Silurian clastic and tuff-jasper, differentiated Devonian volcanic rock, and Middle Devonian to Early Carboniferous tuff and clastic rocks that are intruded by Early to Middle Carboniferous collisional granite, and Permian late-stage orogenic granite. The major deposits are at Khaltar-uul I and II and Ereen Uul.

Au in Shear Zone and Quartz Vein Occurrences

Various occurrences consist of concordant quartz-carbonate veins or saddle reef and ladder veins that are hosted in concordant altered zones. Quartz veins occupy a large area. Most veins are composed mainly of quartz, but more productive Au veins consist of quartz and carbonates that occurs in the contacts of veins. Host Early Carboniferous greenschist is intensely altered to carbonate, , pyrite, and sericite, and weak silica. Quartz-carbonate veins are mostly low sulfide with variable amount of sulfides. Major ore minerals are pyrite, chalcopyrite, sphalerite, galena, and Au. Major gangue minerals are quartz and carbonates. The grades of Au and Ag are closely correlated and with amount of sulfides. Quartz-carbonate vein Au occurrences are closely related spatially and genetically related and contain mountain quartz crystals in of saddle reefs. Quartz veins and ladder veins are concentrated mostly along weak fault zones, and form large districts.

Khaltar Uul II Au in Shear Zone and Quartz Vein Deposit

This deposit (T. P. Gridasova and others, written commun., 1960; Blagonravov and others, 1977) is hosted in the Early Carboniferous Nukhniinuruu Formation that consists of sandstone, siltstone, mudstone, siliceous shale, andesite, tuffaceous sandstone, and tuff. The deposit occurs in a northwest-trending large shear zone that ranges up to, 2.5-3.0 km wide and 7.0 km long. The shear zone occurs along a northwest-trending fault zone. Host rock is deformed and altered to carbonate, sericite, and pyrite. The zone contains more 200 concordant lenses and saddle-reefs veins that range up to 350 m long and 1.5-2 m wide. Four large zones are studied. As an example, quartz vein zone No. 1 contains a vein that ranges up to 5.0 m wide and 58.0 m long. The vein occurs in phyllite and greenstone derived from tuffaceous sandstone. The vein dips steeply. Quartz is fractured and with fillings of Fe hydroxide and yellow and red-brown gouge. Ore minerals are rare chalcopyrite, galena, malachite, and azurite. Host rocks are altered and contain iron oxides and quartz veinlets. The thickness of the alteration from 6 m to 15 m. Channel samples contain from 0.033% to 3% Pb and Zn (average of 0.2%), 0.2 g/t to 26.6 g/t Au (average-3.3 g/t), 5.0-146 g/t Ag (average of 20.7 g/t). Probable resource of gold to 40 m depth is 345 000.0 tonnes ore with 7141.5 kg at average grade-20.7 g/t Ag, and 1138.5 kg Au grading 3.3 g/t Au. The entire deposit is large with an average grade of 0.9 g/t Au, 7.25 g/t. Ag.

Origin and Tectonic Controls for Baruunhuurai Metallogenic Belt

The belt is interpreted as forming during regional metamorphism and vein emplacement association with accretion of the Beitianshan-Atasbogd and Zhongtianshan terranes.

REFERENCES: Ruzhentsev and others, 1990; Dejidmaa, 1996; Suprunov, Podkolzin, Dobrolyubov, and Levintov, 1990; Dejidmaa and others, 1996; Tomurtogoo and others, 1999.

Hangai Metallogenic Belt of Volcanogenic-Sedimentary Mn and Fe Deposits (Belt HAN) (Central Mongolia)

This Lower to Middle Devonian metallogenic belt is hosted in layers in the Hangay Dauria accretionary wedge terrane in the Hangay subterrane (Tomurtogoo and others, 1999). The deposits are hosted in the Early to Middle Devonian Erdenetsogt and Carboniferous the Tsetserleg Formations. Most sedimentary Fe, Fe-Mn and Mn occurrences are hosted in the Erdenetsogt Formation that consists of intercalated chert, jasper, shale, siltstone, and sandstone along with with marine basalt flows and keratophyre and siliceous volcanic rock. The deposits occur in lenses and tabular bodies in chert and jasper layers. The belt is strongly controlled by the Middle Devonian Erdenetsogt Formation composed of chert and clastic rocks. The belt is sickle shaped and surrounds the central part of the Hangai Mountain Range. The major deposits is at Zoogiin.

Zoogiin Volcanogenic-Sedimentary Fe Deposit

This deposit (Filippova and Vydrin, 1977) consists of massive and thickly disseminated magnetite and hematite. Minor ore minerals are pyrolusite and psilomelane and rare malachite and azurite. Host rocks are Early to Middle Devonian terrigeneous rocks composed of volcanic porphyry and jasper in the Erdenetsogt Formation. The deposit has a surface area of 15 by 20 m by 800 m and occurs in lower part of a 25 m thick jasper bed. The deposit is small with resources of 46 million tonnes grading 42.2% Fe in masses, and 36.18% Fe in disseminations.

Origin and Tectonic Controls for Hangai Metallogenic Belt

The belt is interpreted as forming in marine sedimentary rocks that were incorporated into an accretionary wedge. The belt is strongly stratigraphically controlled by the Early to Middle Devonian Erdenetsogt Formation composed mainly of chert and clastic rocks.

REFERENCES: Filippova and Vydrin, 1977; Bakhteev, Chizhova, 1984; Tomurtogoo and others, 1999.

Edrengiin Metallogenic Belt of Volcanogenic Cu-Zn Massive Sulfide (Urals type) and Volcanogenic-Sedimentary Mn and Fe Deposits (Belt ED) (Southwestern Mongolia)

This Early Devonian metallogenic belt is related to volcanic and sedimentary rock in the Edren island arc terrane (Tomurtogoo and others, 1999). Massive Cu sulfides and volcanogenic-sedimentary Mn deposits occur in the Early Devonian Olgiibulag Formation that is composed mainly of pillow basalt, chlorite shale, and siliceous sedimentary rock with quartzite layers. Cu and Mn occurrences are located in northwestern part of the belt, trend northwest-southeastern trend, and were discovered Rauzer and others (1987). The major deposits are the Olgii nuruu Cu and Olgii bulag Mn occurrences.

Olgii nuruu Massive Sulfide Cu Occurrence

This occurrence (Rauzer and others, 1987) is hosted in brecciated pillow basalt horizon that ranges up to 25 m thick and extends up to 2 km. Massive sulfide lenses range up to 2 m thick and consist of chalcopyrite and chalcocite that occur in the central part of pillow basalt horizon with disseminated sulfides in the marginal part. Fe quartzite lenses and horizons occur parallel to pillow basalt and consist of massive magnetite lenses that range up to 1.5 m thick. Massive pyrite sheet-like bodies have dimensions to 0.25-0.5 by 100 m and occur adjacent to massive and disseminated Cu sulfides. Sulfides are strongly oxidized with widespread Fe oxides, malachite and azurite.

Olgiibulag Volcanogenic-Sedimentary Mn Deposit

This deposit (A. Rauzer and others, written commun., 1987) consists of Mn minerals in quartzite lenses in a Early Devonian chert and quartzite bed that ranges up to 4 m thick in the Early Devonian Olgii Formation. Lenses range up to 1 m thick and 100 m long. Main ore minerals are pyrolusite, with hematite. Grab samples contain from 2-30% Mn, up to 0.4% Co, and up to 2.0 g/t Ag. The deposit is small with an average grade of 2.0-30% Mn+Fe and resources of 100,000 tonnes Mn.

Origin and Tectonic Controls for Edrengiin Metallogenic Belt

The belt is interpreted as forming in island arc or ophiolite complex. Deposits are hosted in pillow basalt and siliceous rock.

REFERENCES: Rauzer and others, 1987; Tomurtogoo and others, 1999.

Bayangovi Metallogenic Belt of Au in Shear Zone and Quartz Vein Deposits (Belt BG) (Southern Mongolia)

This Devonian metallogenic belt (Zabotkin and others, 1988) is related to replacements in the Govi-Altai continental-margin turbidite terrane. The deposits are mainly Au quartz-carbonate vein occurrences. The Govi-Altai turbidite terrane consists of mainly of Ordovician to Silurian turbidite that is overlain by Devonian shallow marine sedimentary rock (Tomurtogoo and others, 1999). The metallogenic belt was defined by Dejidmaa and others (1996) and contains the Bayangovi Au district (Dejidmaa, 1996). Au quartz-carbonate vein occurrences consist of concordant pyrite alteration zones with thin ladder quartz veins that are spatially related with Early Devonian granitoid in the Nudenhudag gabbro, tonalite, and plagiogranite complex. The host Silurian and Early Devonian sedimentary rock is metamorphosed to greenschist facies. The major deposits are at Bayangovi, Oortsog, and other occurrences.

Bayangovi Au in Shear Zone and Quartz Vein District

This deposit (D. Togtokh and others, written commun., 1991; A.A. Rauzer and others, written commun., 1987) consists of quartz veins in the Early Devonian Ulaan Khan uul, Gichigenet, and Khondolon Formations of sedimentary and volcanic rock. The formations are intruded by concordant bodies of foliated quartzic diorite, plagiogranite and gabbro of the Nuden khudag Complex by extensive subvolcanic bodies and dikes of andesite, basalt, gabbro, and diabase. Main faults strike to the northwest direction and they cut by more late faults striking to the North and to northeast. Intensive development of quartz veins and silicification are characteristic for the target area. There are few Au occurrences. Veins consist of milk-white, coarse- and medium-grained quartz in long extended zones. Chip samples contain 0.1-0.5 g/t Au. Also occurring are quartz stockworks quartz and polymictic sandstone with chloritic cement. Pyrite occurs in margins of quartz stringers and in host sandstone and ranges up to 3-5%. 156 rock chip and channel samples (from each 0.5 m of 14 trenches) were taken from these zones. Gold is fine-grained, and ranges from 0.1-0.2 mm and rarely up to 0.5-0.8 mm. Most gold forms plates and some is intergrown quartz and pyrite. Other ore minerals are galena and chalcopyrite. Also in the district is the similar Bayangovi II gold occurrence with a stockwork that grades 0.05-3.0 g/t Au. Also in the district is the Bituugiin khar occurrence with a quartz stockwork that is 2 m thick and 600 m long with channel samples grading 0.3-1.5 g/t Au.

Origin and Tectonic Controls for Bayangovi Metallogenic Belt

The belt is interpreted as forming regional metamorphism of Govi-Altai terrane that occurred during collision with the Lake terrane.

REFERENCES: Dejidmaa, 1996; Dejidmaa and others, 1996; Zabotkin and others, 1998; Tomurtogoo and others, 1999.

Bayanleg Metallogenic Belt of Besshi Cu-Zn-Ag Massive Sulfide Deposits (Belt BL) (Southern Mongolia)

This Early Devonian metallogenic belt is related to stratiform units in the Bayanleg accretionary wedge terrane. The Bayanleg terrane consists of a disrupted assemblage of pillow basalt, diabase, gabbro, chert, minor limestone, sandstone and ultramafic rock, and is metamorphosed from greenschist to amphibolite facies. The Bayanleg terrane is interpreted as tectonically-linked subduction zone complex for the Govi-Alay island arc terrane (Tomurtogoo and others, 1999). The major deposits are the Bayantsagaan, Khoondloi, and Dohom occurrences.

Besshi Cu-Zn-Ag massive sulfide occurrences consist of massive and disseminated Cu sulfides hosted in pillow basalt and (or) quartzite horizons (Rauzer and others, 1987). The occurrences consists of thin, sheets of massive to disseminated pyrite, pyrrhotite, chalcopyrite, and lesser sulfides that are hosted sedimentary rock, basalt, mafic tuff, and quartzite. The Bayantsagaan occurrence is hosted in apobasalt chlorite shale and in quartzite layers. The Dohom and Hoondloi occurrences are hosted in apobasalt schist and consist of pyrite massive sulfide layers with chalcopyrite, sphalerite, and galena. Massive sulfide horizons extend a few km and range up to 250 m wide.

Bayantsagaan 2 Besshi Cu-Zn-Ag Massive Sulfide Deposit

This deposit (A.A. Rauzer and others, written commun., 1987) is hosted in Devonian basalt, andesite, greenstone, and chert that contains two Cu horizons. The lower horizon occurs in chlorite schist derived from basalt with malachite nests. The horizon extends for about 1.0 km. Channel samples contain 0.1-2.0% Cu, and 0.003-1.0 g/t Au. The upper Cu horizon occurs in chert with chalcopyrite and malachite. The horizon is about 1.0 km long. Channel samples contain 0.05-0.3% Cu and up to 1.0 g/t Au. Extensive quartz veinlets occur in area 0.2 by 1.0 km. Ore minerals are chalcopyrite, malachite, and. Chip samples contain up to 1.0% Cu and up to 1.0 g/t Ag.

Origin and Tectonic Controls for Bayanleg Metallogenic Belt

The belt is interpreted as forming in marine sedimentary rocks incorporated into an accretionary wedge. The host Bayanleg terrane is interpreted as subduction zone complex that was tectonically linked to the Govi-Alay island arc terrane.

REFERENCES: Rauzer and others, 1987; Tomurtogoo and others, 1999.

Ulziit Metallogenic Belt of Au in Shear Zone and Quartz Vein Deposits (Belt UZ) (Southern Mongolia)

This Devonian(?) metallogenic belt is related to replacements in the Govi Altai continental-margin turbidite terrane. The metallogenic belt (Dejidmaa and others, 1996) contains Au quartz-carbonate vein occurrences (Goldenberg and others, 1978). The host Govi-Altai continental-margin turbidite terrane consists of mainly of Ordovician to Silurian turbidite that is overlain by by Devonian shallow-marine sedimentary rock (Tomurtogoo and others, 1999). The major deposits are at Olon Ovoot, Khorimt hudag, Dayangar, An tsavyn, and Altagany uhaagchin hudag.

Olon Ovoot Au in Shear Zone and Quartz Vein Deposit

This deposit (Goldenberg and others, 1978; L. Dorligjav and others, written commun., 1993; Sillitoe and others, 1996; Jargalsaihan and others, 1996; Dejidmaa, 1996; Dejimaa and others, 1996) consist is hosted in the Silurian Mandal Ovoo Formation that contains siliceous sandstone and mudstone and is intruded by syn-orogenic gabbro-diorite and diorite sils. Deposit occurs in altered quartz diorite with sericite-quartz replacement and in quartz veins. Quartz diorite is altered to epidote, chlorite, sericite, and carbonate. Quartz veins consist of white, partly limonitized, massive and brecciated quartz withup to 10% carbonate and up to 2% ore minerals. More than 10 quartz occur in a 0.5 km by 0.2 km area. Veins range up to 0.7 m thick and 80 m long. The main Tsagaantolgoi vein forms a saddle reef. Main ore mineral is pyrite with rare gold. The size of gold grains ranges from 0.0050-0.7 mm.

Origin and Tectonic Controls for Ulziit Metallogenic Belt

The belt is interpreted as forming regional metamorphism of Govi-Altai terrane during collision with Idermeg terrane.

REFERENCES: Dejidmaa, 1996; Dejidmaa, G and others, 1996; Goldenberg V.I. and others, 1978; Tomurtogoo and others, 1999.

Sulinheer Metallogenic Belt of Podiform Chromite Deposits (Belt Sul) (Southeastern Mongolia)

This Carboniferous(?) metallogenic belt is related to ultramafic plutons in the Sulinheer accretionary wedge terrane that consists of a dismembered Late Devonian and Early Carboniferous ophiolite and Middle Carboniferous and Early Permian tholeite pillow lava, and volcaniclastic sandstone that contain fusulinid-bearing limestone and olistostome (Tomurtogoo and others, 1999).

Sulinheer Podiform Chromite Occurrence

This occurrence (Filippova and others, 1977; Jargalsaihan and others, 1996) is hosted in the Sulinheer ultramafic pluton that occurs along the border between Mongolia and China. The ultramafic pluton occurs in the major Sulinheer fault zone that that trends from northeast to east-west. The pluton ranges from 10 to 100 m^2 and consists of serpentinite, serpentinized peridotite, and dunite. Listvenite composed of quartz, carbonate, and pyrite forms thick zones in serpentinite. Deposits consist of massive, thick to intermediate size disseminations and layers of banded chromite. Thickness of massive chromite layers ranges from a few tens of cm to one meter. The ultramafics are weathered intensively, and are cut by quartz-chalcedony-carbonate veinlets. The occurrence consists of two part located 800 m apart. The Eastern part contains 15 lenses that from 20 m to 100 m long, dip steeply, and vary from 3.0-25.0 m wide. Massive chromite occurs in lenses from 0.35 m up to 1.0 m thick with up to 37-45% Cr_2O_3. Disseminations contain up to 11% and layers contain from 11% to 26% Cr_2O_3. Two steeply -dipping lenses -occur in the Western part with an average grade of 20% to 30% Cr_2O_3.

Origin and Tectonic Controls for Sulinheer Metallogenic Belt

The belt is interpreted as forming in a middle Paleozoic ophlolite complex that was structurally incorporated into an accretionary wedge.

REFERENCES: Filippova and Vydrin, 1977; Tomurtogoo and others, 1999.

Hegenshan Metallogenic Belt of Podiform Chromite Deposits (Belt Heg) (Northeastern China)

This Middle Devonian metallogenic belt is related to dunite dikes that are part of an ophiolite in the Hegenshan accretionary wedge terrane. The belt trends north-northeast, is about 180 km long, and ranges up to 30 km wide. The significant deposit is Hegenshan-3756.

Hegenshan-3756 Podiform Chromite Deposit

This deposit (Bai Wenji and others, 1994) consists of about 180 podiform chromite bodies that are hosted in dunite dikes. The largest deposit is 850 m long with extends downdip for 260 m, and ranges up to 17 m thick. The host rocks are mainly dunite with minor peridotite. The deposit occurs in the elliptical Devonian Hegenshan ophiolite that crops out over an area of 60 km^2 and trends north-south. The units in the opohiolit, from older to younger, are: (1) peridotite with about contains 1,600 dunite dikes that range form several tens to hundred meters long and are less than ten meters wide; (2) cumulate dunite, peridotite, ferellenstein, and gabbro that are about 350 m thick; (3) conformably overlying metamorphosed mafic lava that is about 1490 m thick and is intercalated with silexite and limestone layers; and (4) conformably overlying Middle Devonian cataclastic rock, tuff, limestone, and silexite that range up to 2,000 m thick. Some dunite dikes in the peridotote contain chromite deposits. The deposit is medium size with reserves of 1 million tonnes grading >32% Cr_2O_3.

Origin and Tectonic Controls for Hegenshan Metallogenic Belt

The belt is interpreted as forming in a middle Paleozoic ophlolite complex that was structurally incorporated into the Hegenshan accretionary wedge terrane that contains ultramafic rock that extend 700 km east-west and range from 1 to about 40 km wide. The terrane mainly consists of: (1) dunite, olivine gabbro, and tholeiite lava with intercalated radiolaria and pillow basalt, limestone, and tuff; (2) plagioclase-augite peridotite with a K-Ar isotopic age of 380 Ma and chert with Devonian radiolaria; and (3) unconformably overlying Carboniferous to Permian marine carbonate, clastic rock, and volcaniclastic rock.

REFERENCES: Bai Wenji and others, 1994.

Yaroslavka Metallogenic Belt of Fluorite Greisen and Sn-W greisen, Stockwork, and Quartz Vein Deposits (Belt YA) (Russia, Far East)

This Late Cambrian and though Devonian metallogenic belt is hosted in numerous Paleozoic granitoid plutons that intrude in Cambrian clastic and limestone units of the Vosensenka continental-margin terrane of the Khanka superterrane. The Li-F alaskite granite that hosts the Voznesenka-II deposit has Rb-Sr isotopic ages of about 512 to 475 Ma. The formation of the deposits is interpreted as related to intrusion of Late Cambrian leucogranite. The major fluorite greisen deposit is at Voznesenka-II, and the major Sn-W greisen, stockwork, and quartz vein deposit is at Yaroslavka.

Yaroslavskoe Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Govorov, 1977) occurs mainly in greisen that mainly replaces skarn, limestone, and shale, and to lesser extent granite and granite porphyry that has a Rb-Sr isotopic age of 408 Ma and an initial Sr ratio of 0.7136. Sn quartz and quartz-tourmaline veins also replace skarn along with greisen. The Sn bodies occur in three mineral assemblages: (1) tourmaline and quartz; (2) tourmaline and fluorite; and (3) sulfide, tourmaline, and quartz with subordinate cassiterite, polymetallic sulfides, and chlorite. The sulfides are mainly pyrite, arsenopyrite, galena, and sphalerite. The deposit occurs along the contact of a early Paleozoic biotite granite (with an approximate isotopic age of 400 Ma) that intrudes Early Cambrian shale, siltstone, sandstone, and limestone. The relatively older pyroxene-scapolite, vesuvianite-garnet, and epidote-amphibole skarns replace limestone and shale along granite contacts, and in rare limestone inclusions in the granite. Over forty Sn occurrences occur in the metallogenic belt. The deposit is medium size with an average grade of 0.52% Sn. The deposit was ined from the 1950's to 1970's.

Voznesenka-II Fluorite Greisen Deposit

This deposit (Androsov and Ratkin, 1990) consists of massive to disseminated fluorite that occurs above the apex of a 1.5 km wide intrusion of Late Cambrian Li-F alaskite granite with an isotopic age of 512 to 475 Ma. The deposit consists of vein and greisen that occurs along a north-south-trending fault. The deposit consists of muscovite-fluorite aggregates that occur along the periphery whereas vein greisen occurs in the middle. Greisen is often brecciated, indicating a two-stage origin. Fragments of breccia consist of mica and fluorite, fluorite limestone, greisen, and granite altered to greisen. Fragments are cemented by quartz-topaz-micaceous-fluorite aggregate that formed during a second stage. The deposit is interpreted as forming during metasomatic replacement of Early Cambrian black organic limestone and alteration to greisen. The deposit is large and contains 450 million tons fluorite ore with an average grade of 30 to 35% fluorite. The deposit has been mined since the 1960's, and currently is the largest producer of fluorite in Russia.

Origin and Tectonic Controls for Yaroslavka Metallogenic Belt

The belt is interpreted as forming in a collisional arc that formed along the margin of a fragment of Gondwanaland. The host leucogranite hosting the fluorite and Sn-W greisen, stockwork, and quartz vein deposits is Li-F-REE enriched. The extensive deposits occur in the apical parts of plutons that are altered to quartz-mica-fluorite-REE greisen. The host leucogranite plutons are interpreted as forming during anatectic melting of older granitic gneiss and Cambrian sedimentary rock. The anatectic melting is interpreted as occuring during early Paleozoic collision of the Voznesenka and Kabarga terranes. The host leucogranite plutons intrude Early Cambrian limestone of the Voznesenka passive continental-margin terrane that is interpreted as a fragment of a Neoproterozoic to early Paleozoic carbonate and rich sedimentary rock sequence that formed on a passive continental margin.

REFERENCES: Govorov, 1977; Nokleberg and others 1994, 1997, 1998, 2003; Androsov and Ratkin, 1990; Khetchikov and others, 1992; Ryazantzeva and Shurko, 1992; Rayazantseva and others, 1994; Khanchuk and others, 1996, 1998; Ryazantzeva, 1998.

Edren-Zoolon Metallogenic Belt of Au in Shear Zone and Quartz Vein Deposits (Belt EZ) (Southern Mongolia)

This Late Devonian and Early Carboniferous metallogenic belt (Tcherbakov and Dejidmaa, 1984) occurs in veins and replacements in the Edren island arc and the Zoolon accretionary wedge terranes (Tomurtogoo and others, 1999). The belt consists of Au in shear zone and quartz vein deposits that are hosted in regionally metamorphosed rock. Numerous occurrences are in the Edren and Nemegt districts. The Edren island arc terrane consists of Middle Devonian andesite, tuff, chert, siliceous tuff, limestone, Middle and Late Devonian basalt and andesite, and overlhying Early to Middle Carboniferous molasse (Ruzhentsev and others, 1990). Early Devonian age pillow basalt, siliceous sedimentary rock of Olgiibulag Formation occur in northwestern part of the terrane (Rauzer and others, 1987). The Zoolon terrane consists of tectonic sheets, slivers, and melanges of Silurian and Devonian volcanic rock, volcaniclastic rock, chert, and ultramafic rock that are metamorphosed to greenschist facies (Tomurtogoo and others, 1999). The major deposit is at Khadat Gunii khudag.

These Au quartz-carbonate vein and stockwork occurrences are mostly hosted in greenstone, greenschist, and local altered ultramafic rock (Dejidmaa, 1996; Dejidmaa and others, 1996). The quartz-carbonate veins are concordant with host shale. Vein size is variable and ranges from few mm to several meters thick. Thin veins form occur in linera zones that are about a hundred meters long uyp to several tens of meters wide. Host rocks are mostly intensely altered to pyrite. Veins are low sulfide type, major ore mineral is pyrite, and minor minerals are chalcopyrite and native Au. The deposits are mainly in the Edergenii nuruu and Nemegt Au districts (Dejidmaa, 1996). Related placer Au deposits occur in the Edren, Ongon Uul, and Nemegt districts where placer Au and placer Au-PGE deposits were mined in ancient time.

Khadat Gunii khudag Au in Shear Zone and Quartz Vein Deposit

This deposit (Podkolzin and others, 1990) consists of a northeast-trending steeply dipping, quartz vein that ranges from 0.3-0.5 m thick, and extends 100 m in chert and basalt in the Early Devonian Olgii Formation. Host rocks are weak altered to silica, carbonate, limonite, and epidote. Ore minerals are pyrite, chalcopyrite, and galena and rare gold. Heavy concentrate samples contain galena, arsenopyrite, sphalerite, pyrite, cerussite, anglesite, and gold that ranges from 0.1 mm to 0.9 mm. Rock chip samples contain 0.1-30.0 g/t Au. A northeast-trending quartz veinlets zone occurs 500 m in southeast and consists of sericite-chlorite schist cut by quartz veinlets and stringers with pyrite, chalcopyrite, galena, and gold that ranges up to 3 mm. A rock chip sample contains 10 g/t Au. Local placer Au deposits were exhausted in ancient time.

Origin and Tectonic Controls for Edren-Zoolon Metallogenic Belt

The belt is interpreted as forming as forming during regional metamorphism and vein emplacement associated with accretion of Beitianshan-Atasbogd and Zhongtianshan terranes

REFERENCES: Tcherbakov and Dejidmaa, 1984; Rauzer and others, 1987; Ruzhentsev and others, 1990; Dejidmaa, 1996; Dejidmaa and others, 1996; Sharhuuhen, 1999; Tomurtogoo and others, 1999.

Tsagaansuvarga Metallogenic Belt of Porphyry Cu (±Au) and Porphyry Cu-Mo (±Au, Ag) and Granitoid-related Au Vein Deposits (Belt TsS) (Southeastern Mongolia)

This Late Devonian to Early Carboniferous metallogenic belt is related to granitoids in the Gurvansayhan island arc terrane. The major deposits are the Oyu Tolgoi porphyry Cu deposit, the Tsagaansuvarga Cu-Mo deposit, and the Oyut, Bor Ovoo, and other porphyry Cu-Mo occurrences, including the Alagtolgoi Au occurrence. Yakovlev (1977) first defined the Cu Tsagaansuvarga district, and Shabalovskii and Garamjav (1984) and Sotnikov and others (1984, 1985) assigned the district to the South Mongolian metallogenic belt that contains Early Carboniferous porphyry Cu (±Au) deposits including the Tsagaan suvarga deposit. Various porphyry Cu-Mo (±Au, Ag) occurrences, at Oyut, Bor Ovoo, and Khatavchiin tolgod, occur in Ordovician volcanic and sedimentary rock, or in Early Devonian volcanic rock, and are closely related to intrusive porphyry dikes or small intrusive bodies. Various granitoid-related Cu vein-stockwork occurrences, as at Alagbayan, Zargyn Ovoo, Yamaat uul, and others, occur in Early Carboniferous basalt and andesite of the Sainshand khudag Formation.

Oyu Tolgoi Porphyry Cu (±Au) Deposit

A major new deposit is being developed at Oyu Tologi in southern Mongolia (A. Gotovsuren and others, written commun., 1995; Cox and others, 2000; Perello and others, 2001). The deposit is hosted in a rhyolite and dacite volcanic wallrock and occurs in three main mineralized zones that are interpreted as two separate porphyry Cu centers. The central part of deposit consists of a multi-phase hydrothermal breccia that crosscuts an altered, fine-grained feldspar porphyry. Advanced argillic alteration occurs with several assemblages of quartz, alunite, dickite, pyrophyllite, sericite, and other minerals that overprint older K-silicate and quartz-sericite-illite assemblages. The Cu deposit consists of a large supergene chalcocite blanket that replaces a pyrite-rich, hypogene chalcocite-covellite-tennantite suite that formed during advanced argillic alternation. A K-Ar alunite isotopic age of 117 Ma () indicates formation of the supergene chacocite blanket in the central part of deposit formed in the Early Cretaceous. Younger fine-grained granite dikes intrude the host volcanic rocks and are generally less-altered and mineralized than other rocks. Potassic alteration occurs mainly in intrusive rock in southern part of deposit. Cu and Au grades exhibit a positive correlation with intensity of quartz stockwork. Disseminated Cu sulphides are also common. Magnetite, chalcopyrite and bornite are the principle hypogenal minerals along with with minor chalcocite. Oxidation extends to depths of 5 m to 85 m and is underlain by weak supergene minerals. Cu sulfides are associated with the sericite and potassic alteration. Cu grade correlates positively with frequency of quartz veinlets. Surface samples contain > 0.1% Cu, >0.005% Mo, >5 g/t Ag and >0.1 ppm Au over an area of 0.06 km x 0.6 km, including a zone 40 m x 250 m that contains >0.3%Cu. Secondary Cu enrichment is minor. K-Ar isotopic age of 411 Ma occurs for biotite from K silicate alteration and is interpreted as age of alteration and Cu mineralization. The deposit is associated with small, structurally-controlled monzonite and diorite stock and dikes and that intrude Silurian and Devonian volcanic and sedimentary rock. Deposit and host rocks are intruded by Carboniferous syenite. The deposit is large with an estimated 438 million tonnes grading 0.52% Cu and 0.35 g/t Au.

Tsagaan suvarga Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit consists of stockwork veinlets and veins of quartz, chalcopyrite, and molybdenite that occur in or near porphyritic intrusions (Yakovlev, 1977; Sotnikov and others, 1985; Gotovsuren 1991; Lamb and Cox, 1998). The deposit is hosted in the Late Devonian Tsagaan-suvarga granosyenite and granodiorite porphyry stock that is overlain by Carboniferous volcanic and sedimentary rock. The deposit and host rocks are structurally controlled by an important northeast-striking fault. The pluton exhibits both potassic and sericite alteraton. Companion sulfide minerals are cut by felsic dikes and hydrothermal breccia. Cu and Mo minerals occur in centers of potassic alteration. Grade correlates positively with quartz veinlet intensity. Secondary Cu enrichment is minor. Alteration zone is 50 to 400 m wide and extends for 1 or 2 km. Major ore minerals are chalcopyrite, pyrite, barite, covillite, and local chalcocite and molybdenite. Gangue minerals are quartz, sericite, chlorite, azurite, malachite, and calcite. Alteration minerals are quartz, K-feldspar and sericite, and local biotite or chlorite. The highest grade part of the deposit occurs in the potassic alteration zone that contains a well-developed quartz vein stockwork. Intensity of potassic alteration increases with depth. The deposit is large with resources of 317.5 million tonnes grading 0.53% Cu, 0.018% Mo, 119.68 tonnes Re, 26 tonnes Au, and 810 tonnes Ag.

Origin and Tectonic Controls for Tsagaansuvarga Metallogenic Belt

The belt is interpreted as forming in a mature island arc or continental-margin arc. Age of Tsagaansuvarga pluton, that consists of of gabbro, diorite, granodiorite, granosyenite, syenite and related dikes, is interpreted as Devonian. The overlying volcanic and sedimentary strata are Early Carboniferous (Goldenberg and others, 1978). A $^{40}Ar/^{39}Ar$ isotopic age of 364.9± 3.5 Ma (Late Devonian) for biotite alteration in the Tsagaan suvarga porphyry Cu (±Au) deposit agrees with this Devonian age (Lamb and Cox, 1998). The host rock assemblage is interpreted as part of a Late Devonian Andean magmatic belt (Lamb and Cox, 1998), This interpretation agrees with that of a mature island arc or continental volcanic arc (Zorin and others, 1993; Lamb and Badarch, 1997). The shape of the metallogenic belt is complicated by younger, late Paleozoic, Mesozoic and Cenozoic tectonic events. The belt occurs in two parts: (1) a northeastern half that hosts the Tsagaan suvarga deposit and extends northeast-southwest; and (2) a western half that trends east-west and contains the Oyu Tolgoi, Bor-Ovoo Cu-Mo, and other Cu and Au occurrences.

REFERENCES: Berman, and Vogdin, 1968; Chebanenko, and others, 1968; Yakovlev, 1977; Goldenberg and others, 1978; Sotnikov and others, 1980; Shabalovskii and Garamjav, 1984; Sotnikov and others, 1984, 1985; Byamba 1996; Lamb and Cox, 1998; Cox and others, 2000; Perello and others, 2001.

Hongqiling Metallogenic Belt of Mafic-Ultramafic Related Cu-Ni-PGE, Polymetallic (Pb, Zn±Cu, Ba, Ag, Au), and Volcanic-Hosted Metasomatite Deposits (Belt HQ) (Northeastern China)

Belt is interpreted as forming during extension that occurred after accretion of the Zhangguangcailing superterrane to the basement of the Sino-Korean Craton (Jilin-Liaoning-East Shandong terrane). The mafic and ultramafic plutonic intrusions, that occur in swarms in the Hongqiling, Changren, Piaohechuan, and other areas, consist of gabbro, pyroxenite, peridotite, orthopyroxenite, and cortlandtite. The mafic-ultramafic intrusions have isotopic ages of 331 to 350 Ma, and are controlled mainly by northwest-trending major faults that occur along the northern margin of the Sino-Korea Platform. The plutons intrude metamorphosed volcanic rock, terrigeneous, clastic, and carbonate rock of the early Paleozoic Hulan Group. However, new data indicate a possible Triassic age for the mafic-ultramafic plutons and related Cu-Ni deposits (new ^{40}Ar-^{39}Ar isotopic age is 250 Ma (Xi Aihua, in press)).The mafic-ultramafic plutonism and associated Cu-Ni deposits are herein interpreted as forming during extension after accretion. The Early Carboniferous volcanic and sedimentary strata hosting the Guama deposit occur in an extensional basin that is interpreted as forming after the accretion of the Zhangguangcailing superterrane. The Hongqiling Cu-Ni deposit may be related to major regional faults that controlled a back-arc basin (Fu Debin, 1998).

Hongqiling Mafic-Ultramafic Related Cu-Ni-PGE Deposit

This deposit (Ge, Chaohua and others, 1994) consists of stratiform, tabular and pod-like deposits in a mafic-ultramatic intrusion that intrudes the early Paleozoic Hulan group. The mafic-ultramafic intrusions consist of norite, pyroxenite, enstatotitite and peridotite. The deposit is hosted in olivine pyroxenite. Ore minerals are pentlandite, pyrrhotite, chalcopyrite, pyrite, violarite, millerite, niccolite, maucherite, molybdenite, magnetite, and rutile. Pentlandite, pyrrhotite, and chalcopyrite are dominant. The mafic-ultramafic pluton is controlled by a major fault zone and has K-Ar isotopic ages of 331 to 350 Ma. The deposit is part of adistrict in the east-west-trending Tianshan-Xingan orogenic belt that occursadjacent to the northern margin of Sino-Korean Plate. The deposit is large with reserves of 188,230 tonnes grading 2.3% Ni, < 0.1ppm RGE, 5-50% sulfides

Guanma Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Deposit

This deposit (Wang Enyuan, 1989) occurs in thin-bedded horizons of intermediate and siliceous tuff and marble in the lower part of the Early Carboniferous Lujuantun Formation. Most deposits occur in tuff, in stratiform layers and lenses and are concordant and co-deformed with host rocks. Five separate deposits occur. The No.1 deposit is 300 m long, extends 200 m downdip and ranges from several to more than ten meters thick. The main deposit occurs in gray siliceous rock that contains minor arsenopyrite and pyrite, and is sulphide-poor. Some Au deposits also occur in the intercalated siliceous tuff in marble and in siliceous tuff intercalated with marble. Silica alteration occurs in siliceous rocks along the contact of marble and tuff. In Au-bearing siliceous rocks are local diopside skarn and wollastonite-bearing marble. From siliceous rock outwards into tuff for a width of 20 to 50 m, sericite, chlorite and carbonate alterations are widespread, along with local talc and dolomite. The deposit is interpreted as forming during sedimentary exhalation or hydrothermal alteration. The deposit is medium size.

Origin and Tectonic Controls for Hongqiling Metallogenic Belt

The belt is interpreted interpreted as forming during extension that occurred after accretion of the Jilin-Liaoning-East Shandong terrane. The belt hosted in Mississipian mafic-ultramafic plutons intruding Shandong terrane. The mafic and ultramafic plutonic intrusions, that occur in swarms in the Hongqiling, Changren, Piaohechuan, and other areas, are composed of gabbro, pyroxenite, peridotite, orthopyroxenite, and cortlandtite. The mafic-ultramafic intrusions have isotopic ages of 331 to 350 Ma, and are controlled mainly by northwest-trending major faults along the northern margin of the Sino-Korea Platform. The plutons intrude metamorphosed volcanic rock, terriginous, clastic, and carbonate rock of the early Paleozoic Hulan Group. However, new data indicate a possible Triassic age for the mafic-ultramafic plutons and related Cu-Ni deposits (a new 40Ar-39Ar Age is 250 Ma, Xi Aihua (in press)).The mafic-ultramafic plutonism and associated Cu-Ni deposits ae herein interpreted as forming in magmatic events during extension after accretion. The Early Carboniferous volcanic and sedimentary strata hosting the Guama deposit occur in an extensional basin that is interpreted as forming after the accretion of the Zhangguangcailing superterrane. The Hongqiling Cu-Ni deposit may be related to major regional faults that controlled a back-arc basin (Fu Debin and Qu Lili, 1994).

REFERENCES: Fu Debin, 1998.

LATE CARBONIFERROUS (PENNSYLVANIAN) THROUGH MIDDLE TRIASSIC METALLOGENIC BELTS (320 to 230 Ma)

Severo-Zemelsk Metallogenic Belt of Mafic-ultramafic Related Cu-Ni-PGE Deposits (Belt SZ) (Severnaya Zemlya Islands, Russia)

This Permian toTriassic metallogenic belt is related to mafic-ultramafic plutons related to Tungus plateau basalt, sills, dikes and intrusions that intrude the Kara terrane. The belt occurs at the Severnaya Zemlya Islands (Kara terrane) and forms a narrow band of northeast strike and about 100 km long. Cu-Ni-PGE deposits are medium (Ozernaya River) and small occurrences hosted in slightly differentiated mafic-ultramafic intrusions. They are composed of olivine gabbro to gabbro diorite and intrude Proterozoic volcanic and sedimentary sequence. Ore occurrences occur along the major faults of various strike.

Ozernaya River Mafic-ultramafic Related Cu-Ni-PGE Deposit

This deposit (Dodin and others, 1985) consists of zones of streaks and disseminations of Cu-Ni sulfides in Permian and Triassic gabbro and diabase and diabase that intrude sandstone, limestone and sandy dolomite. Ore minerals are chalcopyrite, pyrrhotite, pentlandite, and pyrite. The metallogenic belt may be a northern extension of the Yenisei-Sererozemelskiy belt that trends north-northeast for up to 1600 km, ranges up to 300 km wide, and extends from Kureika River in the south to the Severnaya Zemlya Islands to the north. The deposit is medium size.

Origin and Tectonic Controls for Severo-Zemelsk Metallogenic Belt

The belt is interpreted as related to mafic-ultramafic magmatism of transextension zones related to transform micro plate boundaries and within plate (plume) environment**.**

REFERENCES: Dodin and others, 1985; Dyuzhikov and others, 1988.

Birulinsk Metallogenic Belt of REE-Li Pegmatite Deposits (Belt Bir) (Taimyr Peninsula, Russia)

This Permian(?) belt is related to veins and dikes that occur in zonal metamorphic zones (unit to small to show on 5 and 10 M maps) in the Kara continental margin turbidite terrane, The belt is narrow and extends about 200 km along a northeast trend. The belt contains large pegmatite districts with numerous beryl-muscovite pegmatite veins (Ravich and Markov, 1959; Serdyuk and others, 1998). Both metamorphic and magmatic pegmatites occur (Vernikovskiy, 1996). Metamorphic pegmatite occurs in the sillimanite zone of amphibolite facies metamorphism in migmatite. Ceramic and muscovite pegmatite is typical. The largest pegmatites are hosted in intercalated biotite and high-alumina plagiogneiss that are derived from flysch. Magmatic pegmatite is the REE-muscovite type and are intensely altered to albite and rarely to greisen. Magmatic pegmatite contains beryl, cassiterite, columbite, spodumene, and other minerals. The small Birulinskoye deposit is the most thoroughly studied (Serdyuk and others, 1998).

Birulinskoye REE-Li Pegmatite Deposit

This deposit (Ravich, 1959; Ravich and Markov, 1959; Serdyuk and others, 1998) consists of beryl-muscovite pegmatite bodies that occur in Proterozoic two-mica granite and rarely-in plagiogneiss. The pegmatite bodies generally exhibit a zonal structure. The deposit is part of a pegmatite district that contains about 3,000 pegmatite bodies with extremely irregular beryl distribution. Beryl content varies from sporadic crystals to 21.8 kg/t. Weight of individual beryl crystals ranges up to 5.5 kg. Be oxide ranges up to 0.41%. Low concentrations of scheelite occur in pegmatite selvages. The deposit is small.

Origin and Tectonic Controls for Birulinsk Metallogenic Belt

The belt is interpreted as related to late Paleozoic collision and associated regional metamorphism and granitoid magmatism related to transform micro plate boundaries and within plate (plume) environment.

REFERENCES: Ravich, Malikh, 1959; Vernikovskiy, 1996; Serdyuk and others, 1998.

Norilsk Metallogenic Belt of Mafic-Ultramafic Related Cu-Ni-PGE, Basaltic Native Cu, and Porphyry Cu-Mo (±Au, Ag) Deposits (Belt NR) (Northwestern North Asian Craton, Russia).

This Early Triassic metallogenic belt is related to the Tungus plateau basalt, sills, dikes, and intrusions that extend sublongitudinally to the west and sublatitudinally to the east. The belt is about 600 km long and varies from 60 to 150 km wide. The belt occurs in the area of trapp magmatism. The shape of the belt is controlled by fault zones related to the West-Siberian and Yenisei-Khatanga rifts (Dodin and others, 1985; Dyuzhikov and others, 1988). The belt contains major Cu-Ni-PGE deposits. The largest Cu-Ni-PGE deposits (Norilsk, Talnakh, Oktyabrskoye) are the very important for the mineral industry of Russia (Dodin and others, 1998, 1999). Deposit-hosting intrusions differentiated, stratiform plutons that range from 80 to 400 m thick and composed of variable rock sequences range from plagioclase dunite to gabbro and diorite. Cu-Ni-PGE sulfides occur both in magmatic rocks and Paleozoic host rocks adjacent to exocontacts. Basalt native copper deposits (Arylakhskoye deposit) occur in the upper part of a Triassic welded tuff sequence. Cu deposits generally occur in basalt flows and in breccia. The Bolgochtonskoye porphyry Cu-Mo (±Au, Ag) deposit occurs in the endocontact and exocontact zones of a granitoid stock that intrudes Silurian and Devonian argillaceous carbonate sequence.

Norilsk I Mafic-Ultramafic Related Cu-Ni-PGE Deposit

This deposit (Godlevskiy, 1959; Ivanov and others, 1971; Smirnov, 1978) consists of Cu-Ni sulfide deposits hosted in the Triassic Norilsk differentiated mafic-ultramafic intrusive. The intrusive has a layered bed-like form that extends for 12 km and ranges from from 30 to 350 m thick (130 m average). The intrusive is composed by gabbro, diabase, and norite that intrude Permian sedimentary rock, trachydolerite, trachybasalt, and andesite, and basalt. Sulfides occur in disseminations and nests of pyrrhotite, pentlandite, and chalcopyrite mainly in the lower olivine-rich picrite and diabase, and to a lesser extent in bands in diabase near the bottom of intusive. Veins of massive sulfides occur in the lower part of intrusive and in underlying rocks and consists of streaks and disseminations in wall rocks. These veins form an interrupted aureole around the intrusive and extend for 15 km and range from 3-8 m thick. The sulfides mainly comprise form a stable layer that is concordant in plan view with the intrusive outline. The main mineral assemblages are: pyrrhotite; chalcopyrite-pyrrhotite with pentlandite; cubanite-pentlandite-chalcopyrite; bornite-chalcocite; and millerite-pyrite. Elevated Pt in sulfides is characteristic. The oldest Cu-Ni sulfides are overprinted by low-temperature hydrothermal replacement with development of carbonate, chlorite, galena, and sphalerite. The deposit is large.

Norilsk II Mafic-Ultramafic Related Cu-Ni-PGE Deposit

This deposit (Zolotukhin and Vasil'ev, 1967) consists of Cu-Ni sulfides in a differentiated mafic-ultramafic intrusive that has a honolithe form, and extends for 7 km, ranges from 100 to 300 m thick, and ranges from 100 to 800 m wude in plan view. The intrusion is layered and consists of gabbro and diabase at the top and olivine-biotite and picritic at the bottom. An irregular sulfide horizon occurs near the base of the intrusive, but often occurs in the footwall. The principal ore minerals are pyrrhotite, pentlandite, cubanite, chalcopyrite; bornite, chromite, valleriite, pyrite, PGE-minerals also occure. The ores are enriched in PGE. The deposit is a large and world-class.

Oktyabrskoye 3 Mafic-Ultramafic Related Cu-Ni-PGE Deposit

This deposit (Zolotukhin and others, 1975; Smirnov, 1978) consists of Cu sulfides-Ni deposits in differentiated mafic-ultramafic Talnakh intrusive (P-C). Intrusive composed by gabbro, non-olivine-, and olivine-biotite gabbro and diabase. The role of olivine-rich rocks increases to the intrusive floor. Deposit-hosting intrusive is at the 600 to

1400 m depth and hosted in metamorphosed rocks of Middle Devonian age. Three types of Cu sulfides-Ni ore are distinquished: massive, disseminated in intrusive rocks, and disseminated essentially Cu ores in host rocks. Massive sulfide ores compose dipping at low angle deposit with area of about 4 km2 and from 1 to 46 m thick. Disseminated ores compose some horizons at the base of intrusive having total thickness up to 40 m. Disseminated essentialy Cu ores occur in contact zone of intrusive and are from 2 to 10 m thick. Principal ore minerals are: pyrrhotite, pentlandite, chalcopyrite, cubanite. Secondary minerals: magnetite, ilmenite, chromite, valleriite, bornite, pyrite. The ores are by PGE-enriched. The deposit is large and world class.

Arylakhskoye Basaltic Cu (Lake Superior type) Deposit

This deposit (Dyuzhikov and others, 1976, 1977, 1988) consists of stratiform layers of native copper in Permian and Triassic carbonaceous breccia, in overlying basalt, and in underlying tuff. Ore minerals are native copper, cuprite, tenorite, chalcocite, and covellite. Gengue minerals are calcite, zeolite, chlorite, adularia, and quartz. The deposit and host rocks are regionally metamorphosed, and exhibit carbonate, chlorite, and zeolite alteration. Cu-bearing horizon is 2 to 10 m thick and extends for 40 km along the flank of the trapp basins. The highest concentration of native copper is in brecciated carbonate rocks. Native Cu occurs along the contacts of fragments in a carbonaceous matrix. Coarse grains (up to 0.7 to 1 cm) and dendrite (up to 3 to 5 cm) are widespread. The native copper occurs in veinlets, nests, fine disseminations, and amygdules. In tuff Cu occurs fine disseminations. Large aggregates (15 by 20 cm) and dendrite-like crystals (5 to 10 mm) of native copper occur in large amygdules and carbonate veins. The deposit is medium size.

Bolgokhtonskoye Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Matrosov and Shaposhnikov, 1988; Dyuzhikov and others, 1988) consists of Cu-Mo sulfides in veinlets and disseminations in hydrothermally-altered rock along contact of Bolgokhtokh granite pluton, in both the pluton and in adjacent intrusive rock. The granite pluton stock intrudes Silurian and Devonian limestone, marl, and siltstone and Permian and Triassic volcanic rock and diabase. Metasomatite consists of calc-silicate skarn, quartz-feldspar, quartz-sericite and quartz-calcite-chlorite rock. Two main districts occur. A Southern district occurs at depth and consists of streaks and lesser disseminations and nests. Thickness ranges up to 0.8 to 1 cm. A Western zone crops out at the surface and consists of streaks and disseminations. Ore minerals are magnetite, molybdenite, chalcopyrite, sphalerite, pyrite, scheelite, bornite, fahl orewolframite, and galena. Gangue minerals are quartz, sericite, K-feldspar, and carbonate. Polymetallic sulfides increase in the propylite in the exterior part of the deposit. The deposit is medium size.

Origin and Tectonic Controls for Norilsk Metallogenic Belt

The belt is interpreted as related to mantle-derived superplume magmatism that formed widespread of trapp magmatism on North Asian Craton. The major Cu-Ni-PGE deposits occur in an area of orthogonal intersection of the Mesozoic Yenisei-Khatanga rift basin and the West-Siberian rift system. The deposits in the Norilsk district occur along ongitudinal linear structures that coincide with the major faults and axial zones of volcanic-tectonic basins. The major Norilsk-Kharaelakh fault is interpreted to be the major magmatic and deposit-controlling structure (Dyuzhikov and others, 1988). Magma generation is interpreted as related to the mantle-derived superplume that resulted in widespread trapp magmatism on the North Asian Craton (Dobretsov, 1997). Initial picrite magma is interpreted as a source for mafic-ultramafic host for the Norilsk metallogenic belt (Zolotukhin and Vasiliev, 1976; Dyuzhikov and others, 1988). $^{40}Ar/^{39}Ar$ isotopic age for basalt of the Norilsk ore district is 241.0 to 245.3 Ma and the age for mafic-ultramafic intrusions is 248.7 to 248.9 Ma (Dalrymple and others, 1991, 1995). The $^{40}Ar/^{39}Ar$ isotopic age for Bolgokhtonsk granitoid that hosts the porphyry Cu-Mo (±Au, Ag) deposits is 223.3 Ma (Zolotukhin, 1997). The granitoid magmatism is interpreted as resulting from evolution of the magmatic system during rifting (Dyuzhikov and others, 1988). Basalt native copper deposits formed later than the Ni-bearing mafic-ultramafic plutons (Dyuzhikov and others, 1988).

REFERENCES: Zolotukhin, Vasiliev, 1976; Dodin and others, 1985, 1998, 1999; Dyuzhikov and others, 1988; Dalrymple and others, 1991, 1995; Dobretsov, 1997.

Maimecha-Kotuisk Metallogenic Belt of Fe-Ti (±Ta, Nb, Fe, Cu, apatite) Carbonatite, REE (±Ta, Nb, Fe) Carbonatite, and Phlogopite Carbonatite Deposits (Belt MK) (Northwest of the North-Asian Craton, Russia)

This Late Permian to Early Triassic metallogenic belt is related to volcanic flows of the Tungus plateau basalt that occurs in the northwestern North Asian Craton. The eastern boundary is the western border of the Anabar Shield. Varied Permian and Triassic magmatic rocks are widespread in the belt consist of tholeiite, diabase, trachybasalt, picrite, and melanonephelinite extrusive and intrusive rock, and ijolite, carbonatite, and kimberlite complexes (Egorov, 1970; Malich and others, 1987). More than twenty, central-type, alkalic ultramafic plutons with carbonatite occur in the belt: The largest are the Gulinskoe pluton (about 500 km^2), Odikhincha pluton (56 km^2), Magan pluton (42 km^2), Bor-Uryach pluton (17 km^2), Kugda pluton (16.5 km^2), Essey pluton (6 km^2), and Irias pluton (6 km^2). Ijolite and carbonatite are most prevelant rock types. Most alkalic ultramafic carbonatite intrusions contain magnetite, titano-magnetite, perovskite, REE, phlogopite, apatite, and nepheline deposits (Malich and others, 1987). Several groups of deposits occur in the belt: (1) large-and average-size Fe-Ti carbonatite (Gulinskoye I), Magan I, Bor-Uryach and others; (2) large REE (±Ta, Nb, Fe) carbonatite (Gulinskoye I); and (3) medium-size phlogopite-carbonatite (Odikhimcha I and others).

Gulinskoye 1 Fe-Ti (±Ta, Nb, Fe, Cu, apatite) Carbonatite Deposit

This deposit (Kalugin and others, 1981; Sinyakov, 1988) consists of titanomagnetite in the Gulinsk alkalic central type ultramafic pluton. Titanomagnetite occurs in pyroxenite and peridotite in a half-ring zone that 30 km long and 100 m wide. Titanomagnetite occurs as dissemination and locally in veins, nests, lenses, and large deposits that comprise up to 25 to 30% pyroxenite bodies by volume. Dimensions of discrete concentrations range from 100 to 200 m to 5 km along strike and from 10 to 30 to 600 m thick. The deposit is large. Resources are 1.8 billion tonnes to a depth of 100 m with an average grade of 22.4% Fe.

Gulinskoye 2 REE (±Ta, Nb, Fe) Carbonatite Deposit

This deposit (Kavardin, 1967) consists of REE in alkalic ultramafic carbonatite plutons. Two carbonatite plutons of with outcrop areas of 3 km^2 and 5 km^2 occur around the Gulinskoye phlogopite deposit. The plutons consist of vertically-dipping, isometrical bodies of mainly ankaratrite, picrite, peridotite, and melilite. Deposits consist of irregular, fine-grained disseminations of ore minerals in calcite, calcite-magnetite, calcite-dolomite, and dolomite carbonatite. Pyrochlore occurs with magnetite, serpentine, and REE minerals. Perovskite occurs in nests with magnetite and melanite, and is more abundant in micaceous melanite and pyroxenite in the Gulinskii pluton. The deposit is and large world class.

Odikhincha 1 Phlogopite Carbonatite Deposit

This deposit (Prochorova and others, 1966; Dyad'kina and Orlova, 1976; Malich and others, 1987) consists of phlogopite deposits in the central type Odikhincha alkaline-ultramafic pluton. Phlogopite formation occurred in the ijolite and carbonatite stages of the pluton. The major phlogopite concentrations occur in dunite and and along contacts with ijolite-melteigite. Dunite contains up to 10 to 30% phlogopite. Monomineral phlogopite veins occur in fissure zones in dunite. The veins range up to several tens of meters long and up to 1.5 to 2 m thick. Veins also contain olivine, titanomagnetite, calcite, and perovskite. Diopside-phlogopite veins occur near the contact of the pluton with wallrock. Phlogopite also occurs in of garnet-nepheline-pyroxene and nepheline-melilite pegmatite veins. The deposit is medium size.

Origin and Tectonic Controls for Maimecha-Kotuisk Metallogenic Belt

The belt is interpreted as related to mantle-derived superplume magmatism that resulted in widespread development of trapp magmatism on the North Asian Craton. Magmatic rocks include tholeiite, diabase, trachybasalt, and melanonephelinite volcanic and intrusive rock, and ijolite-carbonatite and kimberlite complexes. The belt occurs at intersection of the trans-Asian longitudinal Taimyr-Baikal lineament and the major Yenisei-Kotuisk sublatitudinal fault belt. The distribution of the plutons of alkalic and ultramafic rock is determined by intersections of the major faults. Abyssal differentiation of mantle olivine-melilite magma was a crucial factor in multistage development of deposit-hosting plutons. Their compositions were complicated by superimposed metasomatic processes (Egorov, 1970; Samoilov, 1977). According to the $^{40}Ar/^{39}Ar$ data, the age of deposit-hosting intrusions ranges from 249.88 to 253.3 Ma (Basu and others, 1995) that corresponds to the Early Triassic stage of development of trappean magmatism at North Asian Craton (Zolotukhin, 1997). The origin of alkalic ultramafic-carbonatite plutons and accompanying deposits is geodynamically related to continental rifting occurring above a hot spot in tthe southern flank of the Yenisei-Khatanga rift (Yaskevich and others, 1980).

REFERENCES: Egorov, 1970; Samoilov, 1977; Yaskevich and others, 1980; Malich and others, 1987; Basu and others, 1995; Zolotukhin, 1997.

Kureisko-Tungsk Metallogenic Belt of Fe Skarn, Mafic-Ultramafic Related Cu-Ni-PGE, and Metamorphic Graphite Deposits (Belt KT) (Western North Asian Craton, Russia)

This Permian to Triassic metallogenic belt is related to replacements and plutons in the Tungus plateau basalt, sills, dikes, and intrusions, and occurs in a wide band along the western margin of North Asian Craton for more than 900 km (Malich and others, 1987). The belt contains Fe skarn deposits, Cu-Ni-PGE sulfide deposits related to mafic-ultramafic rock, and metamorphic graphite deposits. The belt is controlled by the area of the Triassic trapp magmatism and the major Yenisei sublongitudinal fault zone that occurs along the western border of the Tungussk syncline. The metallogenic belt is conjugated with the Norilsk metallogenic belt to the north. Fe skarn deposits occur along exocontacts of subalkalic diabase and rarely farther removed (Pavlov, 1961). The age of host rocks ranges from Early Cambrian to Early Triassic. Cu-Ni-PGE deposits are hosted in dunite, gabbro, troctolite, and diabase intrusions (Kavardin, 1976; Dyuzhikov and others, 1988). Graphite deposits occurs in areas of contact metamorphism of Permian coal-bearing sequences by Triassic trapp intrusions (Malich and others, 1987).

Suringdakonskoye Fe Skarn Deposit

This deposit (Pavlov, 1961; Staritskiy and others, 1970; Kalugin and others, 1981) consists of a steeply-dipping magnetite body in Late Devonian limestone and Permian clastic rock of age intruded by trapp magma. The deposit is 1.9 km long and varies from 35 to 40 m thick. Along strike massive ore grade into streaks and disseminations in a zone that extends for 1.5 km and ranges from 50 to 350 m thick. Host rock for streaks and disseminations is garnet-chlorite-carbonate metasomatite. Masses grade 58.43% Fe, and disseminations grade 20.39 to 47.07% Fe. The deposit is large with resources of 600,000,000 tonnes grading 20-59% Fe.

Bilchany River Mafic-Ultramafic Related Cu-Ni-PGE Deposit

This deposit (Kavardin and others, 1967; Kavardin, 1976.) consists of Cu-Ni sulfides in a Triassic dolerite intrusive. The sulfides occur in nests and disseminatons. Ore minerals are pyrrhotite, pentlandite, chalcopyrite, and pyrite. The deposit is small.

Noginskoye Metamorphic Graphite Deposit

This deposit (Malich and others, 1974, 1987) consists of beds of amorphous (cryptocrystalline) graphite in an Early Jurassic coal-bearing sedimentary sequence that is intruded by a stratified trapp Triassic intrusion. Host rock consist of graphite and contact metamorphosed and graphite shale. Two beds of high-quality graphite occur, a lower bed that ranges up to 6.7 m thick, and an upper bed that is 1.7 m thick. The beds extend for 1.2 km. Graphite occurs in crystalline form and comprises up to 40% by volume. Small amounts of hydrothermal graphite occur in carbonate veinlets with sulfides. Graphite ores occur in columns, layers, masses, and breccia. The deposit is large with average grade of 71.33 to 90.56% C, 8.53 to 24.34% ash, and 0.28 to 3.06% volatiles. The deposit was abandoned.

Origin and Tectonic Controls for Kureisko-Tungsk Metallogenic Belt

The belt is interpreted as related to mantle-derived superplume magmatism that resulted in widespread development of trapp magmatic rocks on North Asian Craton along the long-lived West-Siberian rift and major

Yenisei sublongitudinal fault (Surkov, 1986; Dobretsov, 1997). This belt occurs in the intersection of two lithospheric plates, the oceanic West-Siberian and continental Siberian plates. The Priyeniseisk deep-fault zone contains numerous Triassic diabase intrusions and ore occurrences, mainly Fe skarn (of Angara-Ilim type). The majority of deposits occur along intersections of sublongitudinal and sublatitudinal faults (Malich and others, 1987). Graphite deposits formed as a result of thermal metamorphism of the late Paleozoic coal-bearing sedimentary rock during intrusion by numerous diabase intrusions (Malich and others, 1974).

REFERENCES: Pavlov, 1961; Malich and others, 1974; Kavardin, 1976; Dyuzhikov and others, 1988; Surkov, 1986; Dobretsov, 1997.

West Verkhoyansk Metallogenic Belt of Au in Black Shale and Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposits (Belt WV) (Russia, Central part of the \ Verkhoyansk fold and thrust belt)

This Late Carboniferous and Early Permian metallogenic belt is hosted in clastic sedimentary rock in the passive continental margin Verkhoyansk fold and thrust belt in the North Asian Craton Margin. The host rocks are Carboniferous and Permian shelf clastic rock that occurs in forming large longitudinal simple folds. The belt contains large stratabound Ag (Mangazeika 2) and Ag-Au (Kysyltas) vein deposits and occurrences. The belt is interpreted as related to basalt eruption during rifting of a passive margin (Kostin and others, 1997).

Mangazeika 2 Au in Black Shale Deposit

This deposit (Indolev and Nevoisa, 1974;Kostin and others, 1997) consists of high-angle veins that have a variable dip and strike, and thin or branch into closely-spaced veinlets. The veins range from tens of centimeters to 2 to 2.5 m wide (in swells) and extend from a few meters to tens of meters to 700 to 1000 m long. Stock-like swells in veins range up to 25 to 30 m thick. Crush zones and closely spaced vein systems also occur. Deposit is discontinous in an area 3 km across and 19 km long and is hosted in Late Carboniferous and early, Early Permian clastic rock. The deposit contains native Ag, Sb Ag minerals, animikite, allargentum, acanthite, Pb-acanthite, Cu-acanthite, Ag2S-Cu2S sulfide series, galena, sphalerite, chalcopyrite, stannite, pyrite, arsenopyrite, bismuthinite, and stibinite. Also occurring are sulfosalts, including fahl, pyrargyrite, miargyrite, diaphorite, owyheeite, polybasite, stephanite, canfieldite, freieslebenite, geocronite, bournonite, boulangerite, gustavite, and Ag-Bi-sulfotelluride. The deposit is interpreted as forming during Devonian rifting. Metals are interpreted as having been leached from Devonian basalt by sea water that circulated along faults. The deposit is large.

Kysyltas Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (Ivensen and others, 1975; Kostin and others, 1997b) consists of quartz-sulfide veins with galena, sphalerite, bournonite, pyrite, arsenopyrite, tetrahedrite, Ag-tetrahedrite, freibergite, pyrargyrite, covellite, and free gold. The veins cut Middle and later Carboniferous and Early Permian siltstone and sandstone in the core of the Kysyltas anticline. The Pentium vein 1 has an average grade of 575.5 g/t Ag, 3.06 g/t Au, 11.5% Pb, 8.32% Zn; the Pozolota vein has an average grade of 3.38-14.1% Pb, 0.12-2.16% Zn, 60-1500 g/t Ag, 0.4-200 g/t Au.

Origin and Tectonic Controls for West-Verkhoyansk Metallogenic Belt

The belt is interpreted as forming along passive continental margin of North Asian Craton during Devonian and Missippian rifting.

REFERENCES: Indolev and Nevoisa, 1974; Kostin and others, 1997; Parfenov and others, 1999; Parfenov and others, 2001; Nokleberg and others, 2003.

Central Tungussk Metallogenic Belt of Hydrothermal Iceland Spar Deposits (Belt CT) (Siberian Platform, Russia)

This Early Triassic metallogenic belt related to replacements associated with the Tungus plateau basalt, sills, dikes, and intrusions, and occurs in the central, northeast, and northwest parts of the Tungussk syncline on the North Asian Craton. The belt coincides spatially with Triassic volcanic and intrusive tholeiitic basalt. Iceland spar occurs in in pillow-lavas and mandelstone in the bottoms of lava sequences and in fracture zones in volcanic, sedimentary, and mafic intrusive rock. Iceland spar forms medium and small deposits. The largest is the Krutoye (Gonchak) deposit.

Krutoye (Gonchak) Hydrothermal Iceland spar Deposit

This deposit (Andrusenko, 1971; Kievlenko, 1974; Malich and others, 1987) consists of nests, veins, and aggregates of Iceland spar in Triassic basalt sheets. The thickness of basalt sheets ranges up to 30 m. Vein deposits occur in mandelstone underlying lava. Ore veins range up to 7 m long and up to 1 m thick in swells. Iceland spar occurs in the central part of veins and is replaced by quartz (amethyst) and chalcedony towards the margin. Nests and veins of Iceland spar occurs also in spherulitic lavas. Cement of spherulitic lavas is hydrothermally altered with formation of palagonite-chlorophaeite, zeolite, calcite, analcite, apophyllite, chalcedony, and quartz. The lenses of spherulitic lavas vary from 20 to 360 m length and range up to 8 m thick. The deposit is medium size.

Origin and Tectonic Controls for Central-Tungussk Metallogenic Belt

The belt is interpreted as related to widespread development of trapp magmatism on North Asian Craton. The belt coincides with Triassic tholeiite volcanic and intrusive rock. Paleobasins and regional faults that occur along the paleouplift boundaries control the location of the districts and deposits in the metallogenic belt (Malich and Tuganova, 1980). The volcanic structures and volcanic domes are favorable for localization of Iceland spar. Deposit-hosting structures are fissure intersections, cavities in breccia, roofs of lava flows, spherical joints in mandelstone, and fracture zones in diabase (Kievlenko, 1974). The hydrothermal genesis of Iceland-spar deposits and a relation with basalt magma is advocated by most investigators (Andrusenko, 1971; Skropyshev and others, 1971). A juvenile-meteoric genesis for Iceland spar deposited is proposed (Gurinova, 1964; Kievlenko, 1974). The temperature of formation of Iceland spar is estimated to be 200 to 50°C (Andrusenko, 1971). The age of Iceland spar deposits is estimated from a $^{40}Ar/^{39}Ar$ isotopic age of 248.0 to 248.9 Ma for basalt from the northern Tungussk syncline (Renne, Basu, 1991). This age corresponds to the age of Early Triassic trapp magmatism.

REFERENCES: Malich, 1959; Gurinova, 1964; Andrusenko, 1971; Skropyshev and others, 1971; Kovalenko, 1974; Malich and Tuganova, 1974, 1980; Renne and Basu, 1991.

Angara-Ilim Metallogenic Belt of Trap-Related Fe skarn (Angara-Ilim type), REE (±Ta, Nb, Fe) Carbonatite, and Weathering Crust Carbonatite REE-Zr-Nb-Li Deposits (Belt AI) (Southwestern North Asian Craton, Russia)

This Late Permian to Early Triassic(?) metallogenic belt is related to replacements associated with the Tungus plateau basalt, sills, dikes, and intrusions that overlie and intrude the southern part of the North Asian Craton. The belt forms a wide and elongated band about 40,000 km^2 at the southern closure of the Tungussk syncline. Fe skarn deposits are associated with with Triassic explosive, intrusive basalt trapp complexes in central type diatremes (Fon-der-Flaas, 1981). Deposits occur mainly along exocontacts of subalkalic diabase intrusions and rarely in adjacent Early Cambrian to Early Triassic wall rock. Lithological factors control deposit distribution and include favorable composition of host clastic, carbonate (dolomite), and evaporite rock, and the screening effect of mafic trapp rock. REE (±Ta, Nb, Fe) carbonatite deposits are related to central-type alkalic ultramafic intrusions that are exposed on the slopes of the uplifted basement as at the Chadobetsk uplift (Lapin, 1992; Lapin and Tolstov, 1993).

Korshunovskoye Trap-Related Fe skarn (Angara-Ilim type) Deposit

The deposit (Antipov, 1960; Vakhrushen and others, 1976; Momdzhi, 1976; Strakhov, 1978; Fon-der-Flaas, 1981; Seminsky and others, 1994) occurs in southwestern North Asian Craton in the southern closure of the Tungussk syncline. The deposit consists of a stockwork (with plan dimensions of 2,400 by 700 m) composed of four partly merged layers that contain variable amount of hematite and martite in upper layers, calcite and magnetite in middle layers, and halite and magnetite in lower layers. In the first type of deposit, the major minerals are magnetite, pyroxene, chlorite, and minor epidote. Lesser minerals are amphibole, serpentine, calcite, and garnet, and rare quartz, apatite, and sphene. Ore minerals occurs in oolites, druses, masses, and disseminations. In the second type pf deposit, the calcite increases to 20 to 30%, and ore minerals occur in nets, streaks, disseminations, and layers. In the third type of deposit, halite, amphibole, Mn magnetite are more abundant and the ore minerals occur in incrustates, and streaks. All deposits contain pyrite, chalcopyrite, and pyrrhotite. Magnetitite-rich deposits are polygenic-hydrothermal-metasomatic deposits, skarn deposits are associated with magmatic intrusion, and rare metamatite-martite deposits are hypergenic. Host rocks are Early Carboniferous limestone, Ordovician salt-bearing rock, and Permian through Triassic tuffaceous sandstone. The deposit is large with resources of 637 million tonnes ore grading 26% Fe to depth of 1200 m.

Chuktukonskoye REE (±Ta, Nb, Fe) Carbonatite and Weathering Crust Carbonatite REE-Zr-Nb-Li Deposit

The deposit (Lapin, 1992, 1996; Lapin and Tolstov, 1993) consists of Nb-REE minerals and phosphate minerals that occur in weathered carbonatite that is part of the Chadobetsk alkalic ultramafic complex. The carbonatite contains mainly calcite and dolomite, has an isotopic age of 260 to 200 Ma. The weathered crust varies from 70 to 100 to 350 m and more thick. Minerals inthe crust are of goethite, hematite, psilomelane, pyrolusite, barite, monacite, florensite, gorceixite, cerianite, and pyrochlore. At the bottom of the crust is francolite, quartz, and hydromica. Nb-REE minerals occur in residual lateritic ochre that formed in a leach zone and contains from 1 to 1.5% Nb_2O_5, 3 to 6% TR_2O_3 (0.1 to 0.3% Y_2O_3). Phosphatic and Nb-phosphate minerals occur in francolite rocks in a cemented zone and contain from 10 to 30% P_2O_5 (average of 17 to 20%). Ore minerals formed in an epigenetic altered weathered crust at the top of the deposit in a bleached horizon that is depleted in Fe and Mn and rich in Nb (up to 3 to 5% Nb_2O_5) and REE (up to 15 to 20% TR_2O_3). Thickness of this horizon ranges from 3 to 12 m. Ore minerals are monazite, florensite, crandallite, pyrochlore, anatase, pyrite, and goethite. The deposit is medium size.

Origin and Tectonic Controls for Angara-Ilim Metallogenic Belt

The belt is interpreted as related to widespread development of trapp magmatism on North Asian Craton. Fe skarn deposits associated with Triassic explosive and intrusive basaltic trapp complexes in diatremes. REE-Ta-Nb carbonatite deposits are associated with alkalic ultramafic intrusions. The deposits are interpreted as forming during intrusion of mantle-derived mafic magma and are mainly controlled by the major sublongitudinal and sublatitudinal regional faults. The belt occurs in two bow-shaped bands along the northern and southern boundaries of the Priangara syncline (Seminskiy, 1985). The origin of the metallogenic belt is related to development of Permian and Triassic trapp magmatism in the Tungussk. Ancient, long-lived interblock basement fault zones were magmatic channels. Various districts occur in melanocratic and mesocratic igneous blocks in Platform basement rocks along local uuplifted blocks. The widespread Permian and Triassic trapp magmatism is interpreted as related to a mantle superplume (Dobretsov, 1997). The K-Ar isotopic age of alkalic ultramafic rock of the Chadobetsk Uplift ranges from 229 to 263 Ma (Khlebnikov, 1971).

REFERENCES: Khlebnikov, 1971; Fon-der-Flaas, 1982; Seminskiy, 1985; Lapin, 1992; Lapin, Tolstov, 1993; Dobretsov, 1997.

Barlaksk Metallogenic Belt of W-Sn-W Greisen, Stockwork, and Quartz Vein Deposits (Belt BA) (Russia, Eastern Siberia).

This Middle Triassic metallogenic belt consists of replacements related to granitoids of Belokurikha plutonic belt and occurs in the Tom'-Kolyvan fold area in, Eastern Siberia. The belt extends northwest along the Ob River to the north from Novosibirsk and is hosted in isometric and oval Triassic granite and leucogranite plutons. Individual intrusives range from 30 to 140 km^2 in area. The plutons intrude Early Carboniferous flysch, mainly slate and sandy-siltstone in the Novosibirsk basin. Geophysical data suggest the separate plutons may join at depth. The plutons are homogeneous and consist of porphyritic biotite and two-mica leucogranite. Dikes of aplite and granite porphyry, and aplite-pegmatite veins occur in the plutons. The granitic rocks are ultrasiliceous and moderately alkalic (Sotnikov and others, 1999). The small Sn pegmatite and greisen deposits are hosted in granite of the Kolyvan and Barlak plutons (Vasyutinskaya and Mikhailovskiy, 1963; Roslyakov and Sviridov, 1998). The local small cassiterite placers are related to pegmatite and greisen associated with the granite. The major deposit is at Kolyvanskoye.

Kolyvanskoye W-Sn-W Greisen, Stockwork, and Quartz Vein Deposits

This deposit (Vasjutinskaja and Michailovskiy, 1963; Verigo, 1969; Kuznetsov, 1982; Roslyakov and Sviridov, 1998) consists of quartz veins and greisen zones in the Triassic Kolyvan leucogranite. Veins range up to 60 cm thick and contain cassiterite,wolframite, arsenopyrite, beryl, molybdenite, and bismuthite. Gangue minerals are muscovite, K-feldspar, topaz, fluorite, and lepidolite. Adjacent to veins are greisen zones that range up to 1 m thick. Composition of quartz veins is: from 0.27-12.5% Sn, 0.27-0.52% WO_3, and up to 0.14% Bi. Also occurring are small-scale pegmatite veins with coarse-grained quartz, K-feldspar, muscovite, beril, and topaz, and rare cassiterite. The deposit is small.

Origin and Tectonic Controls for Barlaksk Metallogenic Belt

The belt is interpreted as related to interplate rifting. The belt is hosted in intraplate in the Barlak granitoid pluton that intruded along strike-slip faults. Petrochemical and fluid inclusion data indicate the granite is similar to Sn granites in other metallogenic provinces. For the leucogranite intrusions, the Kolyvan pluton has a $^{40}Ar/^{39}Ar$ isotopic age of235.9±2.6 Ma-233.0±1.8 Ma, and the Barlak pluton has a Rb-Sr isochron age 232.0±6.9 Ma. The occurrence of the Barlak granite pluton along a northeast-striking strike-slip fault suggests a change from a collisional to a rift tectonic setting. These granite hastypical Y, Yb, Nb, and Ta intraplate characteristics. Associated mafic intrusions containing Cu-Ni deposits are older relate to Sn granite. The $^{40}Ar/^{39}Ar$ isotopic age of mafic intrusion is 255.0±5.5 to 252.6±1.5 Ma (Sotnikov and others, 1999). The younger granitoid magmas and associated hydrothermal solutions transformed the older Cu-Ni sulfide deposits and supplied additional Sn, Li, Pb, Zn, and Ag. The mafic intrusions are interpreted as forming during older collisional.

REFERENCES: Vasyutinskaya and Mikhailovskiy, 1963; Dergachev and others, 1980; Roslyakov, Sviridov, 1998; Glotov, Krivenko, 1998; Sotnikov and others, 1999.

Zashikhinskiy Metallogenic Belt of Ta-Nb-REE Alkaline Metasomatite and Clastic-Sediment-Hosted Hg (±Sb) Deposits (Belt Zsh) (Russia, East Sayan)

This Late Carboniferous to Middle Triassic metallogenic belt is related to granitoids and replacements in the Ognit and other complexes (too small to show at 10 M scale). The belt occurs in the northwestern part of Eastern Sayan, in the upper Uda River. This belt is small, extends for 105 km, is 60 km wide, and occurs in the Aksut-Sorugsky alkalic granite group that hosts the composite REE deposits. The Aksuy-Sorugsky alkalic granite occurs at the junction of the major Kandatsky and Sayan faults, close to the junction of Kizir-Kazyrsky and Khamsarinsky (Caledonide) zones with East-Sayan anticlinorium (Baikalide). The basement units consist of Derbinsky (DR) and Birjusinsky (BI) paragneiss terranes. The metallogenic belt contains mainly Ta-Nb-REE alkaline metasomatite deposits and lesser Hg deposits. The belt is promising for undiscovered REE and lesser Hg deposits. The major deposits are at Zashikhinsky and Gorkhonskoye.

Zashikhinskoye Ta-Nb-REE Alkaline Metasomatite Deposit

This large deposit at Zashikhinskoye (Arkhangelskaya, and others, 1997) occurs in an alkaline granite pluton with riebeckite and rare aegerine-riebeckite. The pluton is a small lenticular stock with a surface area of 1 to 1.5 km^2. The alkaline granite contains autometasomatic and post-magmatic albite alteration and associated Ta, Nb, REE, and Zr minerals. The rich albite Ta-Nb metasomatite deposit occurs in the apical part of the pluton and at deeper levels is replaced by low-grade Ta-Nb deposits consisting of quartz, albite, microcline, riebeckite, and arfvedsonite that occurs in a protolithionite metasomatite. The deposit contains Ta, Ni, Zr, Sn, Hf, and REE. The deposit is large and contains up to about 0.072% (on average 0.033%) Ta_2O_5 , and average 0.25% Nb_2O_5.

Gorkhonskoye Clastic-Sediment-Hosted Hg (±Sb) Deposit

This deposit (Geological Studies of the USSR (Irkutsk Oblast), 1969) consists of two districts with nests, streaks, and stockworks. The two districts occur along the feather branches of the Iisky-Gorkhon fault. In the first district, the deposit for 220 m for 100 m in the second district. Deposit consists of veinlets, nests, and irregular bodies. The ore minerals are cinnabar and pyrite, and rare chalcopyrite, markasite, quartz, sericite, and hydromica. Layers of ore minerals also occur in dolomite occurring in the core and flanks of anticlines.The main host rocks are Neoproterozoic sandstone, shale, and dolomite that are discordantly overlapped by conglomerate and sandstone. The deposit is small with an average grade of 0.2-0.85% Hg.

Origin and Tectonic Controls for Zashikhinskiy Metallogenic Belt

The belt is interpreted as forming during rifting and intraplate magmatism. The important late Paleozoic and early Mesozoic geological history for this region consisted of a relative tectonic lull of previously-consolidated Baikalides and early Caledonides structures that underwent tectonic and magmatic rejuvenation including intrusion of alkaline granitoids that host the REE deposits. Associated faults and ruptures host Hg deposits.

REFERENCES: Pavlov, 1969; Arkhangelskaya and others, 1997.

Kolyvansk Metallogenic Belt of W-Mo-Be Greisen, Stockwork, and Quartz Vein and W±Mo±Be Skarn Deposits (Belt Kol) (Gorny Altai Mountains, Eastern Siberia, Russia

This Early Triassic metallogenic belt is related to replacements in granitoids in the Belokurikha plutonic belt. The beltextends along a sublatitudinal trend for about 250 km and ranges from 20 to 100 km wide. The belt is associated with Permian and Triassic granitoid plutons that contain a large variety of granitoids, including calc-alkali granite, REE plumasite granite, subalkalic syenite, granosyenite, and alaskite. The granitoids are interpreted as forming in a postcollisional setting (Berzin and others, 1994). REE deposits occur both in granitoid plutons and exocontacts in early Paleozoic sandstone and shale (Sotnikov and Nikitina, 1977; Kuznetsov, 1982). The belt contains small W-Mo-Be greisen, stockwork, and quartz vein deposits (Kolyvanskoye), medium-size W±Mo±Be skarn (Beloretskoye), and small W-Mo vein and stockwork deposits (Plotbishchenskoye). Some deposits are partly mined.

Kolyvanskoye W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Potapjev, 1965; Sotnikov and Nikitina, 1977) consisting of steeply-dipping quartz veins that extendup to 120 to 150 m, lenses, and nests that occur in a thick aplite granite dike that is interpreted as a an apophysis of a major biotite granite pluton. The quartz veins extend at least 500 m deep. The ore minerals are wolframite, scheelite, pyrite, chalcopyrite, molybdenite, arsenopyrite, and Bi-minerals. Gangue minerals are quartz, muscovite, fluorite, K-feldspar, and tourmaline. From 1936 to 1960, 13 veins were mined with average grade of 0.65% WO_3, 1.4% Cu, 0.15% Bi. Contact metamorphosed shale contains streaks and disseminations of quartz, fluorite, and wolframite. The deposit is small with an a Average grade of 0.68% WO_3, 1.4% Cu.

Beloretskoye W±Mo±Be Skarn Deposit

This deposit (Jakovlev and others, 1964, 1965; Kosals, 1968, 1971; Kuznetsov, 1982) consists of W-Be minerals in skarn, quartz vein, and greisen in granite porphyry and adjacent Late Silurian limestone. Pyroxene-garnet-vesuvianite skarn is dominant. Skarn bodies are up to 600 m long and 80 to 150 m thick. Major minerals are wolframite, helvine, chalcopyrite, sphalerite, galena, molybdenite, beryl, and fluorite. Quartz veins cut granite and skarn, are 0.2 to 1.5 m thick, range up to 100 m long. Main ore minerals are: wolframite, beryl, molybdenite, and sulfides. Greisen replaces granite and forms a band that is 450 m long and 70 m thick. The greisen contains numerous quartz and fluorite-feldspar-quartz veinlets and disseminations. Quartz veins wall rocks are altered to greisen. The quartz-wolframite vein has been mined. The deposit is medium size.

Plotbistchenskoye W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Kuznetsov, 1982) consists of quartz-molybdenite veins in an aplite granite stock that is interpreted as an apophysis of the Ust-Belovsk granitoid pluton. The veins are range up to 90 m long and vary some cm to 1 m thick. Ore minerals are molybdenite, chalcopyrite, pyrite, galena, sphalerite, hematite, and rare scheelite. Host rocks along veins margins are altered to silica and sericite. The deposit is small.

Origin and Tectonic Controls for Kolyvansk Metallogenic Belt

The belt is interpreted as forming during granitoid magmatism in a post-collisional interplate environment. All the types of deposits occurring in the Kolyvansk metallogenic belt are genetically related to development of postcollisional Permian and Triassic granitoid magmatism of Belokurikha plutonic belt. The Rb-Sr isotoopic age of the REE granite is 245.0±8.0 to 241.2±4.5 Ma (Vladimirov and others, 1997). The initial $^{87}Sr/^{86}Sr$ ratio for the various plutons is 0.7051 to 0.7071 and iondiciates a lateral heterogeneity of magma. The plutonic belt occurs along strike-slip faults that are interpreted as forming during the Middle Carboniferous accretion of the Gorny Altai and Rudny Altai terranes (Shokalskiy and others, 1996; Vladimirov and others, 1997).

REFERENCES: Sotnikov, Nikitina, 1977; Kuznetsov, 1982; Berzin and others, 1994; Shokalskiy and others, 1994; Vladimirov and others, 1997.

Onor Metallogenic Belt of Volcanogenic-Sedimentary Fe Deposits (Belt Onr) (Northeastern China)

This Late Carboniferous metallogenic belt is related to volcanic and sedimentary rocks in the late Paleozoic marine volcanic, clastic, and carbonate rock of the Mandalovoo-Onor island arc terrane. The belt trends northeast, and is about 400 km long and ranges from 20 to 30 km wide. The Mandalvoo-Onor terrane is mainly composed of: (1) Silurian slate, phyllite, metatuffaceous siltstone, metatuffaceous sandstone, and metasandstone, brachiopods, and anthozoa; (2) late Silurian metasandstone, slate and limestone with Gondwana brachiopods; (3) overlapping Devonian chert, spilite, keratophyre, quartz keratophyre, andesite basalt and the terrigenous clastic rocks with intercalated intermediate and siliceous volcanic rock with Early Carboniferous marine fossils. Terrane is intruded by syntectonic ultramafic and granitic plutons with a Rb-Sr isotopic age of 354 Ma. Terrane unconformably overlapped by Permian volcanic rocks and terrigenous clastic rocks. The significant deposit is at Xieertala.

Xieertala Volcanic-Sedimentary Fe Deposit

This deposit (Zhang Xianbao, 1993) is hosted in a marine and marine and terrestrial of alternating intermediate, mafic, and siliceous volcanic lava, pyroclastic rock, and carbonate of the Late Carboniferous Xieertala Formation. The volcanic rocks formed adjacent to a volcanic vent. The deposit contains two zones that trend northwest, are 600 m long and 500 m wide, and are hosted in volcanic rock. The deposit us stratiform, lensoid, and concordant to host rocks. Rich deposits occur in lean areas and in lenses and pockets. The three types of ores are Fe, Zn-Fe and Zn. The Fe ore is mainly hematite whereas the Zn ore is mainly sphalerite. The Fe ore is idiomorphic-hypidiomorphic, and occurs in bunches and radial structures. Rich Fe ore is massive, and lean Fe ore is usually disseminated to banded. The hanging and foot walls of the deposits consist of garnet rocks, garnet and diopside, and diopside garent. Rich Fe ore exhibits a sharp boundary with host rock whereas a gradational boundary occurs between the lean ore and host rock. The deposit is interpreted as of volcanic and sedimentary origin with subsequent hydrothermal modification. The deposit is medium size with reserves of 58.51 million tonnes Fe, 0.27 million tonnes Zn, 1,202 tonnes Cd, and 159 tonnes In. Average grade is 38.28% Fe, 0.7-2% Zn, 0.0057% Cd, and 0.0008% In.

Origin and Tectonic Controls for Onor Metallogenic Belt

The belt is interpreted as forming in a Late Carboniferous marine volcaniclastic and carbonate sequence that is a upper part of the late Paleozoic Mandalovoo-Onor island arc terrane.

REFERENCES: Zhang Xianbao, 1993.

Duobaoshan Metallogenic Belt of Porphyry Cu-Mo (±Au, Ag) Deposits (Belt DB) (Northeastern China)

This Pennsylvanian metallogenic belt is related to granitoids in the Nora-Sukhotin-Duobaoshan island arc terrane and occurs in the western Heilongjiang Province. The belt trends northeast and is about 130 km long and 30 km wide. The Nora-Sukhotin-Duobaoshan terrane is composed of: (1) Cambrian metasandstone, phyllite with the intercalation of the lenticulars of limestone; (2) Ordovician and Silurian metabasalt, metaandesite, metadacite and volcanic breccia with intercalated marble; (3) Early Devonian mudstone, tuff spilitic keratophyre; (4) Middle to Late Devonian sandstone, mudstone, and limestone; and (4) Late Carboniferous and Permian granite. The significant deposit is at Duobaoshan.

Duobaoshan Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Ge Chaohua and others, 1994) consists of disseminations, veinlets, and breccias in granodiorite and late Ordovician andesitic porphyry and tuff in the Duobaoshan Formation. The granodiorite forms a composite batholith with a surface exposure of 8 km^2. In the west part of the batholith is a several granodiorite porphyry with a surface area of 0.16 km^2. Circular zonal alteration occur around the silicified porphyry and consists of K-feldspar, sericite, and propylitic alteration zones from core to periphery. Main ore minerals are pyrite, chalcophyrite, and bornite, with minor molybdenite, chalcocite, magnetite, sphalerite, pyrrhotite, tetrahedrite, and galena. A K-Ar isotopic age for the batholith is 292 Ma and K_2O/Na_2O is 0.5. The deposit occurs in a transitional uplift between the Daxinganling Mountain Range and the Songliao Basin. The deposit is large with reserves of 2.37 million tonnes grading 0.45% Cu.

Origin and Tectonic Controls for Duobaoshan Metallogenic Belt

The belt is interpreted as a subduction-related Pennsylvanian granodiorite porphyry that formed in the Ordovician to in Late Devonian Nora-Sukhotin-Duobaoshan island arc terrane. The subduction-type granodiorite porphyries that host the porphyry Cu-Mo (±Au, Ag) deposit, and adamellite are Late Carboniferous. The Middle Ordovician andesite volcanic rock may also host part of the deposit (Du Qi, 1980; Nei Zhongyao, 2000). Major major faults strike northwest and are an important control for the Duobaoshan metallogenic belt.

REFERENCES: Du Qi, 1980, Ge Chaohua and others, 1989; Nei Zhongyao, 2000.

Melgin-Niman Metallogenic Belt of Felsic Plutonic U-REE and Porphyry Mo (±W, Sn, Bi) Deposits (Belt MN) (Russia, Far East)

This Permian(?) metallogenic belt is related to granitoids in the widespread Permian(?) Tyrma-Burensk granitic assemblage that intrudes the Bureya metamorphic terrane. The assemblage consists of: (1) gabbro and diorite; (2) biotite-hornblende granodiorite and granite, and rare quartz diorite; (3) biotitic granite; and (4) leucogranite. The significant deposits are the Chergilen felsic plutonic U-REE deposit, and the Melginskoye and Metrekskoye porphyry Mo deposits.

Several poorly-studied REE-Ta occurrences also occur in the belt in exocontact zones of Li-F leucocratic granitic plutons and contain Ta-Nb minerals, cassiterite, Li-mica, quartz, albite, microcline, apatite, tourmaline, topaz, beryl, and other minerals. The occurrences occur as dike-like or lenticular bodies that range in size from few meters to hundreds of meters long, and from 1 to 10 meters wide. Associated rare REE-Li pegmatite consist of Li-mica, Ta and Sn-W minerals.

Chergilen Felsic plutonic U-REE Deposit

This deposit (Onikhimovsky and Belomestnykh, 1996) consists of a late Paleozoic granitoid composed biotite granite, granodiorite, quartz diorite, and diorite. The granitoid intrudes Cambrian limestone and siltstone. These units in turn are intruded by a Mesozoic leucocratic granite. The late Paleozoic granitoid and host rocks are altered to quartz albite and albite metasomatite that occur in stockwork with a complicated mineralogy. The ore minerals occur are zircon, bastnaesite, malacon, xenotime, monazite, chrysoberyl, phenakite, orthite, cuspidine, caryocerite, britholite, magnetite, cassiterite, and ilmenite. The deposit is large with resources of 690 tonnes BeO, 6.49 tonnes REE, 2,800 tonnes Ce, 360 tonnes Ga, 6,800 tonnes Zr, 965 tonnes Nb. The deposit contains up to 0.022% Be, 0,2% Y, 0.19% La, 0.38% Ce, and 0.02% Zr.

Metrekskoye Porphyry Mo (±W, Sn, Bi) Deposit

This deposit (S. Sukhov and S.M. Rodionov, written commun., 1986; Onikhimovskiy and Belomestnykh, 1996) consists of numerous (about 80) quartz-molybdenite veins that exhibit a complicated morphology and contain low-grade disseminated sulfides, mainly, pyrite, molybdenite, and chalcopyrite, and wolframite and Bi minerals. The veins occur in an area of approximately 1.5 km^2. The deposit is hosted in brecciated and altered intrusive host rock that occurs along a contact zone of a late Paleozoic leucocratic granite that intrudes Precambrian gneiss in along the northeastern flank of the Burea terrane. The deposit is large with resources of 47,500 tonnes Mo grading 0.1% (0.02-0.85%) Mo.

Origin and Tectoinic Controls for Melgin-Niman Metallogenic Belt

The belt interpreted as forming during intrusion of Tyrma-Burensk granitic assemblage in a subduction-related granitic belt.

REFERENCES: Kozlovsky, 1988; Natal'in, 1991; V.A. Stepanov, this study.

Wuxing Metallogenic Belt of Mafic-Ultramafic Cu-Ni-PGE Deposits (Belt WX) (Northeastern China)

This Pennsylvanian metallogenic belt is related to mafic and ultramafic plutons of Wuxing complex that intrude the Zhangguangcailing continental margin arc superterrane. The plutons are too small to be shown on 5 M map. The belt occurs in the eastern Heilongjiang Province, trends east-west, and is about 30 km long and 20 km wide. The significant deposit is at Wuxing.

Wuxing Mafic-Ultramafic Cu-Ni-PGE Deposit

This deposit (Qu, Xueqin and others, 1992) consists of two bodies in five gabbro and diorite intrusions that trend north-northeast along an east-west-trending fault. The deposits occur at the base of diopside layer and the top of an olivine-diposide layer in lenses and bands that range from several tens to 420 m long and from several meters to 17 m thick. The ore minerals are medium-to coarse-grained with local cataclastic textures. The ore minerals occur in disseminations, masses, veinlets, stockworks, and breccias. The main ore minerals are chalcopyrite, pyrrhotite, stibiopalladinite, sperrylite, cobaltine, and about other 70 minerals, The host intrusions are widely but weakly altered with formation of minor chlorite and serpentinite in external alteration zones, and alteration to amphibole, serpentine, chlorite, carbonate, biotite, and iddingsite in the diopside-olivine layers. The deposit is small with Reserves of 8.33 tonnes Pt+Pd grading 0.289 g/t Pt and 0.490 g/t Pd.

Origin and Tectonic Controls for Wuxing Metallogenic Belt

The belt is interpreted as forming during extension after accretion of the Zhangguangcailing continental margin arc superterrane. The belt is hosted in post-accretionary mafic and ultramafic plutons that intruded along major east-west-trending faults. The Zhangguangcailing superterrane (an early Paleozoic continental margin arc) is intensely intruded by Hercynian and Mesozoic plutons. The Wuxing metallogenic belt is related to the Pennsylvanian postaccretion mafic-ultramafic plutons that inrude the Paleozoic Zhangguangcailing superterrane. The mafic-ultramafic intrusion is controlled by a major east-west striking fault.

REFERENCES: Qu Xueqin and others, 1992.

Altay Metallogenic Belt of REE-Li Pegmatite, Muscovite Pegmatite, and Sn-W Greisen, Stockwork, and Quartz Vein Deposits (Belt AT) (Southwestern Mongolia)

This Late Carboniferrous metallogenic belt is related to veins, dikes, and replacements related to granitoids in the Pennsylvanian Altai volcanic-plutonic belt that intrudes the Paleoproterozoic Altai passive continental margin turbidite terrane in the Altay Mountain Range. More than 10,000 pegmatite veins occur in the metallogenic belt, and the belt contains numerous large and superlarge Li, Be, Nb, Ta pegmatite deposits and several tens of moderate to large muscovite pegmatite deposits. Muscovite reserves comprise more than 60% reserves for Mongolia. The belt trends northwest and is more than 450 km long and 70 to 80 km wide. The significant deposits are at Keketuohai and Ayoubulake.

Keketuohai Li-REE Pegmatite Deposit

This deposit (Lin, Chuanxian and others, 1994; Editorial Committee of the Discovery History of Mineral Deposits, 1996) consists of: mitriform pegmatite bodies that extend for 250 m, extend to a depth of 250 m, and are 150 m wide; and gently dipping pegmatite veins that extend for 2000 m long, extend to a depth of 1500 m, and are 40 m wide. The zoning of the mitriform pegmatite bodies from the margin to the center is: (1) graphic and graphic-like pegmatite; (2) sucrosic albite; (3) massive microcline; (4) muscovite-quartz; (5) cleavelandite-spodumene; (6) quartz-spodumene; (7) muscovite-lamella albite; (8) lamella albite-lepidolite; (9) central massive microcline and quartz zone. The pegmatite veins are divided into seven zones. The main alterations are biotite, Li muscovite, Cs biotite, Li glaucophane, and fluorite alterations. The average grade in pegmatite is 6.5% muscovite, 0.05% lepidolite, 4.15% spodumene, 0.49% beryl, 0.05% pollucite. The mitriform pegmatite contains on average of 3650 ppm LiO_2, 1080 ppm Rb_2O, 190 ppm Cs_2O, 630 ppm BeO, 78 ppm Nb_2O_5, 91 ppm Ta_2O_5. REE content is variable. The pegmatite bodies are related to Hercynian biotite microcline granite that is widespread and Ordovician biotite schist, staurolite schist, glaucophane schist that occur as relics in the granite intrusion. The granite also intrudes Paleozoic gabbro with an isotopic age of 330 Ma. The Keketuahai pegmatite no.3 is a world class Be-Ta-Li pegmatite deposit. The deposit is large with reserves of 244 tonnes Ta_2O_5. Average grade is 0.024% Ta_2O_5, 0.051% BeO, 0.982% Li_2O.

Ayoubulake Muscovite Pegmatite Deposit

This deposit (Nie, Fengjun and others 1989; Ge, Chaohua and others, 1994) consists of 34 muscovite pegmatite veins that range from 15 to 490 m long, extend several tens of meters downdip, and range from 0.5 to 15 m thick. Muscovite and quartz occurs in masses mainly in intermediate-coarse grained pegmatite. The host rocks are Ordovician staurolite schist, sillimanite schist, gneiss and Hercynian biotite granite. An associated alteration zone is about 1 m wide and consists of muscovite, biotite and toumaline. The deposit is large.

Origin and Tectonic Controls for Altay Metallogenic Belt

Thie belt is interpreted as forming in during intrusion of anatectic granite that formed during collision of the Kazakhstan and North Asian Cratons and resultant occurrence of high-grade metamorphism with crustal melting and generation of granite. The belt is hosted in post-accretionary mafic and ultramafic plutons that intrude along major east-west-trending faults. The host granite is mainly calc-alkaline and has a K-Ar isotopic age of 219 Ma. The granite intrudes both early Paleozoic metamorphic rock and Devonian to Early Carboniferous volcanic rock ahd turbidite that are regionally metamorphosed at moderate to low pressure and high temperature (Rui Xingjian and others, 1993, Tao Weiping and others, 1994).

REFERENCES: Rui Xingjian and others, 1993, Tao Weiping and others, 1994.

Central Mongolia Metallogenic Belt of Fe-Zn Skarn, Sn Skarn, Zn-Pb (±Ag, Cu) Skarn, W±Mo±Be Skarn, Cu (±Fe, Au, Ag, Mo) Skarn, Porphyry Cu-Mo (±Au, Ag); Porphyry Mo (±W, Bi), Granitoid-Related Au Vein, Cu-Ag Vein, W-Mo Greisen, Stockwork and Quartz Veins, and Basaltic Native Cu Deposits (Belt CM) (Central Mongolia)

This Early to Late Permian metallogenic belt is related to replacements and granitoids in the Selenga sedimentary-volcanic plutonic belt, occurs around the Hangay Mountain Range, and forms a large sickle shape in central Mongolia. The Selenga assemblage overlaps parts of the Late Archean and Paleoproterozoic Baydrag cratonal, Vendian to Middle and Late Cambrian Lake island arc, and Neoproterozoic to early Cambrian Idermeg passive marginal terranes (Tomurtogoo and others, 1999). The Central Mongolian metallogenic belt is interpreted is dominated by skarn and porphyry deposits (Dejidmaa and others, 1996).

The major deposits are: Menget and Sharain hudeg Fe-Zn skarn occurrences; Buyant group Fe-Sn skarn occurrences; Uzuur tolgoi, Berh Zn-Pb (±Ag, Cu) skarn occurrences; Chandmani Uul group and Buutsagaan Fe (Cu, Au) skarn occurrences; Buyant group W skarn, Khohbulgiin hondii and Buutsagaan Au-Cu skarn occurrences; Saran uul porphyry Cu (±Au)-Au deposit, Tsahir hudag and Beger porphyry Cu (±Au) (Au, Ag) occurrences; Arynnuur porphyry Cu deposit, Naranbulag and Zost Uul porphyry Mo (±W, Bi) occurrences; Tsahir hudag and Chandmani uul group of granitoid-related vein and stockwork Cu occurrences; Oortsog, Olziit and Delgereh group of granitoid-related-vein and stockwork Au occurrences; Hatanbulag and Baga Bogd vein and stockwork Mo occurrences; and Buutsagaan group Cu basalt occurrences.

The skarns deposits are related to highly alkaline granitoids. Vein and stockwork Mo occurrences, as at Baga Bogd and Hatanbulag, occur in central part of the belt in the Ih Bogd and Baga Bogd areas and are interpreted as forming during intrusion of Permian subalkaline leucogranite stocks. Various porphyry Mo deposits and occurrences are related to granite porphyry stocks that are concentrated in the central part of the belt and are related to Late Carboniferous or Permian granodiorite and monzonite porphyry stocks. Granitoid-related vein and stockwork Cu occurrences are more extensive in northern and central parts of the belt. Various basalt native Cu occurrences in the Buutsagaan area are closely related to Permian basalt in the Hureemaral Formation.

Buutsagaan Au Skarn Deposit

This deposit (Filippova and others, 1977; Podlessky and others, written commun., 1988; A. A. Rauzer and others, written commun., 1987) consists of consists of magnesium skarn formed along the contact of Proterozoic schist and carbonate with a Permian granite massif. The deposit contains magnetite lenses and veins in an area of 0.25 by 0.75 km. The lenses and veins range from 6 m to 300 m long and 0.3 m to 4.5 m thick Also occurring are tourmaline, plagioclase, and quartz stringers occur. Magnesium skarn is zoned intrusive to host metamorphic rocks with the following zones: granite replaced by pyroxene-plagioclase skarn; pyroxene-spinel skarn; pyroxene-spinel-forsterite skarn; forsterite-calcifire skarn; and dolomite marble. Most magnetite is deposited in magnesium skarn. During calcic skarn formation spinel-pyroxene skarn overprinted magnesium skarn, and grossular-vesuvianite-salite-sulfide skarn along the endocontact of the granite massif. In Cu sulfide skarn, the grade ranges up to 150.0 g/t Au. Grab samples contain up to 2.0% Cu, up to 30.0 g/t Cd, up to 1.0-1.5% Zn, and up to 50.0 g/t Ag.

Zos Uul Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Chilkhaajav and others, 1980; Bayandorj and others, written commun., 1980; Sotnikov and others, 1981, 1985) consists of Late Permian and Early Triassic granitoids that intrude Paleoproterozoic metamorphic rock Early Proterozoic granite, Cambrian gabbro, granodiorite, and granite, and Early Devonian volcanic rocks, and Permian granosyenite and granite. The Late Permian and Early Triassic granitoids consist of a granodiorite and granite massif, and porphyry in stocks and dikes. The porphyry stock and dikes and host rocks are intensively altered to silica, sericite, and pyrite. Quartz-sulfide vein and stockwork occur in altered rocks. The size of the stockwork is 2.0 km by 2.2 km. Quartz-sulfide vein and veinlets are extensive in the western, eastern, and southern margins of the granite porphyry stock. The quartz-sulfide vein and stockwork contain rare molybdenite, quartz-molybdenite and quartz-pyrite-chalcopyrite-molybdenite stringers and disseminations. Also occurring is extensive hydrothermal alteration with quartz-sericite and quartz replacements in bodies ranging up to 20.0 m by 40.0 m. Locally occurring are relicts of early-stage potassium feldspar alteration that is intensively developed in a granite-porphyry stock. Also occurring are rare quartz-potassium feldspar veinlets with pyrite, garnet-epidote skarn that is overprinted by pyrite-chalcopyrite stringers. Deposit developed in following stages: K feldspar-quartz, quartz-magnetite, quartz-sericite-chalcopyrite-molybdenite, quartz-polymetallic (sphalerite and galena), and post-ore chlorite-epidote-carbonate. Ore minerals are more abundant in quartz-sericite replacement. The deposit is small with a resource of 100,000 tonnes Mo and an average grade of 0.2% Cu, 0.01% Mo.

Erdenekhairkhan Cu (±Fe, Au, Ag, Mo) Skarn Deposit

This deposit (A. Enkhbayar and others, written commun., 1982; B.A. S. Samozvantsev and others, written commun., 1982.) is hosted in Vendian and early Paleozoic carbonate rocks of the Tsagaanolom Formation that is intruded by a Permian syenite stock. According to a magnetic anomaly, the skarn is 600.0 m long and 300.0-400.0 m wide. The skarn is cut by two northeast-trending, steeply dipping faults that define three blocks. The central block is uplifted and more eroded; the northern and the southern blocks are downdropped. Three small openpits of size with surface dimensions of 2 by 70-80 m to 4 by 200 m occur in the central block. The deposit consists of disseminations and stringers of chalcopyrite and bornite. Host carbonate rock is locally altered to serpentinitie and recrystallized. Ore minerals are magnetite-hematite (5-70%), Fe oxides (up to 7%), and minor chalcopyrite, bornite, chalcocite, malachite, native copper, covellite, native silver?, and pyrrotite. Channel samples contain 0.89-2.34% Cu, and core-samples 0.2-1.0% Cu, up to 1.8 g/t Au, and 0.4 g/t Ag . Grab samples grade from 0.1-1.0% to 7.88% Cu, 10.0-50.0-100.0 g/t Ag. Extensive northeast-trending quartz-carbonate veins occur in the eastern and south-eastern parts of the deposit and range from 0.2-0.5 m thick, and 20.0-100.0 m long. Au soil anomaly in an area 300.0 by 350.0 m occurs close relation to skarn. The average grade of the deposit is 1.3-1.4 g/t Au, 0.2-1.0% Cu, and 10.0-50.0 g/t Ag.

Origin and Tectonic Controls for Central Mongolia Metallogenic Belt

The belt is interpreted as forming along an active continental margin. Tomurtogoo and others (1999) interpret the host Selenge assemblage as an intercontinental volcanic belt. However, the assemblage is herein interpreted as an overlapping Late Carboniferous to Late Permian continental margin arc that was tectonically linked to a subduction zone on the margin of Mongol-Ohotsk Ocean. Remnants of the ocean occur in a narrow band that extends for 3000 km from central Mongolia to the Ohotsk Sea (Obolenskiy and others, 1999).

REFERENCES: Yakovlev, 1977; Podleaaky and others, 1984; Sotnikov and others, 1984, 1985; Dejidmaa and others, 1996; Tomurtogoo and others, 1999.

Bayanhongor-2 Metallogenic Belt of Granitoid-related Au Vein and Cu (±Fe, Au, Ag, Mo) Skarn Deposits (Belt BH-2) (Central Mongolia)

This Carboniferous to Permian metallogenic belt is related to granite and diorite plutons and quartz-porphyry dikes in Telman volcanic-plutonic belt that intrudes the Baydrag cratonal, Bayanhongor oceanic, Orhon continental margin arc, and Zag-Haraa turbidite terranes. The major deposits are at Tsagaan Tsahir Uul and Khokhbulgiin khondii.

The extensive Late Carboniferous and Permian granitoid-related Au deposits (Tsagaan Tsahir Uul) and occurrences (Dalt, Tsaatsyn gol, Haraat uul, Bombogor and others) are closely related to diorite and granite stocks that contain different composition dikes. The Tsagaan Tsahir uul vein type Au deposit occurs mostly in outer contact of Shar burd monzodiorite stock that intrudes Proterozoic gneiss and Riphean granodiorite and granite. Some Au-bearing veins intrude the stock. The Shar burd diorite has a K-Ar isotooic age of 341 Ma (Borzakovskii and Suprunov, 1990), a Rb-Sr whole rock isotopic age of 250 Ma (Takahashi and others, 1998;.Zabotkin, 1988), and a K-Ar isotoic age for biotite from coarse-grained facies of Shar us gol granite batholith is 235± 12 and 242± 12 Ma (Late Permian) (Takahashi and others, 1999). The Haraat Uul and Bombogor vein and stockwork Au occurrences are closely related to diorite and diabase dikes associated with the Tsogt Khayrhan complex (Takahashi and others, 1998) that has a K-Ar isotopic age of 312 Ma (Izoh and others, 1990). The Daltyn am diorite (Oyungerel and takahashi, 1999) stock contains stockwork Au-W deposits and has a Rb-Sr whole rock isochron age of 287± 8 Ma. These isotopic age data indicate that granitoid-related Au deposits and occurrences are Late Carboniferous to Early Permian. The late Paleozoic granitoids related to the Cu and Au deposits and occurrences in Bayanhongor zone are related to magnetite-series granitoids (Takahashi and others, 1998).

Tsagaantsakhir Granitoid-Related Au vein Deposit

This deposit (D. Andreas and others, written commun., 1970; Jargalan and Fujimaki, 2000) is hosted in Middle to Late Cambrian granodiorite and granite that intrudes early and middle Riphean schist of the Burd-gol Group. Also occurring is a late Paleozoic diorite stock, and extensive diotite porphyry, gabbro porphyry, and quartz porphyry dikes. The quartz veins contain veins with economic Au at four sites. Ore minerals are pyrite, arsenopyrite, sphalerite, chalcopyrite, tetrahedrite, galena, bournonite, native gold, altaite, gessite, and tellutium-busmuthine. The deposit is medium size with probable reserves of 15 tonnes Au. The average Au fineness is 900, and maximum grade in some veins is 645 g/t Au.

Taatsyngol Granitoid-Related Au Prospect

This prospect (Zabotkin L.V., and others, 1988) consists of WNW-ESE trending, and gently S or SW dipping ($10^{0-}30^{0}$) quartz veins that range up to 0.5 m thick and 800 m long. Quartz veins form multi-floor systems that are spatially related to diorite and diorite-porphyry dikes. Host rocks are altered adjacent to veins to quartz-sericite-carbonite with rare pyrite. Two areas with intensive sheelite occur in the central part of the prospect. Local cataclastic zones, that range up to 20 m wide and 20-50 m long contain abundant quartz-sheelite veins up to 0.3 m thick and are hosted in gneiss, schist, and granite pegmatite. Grade ranges from 0.001 to 1.0% W in quartz veins, and from 0.001 to 0.15% W in silicified rock with quartz stringers, and from 0.001 to 0.006% W in host metamorphic rocks. Sheelite is associated with pyrite and fluorite, and rare gold, galena, tetrahedrite, malachite, arsenopyrite, and sphalerite in quartz veins. Occurrence belongs to gold-sheelite-quartz vein type. Erosion level of the occurrence territory is low in the central part, where only upper part of W ore bodies occur, but erosion level of periphery is higher and contains lower and middle part of Au ore bodies. Host rocks are Paleoproterozoic biotite and biotite-amphibole gneiss schist, mica quartzite (metamorphosed chert), amphibolite, and marble that are intruded by Neoproterozoic leucogranite and pegmatite. These older units are intruded by upper Permian granite.

Khokhbulgiin khondii Cu-Au Skarn Deposit

This deposit (Andreas and others, 1970) consists of five skarn bodies (or mineralized zones) that occur along the lower and the upper contacts of a metadiabase sill. Bodies are 2,040 m wide and 140-160 m long. Deposit minerals are chalcopyrite and bornite and minor native gold. Gold ranges up to 0.5 mm diameter. The bodies consist of layers of skarn and hornfels. Layers in bodies range from 0.01 to 0.4 m in skarn, up to 0.8 m in hornfels, and up to 2.8 m in skarn. Skarn consists of grossular-andradite, minor clinopyroxene and calcite, and rare vesuvianite in nests, and amphibole in narrow stringers. Skarn consists mostly of feldspar, scapolite, or epidote. Hornfels consists of masses of quartz, albite, and biotite. Primary ore minerals are native Bi, bismuthine, arsenopyrite, pyrite, sphalerite, enargite, bornite, tetrademite, chalcopyrite, cubanite, vittihenite, pyrrhotite, and gold. Most gold occurs in gangue minerals and forms rounded, irregular masses, or stringers, and varies from less than 1 to 160 microns. Gold is also intergrown with with chalcopyrite and bornite, and rare arsenopyrite. Fineness of gold varies from 800 to 900. Oxide ore minerals are chalcocite, covellite, malachite, azurite, and Fe oxides. This deposit occurs adjacent to a late Paleozoic quartz diorite and granite stock with a K-Ar isotopic age of 252 Ma that intrudes the Neoproterozoic Burdgol Formation that consists of intercalated limestone, calcic sandstone, calcic shale, and sandstone. The average grade is 5.6 g/t Au, 0.685% Cu with resources of 8.8 tonnes Au, 10700 tonnes Cu. Estimated reserves in mineralized zone 1 are 524,300 tonnes ore with 6.4 tonnes Au at average grade 12.28 g/t Au, and 10,774 tonnes Cu at an average grade of 0.3% Cu.

Origin and Tectonic Controls for Bayanhongor Metallogenic Belt

The belt is interpreted as forming in a subduction-related gabbro, diorite, and granodiorite stocks and dikes. The late Palaeozoic granitoids hosting the belt are interpreted as subduction-related gabbro, diorite, granodiorite stocks and dikes that formed between a volcanic-plutonic belt on inner continental side and S-type REE granite zone on the oceanic side of a late Paleozoic continental margin arc related to Mongol-Ohotsk Ocean. The Bayanhongor metallogenic belt has been extensively studied (Blagonravov and Shabalovskii, 1977; Blagonravov and Tsypukov, 1977; Tcherbakov and Dejidmaa, 1984).

REFERENCES: Andreas and others, 1970; Izoh and others, 1990; Takahashi and others, 1998, 1999; Oyungerel and Takahashi, 1999.

Battsengel-Uyanga-Erdenedalai Metallogenic Belt of Granitoid-Related Au Vein Deposits (Belt BUE) (Central Mongolia)

This Late Carboniferous to Permian metallogenic belt is related to small stitching plutons that in the early stage of intrusion of the Hangay plutonic belt that intrudes Hangay-Dauria and Onon accretionary wedge terranes The metallogenic belt strikes northwest and is related Permian(?) granitoids that from northwest to southeast intrude: (1) the Hangay Dauria accretionary-wedge terrane, (2) the Onon accretionary-wedge terrane, and (3) the Permian Predhentey continental basin (part of Late Permian North Gobi overlapping assemblage) (Tomurtogoo and others, 1999) into which small Late Permian stocks and dikes of gabbro, diorite, granodiorite, and granite intrude coarse-grained sedimentary rock intrude. Dejidmaa and others (1993) and Dejidmaa (1996) first studied and named this Au metallogenic belt as the Eastern Hangay belt that surrounds the Hangay Mountain Range to the northeast. The belt contains the Battsengel, Uyanga-Taragt, and Erdenedalai Au-bearing districts.The major deposits are at Mongot, Battsengel, Uyanga, Sharga Ovoo, and Tsagaan Ovoo.

The granitoid-related Au vein occurrences consist of simple quartz veins and complicate metasomatitic zones with quartz veins and extend northwest. The occurrences are closely related to late Paleozoic diorite and granodiorite dikes and stocks. The occurrences are the sources for associated placer Au deposits The belt is bounded by the Orhon regional fault to northeast. The granitoid-related Au deposits are similar to those of the Ordovician Bayanhongor metallogenic belt described above. However, the age of granitoids hosting Au deposits in the Battsengel-Uyanga-Erdenedalai belt is not older than Late Permian as determined for the Sharga Ovoo and Tsagaan Ovoo Au occurrences in the southeastern part of the metallogenic belt. The Tsagaan Ovoo quartz vein occurrence is in Permian sedimentary rock and is closely associated with an intruding diorite and granodiorite stock and dikes. Placer Au occurrences mined in ancient, small openpits are long known (Blagonravov and Shabalovskii, 1977).

Sharga Ovoo Granitoid-Related Au Vein Deposit

The deposit (O. Jamyandorj and others, written commun., 1972) is hosted in early Paleozoic gneissic granite and granodiorite that are intruded by granodiorite porphyry and diorite porphyry dikes and quartz veins. The quartz veins dip steeply, form a stockwork, occur along a northwest-trending weak shear zone, and form an en-echelon pattern. The stockwork consists of eight quartz veins quartz veinlets, and local breccia varies from 40-300 m wide and 0.5-4.0 m thick. The host granite is silicified and cut by quartz stringers. The width of altered host rock varies from 1.0 to 20 m. Veins are white-grey, and contain coarse-grained quartz with pyrite, limonite, rare gold. Gold ranges up to 2 mm and is mostly fine-grained. Local visible gold occurs along selvages, especially in lower selvages. Channel samples containfrom 0.1 g/t to 5.6 g/t Au, and rock chip samples contain up to 14.0-56.0 g/t Au.

Origin and Tectonic Controls for Battsengel-Uyanga-Erdenedalai Metallogenic Belt

The belt is interpreted as forming during intrusion of subduction-related gabbro, diorite, and granodiorite stocks and dikes along the North Govi active continental margin arc.

REFERENCES: Blagonravov and Shabalovskii, 1977; Dejidmaa and others, 1993; Dejidmaa, 1996; Tomurtogoo and others, 1999.

Orhon-Selenge Metallogenic Belt of Porphyry Cu-Mo (±Au, Ag) Deposits (Belt OS) (Central Mongolia)

This Triassic metallogenic belt is hosted in granitoids in and stratiform layers in the Selenga sedimentary-volcanic plutonic belt. The belt occurs in northeastern half of the North Mongolian metallogenic belt of porphyry Cu-Mo (±Au, Ag) (Sotnikov and others, 1984, 1985) in the northeastern part of North Mongolian volcanic belt that was named the Orhon-Selenge Basin (Mossakovskii and others, 1976) The metallogenic belt contains the major Late Triassic to Early Jurassic Erdenet porphyry district (Sotnikov and others, 1985) that is coeval with trachyandesite volcanic rock. In this part of Mongolia, the Selenge sedimentary-volcanic-plutonic belt consists of Precambrian metamorphic rock, Permian volcanic rock in the Hanui Group, Late Permian gabbro, granodiorite, granosyenite, and granite in the Selenge complex, Late Permian and Early Triassic trachyandesite, Late Triassic and Early Jurassic gabbro, diorite, and granite stocks, and the Erdenet porphyry complex (Dejidmaa and Naito, 1998). Porphyry stocks and dikes developed in Erdenet disrict are called the Erdenet complex (Sotnikov and others, 1985).

The following districts occur from northeast to southwest in the metallogenic belt (Dejidmaa and others, 1996): (1) Darhan district with porphyry Cu-Mo (±Au, Ag) occurrences; (2) Baruunburen district with porphyry Cu (±Au) occurrences; (3) Erdenet districts with porphyry Cu-Mo (±Au, Ag) deposits and occurrences; and (4) Bulgan district with porphyry Cu-Mo (±Au, Ag) and basalt Cu occurrences). Most porphyry Cu-Mo (±Au, Ag) deposits and occurrences are in the Erdenet district. The major deposits are at Erdenetiin Ovoo, Central, Oyut Cu-Mo deposits; Shand Cu-Mo deposit; Zuiliin gol Cu-Mo occurrence.

Erdenet Porphyry Cu-Mo (±Au, Ag) District

This district (Khasin, and others, 1977; Gavrilova, and others, 1984; Sotnikov and Berzina, 1985, 1989; Dejidmaa and Naito, 1998) contains the world's largest porphyry Cu-Mo (±Au, Ag) deposit at Erdenetiin Ovoo. This and the Central, Zavsryn, and Oyut deposits occur along the northwest-striking Buhaingol fault zone into which are intruded porphyry stocks and dikes of the Erdenet Complex. Erdenet Complex contains two phases of granodiorite porphyry stocks, and dikes of diorite porphyry, plagiogranite porphyry, dacite porphyry, syenite porphyry, and andesite porphyry. Syenite porphyry and andesite porphyry occur in post-ore dikes. Quartz-sericite metasomatite at the Erdenetiin Ovoo deposit has a K-Ar isotopic age of 210 to 190 Ma and an explosive breccia has a K-Ar isotopic age of 210 Ma K-Ar (Late Triassic to Early Jurassic) (Sotnikov and others, 1985). Younger K-Ar isotopic ages for three porphyrytic stages are 240 to 250 Ma for the deposit-hosting stage. K-Ar and Rb-Sr ages are 220 Ma for a younger stage with less extensive deposits. A K-Ar isotopic age is 185 Ma for a post-ore stage (Sotnikov and others, 1994). A $^{40}Ar/^{39}Ar$ isochron age of 207± 2 Ma is reported for white mica from the highest grade part of the Erdenet mine (Lamb and Cox, 1998). The major deposit is at Erdenetiin Ovoo that consists of the north-eastern or the Erdenetiin Ovoo, the central, and the Zavsryn and the Qyut parts. The small Shand deposit occurs south of the Erdenetiin Ovoo. Besides the Shand deposit, most porphyry Cu-Mo (±Au, Ag) occurrences in this belt constitute potential for concealed deposits at depths of 200 to 300 m.

Erdenetiin Ovoo Porphyry Cu-Mo (±Au, Ag) Mine

This deposit (Sotnikov and others, 1985; Koval and Gerel, 1986; Gerel, 1989; Dejidmaa, 1996) consists of stockwork veinlets and veins of quartz, chalcopyrite, and molybdenite in or near granodiorite porphyry of Selenge Complex. The size of the stockwork at the surface is 2800 m by 300-1300 m and the primimary ore dimensions are 1000m by 600 m. The deposit is related to intensive hydrothermal alteration of host rocks. A quartz-sericite zone is strongly developed in the center of the stockwork and grades outward into sericite-chlorite and carbonate-epidote-chlorite zones. In the upper part of the stockwork argillite alteration occurs, and K feldspar alteration, locally with hydrothermal biotite and tourmaline occurs. Altered quartz-sericite rocks is called a secondary quartzite. In the eastern part of the deposit, the porphyritic rock and alteration zone is cut by a central meridian fault. This mine contains numerous supergenic halos. The northwest trending fault zone is important for the ore location process. The host rocks are for the deposit are Precambrian basement composed of amphibolite, schist, and volcanic and edimentary rocks.

Five stages of mineralization corresponding to 5 phases of porphyry intrusion. The stages are: magnetite, quartz-pyrite, molybdenite-quartz, chalcopyrite-pyrite-quartz, pyrite metacrystals, pyrrotite (cubanite)-chalcopyrite, chalcocite-bornite, galena-sphalerite-tennantite, and zeolite-gypsum-carbonate in both primary and secondary enrichment zones. The main minerals in the oxide zone are malachite, azurite, cuprite, iron oxides, and native copper. A vertical zonation consists of: (1) oxidized and leached ore (from 10 m to 90 m thick); (2) secondary sulphide enrichment zone (from 60 m to 300 m thick); and (3) primary ore (to a depth 1000 m). Cu grade varies from 0.8% to 7.6% Cu in secondary sulphide zone in the central part of the deposit and decreases to the periphery. Mo grade of varies from 0.001% to 0.76% Mo in the econdary sulphide zone. Cu grade in primary ore decreases from the centre of stockwork (0.4-0.5% Cu) to 0.2-0.3% Cu at the periphery and to 0.2-0.25% Cu from 500 to 1000 m. Mo grade is variable and is somewhat antithetic to Cu grade. The secondary enrichment zone include 85% reserves. From 0.8% to 7.6% Cu and from 0.001% to 0.76% Mo occurs in the secondary enrichment zone, and 0.2

to 0.5% Cu and 0.025 Mo% occurs in primary ore. The highest grade part is a chalcocite blanket composed of quartz, white mica, pyrite, chalcopyrite with a well-developed quartz vein stockwork. Secondary chalcocite forms coatings on both pyrite and chalcopyrite. Potassic alteration occurs mainly in the deep part of deposit. The deposit is large with reserves of 10,851,000 tonnes Cu and 167,073 tonnes Mo.

Shand and Zuiliingol Porphyry Cu-Mo (±Au, Ag) Occurrence

This occurrence (V.P. Arsentev and others, written commun., 1985) consists of a Cu sulfide zone with surface dimensions of 350 by 1100 m. The zone occurs in the southwestern and western part and along the contact of a granodiorite porphyry stock. Ore minerals are: chalcopyrite, molybdenite, sphalerite, galena, magnetite, and hematite. Grab grade from 0.1% to 1.0% Cu, and from 0.001% to 0.015% Mo, and up to 0.001% Ag. Core samples gradefrom 0.1% to 0.4-0.5%, Cu and from 0.0001% to 0.1% Mo. The deposit is small with probable reserves of 500,000 tonnes Cu and an average grade of 0.1-0.5% Cu, 0.0001%-0.1% Mo. This occurrence at Shand and and another at Zuiliingol have potential for small concealed deposits at depths of 200 to 300 m.

Origin and Tectonic Control for Orhon-Selenge Metallogenic Belt

The belt is interpreted as forming during oblique subduction of oceanic crust of the Mongol-Okhotsk paleoocean under the southern margin of the Siberian continent. The Late Permian to Early Jurassic plutonic rocks of the Orhon-Selenge metallogenic belt are part of the mainly Permian Selenga sedimentary-volcanic plutonic belt (Tomurtogoo and others, 1999). This belt is interpreted as part of an overlapping Late Carboniferous to Early Jurassic continental margin arc that was tectonically linked to a subduction zone along the margin of the Mongol-Ohotsk Ocean. Remnants of this ocean are preserved in a narrow band that extends 3000 km from central Mongolia to the Okhotsk Sea (Obolenskiy and others, 1999).

REFERENCES: Yakimov, 1977; Yakovlev, 1977; Gavrilova and others, 1984, 1989; Khasin and others, 1984; Sotnikov and others, 1985; Dejidmaa andi Naito, 1998; Lamb and Cox, 1998.

Buteeliin nuruu Metallogenic Belt of Peralkaline Granitoid-related Nb-Zr-REE, REE-Li Pegmatite, W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposits (Belt BU) (North Mongolia)

This Early Permian metallogenic belt is related to high alkaline granitic rock of the Selenga sedimentary-volcanic plutonic belt that intrudes the West Stanovoy terrane and to associated regional metamorphism. The belt extends 200 km and is about 30 km wide. The belt includes various deposits related to highly alkaline early Mesozoic granite stocks and associated rocks including U-Zr-REE, Ta-Nb-REE metasomatite, granitoid-related vein Bi, granitoid-related vein and stockwork U-Mo, Nb-Zr-REE peralkaline granite-hosted, Sn-W greisen, stockwork, and quartz vein deposits. Many of these deposits occur in the northeastern late Paleozoic North Hangai REE metallogenic belt (Kovalenko and others, 1988, 1990; Kovalenko and Yarmolyuk, 1990) along the east-west trending Hangai regional fault. The early Permian age for the host granitic rocks is based on a U-Pb zircon isotopic age of 275 Ma for strongly foliated to mylonitized granite-gneiss. Contrasting K-Ar isotopic ages of 89 to 129 Ma (Koval and Smirnov, 1979) exist for migmatite, gneissic granite, leucogranite, aplite, and pegmatite. The younger ages are herein interpreted as forming during Late Mesozoic uplift and granitization. The major deposits are at the Bayangol district, Zelter Bi occurrences, and Arshivert occurrence.

Bayangol District of Peralkaline Granitoid-related Nb-Zr-REE and REE-Li Pegmatite Occurrences

This district (Tsyba, 1990) occurs in southwestern margin of the Buteeliinnuruu belt and is hosted in a granite-gneiss cupola with diameter of 12 km. The occurrence consists of quartz-K-feldspar-albite and albite metasomatite with high U, Th, REE, Zr, Ta, Nb. The metasomatite occurs in weak fracture zones. The Gunondoriin Tsohio district is similar to the Bayangol deposit, occurs in the middle part of the belt, and consists of quartz-K-feldspar-albite metasomatite veins with high content of U, Th, Y, Yb, Nb, Ta, Zr, Ce, La, Hf, and Gd. This district forms an east-west-trending zone with surface dimensions of 3 km by 13 km.

Bayangol 1 REE-Li pegmatite Deposit

This deposit (Kudrin and Kudrina, 1959) consists of two spodumene pegmatite veins that are 100-200 m long and 10-20 m thick that cut Mesoproterozoic marble. The veins are composed of quartz, albite, spodumene, apatite, muscovite, beryl, columbite, pyrite, fergusonite, cassiterite, zircon, and lepidolite. Spodumene pegmatite occur for 400 m along strike. The deposit is small.

Origin and Tectonic Controls for Buteeliinnuruu Metallogenic Belt

The belt is interpreted as related to an Early Permian core complex containing granitoids of the Selenga sedimentary-volcanic plutonic belt that intrude granite-gneiss and mylonite in the West Stanovoy terrane. Alternatively, the belt may be related collisional granitoids generated during late Mesozoic closure of Mongol-Okhotsk Ocean.

REFERENCES: Kovalenko and others, 1988; Kovalenko and Yarmolyuk, 1990; Tsyba, 1990; Kovalenko and others, 1990; Tomurtogoo and others, 1999.

Laoeling-Grodekov Metallogenic Belt of Porphyry Cu-Mo (±Au, Ag) and Au-Ag epithermal Vein Deposits (Belt LG) (Russia, Far East)

This Permian metallogenic belt is hosted in granitoids in the Laoeling-Grodekov island arc terrane that consists chiefly of (1) A lower tectonic melange of: (1) discontinuous Early Silurian sedimentary and volcaniclastic rock; and (2) Late Carboniferous(?), Early and Late Permian carbonate, clastic and volcanic rock. The terrane is intruded by Permian zoned dunite and clinopyroxenite gabbro Alaskan-type plutons and by local tonalite and plagiogranite that are interpreted as part of a Permian volcanic arc. Younger, collision-related, Late Permian granitic plutons intrude the terrane and are co-magmatic with Permian volcanic rock in the Khanka superterrane. This relation suggests that accretion of the Laoelin-Grodekovsk terrane and Khanka superterrane occurred at the end of the Paleozoic. The porphyry Cu-Mo (±Au, Ag) deposits and Au-Ag epithermal vein deposits in the belt are hosted in a thick Permian marine sequence of felsic and mafic volcanic rock that may also be favorable for undiscovered kuroko massive sulfide deposits. Small lenses of conformable sphalerite occur in shale in this sequence. The region and metallogenic belt is poorly exposed and poorly studied. The principal deposit porphyry Cu-Mo (±Au, Ag) deposit is at Baikal, and the significant Au-Ag epithermal vein deposit is at Komissarovskoe.

Baikal Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Petrachenko and Petrachenko, 1985) consists of veinlets and disseminations that occur along contacts of gabbro, diorite, gabbro, and syenite, in and adjacent to the intrusive rocks. The deposit covers an area of 150 to 200 m^2 and consists of hydrothermally altered biotite-K-feldspar rock that is surrounded by epidote-chlorite alteration. The ore minerals are chalcopyrite, bornite, pyrite, and molybdenite. The hydrothermally altered area exhibits anomalous Au. The host rocks are metamorphosed Silurian and Devonian sedimentary and siliceous volcanic rock, and Permian(?), subalkaline, gabbro, diorite, gabbro, and syenite, and granite porphyry that intrude the sedimentary sequence. The gabbro and diorite are highly alkaline. The gabbro and syenite and granite porphyry hosting the deposit are K-enriched. Ore minerals are highly oxidized. The deposit is small. Average grade is 0.01% Cu and about 0.01% Mo.

Komissarovskoe Au-Ag epithermal Vein Deposit

This deposit (S.N. Rodionov, written commun., 1991) consists of low-grade, short Au-Ag-pyrite veins that occur in dacite volcanic rock that is interpreted as part of a Permian volcanic sequence The veins contain minor galena and sphalerite, occur in metasomatic sericite-biotite-quartz bodies in fracture zones, and are both conformable to, and crosscut bedding. The deposit may be related to areas of higher carbon in thin-bedded siltstone and argillite. Associated Au placer deposits occur in adjacent western parts of the terrane. The deposit is small with an average grade of 1.92 g/t Au and 49-52 g/t Ag.

Origin and Tectonic Controls for Laoelin-Grodekov Metallogenic Belt

The belt is interpreted as forming in an Permian island arc.

REFERENCES: Shcheka and others, 1973; Petrachenko and Petrachenko, 1985; Khanchuk and others, 1988; Zhang and others 1989, 1996; S M. Rodionov, written commun., 1991; Nokleberg and others, 1994, 2003; Khanchuk and others, 1996.

Harmagtai-Hongoot-Oyut Metallogenic Belt of Porphyry Cu-Mo (±Au, Ag), Porphyry Au, Granitoid-Related Au Vein, and Au-Ag Epithermal Vein Deposits (Belt HHO) (Southern Mongolia)

This Middle Carboniferous to Early Permian metallogenic belt is related to granitoids of the Mandah intrusive complex that form part of in the southern part of the South Mongolian volcanic-plutonic belt that intrudes the Mandalovoo-Onor island arc and Mandah accretionary wedge terranes. The Harmagtai-Hongoot-Oyut belt extends southwest-northeast for 450 km and ranges from 30 km to 60 km wide. Yakovlev (1977) first defined the Mandah Cu district. Subsequently, Shabalovskii and Garamjav (1984) and Sotnikov and others (1984, 1985) defined the South Mongolian porphyry Cu (±Au) metallogenic belt. We interpret that late Paleozoic age porphyry deposit and occurrences, related to Southern Mongolian volcanic-plutonic belt and vein and stockwork Au-Ag-Cu occurrences as the Harmagtai-Hongoot-Oyut metallogenic belt that forms the northern part of South Mongolian metallogenic belt (Sotnikov and others, 1984, 1985).

The Mandah intrusive complex consist of monzodiorite, granodiorite, and granite, and deposit-hosting diorite porphyry and granodiorite porphyry stocks and dikes. The complex is coeval with andesite, dacite, and rhyolite volcanic rock of Doshiin ovoo Formation. The Mandah complex was described as Late Carboniferous and Early Permian (Goldenberg and others, 1978) or as Middle and Late Carboniferous (Tomurtogoo, 1999). Geological and isotopic age data indicate that plutons (South Mandah, Hongoot and others) in the eastern belt are Late Carboniferous (Sotnikov and others, 1984), whereas putons (Harmagtai and others) in the western belt are Late Carboniferous and Early Permian.

From east to west the belt contains the Oyut, Nariin hudag, Hongoot, and Harmagtai districts. Special features of the belt are high Au in porphyry Cu-Mo (±Au, Ag) deposits and occurrences, and a close spatial and genetic relation of porphyry Cu-Mo (±Au, Ag) and vein and stockwork Au-Ag-Cu deposits. The major deposits are at Nariinhudag porphyry Cu (±Au) deposit, Hongoot porphyry Cu-Mo (±Au, Ag) occurrence, Uhaa hudag and Kharmagtai 2 porphyry Au occurrences, Shine, Hatsar, and other Au-Ag-Cu occurrences.

Shine Granitoid-Related Au Vein Occurrence

The occurrence (A.E. Shabalovskii and others, written commun., 1978; Sotnikov and others, 1985) is related to the Oyut granitoid massif in Middle to LateCarboniferous Mandakh Complex at a distance of 400 to 1500 m from the contact. The deposit contains stringers and disseminations of epidote, pyrite, molybdenite, and chalcopyrite grading 0.3-3.38% Cu and average 0.008% Mo. The deposit is located in zone that dips northwest, and ranges from 100-120 m wide and 350-400 m long. The zone is hosted in Devonian brecciated andesite is altered to K feldspar, epidote, sercite, and chorite. The ore and replacement minerals are formed in following sequence: K-feldspar-epidote; molybdenite; chlorite-sericite; pyrite-chalcopyrite; calcite). The occurrence probably formed in the upper part of a magmatic system. Drill cores range to a depth of 82 m and contain 0.3-1.0% Cu, 0.01- 1.0 g/t Au, and trace to 0.003%, Mo.

Kharmagtai 2 Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Yakovlev, 1977; Sotnikov and others, 1985) is hosted in Late Carboniferous and Early Permian diorite and granodiorite that intrudes Devonain tuff, andesite, and tuffaceous sandstone and siltstone. The ore minerals are chalcopyrite, covellite, bornite, and molybdenite. Oxidation minerals are malachite, azurite, and cuprite. Associated minerals are pyrite and magnetite and peripheral sphalerite, galena, and gold. The deposit is related to subvolcanic bodies of diorite and granodiorite porphyry in two stocks and bodies explosive breccia. Each bodies ranges from 200 to 400 m wide, 900 m long. Surface grades are 0.05-0.4% Cu and 0.003-0.03% Mo over an area of 400 by 900 m. A zone 100 by 300m contains >0.3 wt% Cu. Deposit extends at least to a depth of 250 m and is defined by stockwork veinlets of quartz with chalcopyrite and molybdenite that occur across the breccia pipe. Hydrothermal alteration minerals are weakly developed silica, sericite, K feldspar, chorite, epidote, and tourmaline. Sericite, potassic, and silicic alterations occur in the center of alteration zone, and chlorite and epidote alteration occurs along the periphery. Potassic alteration occurs mainly in the deeper part of deposit. The deposit is not well studied. The deposit is small with resources of 0.8 million tonnes Cu grading 0.35% Cu.

Origin and Tectonic Controls for Harmagtai-Hongoot-Oyut Metallogenic Belt

The belt is interpreted as forming in a continental margin arc. Herein we interpret the South Mongolian volcanic-plutonic belt that contains theMandah complex. The volcanic-plutonic belt forms an continental margin arc overlapping the Mandalovoo-Onor island arc terrane and Mandah accretionary wedge terranes.

REFERENCES: Yakovlev, 1977; Goldenberg and others, 1978; Shabalovskii and Garamjav, 1984; Sotnikov and others 1984, 1985; Tomurtogoo, 1999; Tomurtogoo and others, 1999.

Sumochaganaobao Metallogenic Belt of Hydrothermal-Sedimentary Fluorite Deposits (Belt SC) (North-Central China)

This Early Permian metallogenic belt is related to volcaniclastic rocks in Solon accretionary wedge terrane. The belt trends east-west and is about 70 km long and 25 km wide. The significant deposit is at Sumochaganaobao.

Sumochaganaobao Hydrothermal-Sedimentary Fluorite Deposit

This deposit (Chen, Xianpei and others, 1994) consists of beds that extend up to 2900 m long, 1200 m wide, range from 0.49 to 22.48 m thick, and extend to 588 m deep. The deposits are concordant to the host limestone, calcareous sandstone. The lower host layer is Early Permian siliceous volcanic lava, tuff, and sedimentary rock that occur in a northeast-dipping monocline. The fluorite textures are granoblastic, massive, laminated, or breccia. The deposit consists of fine-grained fluorite or fluorite andquartz, and minor calcite and clay. The fluorite layers display sedimentary features and are usually interbedded with argillaceous, calcareous, and siliceous sedimentary rock. The Early Permian strata in the area have two fluorite-bearing layers. In an area of 500 km^2 are more than twenty similar fluorite. The sedimentary features of the deposit are partly modified by intrusion of Cretaceous granite and hydrothermal fluorite veins. The deposit is large with reserves of 10.250 million tonnes fluorite.

Origin and Tectonic Controls for Sumochaganaobao Metallogenic Belt

The belt is interpreted interpreted as forming during during hydrothermal activity and associated with volcanic and sedimentary rock that were incorporated into an accretionary wedge. The belt is hosted in volcaniclastic and carbonate rock of Xilimiao Formation in the Solon accretionary wedge terrane that contains two units: (1) Middle to Late Carboniferous ophiolite, limestone, and chert; and (2) Permian volcaniclastic rock, andesite, tuffaceous sandstone, sandstone, conglomerate, and limestone. The Solon terrane is interpreted as forming during subduction of the late Paleozoic Paleopacific ocean crust.

REFERENCES: Chen Xianpei and others, 1994

Bieluwutu Metallogenic Belt of Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposits (Belt BL) (North-Central China)

This Pennsylvanian metallogenic belt is related to Carboniferous and Permian volcanic and sedimentary rocks in the small Bieluwutu Basin that is part of Daxinganling sedimentary assemblage that overlaps the Wundurmiao accretionary wedge terrane. The belt occurs in the eastern Inner Mongolia, trends northwest, and is about 70 km long and 20 km wide. The significant deposit is Bieluwutu.

Bieluwutu Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposit

This deposit (Zhang Hongtao and Nie Fengzhun, 1994) occurs in eastern Inner Mongolia. Host rocks are mainly Late Carboniferous volcanic and sedimentary rock, and flysch of the Early Permian Sanmianjing Formation. Two unconformable sequences occur. The deposit horizon contains a lens of monomineralogic tourmaline rock and local hydrothermal breccia. In both the hanging wall and footwall is monomineralogic tourmaline rock. The deposit contains tourmaline inirregular lenses, masses, and peneocrystals. The deposit consist of four areas. The deposit minerals occur in stratiform layers, bands, and lenses. Main metallic minerals are chalcopyrite, pyrite, and pyrrhotite, lesser galena, sphalerite, magnetite, arsenopyrite, realgar, and orpiment. The deposits are mainly hosted in a transitional horizon between the fine-grained tuffeous sandstone and rhyolite and dacite, and are concordant to host rocks. Alteration is not well developed However, a weak alteration zonation consists of chlorite grading to carbonate to sericite to silica to K-feldspar minerals from the lower to upper parts of the deposits. The deposit is medium size.

Origin and Tectonic Controls for Bieluwutu Metallogenic Belt

The belt is interpreted as forming during exhalative-sedimentary sedimentation in a restricted marine basin during Carboniferous extension of northern margin of the Northern China Platform during formation of the Solon accretionary wedge terrane. The belt related to magmatism in transtensional zones occurring along transform micro plate boundaries and within plate (plume) environment.

REFERENCES: Zhang Hongtao and Nie Fengzhun, 1994.

Kalatongke Metallogenic Belt of Mafic-Ultramafic Related Cu-Ni-PGE and Granitoid-Related Au Vein Deposits (Belt KL) (Northwestern China)

This Pennsylvanian metallogenic belt is related to mafic-ultramafic and granitic plutonic rocks in the Waizunger-Baaran island arc terrane. The belt occurs in the Ertix and Ulungur River areas south of the Altay Mountains, trends northwest, is 500 km long, and ranges up to 70 km wide. The mafic-ultramafic plutons host Cu-Ni-PGE sulfide deposits and the granite plutons contain Au deposits. The significant deposits are at Kelatongke and Alatasi.

Kalatongke Mafic-Ultramafic Related Cu-Ni-PGE Deposit

This deposit (Wang, Futong and others, 1992; Editorial Committee of The Discovery History of Mineral Deposits, 1996) consists of nine Carbonaceous mafic-ultramafic intrusions with the no.1 intrusion being the largest. The intrusion is lenticular in plan view, and is 640 m long and 35 to 350 m wide, trends northwest, and dips 20 to 28° northeast. In cross section, the pluton is wedge-shaped with a wide upper and narrow lower part. The margin of the upper part consists of biotite diorite, gabbro, and contains sparse sulfide. The center of the upper part is gabbro and norite facies consisting mainly of biotite amphibole norite, gabbro and quartz-bearing amphibole norite and contains lean Cu-Ni sulfides at the base. The center of the lower part is biotite-amphibole norite, biotite-olivine norite, and peridotite with more abundant sulfides at depth. The marginal part of the lower part is biotite-amphibole diabase and gabbro, olivine-amphibole diabase and gabbro and contains lean sulfides. The intrusion is ultramafic with a Mg/Fe ratio of 2/3. Ore minerals are mainly pyrrhotite, chalcopyrite, pentlandite, pyrite, and magnetite and 60 other lesser sulphides and oxide minerals. Ore minerals occur in masses and and disseminattions. Autometamorphism is widespread with formation of serpentinite, talc, bioitite, and uralite. The deposit formed during intrusion of magma, injection of magma with subsequent hydrothermal and weathering. The deposit is large with eserves of 410,800 tonnes Cu, 1.740 tonnes Pt, 2.161 tonnes Pd. Average grade is 0.58--0.88% Ni, 1.40% Cu, 0.07 g/t Pt, and 0.09 g/t Pd.

Alatasi Granitoid-Related Au Vein Deposit

This deposit (Rui Xingjian, 1993) trends northwest for about 70 km in the metallogenic belt contains several tens of veins and altered zones that vary from 1 to 3 km long and 0.05 to 0.4 km wide. These zones veins and lenses that are concordant to host strata, or crosscut host strate at low angles of 5 to 15°. The ore minerals occur in veinlets and disseminations, stockworks with idiomorphic-hypidiomorphic and caulking textures. The main ore minerals are pyrite, galena, native Au, and magnetite. Alterations are pyrite, bericite, silica, carbonate, hydromica alterations. The host rocks are Middle Devonian andesitic and basalt tuff and tuffeous breccia, and Late Devonian sandstone, siltstone, and mudstone, and local andesite, rhyolite and trachyte. The host rocks and Au deposits are related biotite granite, granodiorite, potassic granite, granite porphyry, quartz porphyry, diorite, and diorite porphyry. The deposit is medium size.

Origin and Tectonic Controls for Kelatongke Metallogenic Belt

The belt is interpreted as forming in an island arc, The Waizuger island arc terrane that hosts the belt consists of: (1) Ordovician limestone with intercalated andesite, clastic rock, tuff, mafic and siliceous volcanic rock, and muddy limestone; (2) Silurian sandstone, conglomerate, limestone, pyroclasic rock; (3) Devonian mafic and intermediate and mafic volcanic rock that consist mainly of siliceous volcanic rock and tuff, fine-grained sandstone, siltstone and limestone, (4) Carboniferous clastic rock; and (5) Permian continental volcanic and clastic rock with local coal. The calc-alkalic granite related to the Au deposits and the mafic-ultramafic volcanic-plutonic complex related to Cu-Ni sulfide deposits are interpreted as part of the island arc that was tectonically linked to a subduction zone to the south in Wulungu River area (Kong Qinshou, 1994 and Rui Xingjan and others, 1993). Some authors interpreted the Cu-Ni sulphide deposits and related mafic-ultramafic plutonic rocks as forming in an extensional basin controlled by major major faults along the southern margin of the Altay continent with lithosphere thinning and upwelling of upper mantle rocks resulting in emplacement of the mafic-ultramafic plutons into shallow crust (Tang Zhongli and Li Wenyuan, 1991).

REFERENCES: Tang Zhongli and Li Wenyuan, 1991; Rui Xingjan and others, 1993; Kong Qinshou, 1994.

Yanbian Early Metallogenic Belt of Volcanogenic Hydrothermal-Sedimentary Massive Sulfide Pb-Zn Deposits (Belt Yan) (Northeastern China)

This Early Permian metallogenic belt is related to structural units in the North Margin accretionary wedge terrane. The belt occurs in the eastern Jilin Province, trends east-west, is about 50 km long, and ranges up to 20 km wide. The significant deposit is Hongtaiping

Hongtaiping Volcanogenic Hydrothermal-Sedimentary Massive Sulfide Pb-Zn Deposit

This deposit (Song Qun, 1991) consists of three stratiform layers that occur concordant to host rocks. The uppermost layer contains mainly Cu sulfides, is 150 m long, 50 m wide, is 3 m thick, and is concordant to host dacite tuff and lava. The second layer is 10 m below, is 650 m long, trends east-west, varies from 60 to 150 m wide, averages 2.16 m thick, and contains 1.26% Cu, 1.42% Pb and 2.61% Zn. The footwall rocks are subhorizontal marl and black slate and the hanging wall is subhorizontal tuff and tuffeous sandstone. The third layer contains mainly Zn (6.2%), is 50 m long and wide, and is is 1.34 m thick. Weak alterations are sericite, chlorite, epidote, carbonate, and garnet alterations. Ore minerals are chalcopyrite, sphalerite, galena, arsenopyrite, pyrite, pyrrhotite, and magnetite. Guangue minerals are calcite, chlorite, chalcedony, quartz, sericite, and andradite. Ore mineral structures are mainly of laminated and rhythmic with local masses and bands. Deposit and host rocks are weakly metamorposed. Host rocks are marine volcanic and continental clastic rock of the Early Permian Miaoling and Kedao Formations. The volcanic rocks are alkalic-calcic andesite and dacite that are similar to those of island arc volcanic rock. The deposit is medium size with an average grade of 0.1-1.7% Cu, 0.1-1.4% Pb, 0.5-6.2% Zn.

Origin and Tectonic Controls for Yanbian Metallogenic Belt

The belt is hosted in volcaniclastic rocks in the North Margin accretionary wedge terrane that consists chiefly of: (1) pillow lava and ultramafic rock (Early Permian Kedao Formation); (2) carbonate and chert with interlayered siliceous shale; (3) turbidite and olistostrome. The source area for the turbidite include granitic and ophiolite. The belt is interpreted as formed during pre-accretionary Early Permian rift-related marine volcanism. Belt hosted in volcaniclastic rocks incorporated into the North Margin accretionary wedge terrane.

REFERENCES: Song Qun, 1991.

Shanxi Metallogenic Belt of Sedimentary Bauxite and Evaporate Sedimentary Gypsum Deposits (Belt SX) (North China)

This Pennsylvanian metallogenic belt is related to stratiform units in the upper part of the sedimentary platform cover for the Sino-Korean craton. The belt is hosted in Pennsylvanian sedimentary assemblages overlapping the West Liaoning-Hebei-Shanxi Archean terrane. The belt occurs along the Fanhe River and the middle reaches of the Yellow River in West Shanxi Province. The bauxite deposits occur in the lower part of the Pennsylvanian Benxi Formation. The belt trends north-south, is 300 km long, and ranges from 30 to 50 km wide. The belt contains 55 bauxite deposits moderate or large size, with reserve (1997) of 941 million tones that comprise 50% China bauxite reserve (Chen Ping and others, 1997). The most significant deposit is at Keer. A minor evaporate sedimentary gypsum deposit occurs at Lingshi.

Ke'er Sedimentary Bauxite Deposit

This deposit (Editorial Committee, Discovery History of Mineral Deposits of China, Shanxi volume, 1995; Chen Ping and others, 1997) consists of stratiform and lenticular layers that range up to 1800 m long and 400 m wide. Individual bauxite layers range from 0.5 to 11.7 m thick. From bottom to the top the host rocks consists of a volcanogenic-sedimentary Fe deposit (hematite), allite, bauxite, refractory clay, shale, carbonaceous shale and coal seams. The sequence is 8 to 20 m thick and occurs in the lower member of the Benxi Formation. The underlying strata are Middle Ordovician limestone. The lower boundary of the bauxite layer is 2 to 5 m above an ancient weathering-surface of the Ordovician limestone. In the mine, the strata are monoclinal and dip gently at 3 to 5 degrees. Oblique bedding occur in the ores that are massive, rough, and oolitic. The ore minerals are mainly diaspore (98%) and local gibbsite (5 to 7%). Minor minerals are kaolinite, dickite, and hydromica and rare zircon, oysanite, tourmaline, quartz, and barite. Below the bauxite layer is hematite claystone and hematite shale, and local abundant intercalated limonite lenses. The bauxite probably formed during allochthonous surface accumulation on a weathering crust of carbonate and not by mechanical sedimentation. The Carbonaceous and Permian units of the North China Platform contain seven bauxite layers. The layer in the Late Carboniferous Benxi Formation is the most extensive. The deposit is large with reserves of 62,656 thousand tonnes grading 64.43% Al_2O_3.

Origin and Tectonic Controls for Shanxi Metallogenic Belt

The belt is interpreted as forming during weathering of metamorphic rock of the Northern China Platform. The bauxite deposits were deposited in karst and lagoonal basins in a littoral-shallow sea. The entire North China Platform, including the bauxite metallogenic belt, was uplifted, weathered, and eroded during the Middle Ordovician. During the Pennsylvanian, the platform subsided with formation of a littoral shallow sea (Wang Hongzhen, 1985). Bauxite deposits formed in local favorable karst and lagoon basins. The bauxite was derived from weathered metamorphic rock of the North China Platform and not from weathered Ordovician limestone that underlies the bauxite sequence (Chen Ping and others, 1997). However, some authors advocate derivation of bauxite deposits from the weathering of the underlying limestone (Jiang Rong and others, 1986).

REFERENCES: Wang Hongzhen, 1985; Jiang Rong and others, 1986; Chen Ping and others, 1997.

Zibe Metallogenic Belt of Sedimentary Bauxite Deposits (Belt ZB) (Northeastern China)

This Late Permian metallogenic belt occurs in stratiform units in sedimentary cover in the Proterozoic through Triassic Sino-Korea Platform. The belt occurs in the southwestern Shandong Province in units that overlap the West Liaoning-Hebei-Shanxi granulite-orthogneiss terrane in the Sino-Korean Craton. The metallogenic belt trends northeast, is about 30 km long, and ranges up to 20 km wide. The significant deposit is at Zibe.

Zibe Sedimentary Bauxite Deposit

This deposit (Xiang, Renjie, 1999) occurs in the upper part of the first member of the Late Permian Nianning Formation. The first member contains three layers. The first layer is gray, fine-grained muddy sandstone. The second layer is the main deposit layer and varies from 5.6 to 10.7 m thick. The third layer is dark gray to purple mudstone. The bauxite occur in stratiform layers and lenses. The deposits vary from 300 to 1000 m long, 160 to 1000 m wide. The ore minerals consist of fine-grained crystalline and collform diasporite, and kaolinite, and siderite. Typical textures are oolitic and pisolitic. The deposit is small with resources of 2.94 million tonnes grading 54.93% Al_2O_3, 17.21% SiO_2, 11.36% Fe_2O_3.

Origin and Tectonic Controls for Zibe Metallogenic Belt

The belt is interpreted as forming during weathering of metamorphic rocks of the Northern China Platform. Bauxite deposits formed in karst and lagoonal basins in a littoral shallow sea.

REFERENCE: Xiang Renjie, 1999.

Mino-Tamba-Chugoku Metallogenic Belt of Volcanogenic-sedimentary Mn, Podiform Chromite, and Besshi Cu-Zn-Ag Massive Sulfide Deposits (Belt MTC) (Japan)

This Permian (or older) to Jurassic metallogenic belt is hosted in structural units in the Mino-Tamba-Chichibu and Akiyoshi-Maizuru accretionary wedge terranes. The belt occurs in the western part of Honshu Island in the Inner Zone of southwestern Japan, trends east-northeast to west-southwest for more than 900 km, and ranges up to 150 km wide. The eastern margin of the belt is the Tanakura tectonic line. Tsuboya and others (1956) named the belt as the Chichibu geosyncline Fe-Mn metallogenic province. The North Kitakami metallogenic belt is interpreted as an eastern extension of this belt. The Mino-Tamba belt contains a large number of various types of deposits. Mn deposits are hosted in the Mino-Tamba-Chichibu terrane, and podiform chromite and Besshi Cu-Zn-Ag massive sulfide deposits are hosted in in the Akiyoshi-Maizuru terrane. The Mino-Tamba-Chichibu terrane is a Jurassic accretionary complex and Mn deposits are associated with Triassic and Jurassic chert. Podiform Cr deposits occur in ophiolite in the pre-Permian Sangun metamorphic complex. Massive sulfide deposits occur in the Permian forearc Maizuru group. The significant deposit is at Awano.

Wakamatsu Podiform Chromite Mine

This deposit (Hirano, 1996; Miyake and others, 1997) occurs in serpentinite derived from dunite of the Tari-Misaka ultramafic body in the Sangun belt. The ultramafic body is mostly composed of massive harzburgite and dunite. The ultramafic rocks are metamorphosed by a Cretaceous granite. The mine contains three main ore bodies. Main number 7 body is 190 m long, 60 m wide, and 30 m thick and yielded 1,000,000 tonnes ore. The ore mineral is refractory grade chromite. Serpentine and olivine occur in ore. The deposit was discovered in 1899 and the mine closed in 1994. The deposit is medium size, produced 780,000 tonnes ore grading 32% Cr_2O_3.

Yanahara Besshi Cu-Zn-Ag Massive Sulfide Mine

This mine (Mining and Metallurgical Institute of Japan, 1965; Dowa Mining Corporation, 1981) consists of the main Yanahara ore body and nine smaller ore bodies. The ore bodies are stratiform and lenticular, and occur in an area 4.5 by 2 km. The main Yanahara ore body contains the upper, lower, and lowest ore bodies. The upper body is 350 m long along strick, and extends 1000 m down dip, and ranges up to 100 m wide. The lower ore body is similar. The main ore mineral is pyrite; minor ore minerals are pyrrhotite, magnetite, chalcopyrite, and sphalerite. Gangue minerals are quartz, sericite, and chlorite. The deposit is hosted in rhyolite pyroclastic rock and mudstone of Paleozoic Maizuru Group. The deposit occurs immediately above the basalt of the Yakuno Group. The mine started in 1916 and closed in 1991. The mine is medium size with reserves of 3.7 million tonnes grading 44% Fe, 47% S, 0.2% Cu, 0.3% Zn.

Hamayokokawa Volcanogenic-Sedimentary Mn Mine

This mine (Mining and Metallurgical Institute of Japan, 1968; Yoshimura, 1969; Uemura and Yamada, 1988) is located in the Yokokawa (Shiojiri) Mn deposit district that contains 17 deposits. The Hamayokokawa deposit is the largest and contains six main ore bodies. The main ore body is 50 m long, 8 m thick, and extends 120 m down dip. The ore bodies occur in Paleozoic and Mesozoic chert and slate of the Mino belt. The ore minerals are rhodochrosite, hausmannite, manganosite, rhodonite, tephroite, and braunite. The mine closed in 1984. The mine is medium size, and produced 260,000 tonnes ore grading 33-42% Mn.

Origin and Tectonic Controls for Mino-Tamba-Chugoku Metallogenic Belt

The belt is hosted in an accretionary wedge complex composed of marine sedimentary and volcanic rock, and fragments of oceanic crust with ultramafic rock. Besshi deposits are interpreted as forming along a spreading ridge. In the oceanic crustal fragments are podiform chromite deposits hosted in ultramafic rocks, and chert-hosted Mn deposits. The deposits and host rocks were subsequently incorporated into an accretionary wedge of the Mino-Tamba-Chichibu accretionary wedge terrane.

REFERENCES: Tsuboya and others, 1956.

Hitachi Metallogenic Belt of Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposits (Belt Hit) (Japan)

This Permian metallogenic belt is related to stratiform units in the South Kitakami terrane and occurs in the southern end of the Abukuma Mountains in Northeast Japan. The belt is 15 km by 10 km and the western margin of the belt is the Tanakura tectonic line. The metallogenic belt occurs in metamorphic rock (Paleozoic Hitachi Formation). Cretaceous granitoid occur north of the belt and contact metamorphose rocks in the northern belt. The eastern margin of the belt is covered by Neogene sedimentary rock. The metallogenic belt contains the Hitachi deposit, a Kuroko type Cu-Zn deposit. Tsuboya and others (1956) first defined this belt as the Abukuma metallogenic province. The Hitachi Formation consists mainly of mafic to siliceous volcanic rock, slate, and limestone. The formation strikes generally northeast and metamorphic grade increases from east to west, up to amphibolite facies grade (Tagiri, 1971).

Hitachi Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai type) Mine

This mine (Kase and Yamamoto, 1985; Omori and others, 1986; Mariko and Koto, 1994) consists of eight stratiform ore bodies that occur in the Fujimi and Fudoutaki groups according to stratigraphic position. Bodies hosted in greenschist, biotite-quartz schist, sericite-quartz schist, and siliceous schist of Paleozoic Hitachi Metamorphic Rock. The Fujimi ore bodies occurs at, or near the contact between siliceous schist and overlying mafic to intermediate schist. The Fudoutaki bodies occurs in mafic and intermediate schist. Geochemistry indicate origin of basalt in a marginal basin. Presence of calc-alkaline rock also indicates an island arc setting. The ore bodies extend about 3,000 m along strike and about 700 m down dip. Individual ore body range from 150 to 600 m along strike, and 10 to 80 m thick. The main ore minerals are pyrite and chalcopyrite. Other ore minerals are pyrrhotite, sphalerite, galena, magnetite, marcasite, cubanite, and valleriite. Gangue minerals are quartz, barite, biotite, chlorite, sericite, calcite, gypzum, and cordierite. Contact metamorphism from a Cretaceous granite is also recognized. Mining started in 1591 and ceased in 1981. The mine is medium size with production of 440,000 tonnes Cu and 40,000 tonnes of Zn grading 1.5% Cu.

Origin and Tectonic Controls for Hitachi Metallogenic Belt

The belt interpreted as forming in an island arc.

REFERENCES: Tsuboya and others, 1956; Tagiri, 1971; Minato and others, 1979.

LATE TRIASSIC THROUGH EARLY JURASSIC METALLOGENIC BELTS (230 to 175 Ma)

North Taimyr Metallogenic Belt of Granitoid-Related W-Mo-Be Greisen, Stockwork, and Quartz Vein, W±Mo±Be Skarn, and Porphyry Cu-Mo (±Au, Ag) Deposits (Belt NT) (Taimyr Peninsula, Russia)

This Middle and Late Triassic metallogenic belt is related to replacements and granitoids (too small to show on 5 M scale map) intruding the Permian and Triassic volcanic and sedimentary rock of the Lenivaya-Chelyuskin sedimentary assemblage, Central Taimyr superterrane, and Kara terrane. The belt occurs in the Gorny Taimyr region, extends east-northeast for more than 600 km, and contains small early Mesozoic granitoid intrusions and numerous small W-Mo occurrences (Ravich, 1959; Ravich and Markov, 1959). The small intrusions occur in tectonic blocks bounded by post-orogenic faults, and consist of stocks and tabular bodies of granosyenite, syenite, granodiorite, and rare quartz monzonite with dimensions of 1 to 2 to 70 to 75 km^2. Granite porphyry dikes are common. Granitoids intrude Permian and Triassic volcanic and sedimentary rock, a Precambrian metamorphic sequence, and older granitoid plutons. Deposits occur mainly along the exocontacts. The metallogenic belt is still poorly studied and is prospective for undiscovered porphyry Cu-Mo (±Au, Ag) deposits. The significant deposits are at Kolomeitseva River, Morzhovoye, and Mamont River.

Kolomeitseva River W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Ravich, 1959; Ravich and Markov, 1959) consists of quartz veins with disseminated molybdenite. The veins cut Precambrian granitoid and Paleozoic clastic rock and exocontacts of small Permian and Triassic syenite intrusions. Molybdenite occurs also in the exocontact of an augite syenite intrusion in an older granitoid pluton. Scheelite occurs in heavy concentrates. The deposit is small poorly studied.

Morzhovoye W±Mo±Be Skarn Deposit

This deposit (Ravich, 1959) consists of a grossular-diopside-calcite skarn with disseminated molybdenite in a roof pendant in a Triassic(?) syenite intrusive. The ore minerals are fine-grained molybdenite and disseminated pyrrhotite, pyrite, pentlandite, and marcasite. A stockwork of thin garnet-epidote-calcite veins with coarse molybdenite occurs in the northern part of the roof pendant. Altered rock along vein walls contain disseminated pyrite, chalcopyrite, and magnetite. Scheelite occurs in heavy concentrate. The deposit is small.

Mamont River 2 Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Ravich, 1959; Ravich and Markov, 1959) consists of quartz veins with disseminations and nests of molybdenite. The veins occur small Permian and Triassic syenite intrusions that cut large Precambrian granitoid plutons. Quartz veins are accompanied by silica and sericite alteration. Along with molybdenite, the quartz veins contain pyrite, scheelite, sericite, and feldspar. The deposit is small and poorly studied.

Origin and Tectonic Controls for North Taimyr Metallogenic Belt

The belt is interpreted as forming during generation of granitoids during and after collision between the Siberian and Kara continents. The belt is hosted in intrusions in tectonic blocks bounded by post-orogenic faults. The host granitoids intrude Permian and Triassic tuff and lava sequence of the age. Granitoid pebbles occur in Early Cretaceous conglomerate (Ravich, 1959). The isotopic age of granitoid is about 223 to 233 Ma (Vernikovskiy, 1996).

REFERENCES: Ravich, 1959; Ravich, Markov, 1959; Vernikovskiy, 1996.

Byrranga Metallogenic Belt of Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein Deposits (Belt BR) (Taimyr Peninsula, Russia)

This Middle to Late Triassic metallogenic belt is related to granitoids (too small to show at 5 M scale) intruding North Asian Craton Margin, South Taimyr fold belt. The belt occurs in Byrranga Mountains in the southern Taimyr Peninsula, extends along a latitudinal trend for about 300 along the northern edge of the Taimyr Lake, and ranges up to 10 to 20 km wide. The host granitoids intrude The late Paleozoic carbonate and clastic rocks of the passive continental margin of the North Asian Craton and the Late Permian and Triassic clastic and volcanic rift-related sedimentary rock. These units are intruded by numerous diabase sills, small intrusions of subalkalic granite, syenite and nepheline syenite, and a lamprophyres dike complex (minette and cersantite). Small intrusions and dikes intrude the Triassic tuff and lava, and fragments of these rocks occur Early Cretaceous conglomerate (Ravich, 1959; Vernikovskiy, 1996). The major deposits (Partizanskoye and Surovoye Lake I) consist of long quartz-carbonate veins with galena, sphalerite, pyrite, chalcopyrite, and fahl. The main gangue minerals are ankerite and siderite. Polymetallic deposits are controlled by a fault latitudinal system that occurs along the crest of a large anticline. Polymetallic veins also occur along transvere feathering faults structures that control ore clusters. These faults contain breccia zones that range up to 50 m thick and contain fragments of hydrothermally-altered diabase and sandstone cemented by calcite and quartz. Wall rocks exibit albite, carbonate, and sericite alteration, and rare pyrite and silica alteration.

Partizanskoye Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein Deposit

This deposit (Ravich and Markov, 1959; Ravich, 1959) occurs in a district located along the contact of diabase dike and Early Permian sandstone and siltstone. The district extends 1.5 km along strike and averages 1.5 m thick. The deposit is 800 to 900 m long and from 0.25 to 3.5 m thick (in swells). Sphalerite and galena are the main ore minerals with less abundant pyrite, marcasite, chalcopyrite, fahl, pyrrhotite, and native silver. Gangue minerals are siderite, calcite, and quartz. Wall-rock are altered to carbonate, sericite, silica, and argillite. Total grade of Zn+Pb in ores ranges from 15 to 20%. The deposit is medium size.

Origin and Tectonic Controls for Byrranga Metallogenic Belt

The belt is interpreted as forming during intraplate rifting related to extensive trapp magmatism and small intrusions of alkalic granite, syenite, and nepheline syenite, and alkalic basalt dike complexes in the Middle and Late Triassic (Vernikovskiy, 1996). The belt formed in the Kara orogene in northern Taimyr during Late Permian and Early Triassic rifting. Spatially and temporally, the polymetallic deposits are related to the rift-related magmatism (Ravich, 1959). Also occurring are low-grade REE-fluorite deposits (Shanurenko, 1983).

REFERENCES: Ravich, 1959; Shanurenko, 1983; Vernikovskiy, 1996.

Kharadzhulsk Metallogenic Belt of Ni-Co Arsenide Vein Deposits (Belt KhD) (West Siberia, West Sayan Mountains, Russia)

This Triassic(?) metallogenic belt is related to veins that occur along major faults in the North Sayan island arc terrane and Minusa molasse basin and occurs along fault zones that are branches of the larger major North-Sayanian fault that occurs between the early Paleozoic North Sayan island arc terrane and the middle and late Paleozoic Minusa basin. The belt extends north-south for about 100 km. The belt contains Ni-Co arsenide and Cu-Co arsenide-sulfoarsenide deposits (Kharadzhulskoye, Butrakhtinskoye) and some occurrences (Borisenko and others, 1984). The deposits consist of quartz-carbonate veins hosted in Early to Middle Devonian volcanic and sedimentary rock along the faulted dike contacts, faults, and other structures. Superimposed Co-arsenide vein deposits also occurs in the Abakanskoye Fe-skarn deposit in the southern part of the belt.

Kharadzulskoye Ni-Co Arsenide Vein Deposit

This deposit (Unksov, 1961; Levchenko, 1975; Borisenko and others, 1984) consists of steeply dipping veins in keratophyre dikes and Early Devonian mafic extrusive rock. The deposit contains 27 veins that extend up to 1.4 km along strike and 350 m downdip. Vein thickness varies from 1 to 10 m. The ore minerals occur in masses, breccia, disseminations, spots, and streaks. Main ore minerals are chalcopyrite, fahl, pyrite, marcasite, and arsenopyrite. Accessory minerals are sphalerite, rammelsbergite, safflorite, smaltite, chloantite, cobaltite, cubanite, niccolite, and skutterudite. Co-Ni arsenides are associated with with chalcopyrite and arsenopyrite. The deposit is small.

Butrakhtinskoye Ni-Co Arsenide Vein Deposit

The deposit (Unksov, 1961; Borisenko and others, 1984) consists of irregular, steeply-dipping veins in Middle Devonian sedimentary and volcanic rock that isare intruded by porphyry, diabase porphyry, and albite dikes. The veins occur mainly in tuffaceous rock and rarely in dikes. Veins range from 2 to 5 m thick, extend along strike for 50 to 300 m, and extend 70 to 350 m downdip. Eighteen veins occur. Typical ore minerals are fahl, chalcopyrite, pyrite, sphalerite, smaltite, and chloantite, and rare arsenopyrite. The deposit is small.

Origin and Tectonic Controls for Kharadzhulsk Metallogenic Belt

The belt is interpreted as forming during late Paleozoic and early Mesozoic intraplate rifting and interblock strike-slip faulting between North Sayan terrane and Minusa basin with coeval intrusion of basalt dikes. Deposits are hosted in volcanic and sedimentary rock along faulted dikes, faults, and other structures (Borisenko and others, 1984; Levchenko, 1975).

REFERENCES: Levchenko, 1975; Borisenko and others, 1984.

Kalgutinsk Metallogenic Belt of W-Mo-Be Greisen, Stockwork, and Quartz Vein, Ta-Nb-REE Alkaline Metasomatite Deposits (Belt KG) (West Siberia, Gorny Altai Mountains, Russia)

This Early Jurassic metallogenic belt is related to granitoids and replacements related to the Belokurikha plutonic belt (too small to show at 10 M scale) that intrudes the Altai and West Sayan terranes. The belt occurs in the southern part of Gorny Altai region in southern Eastern Siberia and Mongolia, belt extends along a sublatitudinal trend for 300 km, and ranges from 80 to 100 km wide. The belt belt is hosted in early Mesozoic REE plumasite granite plutons that are composed of porphyritic biotite granite, leucogranite, and muscovite-tourmaline pegmatite. Also occurring are local Li-Cs ongonite and spodumene granite porphyry (Dergachev, 1989; Vladimirov and others, 1996, 1998; Dovgal' and others, 1997). REE deposits occurs in granite plutons and along exocontact zones in contact metamorphosed host rock that is mainly Cambrian and Ordovician flysch. Local associated scheelite deposits also occur (Urzarsaiskoye deposit). The major deposit is the large Kalgutinskoye W-Mo-Be greisen, stockwork, and quartz vein deposit that is being mined. Another prospective, medium-size deposit is the Akalakhinskoye Li-Ta-Nb-REE deposit that is hosted in an alkali metasomatite.

Kalgutinskoye 1 W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Pafienko, 1961; Sotnikov and Nikitina, 1977; Sharov and others, 1998) consists of quartz veins that occur in Kalguta granite pluton and in adjacent country Devonian extrusive rock. The deposit consists of more than 300 veins that occur in a northeastern-striking band that is about 2 km long and ranges up to 500 m wide. Single veins reange from from a fedw meters to 330 m long. The quartz veins are divided into W, W-Mo, and Mo types. Major minerals are wolframite, molybdenite, chalcopyrite, pyrite, beril, muscovite, fluospar, scheelite, feldspar, and topaz. Veins are associated with greisen that contain dissiminations and nests of ore minerals. A pipe of muscovite and quartz greisen occurs in porphyry granite and consists of breccia with granite fragments and matrix intensely altered to greisen. The ore minerals occur in the altered matrix and are disseminated molybdenite, chalcopyrite, pyrite, and rare wolframite. The deposit is large with reserves of 12,000 tonnes WO_3, 5,500 tonnes Mo; 235 tonnes Bi_2O_3; and 48 tonnes BeO. Average grade is 1.9% WO_3; 0.36% Mo; 0.11% Bi_2O_3; 0.35% Be.

Urzarsaiskoye W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Obolenskiy, 1960; Sotnikov and Nikitina, 1977; Kuznetsov and others, 1978) consists of a stockwork of scheelite-bearing veinlets hosted contact metamorphosed and locally in weakly metasomatized Cambrian and Early Ordovician sandy shale. The stockwork extends for 600 m long, is 400 m wide, andextends up to 500 m at depth. The stockwork consists of a dense network of quartz, quartz-feldspar, and quartz-feldspar-carbonate veinlets with scheelite, fluorite, beryl, chalcopyrite, and pyrite. Increased W occurs in quartz-feldspar veinlets. Mo increases downward. Wall rocks are silicified and altered to greisen and sericite. The thickness of veinlets varies from 0.2 to 15 cm, and averages 0.5 to 4 cm. Veinlets comprise from 10 to 30% host rocks. The deposit is large with reserves of 100,000 tonnes.Average grade is 0.11% WO_3 with up to 0.3% WO_3.

Akalakhinskoye (Alakha) Ta-Nb-REE alkaline MetasomatiteDeposit

The deposit (Vladimirov and others, 1998) consists of a stock (with dimensions of 1 by 1.5 km) of spodumene-granite porphyry and biotite porphyry granite in the main phase of the Chindagatui pluton. Spodumene granite porphyry is white with a fine-grained groundmass of albite, quartz, and muscovite. Phenocrysts range up to 1 cm and are composed of quartz and spodumene (10 to 30%), and local microcline and muscovite. Accessory minerals are columbite, tantalite, magnetite, and garnet. Grades range from 50 to 150 ppm Ta, 120 to 264 ppm Nb, 3700 to 5100 ppm Li, 1200 ppm Rb, and 260 ppm Cs. Also occurring are of spodumene aplite and muscovite aplite dikes. Muscovite aplite and spodumene granite porphyries are interpreted as forming in the late stage of crystallization of the pluton, significantly after intrusion of the early stage granite that comprises the major part of the pluton.The Ta-bearing spodumene granite porphyry and aplite are the analogues of spodumene and REE pegmatite and contain high Ta, Nb, Li, Rb, Cs, Sn, and Be. The deposit is medium size with reserves of 128,000,000 tonnes. Average grade is 0.8% Li_2O; 0.01% Ta_2O_5; 0.01% Cs; 0.08% Rb.

Baliktigkhem W-Sn-W Greisen, Stockwork, and Quartz Vein Deposit

The deposit (Matrosov and Shaposhnikov, 1988) consists of cassiterite-quartz veins and greisen zones in the apical part of a Devonian granite pluton. The greisen contains tourmaline, topaz, cassiterite, pyrite, arsenopyrite, and beryl. The ore minerals are more abundant in veins and lenses of quartz, muscovite-quartz, and siderophyllite-quartz. Cassiterite is irregularly disseminated and occurs in nests the veins. The deposit is small.

Origin and Tectonic Controls for Kalgutinsk Metallogenic Belt

The belt is interpreted as forming during generation of REE granitoids along transpression zones related to transform micro plate boundaries and within plate (plume) environment. (Vladimirov and others, 1996, 1997, 1998). The REE deposits are genetically related to early Mesozoic REE plumasite granite in the Belokurikha plutonic belt. The age of hosting granite is Late Triassic and Early Jurassic. Rb-Sr isotopic ages are 201.0±1.5 Ma for the Chindagatui pluton, and 204.0±1.6 Ma for the Kalguta pluton-(Vladimirov and others, 1997). The initial $^{87}Sr/^{86}Sr$ ratio is 0.7069 to 0.7103 indicating a incorporation of significant crustal rock. The U-Pb ages of Ta spodumene granite in the Alakha stock are 183 and 188 Ma whereas the Rb-Sr age is 195±3 Ma (Il'in and others, 1994). The Rb-Sr age of Li-F granite porphyry in the Dzulaly stock is 188.0±6.4 Ma (Dovgal' and others, 1997). The belt of REE granite intrudes a middle Paleozoic continental-margin arcs consisting of a calc-alkalic volcanic-plutonic belts (Shokalskiy and others, 1996).

REFERENCES: Sotnikov and Nikitina, 1977; Dergachev, 1989; Il'in and others, 1994; Shokalskiy and others, 1996; Vladimirov and others, 1996, 1997, 1998; Dovgal and others, 1997.

Mongol Altai Metallogenic Belt of W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposits (Belt MA) (Western Mongolia)

This Late Triassic(?) to Early Jurassic(?) metallogenic belt is related to small bodies of leucogranite that intrude the Altai and Hovd Hovd terranes. The belt extends northeast to east (Kovalenko and others, 1988) and subsequently defined the late Paleozoic east-west-trending North Hangai-Selenge metallogenic belt of REE deposits (Kovalenko and others, 1990). Three major mineral districts occur along the northwest-striking Hovd regional fault zone (Borisenko and others, 1992). Herein, we interpret the northwest-striking, early Jurassic Mongol Altai metallogenic belt that occurs along the major Hovd fault zone. The major deposits are at Ulaan Uul and Tsunkheg.

Ulaan uul W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Amitan, 1993; A.N. Demin and others, written commun., 1990; S. Dandar and others, written commun., 1999) consists of about 40 northeast trending quartz-wolframite veins that occur in the western part of the Jurassic Ulaanuul leucocratic granite pluton. Veins range up to 1000 m long and from 0.1 to 1.5 m wide, and contain beryl, molybdenite, Y-bearing fluorite and sulfides. The Ulaanuul pluton is 10 by 2.5 km in size and is elongated northwest along the major Khovd fault. K-Ar isotopic ages range from 180-200 Ma, and Rb-Sr isochron ages are 170-180 and 196 ± 20 Ma. Granite pluton consists of porphyritic coarse-grained biotite granite, medium-grained microcline granite, and microcline-albite leucogranite. The deposit is small with reserves of 2,280 tonnes WO_3 and resources of 5,870 tonnes WO_3, 8.4 tonnes Nb, and 500 kg Y.

Tsunkheg W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Jargalsaihan and others, 1996) consists of complex vein and W stockwork that are hosted in a northeast trending zone of Ordovician-Silurian sandstone, siltstones, tuffstone, and tuffaceous siltstone. Host rock is altered to sulfides, contact metamorphosed, and intruded by minor bodies of gabbro and diabase. Three steeply-dipping quartz-wolframite veins extend for 200-300 m along strike, more than 100 m downdip, and range from 0.3 to 0.45 m thick. The northeast trending zone extends for 950 m and ranges up to 270 m wide, and extends to a depth of 300 m. The ore mineral assemblages are scheelite-quartz-feldspar-molybdenite, wolframite-quartz-pyrite-pyrrhotite-scheelte-chalcopyrite, and sporadic quartz-carbonate. The deposit is large with resources of: 8,000 tonnes WO_3 grading 0.1-40% WO_3 and average grade of 2.39% WO_3; 50,000 tonnes WO_3 grading 0.12-0.2% WO_3, 100 g/t Ag, 0.5-1.0% Cu, 1% Sb, 0.5-1.0% Zn, and 2% As.

Origin and Tectonic Controls for Mongol Altai Metallogenic Belt

The belt is interpreted as forming during Mesozoic intraplate rifting related to magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment. The belt is related to granitoids that intrude along the major Early Jurassic Hovd fault zone. In this region, various REE deposits are related to Middle Devonian collisional, Carboniferous post-collisional, and Permian and Early Jurassic late-stage and post-orogenic granitoids (Demin and others, 1990; Dandar and others, 1999). For the Mongol Altai metallogenic belt, the W-Mo-Be deposits and occurrences in the Ulaan Uul ore-field are related to Early Jurassic granite. The major deposits are the Ulaan Uul and Tsunheg W-Mo-Be deposits, the Tsunheg II, Buraat and Mo stockwork, and W-Mo occurrences in the Ulaan Uul district. The Maraagiin (W, Sn, Mo) and Bodonchiin (W-Sn) districts are similar to the Ulaan Uul district. This belt is interpreted as forming during Mesozoic continental interplate rifting associated with a mantle plume.

REFERENCES: Kovalenko and others, 1988, 1990; Borisenko and others, 1992; Dandar and others, 1999.

Chergak Metallogenic Belt of Ni-Co Arsenide Vein Deposits (Belt ChG) (Tuva, Russia)

This Triassic metallogenic belt is related to veins and associated gabbro intrusions that occur along the Akchem, Severo-Tannuola, and Eldigkhem faults that cut the Khemchik-Sistigkhem basin, Tuva molasse basin, and West Sayan terrane. The belt occurs in southwestern Tuva, trends northeast for more than 200 km, and ranges from 20 to 30 km wide along the northern boundary of the Tuva basin. The belt occurs in an echelon-like strike-slip interblock faults consisting of the major Shapshalsk fault zone and associated feather faults. The Ni-Co arsenide deposits typically occur along intersections of different faults along which are chains of small intrusions of the Cabroniferous Torgalyk gabbro and syenite complex. Sulfoarsenide Cu-Co vein deposits are predominate whereas Ni-Co-arsenide deposits are subordinate (Zaikov and others, 1981). The important deposits are at Chergak and Tolailyk.

Chergak Ni-Co Arsenide Vein Deposit

This deposit (Zaikov and others, 1981) consists of Cu-Co sulfoarsenide veins hosted in Ordovician and Silurian clastic and carbonate rock that are intruded by small Permian gabbro and diorite stocks and dikes. The host rocks are altered to silica and sericite. The deposits occur in fractures and breccia zones that occur along the Chergak fault. In the fault hanging wall, Cu-Co deposits consist of quartz-carbonate and carbonate veins. Individual veins range from 50 to 400 m long, and from 5 to 10 cm to 2.5 m thick. Ore minerals are chalcopyrite, tennantite, tetrahedrite, arsenopyrite, cobaltite, gersdorfite, Co-skutterudite, and pyrite. The Co:Ni:Cu ratio is 2:1:10. Downward, Co and Ni increase and Cu decreases. In the fault footwallm Co-Cu deposits occur along in fracture and crush zones. The deposits consist of the zones of streaks and disseminations, and individual veins. The Co:Ni ratio is 1:5. Host rocks include metasomatite lenses with sericite, calcite, chlorite, tremolite, and quartz. The deposit is small.

Tolailyk Ni-Co Arsenide Vein Deposit

This deposit (Zaikov and others, 1981) consists of Cu-Co sulfoarsenide veins hosted in volcanic and sedimentary rock that are intruded by Permian gabbro, diabase, diorite, and granite porphyry dikes. Deposits are concentrated in quartz and quartz-carbonate veins in Vendian and Cambrian porphyry and Middle Devonian clastic rocks and shale that are intensely altered to chlorite. Ten ore veins occur and range up to 200 m longand 15 to 20 cm wide. Ore minerals are Co-arsenopyrite, glaucodot, lollingite, pyrite, chalcopyrite, and fahl. There is a mineralized zone of crush with the same ore minerals at the deposit. The deposit is small.

Origin and Tectonic Controls for Chergak Metallogenic Belt

The belt is interpreted as forming during Mesozoic intraplate rifting that resulted in magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment (Obolenskiy and others, 1999). The rift structures consist of grabens adjacent to faults and basins that overlap the ancient terranes composed of Early Cambrian island arc complexes, ophiolite, Cambrian and Ordovician greenschist facies turbidite, and Silurian carbonate and clastic rock. The deposits are related to the Early Carboniferous Torgalyk gabbro and syenite compl. Younger Mesozoic basalt and alkali basalt dike complexes are also related to formation of the Ni-Co arsenide and Cu-Co sulfoarsenide deposits (Zaikov and others, 1981; Borisenko and others, 1984).

REFERENCES: Zaikov and others, 1981; Borisenko and others, 1984; Obolenskiy and others, 1999.

Khovuaksinsk Metallogenic Belt of Ni-Co Arsenide Vein Deposits (Belt KhA) (Tuva, Russia)

This Triassic metallogenic belt is related to veins that occur along the Ubsunur-Bayankol fault that cuts the Tuva molasse basin and Tannuola subterrane. The belt occurs in Central Tuva, trends northeast, is more than 180 km long, and ranges up to 20 km wide. The Ni-Co-arsenide deposits are controlled by intersections of the major Ubsunur-Bayankol fault and conjugated strike-slip and thrust faults. The two major districts are at Ulatai to the southwest and Khovuaksinsk to the northeast (Lebedev, 1998). Along with Ni-Co arsenide deposits (as at Hovu-Aksinskoye), numerous occurrences of Cu-Co sulfoarsenide deposits with ankerite, gersdorfite, and tennantite occur in the belt (as at Uzun-Oy and others) (Lebedev, 1967).

Hovu-Aksinskoye Ni-Co Arsenide Vein Deposit

This deposit (Smirnov, 1978; Borisenko and others, 1984; Lebedev, Cherezov, 1989; Lebedev, 1998) consists of carbonate veins with arsenide Ni-cobalt minerals. The host rocks are metasomatically altered and consist of Silurian limestone, Carbonaceous sandstone and siltstone, and Early Devonian porphyry and tuffaceous conglomerate that are intruded by Late Devonian to Early Carboniferous gabbro and syenite plutons. The host rocks are replaced by pyroxene-garnet, garnet-pyroxene-scapolite, and pyroxene-scapolite skarn. During alkaline metasomatism, skarn as transformed into prenite-orthoclase-albite rock. The arsenide Ni-cobalt deposits are displaced from skarn by diabase dikes and plagioclase porphyry intrusions, and by younger faults. Deposit veins range from tens of meters to 1 to 2 km long, are 30 to 40 cm thick, and extend to a depth of 300 m. Locally, 5 to 6 veins form deposit bunches. The veins consist of Co, Ni, and Fe-arsenides along with calcite and dolomite, and rare ankerite, barite, and quartz. Ore minerals are smaltite-chloantite, skutterudite, safflorite, rammelsbergite, gersdorfite, lollingite, native Bi and As, tennantite, chalcopyrite, bornite, pyrite; galena, sphalerite, argentite, and minor native silver. Wall rocks are altered to the following types of metasomatite: talc and chlorite; quartz, hydromica, and kaolinite; chlorite and calcite; and quartz and dolomite. The deposits age is interpreted as late Paleozoic and early Mesozoic. The deposit is medium size.

Uzun-Oy Ni-Co arsenide Vein Deposit

This deposit (Lebedev, 1967, 1971; Zaikov and others, 1981) consists of Cu-Co sulfoarsenide veins hosted in Silurian clastic and carbonate and Early Devonian volcanogenic rock that is intruded by mafic and intermediate dikes. Deposits occur along fractured zones and dike contacts. Deposit veins are typically lenticular, are associated with carbonate and kaolinizate alteration, and contain ore minerals in streaks and disseminations. Individual lenses are 30 to 160 m long and range from 5 cm to 1.7 m in thick. Ore minerals are tennantite, chalcopyrite, pyrite, marcasite, bornite, gersdorfite, and native Bi. Gangue minerals assemblages are quartz-calcite, quartz-ankerite, and quartz-barite. The deposit is small.

Origin and Tectonic Controls for Khovuaksinsk Metallogenic Belt

The belt is interpreted as forming during Mesozoic intraplate rifting that resulted in magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment (Distanov and Obolenskiy, 1994; Obolenskiy and others, 1999). The belt occurs along the northwestern boundary of the Tannuola and Ondum terranes that are composed of fragments of an early Paleozoic island arc system. Rift basins adjacent to faults contain Carboniferous through Jurassic coal molasse. The minor intrusions of gabbro, diabase, granophyre, and granosyenite-porphyry of the Early Carboniferous Torgalyk complex occur along the fault zones and are associated with skarn and metasomatite. Arsenide-carbonate veins formed after intrusion of microdiabase and diabase porphyry dikes that have a K-Ar isotopic age of 240 to 250 Ma (Lebedev, 1971). The K-Ar isotopic age of post-ore diabase and quartz-syenite porphyry dikes is 195±5 Ma (Lebedev, 1998). The deposit-controlling rift zone of the Ubsunur-Bayankol major fault occurs along a sharp gravitational gradient that extends to 8 to 30 km depth (Lebedev, 1998). Chloride solution derived from buried Devonian evaporite is interpreted as providing a significant role in deposit genesis (Borisenko and others, 1984; Lebedev, 1998).

REFERENCES: Borisenko and others, 1984; Distanov and Obolenskiy, 1994; Lebedev, 1998, 1967, 1971; Obolenskiy and others, 1999.

Ulug-Tanzek Metallogenic Belt of Ta-Nb-REE Alkaline Metasomatite Deposits (Belt UT) (Tuva, Russia)

This Late Triassic metallogenic belt is related to replacements in the Ulug-Tanzek granite intrusion (to small to show on 10 M map) that intrudes the Sangilen passive continental margin terrane. The belt occurs in the southeastern Tuva region in the northern Sangilen Ridge Mountains and occurs. The belt contains metasomatite deposits hosted in alkali granite plutons of the Mesozoic Ulug-Tanzek Complex that occurs along major shear zones that form during a post-collisional stage of Caledonian orogeny with subsequent multiple rifting and magmatism. Granite plutons in the Ulug-Tanzek occur in an en-echelon pattern and are spatially associated with Mesozoic lamprophyre dikes of the AGARDAG complex. The plutons have Ni, U, and Th geochemical halos. The metamorphic complex hosting the intrusives is related to the development of an early Paleozoic passive continental margin, and consists mainly of clastic and carbonate argillaceous schist derived from Vendian to Cambrian sedimentary rock (Distanov and Obolenskiy, 1994). The east-west-trending shear zone is 30 to km wide and 70 to km long and contains the Ulug-Tanzek pluton and subalkaline and alkaline granite plutons of the Ulug-Tanzek intrusive Complex. This complex consists of main phase subalkaline biotite granite, quartz syenite, granosyenite, and alkaline granite, and younger felsite and quartz porphyry with anomalous Li, F, Zr, and REE, similar to ongonite (Matrosov and Shaposhnikov, 1988). The Ulug-Tanzek Ta-Nb-REE deposit is a unique resource containing Ta, Ni, Zr, Hf, Th along with Li, REE, U deposits (Holl and others, 2000).

Ulug-Tanzek Ta-Nb-REE Alkaline Metasomatite Deposit

This deposit (Grechishchev and others, 1997) is hosted in the Ulug-Tanzek pluton composed of main phase of subalkaline biotite granite, quartz syenite, granosyenite, and alkaline granite, and younger felsite and quartz porphyry with anomalous Li, F, Zr, and REE. Quartz-albite-microcline metasomatite with uniform low-grade REE replaces mainly the main phase. The pluton forms an inclined lenticular body that is enclosed by marble that dips moderately the southwest. The pluton is 1900 m long, ranges from 100 to 900 m wide, and extends to a depth of 700 m with no sign of wedging out. The deposit consists of fine-and medium-grained quartz-albite-microcline metasomatite. The major rock-forming minerals are albite, microcline, and quartz with minor mica and dark minerals. Aluminofluorides (cryolite, thomsenolite, gearksutite) form up to 10% the metasomatite with an average of 2 to 3%. Tantalum-niobate (columbite and lesser pyrochlore), zircon, thorite are widespread. Columbite and zircon are economically important. REE-minerals, including gagarinite, yttrofluorite, monazite, bastnaesite, and xenotime are limited and less important. The hsot pluton is zoned. Relatively rich ores occurs in columns, lenses, and half-ring bodies in plan view and extend to a depth of several hundred meters. The deposit is large.

Origin and Tectonic Controls for Ulyg-Tanzek Metallogenic Belt

The belt is interpreted as forming during intraplate tectonism and magmatism in an intraplate rift setting. Belt hosted in alkali granite plutons in the Ulug-Tanzek intrusive complex. The belt is characterized by magmatic rocks related to transform micro plate boundaries and within plate (plume) environment. The origin of the metallogenic belt is related to long evolution of the Tuva-Mongolian microcontinent (Sengilen passive continental margin terrane) that was rifted in the late Paleozoic and early Mesozoic. These host rocks were intensely regionally metamorphosed up to amphibolite facies during collision with redistribution of trace elements into granitoids in the Bren intrusive complex (with isotopic ages of 231 to 228 Ma) and the younger Ulug-Tanzek intrusive complex (with isotopic ages of 217 Ma). Subsequently during Mesozoic (up to 209 Ma) rifting and magmatism, the Ta-Nb-REE alkaline metasomatite deposits formed along knots at intersections of the major long-lived faults during volatile migration with multistage development of concentric zones of metasomatite. Sequential alteration to microcline, albite, and silica gradually formed the deposits in the older granitoid. (Grechishchev and others, 1997).

REFERENCES: Matrosov, Shaposhnikov, 1988; Distanov and Obolenskiy, 1994; Grechishchev and others, 1997; Holl and others, 2000.

North Hentii Metallogenic Belt of Granitoid-Related Au Vein and Au in Shear Zone and Quartz Vein Deposits (Belt NH) (North Mongolia)

This Middle Triassic to Middle Jurassic metallogenic belt is related to granitoids related in the Mongol-Transbaikalia volcanic-plutonic belt intrudes and overlaps Zag-Haraa turbidite basin. The granitoids that host granitoid-related Au deposits consist of small intrusive stocks and dikes and are part of the Yoroogol gabbro and granite sequence (Koval and Tsypukov, 1977; Koval and others, 1982) that consists of small hypabyssal stocks and dikes in the margin of a calc-alkaline granitoid baholith in northeast-striking zone bounded by the Bayangol fault to the northwest, and the Yoroogol fault to the southeast. These early Mesozoic intrusive stocks consist of simple gabbro, and (or) multiphase plutons composed of gabbro, diorite, and granite, and single granite plutons with abundant gabbro schlieren. The Au deposits occur in the first three types and Sn deposits occur in simple granite stocks (Tsypukov, 1977). The Yorogol sequence contains abundant variable composition dikes and hydrothermal-metasomatitic alterations. The K-Ar isotopic age of the Yoroogol sequence ranges from 166 Ma to 235 Ma (Koval and others, 1982). REE granite in the Yorogol sequence is mostly Jurassic.

The north and northwestern marginal part of the Central Hentei REE belt of Sn and Sn-W greisen, stockwork, and quartz vein deposits, described below, is overprinted on the eastern and southeastern margin of North Hentii 2 metallogenic belt. This North Hentii metallogenic belt was previously defined as a multiple age Au metallogenic belt containing early Paleozoic and early Mesozoic age hard rock Au, Late Cretaceous Au-bearing conglomerate, and placer Au deposits and occurrences (Blagonaravov and Shabalovskii, 1977; Blagonravov and Tsypukov, 1977; Poznyak and Dejidmaa, 1977; Blagonravov and others, 1984; Tcherbakov and Dejidmaa, 1984).

From northeast to southwest, the granitoid-related Au vein deposits and occurrences are at Yorogol, Boroo-Zuunmod and Zaamar-Ugtaaltsaidam (Dejidmaa, 1996). Only early Mesozoic granitoid-related Au deposits occur in the Boroo-Zuunmod district, Yorogol district, in the Ugtaaltsaidam-Argalynnuruu group in the Zaamar-Ugtaaltsaidam district, and in the Zaamar group of the Zaamar-Ugtaaltsaidam district. Also occurring are a few early Mesozoic Au quartz deposits or disseminated Au-sulfide and quartz vein deposits that are hosted in a metasomatitic zone (Dejidmaa, 1985). The Narantolgoi, Boroo 7, Tsagaanchuluut, Ereen, Urt and Baabgait deposits in Boroo-Zuunmod district, are typical Au quartz vein deposits. The Boroo and Sujigt deposits contain both large disseminated Au-sulfide deposits and high-grade Au-quartz veins. These deposits are hosted in early Paleozoic clastic rock, Devonian granite, Late Devonian to early Carboniferous subvolcanic rhyolite, and early Mesozoic granodiorite. The Au deposits in the North Khenti belt are interpreted as forming during multistage hydrothermal activity related to multistage dikes. For example, gabbro and diabase dikes formed before the deposits, while diorite dikes intruded between the early disseminated Au-pyrite-arsenopyrite and the middle disseminated Au-pyrite-beresite stages of mineralization in the large Boroo deposit (Dejidmaa, 1985).

Boroo Granitoid-Related Au Vein Deposit

This deposit (R. Barsbold and others, written commun.,1960; R. Khenel and others, written commun., 1968, 1970 , G. Choren and others, written commun., 1986, 1988) occurs along a major sub-latitudinal fault zone that dips gently north and cuts sedimentary rock in the early Paleozoic Khara Group the early Paleozoic Borogol granitoid complex. These rocks are intruded by early Mesozoic gabbro, diabase, and diorite dikes that are altered and host the deposit. The deposit extends approximately 2.0 km along strike and ranges from 3-5-34 m thick. The ore mineral assemblages, from older to younger, are: pre-ore epidote-chlorite; quartz-sericite-albite-chlorite; gold-pyrite-arsenopyrite-K-feldspar-quartz; gold-beresite; quartz; gold-sulphide-quartz vein; and post ore calcite. Gold is fine-grained and occurs in pyrite and arsenopyrite, and as free gold in quartz veins. Fineness of gold varies from 700 to 940. Main ore minerals are pyrite, arsenopyrite, sphalerite, chalcopyrite, galena, tetrahedrite, and gold. Main gangue minerals are quartz, sericite, iron-carbonates, calcite, albite and muscovite. Sulphides comprise 5-25% in replacements and 1-2% in quartz veins. The average grade 3.0 g/t Au in replacement zone and 10-20 g/t Au in quartz veins in the replacement zone. Mined by openpit and underground workings from 1948-1955. Reserves of 40.0 tonnes grading 3.0 g/t Au.

Sujigt Granitoid-Related Au Vein Deposit

This deposit (R. Kruse and others, written commun., 1970; Jargalsaihan and others, 1996) consists of quartz veins and stockwork that occurs along a northeast-striking minor fault altered zone that cuts early Paleozoic granite and granodiorite of the Boroogol Complex. The fault zone is a part of the Sujigtgol regional fault and occurs between a middle Paleozoic rhyolite sub-volcanic body and early Paleozoic granodiorite-granite massif. The deposit includes five main quartz veins that range from 110 to 250 m long, 0.27-0.48 m wide, and dip southeast to northeast. Grades range from 10-25 g/t Au. A lower grade stockwork occurs between the veins. Primary ore minerals are pyrite, arsenopyrite, chalcopyrite, sphalerite, galena, tetrahedrite, burnonite, altite, and gold. Ore minerals in oxidized zone are limonite, covellite, chalcocite, malachite, azurite, and cerussite. Sulphides comprise from 2% to 10% veins. Deposit extends to 275 m below surface with downward decrease in Au grade and thickness of the Main vein. The deposit deposit was discovered by Mongolor joint venture in 1913 and mined from 1914-1914. The deposit is medium size with resources of 2918.2 kg Au, and 975.1 kg Ag.

Origin and Tectonic Controls for North Hentii Metallogenic Belt

The belt is interpreted as forming during granitoid intrusion related to the extensional margin of the Khentii collisional uplift. The metallogenic belt is overprinted on the Orodovician Zaamar-Bugant Au quartz vein belt. The granitoid-related Au vein deposits of the North Hentii belt are clearly distinguished by intrusives, mineralogy, and deposit morphology.

REFERENCES: Gottesman, 1978; Blagonravov and others, 1984; Tcherbakov and Dejidmaa, 1984; Dejidmaa, 1985.

Central Hentii Metalogenic Belt of Sn-W Greisen, Stockwork, and Quartz Vein, REE-Li Pegmatite, Ta-Li Ongonite, Ta-Nb-REE Alkaline Metasomatite, Peralkaline Granitoid-Related Nb-Zr-REE, W-Mo-Be Greisen, Stockwork, and Quartz Vein, and W±Mo±Be Skarn Deposits (Belt CHE) (Mongolia)

This Late Triassic to Early Jurassic metallogenic belt is related to replacements and granitoids in the Mongol-Transbaikal volcanic-plutonic belt that intrudes and overlaps Hangay-Dauria terrane and adjacent units. The Sn-W deposits and occurrences are hosted in a Late Triassic and Early Jurassic granodiorite and granite belt that forms the Hentii megadome that is 600 km long, and ranges up to 200 to 220 km wide, and trends northeast. This dome is the Mongolian part of the Hentii-Daurian megadome that has been uplifted from the early Mesozoic to the Recent. The Hentii megadome contains Devonian and Carboniferous turbidite intruded by Paleozoic and Mesozoic granitoids. The major deposits are at Modot, Tsagaan dabaa, Gorkhi, Zuunbayan, Janchivlan, and Avdrant.

Various Sn-W greisen, stockwork, and quartz vein deposits, at at Tsagaan Davaa, Modot, and Janchivlan, occur mainly in the upper part of evolved granite and rarely in host rocks. The host granite has a K-Ar age of 190.49±4.7 Ma and a Rb-Sr age of 188 to 225, and consist of three types: (1) coarse-grained porphyritic biotite granite and rare amphibole-biotite granite, (2) medium-grained two-mica granite, and (3) K-feldspar biotite granite (alaskite) and Li-F granite including microcline-albite, amazonite-albite, lepidolite-albite granite. Many granites are S-type granite higher alkalinity than typical. Li-F granite is A2 type (after Eby, 1992) and formed in post-collisional setting (Gerel, 1995; Gerel and others, 1999). First granite type contains many unique miarolic pegmatites (as at Gorkhi, Zuunbayan, and Janchivlan) with piezoelectrical quartz. The second granite type contains W-Sn veins (as at Modot, Bayan Mod, and Khujihan) and rare scheelite skarn. The third granite type contains Ta-bearing granite deposits (as at Urt Gozgor, Buural Khangai, Borkhujir), and W-Sn vein and Be greisen deposits (as at Tsagaan Davaa). Numerous Sn placers, including the very large Tsenkher Mandal Sn placer deposit occurs nearby. Greisen bears biotite and contains topaz-quartz, tourmaline-quartz, and muscovite-quartz zones.

Modot Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Khasin, 1977; Jargalsaihan and others, 1996) consists of Sn-W quartz veins related to Mesozoic granite pluton with a K-Ar isotopic age of 175-199 Ma. The pluton intrudes Vendian and Early Cambrian metamorphic rock, Paleozoic granitoids and Permian molasse. The deposit occurs along the pluton margin in the pluton or in adjacent hornfels. The veins dip gently and strike northwest to north. Some veins dip steeply. The ore minerals are cassiterite, wolframite, arsenopyrite, pyrite, galena, sphalerite, and chalcopyrite. Greisen alteration occurs. The deposit is small and has produced 300 tonnes WO_3. Deposit

Tsagaan dabaa W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Khasin, 1977; Jargalsaihan and others, 1996) consists of quartz-wolframite veins and zones that occur in a multistage Late Triassic-Early Jurassic granite pluton. Veins mainly occur in the central elevated part of pluton that consists of fine- to medium-grained biotite and leucocratic granite. The veins are 2 km long, 200-500 m wide, occur at different hypsometric levels. The veins form are subhorizontal bodies dip gently south, southeast, and southwest, parallel with pluton roof. Ore minerals are wolframite, cassiterite, molybdenite, and beryl, and rare chalcopyrite and pyrite. Gangue minerals are garnet, fluorite, and biotite. Associated greisen and silica alteration is common. Assemblage of biotite and fluorite is characteristic of the deposit. The deposit is medium size with resource of 3,497 tonnes. Grade ranges from 0.1-12.6% WO_3.

Janchivlan Ta-Nb-REE Alkaline Metasomatite Deposit

This deposit (Kovalenko and others, 1971; Janchivlan, 1984; Ivanov and others, 1996) is hosted in albite-lepidolite and amazonite-albite granite that occurs along the southwest contact of Mesozoic Janchivlan pluton that occurs along the northwest trending Ulaandavaa fault. Associated with the granite and deposit are microcline alteration, quartz-lepidolite greisen, albite metasomatite, and quartz-muscovite greisen, and quartz veins. Granites are composed of albite, quartz, lepidolite, amazonite and microcline, and topaz. Accessory minerals are fluorite, columbite, monazite, Pb-pyrochlore, zircon, and cassiterite. Grade from surface to depth of 100 m is 60 g/t Ta (Ta/Nb= 1.2), 600 g/t Li, 800 g/t Rb, and 50 g/t Sn. Average grade is 0.001 -0.011% Ta.

Avdrant Peralkaline Peralkaline Granitoid-Related Nb-Zr-REE Deposit

This deposit (Kovalenko and others, 1971) is hosted in an albite-amazonite granite that occurs in the upper part of a Mesozoic granite pluton with a K-Ar isotopic age of 222-172 Ma, and in dikes in acjadent host rock. The albite-amazonite granite occurs in a rim of alaskiteor in the core of the pluton, is medium-grained, and composed of amazonite, albite, quartz and zinnwaldite. The amazonite-albite granite contains 330-1400 g/t Li, 6-75 g/t Ta, and 76-350 g/t Nb. Average grade is 0.007% Ta and 0.008% Nb.

Origin and Tectonic Controls for Central Hentii Metallogenic Belt

The Sn-W greisen, stockwork, and quartz vein in the belt are interpreted as forming during generation of collisional granitoids of the Mongol-Transbaikal volcanic-plutonic belt during closure of the Mongol-Okhotsk Ocean (Zonenshain and others; 1976; Kovalenko and others; 1995; Koval, 1998). The REE deposits are related to small plutons that are interpreted as forming during a continental post-collisional event. The margins of this metallogenic belt are northeast-trending faults that may also be favorable for epithermal Au deposits and intrusion-related sedimentary-hosted deposits (Gerel and others, 1999, Cluer and others, 2000).

REFERENCES: Gerel, 1995, 1998; Koval, 1998; Gerel and others, 1999; Gerel and others, 1999; Cluer and others, 2000; Tomurtogoo, 2001.

Delgerhaan Metallogenic Belt of Porphyry Cu (±Au) (Au, Ag) and Granitoid-Related Au Vein Deposits (Belt DE) (Central Mongolia)

This Late Triassic metallogenic belt is related to granitoids in the Mongol-Transbaikalia volcanic-plutonic belt that intrudes Hangay-Dauria terrane, Ononsky terrane, and Gobi-Khankaisk-Daxinganling volcanic-plutonic belt. $^{40}Ar/^{39}Ar$ isochron ages for two samples of plagioclase-biotite porphyry, and and for one sample of biotite granodiorite from Bayan Uul ore-field,are 220 to 223 Ma (Lamb and Cox (1998). The major deposits are the Bayan Uul district with porphyry Cu (±Au) vein and Au-Ag-Cu and and explosive pipe occurrences; Unegt district with Au-Ag-Cu vein and Cu vein and explosive pipe occurrences. Porphyry Cu (±Au), granitoid-related Au and Cu occurrences occur at the junction of the Ovorhangai, Tov and Dundgovi provinces. The main deposit is at Bayan uul 2.

Bayan Uul District

This district (Koval and others, 1989, Ariunbileg and Hosbayar, 1998; G.A. Dolgov written commun., 1984) occurs in the southeastern Delgerhaan area, and is related to tourmaline explosive breccia and subvolcanic granodiorite porphyry, granite porphyry, and syenite porphyry stocks and dikes that occur along a ring structure with dimensions of 2 by 2 km. The ring structure is surrounded by a caldera in which is intensely developed advanced argillic and quartz-sericitic metasomatite with extensive pyrite. Cu deposits extend 150 m downdip in explosive breccia. Cu grade is not high on the surface. Average Cu grade is 0.2% for a width of 600 m and includes 8 to 10 linear zones with a total thickness of 100 to 120 m. The ratio of Cu:Mo is 16:1. Au and Ag deposits occur mostly in the marginof the district. Au grade ranges uo to to 2 g/t with an average if 0.2 g/t for a thickness of 47.5 m in a drill hole. Ag grade ranges from 4.3 g/t for a thickness 15.6 m, to 15 g/t for a thickness 1.0 m. Au grade ranges up to 10 g/t in tourmaline-pyrite veins and breccia. Some tourmaline explosive breccia pipes in margin of the Delgerhaan district contains Cu high grade. The Unegt district occurs north-northwest of the Bayan Uul district and contains Au-bearing pyrite-quartz-tourmaline, pyrite-magnetite-hematite-quartz-tourmaline veins and breccia, and also Cu-bearing tourmaline explosive breccia.

Bayan Uul 2 Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (G.A. Dolgov written commun., 1984; Koval and others, 1989, Ariunbileg and Hosbayar, 1998) consists of quartz-tourmaline-chalcopyrite veins in an area of pervasive sericite and argillic alteration. The deposit is hosted in an early Mesozoic volcanic-plutonic system that includes small porphyritic intrusions of diorite to granite. Alteration zone is nearly oval, is 3 km wide and extends northeast for 5 km. Major ore minerals are pyrite, chalcopyrite, bornite and peripheral sphalerite, galena, and Ag minerals. The deposit consists of stockwork veinlets and veins of quartz, pyrite, chalcopyrite, and molybdenite that occur in or near porphyritic intrusions. The veins contain mainly quartz and carbonate minerals. High-level intrusive porphyry is contemporaneous with abundant dikes, faults, and breccia pipes. Hydrothermal alteration zonation is centered on porphyry intrusion. Central part of alteration zone consists of K-feldspar and biotite alteration and is surrounded by phylitic, and peripheral propylitic alteration zones. Deposit at the surface contains > 0.1 wt% Cu, >0.002 wt% Mo, and >0.1 ppm Au over an area of 0.6k by 2.3 km. A zone 300 by 900 m contains >0.3 wt% Cu, 0.005 wt% Mo. Deposit occur in center of biotite and potassic alteration. Grades correlate positively with quartz veinlet intensity. In the southeastern area, a 40 m thick leached cap occurs with As, Sb, Bi, Pb minerals and minor secondary Cu. The dominance of sericite and advanced argillic and silica alterations and at the surface suggests a relatively shallow porphyry Cu system. The deposit contains contact zone reserves of 300,000 tonnes Cu.

Origin and Tectonic Controls for Delgerhaan Metallogenic Belt

The belt is interpreted as as forming during emplacement of a volcanic-plutonic complex along an extensional margin related to collisonaland uplift. Time of origin of the Bayan Uul ore-field, is similar to origin time of the Erdenetiin Ovoo ore-field located in the Orhon-Selenge metallogenic belt. The Delgerhaan metallogenic belt may be a direct continuation of the Orhon-Selenge metallogenic belt. The Oyuthonhor porphyry Cu-Mo (±Au, Ag) occurrence and the Out Ovoo Cu tourmaline breccia occurrences are hosted in the Avzaga Basin that contains Middle and Late Triassic rock, and Late Triassic to Early Jurassic trachyandesite.

REFERENCES: Yakovlev, 1977; Gerel and others, 1984; Dolgov and others, 1984; Sotnikov and others, 1984, 1985; Koval and Gerel, 1986; Gerel, 1990; Lamb and Cox, 1998.

Govi-Ugtaal-Baruun-Urt Metallogenic Belt of Fe-Zn Skarn, Cu-Zn-Pb (±Ag, Cu) Skarn, Zn-Pb (±Ag, Cu) Skarn, Sn Skarn, Fe Skarn, and Porphyry Mo Deposits (Belt GB) (Central and Eastern Mongolia)

This Late Triassic to Early Jurassic metallogenic belt is related to replacements in the Mongol-Transbaikalia volcanic-plutonic belt that intrudes and overlies Idermeg terane and Gobi-Khankaisk-Daxinganling volcanic-plutonic belt. The major deposits are the Tomortiin Ovoo Fe-Zn skarn deposit, and the Oortsog Sn skarn deposit.

The two major Govi-Ugtaal-Bayanjargalan and Salhit districts are at the southwestern and northeastern ends of the belt, respectively. A few Fe skarn deposits and occurrences are between these two major districts in Borondor area. Major three types of skarn occur: Fe skarn at Mandalyn Hiid, Sainshand hudag,l Fe-Zn skarn at Tomortei; and Fe-Sn skarn at Oortsog in the Goviugtaal-Bayanjargalan district. These skarns are closely related to Late Triassic and Early Jurassic alkaline alaskite and granite stocks (Dorjgotov, 1996). Fe skarn consists mostly of pyroxene, phlogopite, garnet, magnetite, and hematite, and Fe-Zn skarn consists mostly of andradite, pyroxene, epidote, quartz, magnetite, sphalerite, galena, and pyrite. Fe-Sn skarn consists mostly of pyroxene, andradite, vesuvianite, actinolite, epidote, magnetite, molybdenite, and cassiterite. Hematite, sphalerite, molybdenite, and pyrite occur in all three types, but in varying amounts. Fe skarn and Fe-Zn skarn occur mostly in the Salhit district near Baruunurt city. Salhit and Tomortein Ovoo deposits are Fe-Zn skarn deposits, hoswever, sphalerite is dominate. The deposits are hosted in Devonian carbonate and sedimentary rock along the contact of subalkaline biotitic granite (Podlessky and others, 1988). Ore assemblages are: magnetitic-hematite, sphalerite-magnetite, and sphalerite. Sphalerite is major ore mineral in magnetite-sphalerite and sphalerite skarn, and ranges from 45 to 90%. Other sulfides are minor molybdenite, chalcopyrite, and pyritec and galena, and compriseless than 5 to 10% ore. Above mentioned three skarns are overprinted on clinopyroxene, clinopyroxene-garnet, and garnet skarn (Podlessky and others, 1988).

Tumurtiin-Ovoo Fe-Zn Skarn Deposit

This deposit (Yakovlev, 1977; Podlessky and others, 1988; D. Dorjgotov, written commun., 1990) consists of a calcic skarn that occurs along the contact between Devonian limestone and a Mesozoic subalkaline granite. The skarn is elongated to the northwest, dips concordantly with host rock to the southwest. The skarn extends for about 800m along strike, 480 m downdip in the central part, and 200-230m downdip on the eastern and western flanks. Average thickness is 14 m. The major minerals are andradite, hedenbergite, grossular, epidote, quartz, and wollastonite. The deposit is zoned and the major ore minerals are sphalerite and magnetite. The deposit is large with resources of 750,000 tonnes Zn, 1770 tonnes Cd. Average grade is 17% Fe, 9.9-13.1% Zn.

Oortsog ovoo Sn Skarn Deposit

This deposit (Podlessky and others, 1988, Jargalsaihan and others, 1996) consists of a steeply dipping skarn that forms sheets like along the contact between a late Paleozoic granite pluton and marble with beds of calc-silicate schist. The skarn sheets range from 200-1500 m long, 5-80 m wide, comprise up to 25 lenticular bodies composed of garnet, pyroxene, and magnetite, and Sn and base metal minerals. Three stages are: an early stage of pyroxene-garnet and magnetite; cassiterite, stannite, lollingite, Zn sulfide, Pb sulfide, Cu sulfide, and Fe sulfide, and less common fahlore, enargite, bismuthite, and scheelite. Also occurring are hypergene cerussite, smithsonite, anglesite, greenockite, martite, montmorillonite, kaolinite, and gypsum. Grades are 0.02-1.28% Sn, 0.001-0.06% W, 0.02-1.28% Zn, and 0.01-0.9% Cu. Reserves are 39,200 tonnes Sn, 11,500 tonnes Zn, and 1.500 tonnes Cu.

Origin and Tectonic Controls for Govi-Ugtaal-Baruun-Urt Metallogenic Belt

The belt is interpreted as forming during early Mesozoic granitoid magmatism associated with North Govi continental margin arc. The belt is hosted in Late Triassic to Early Jurassic age alaskite, granite, and alkaline granite of the Mongol-Transbaikalia volcanic-plutonic belt. Deposits ae hosed in an alaskite granite and alkaline granite plutons (Dorjgotov, 1996).

REFERENCES: Fillippova and Wydrin, 1977; Batjargal and others, 1997; Yakovlev, 1977; Podlessky and others, 1988; Tomurtogoo and others, 1999.

Nuhetdavaa Metallogenic Belt of W-Mo-Be Greisen, Stockwork, and Quartz Vein, Ta-Li Ongonite, and Polymetallic Pb-Zn±Cu (±Ag, Au) Vein and Stockwork Deposits (Belt ND) (Southern Mongolia)

This Late Triassic to Early Jurassic metallogenic belt is related to replacements and granitoids in the Mongol-Transbaikalia volcanic-plutonic belt that intrudes and overlies the Dongujimqin-Nuhetdavaa terrane and the Hailar-Tamsag sedimentary basin. The metallogenic belt occurs in the Nukhetdavaa uplift, extends along the southeast Mongolian border for more than 170 km, and ranges up to 30 to 40 km wide. The belt was first described as the East Mongolian REE belt (Kovalenko and others, 1986). The deposits are related to Late Triassic and Early Jurassic granite-leucogranite intrusions of Yugzer complex with a K-Ar isotopic age of 210 to 220 Ma (Marinov and others, 1977). The major deposits are the Yugzer wolframite-quartz and wolframite-molybdenite-beryl-quartz vein and greisen deposit, the Nomorgiin gol W vein and Ta granite occurrence, and the Modon ovoo Pb-Zn-Sn occurrence (Marinov and others, 1977). Mesozoic structures and magmatism are superimposed on the Gobi Tengeruul-Nukhetdavaa passive continental margin terrane that consists of a Paleoproterozoic metamorphic complex, Riphean metamorphosed carbonate and sandy-shale, Vendian and Early Cambrian carbonate and clastic complexes (Tomurtogoo, 2001), The early Mesozoic host intrusions are shallow, the largest ranges up to 260 to 300 km^2, and is composed mainly of biotite granite and Li-F leucogranite. The major deposit is Yugzer.

Yugzer W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Khasin, 1977; Jargalsaihan and others, 1996) occurs in the upper part of granite pluton and adjacent early Paleozoic rocks. The deposit consists of Mo bearing greisen that occurs in the upper part of the granite pluton, and quartz-wolframite veins. The greisens are formed in two successive stages: (1) quartz, muscovite, beryl, wolframite, fluorite, molybdenite, pyrite, arsenopyrite, quartz, chlorite, galena, sphalerite, molybdenite, and pyrite (2) W-Mo veins. Veins occur parrallel to cleavage in hornfels. The deposit covers 1 km^2 and contains up to 30 veins that range from 70-80 km long and 0.15-0.20 m wide. Veins also occur in granite porphyry. Ore minerals are quartz, beryl, mica, fluorite, carbonate, wolframite, molybdenite, pyrite, and chalcopyrite, and rare galena, sphalerite, and Bi-minerals. The three types of W-Mo veins are: quartz-beryl-wolframite; quartz-wolframite-sulfide; and quartz-molybdenite. The dominant alteration minerals are quartz and muscovite. The deposit is medium size with resources of 1800 tonnes WO_3 at Yugzer 1, and resources of 20,428 tonnes WO_3, and 693 tonnes Mo, and 4,100 tonnes BeO at. Yugzer 2.

Origin and Tectonic Controls for Nuhetdavaa Metallogenic Belt

The belt is interpreted as forming during interplate granite magmatism associated with late Paleozoic or early Mesozoic collisional or immediately after collisional. Because the age of host intrusions varies from late Paleozoic to early Mesozoic, the age of the belt is not clear. During the Paleozoic, various magmatic arcs and continental blocks accreted in southern Mongolia (Ruzhentsev and Pospelov, 1982; Sengor and Natal'in, 1996; Zorin and others, 1994; Badarch and Orolmaa, 1999). In the Permian, a complicated collage of tectonic units formed in Central Asia along a transform continental margin that included collision, shortening, and strike-slip faulting (Sengor and Natal'in, 1996). The age of metallogenic belt and related tectonic origin is not clear.

REFERENCES: Marinov and others, 1977; Kovalenko and others., 1986; Ruzhentsev and Pospelov, 1982; Kovalenko and Yarmolyuk, 1995; Sengor and Natal'in, 1996; Badarch and Orolmaa D., 1999; Tomurtogoo, 2001.

Harmorit-Hanbogd-Lugiingol Metallogenic Belt of Sn-W Greisen, Stockwork, and Quartz Vein, REE (±Ta, Nb, Fe) Carbonatite, Peralkaline Granitoid-related Nb-Zr-REE, and REE-Li Pegmatite Deposits (Belt HL) (Mongolia)

This Middle Triassic to Early Jurassic metallogenic belt is related to replacements and granitoids in the South Mongolian volcanic-plutonic belt that intrudes and overlaps the Hutaguul-Xilinhot and Gurvansayhan terranes and Lugyngol overlap volcanic and sedimentary basin. The carbonatite related REE deposit at Lugiin gol, the REE –Nb-Zr alkaline granite and pegmatite deposit at Khanbogd, and Sn-occurrences at Kharmorit are related to high alkaline potassic granitoid and Li-F facies leucogranite. The deposits are related to the Khalzan uul Complex with a Rb-Sr isotoic age of 194±9.06. The major deposits are at Khar morit, Lugiin gol, and Khanbogd. Also occurring are associated Sn placer deposits.

Lugiin Gol REE (±Ta, Nb, Fe) Carbonatite Deposit

This deposit (Jargalsaihan and others, 1996; Batbold, 1998) consists of bastneasite carbonatite dikes that occur mainly along the contact zone of the Lugingol alkaline nepheline syenite pluton that intrudes Permian sedimentary rock of the Lugin gol Formation (Batbold, 1997). For the Lugiin gol nepheline syenite pluton a Rb-Sr whole rock isochron age is 244±22.4 Ma and a Rb-Sr whole rock-mineral isochron ages are 222±3.2 and 180 to 199 Ma (Kovalenko and others, 1974; Munkhtsengel, Iizumi, 1999). K-Ar isotopic ages range from 228 to 242 Ma (JICA and MMAJ, 1992). A linear to oval eruptive breccia, cemented by carbonatite, crops out in the western part of the pluton. Carbonatite veins occur in the pluton, host rock, and along the contact. Pluton is altered fluorite, feldspar, sericite, hematite, and Fe sulfides. The veins trend north or east, range up to 430 m long and 0.1 to 0.8 m thick. Synchysite is predominant ore mineral and gangue minerals are fluorite and calcite. The deposit is small with reserves of 14,000 tonnes grading 0.5-3.5% TR_2O_3, 50.7% Ce, 33.0% La, 5.0% Nd, 2.85% Sr, 1-5% Ba, 0.03-0.3 Y, and 5-20% CaF_2.

Khan Bogd Ta-Nb-REE Alkaline Metasomatite Deposit

This deposit (Vladykin and others, 1981; 1988; Jargalsaihan and others, 1996) is hosted in an alkaline granite pluton composed of medium-grained arfvedsonite-aegirine granites with dikes of eckerites, pantellerites, grorudits, and alkaline pegmatite with REE. Pegmatite is composed of microcline, quartz, arfvedsonite, and elpidite, and local aegirine. Metasomatic zone contain aegirine and elpidite. The uppermost part of the pluton contains elpidite and Ti-silicate, and accessory polilitionite, synchisite, monazite, sphene, and other REE minerals. Grades range up to 2-3%, REE, up to 1% Nb, up to 0.07% Th, and up to 7-8% Zr. REE are concentrated in synchizite, monazite, and sphene. Zr is concentrated in elpidite and armstrongite. Average grades are 620 g/t Nb_2O_3, 0.8% TR_2O_3, and 0.04% Hf.

Khar morit Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Amory and others, 1994; Batbold, 1997) consists of zones of greisen and veins in the apical part of a Li-F granite porphyry stock and in adjacent host rocks. The granite has a Rb-Sr isochron age of 194± 9.06 Ma. The zones extend from 100 to 500 m long and up to 3 m wide. The deposit has two parts: cassiterite-wolframite-quartz vein; and cassiterite-wolframite-zinwaldite-quartz greisen; and (2) cassiterite-sulfide with Sn, Cu, Pb, and Zn. The ore minerals are cassiterite, pyrite, arsenopyrite, galena, sphalerite, and chalcopyrite, and rare scheelite and wolframite. Gangue minerals are quartz, muscovite, zinnwaldite, beryl, tourmaline, sericite, and chlorite. Most common are topaz and fluorite. A well developed oxidized zone contains relics of sulfides and secondary minerals. Sn is very irrregular and sometimes very high. The deposit exhibits a complex mineralization, include Sn-sulfide, Zn-Pb and Be, Sn-W greisen, and Sn-W vein stages. The various stages are zoned and occur in the altered cupola of the stock with wolframite andcassiterite, in the contact hornfels with cassiteriteand sulfides, and cassiterite in host sandstone and shale. Associated Sn placer deposits also occur. The deposit is small with resources of 780 tonnes Sn and 65 tonnes WO_3.

Origin and Tectonic Controls for Harmorit-Hanbogd-Lugiingol Metallogenic Belt

The belt is interpreted as forming during late Paleozoic and early Mesozoic continental rifting along a passive continental margin with generation of calc-alkaline and alkaline granitoids.

REFERENCES: Kovalenko and others, 1974; Koval and others, 1982; Ruzhentsev and Pospelov, 1992; Zorin and others, 1993; Amory and others, 1994; Batbold, 1997; Munkhtsengel and Iizumi, 1999.

Wulashan-Zhangbei Metallogenic Belt of Alkaline Complex Hosted Au, Au Potassium Metasomatite, and Granitoid-Related Au Vein Deposits (Belt WZh) (North-Central China)

This Middle Jurassic metallogenic belt is related to granitoids in the Alashan-Yinshan Triassic plutonic belt (too small to show at 10 M scale) that intrudes the Sino-Korean Craton, the Erduosi and Solon terranes, and adjacent units. The belt extends from the Wulashan Mountain of the western Inner Mongolia to the Zhangbei area in the Northwest Hebei Province. The belt is related to a Late Triassic to Early Jurassic alkaline complex and alkaline to subalkaline granite. The belt trends east-west, is about 600 km long, and ranges from 20 to 50 km wide. The discontinuous plutons related to Au deposits form a belt that is 40 to 50 km long and ranges up to 5 to 8 km wide. The significant deposits are at Dongping and Hadamen.

Dongping Alkaline Complex Hosted Au Deposit

This deposit (Song Guorui and Zhao Zhenhua, 1996), that was discovered in 1985 and was explored as a large Au deposit in 1992, consists of several tens of clusters of veins that trend northeast to north to northwest. Each vein cluster contains numerous parallel and oblique veins. The main deposit varies from a Au-pyrite-quartz vein to Au-sulphide-quartz vein to Au sulphides in veinlets-stockworks altered rock. Most of the numerous parts of the deposit are 1 to 4 m thick, 200 to 500 m long, and 200 to 500 m downdip. Sulphides comprise mostly less than 3% and consist mainly of pyrite, and lesser chalcopyrite, galena, and sphalerite. Gold occurs mainly as native Au, and to a lesser amount in calaverite. Gangue minerals are mainly quartz and K-feldspar. Alteration consists of K-feldspar, silica, sericite, and carbonate. The deposit and alteration is strongly controlled by faults and related fissures. The host rock is the Shuiquan alkaline complex that is 5 to 8 km wide, 55 km long, and trends east-west, and intrudes Archean granulite facies metamorphic rock. The intrusion exhibits a strong petrologic zoning. The main rock types are alkali feldspar syenite, quartz-alkali feldspar syenite, pyroxene-amphibole-alkali feldspar syenite, pyroxene syenite, and amphibole monozite. The $^{40}Ar/^{39}Ar$ isotopic ages are 327.4±9 Ma and 157 to 177 Ma for the intrusion and K-feldspar in the deposit, respectively. The deposit is controlled by the east-west striking major Chicheng-Chengde fault at the northern margin of the Sino-Korean Craton. Numerous similar deposits in the area are also related to alkaline intrusions. The deposit is large with reserves of 16.06 tonnes Au grading 5-20 g/t Au.

Hadamen Au Potassium Metasomatite Deposit

This deposit (Zhoukun, 1995) occurs in veins the middle and upper Archean Wulashan Group, mainly in garnet gneiss, granulite, magnetite quartzite, cordierite-, sillimanite-, garnet and graphite-biotite schist, quartzite, and marble. Three km to the west is the Dahuabei potassic granite intrusion. The veins occur in clusters and swarms in large vein groups or plates. Three types of veins occur: (1) Au quartz vein with gold, quartz, pyrite, chalcopyrite, galena, and sphalerite; (2) Au K-feldspar and quartz-K-feldspar veins with Au, K-feldspar, quartz, pyrite, sericite, chlorite, and speculaite; and (3) Au potassic and silica-altered rock with gold, quartz, K-feldspar, albite, sericite, chlorite, calcite, and pyrite, and minor biotite, magnetite, muscovite, and garnet. Alterations include K-feldspar, silica, sericite, and carbonate alteration. Temperature of formation of the deposit varied from an early high temperature of about 400 to 450°C to a later, low temperature of about 172°C. Pressure is estimated at 425 to 461±105 Pa. The deposit is interpreted as forming during magmatic-related hydrothermal alteration related to the Dahuabei granite. The deposit is large with reserves of 20.86 tonnes grading Au 5.21 g/t Au.

Origin and Tectonic Controls for Wulashan-Zhangbei Metallogenic Belt

The belt is interpreted as forming during granitoids generated above a mantle plume in an extensional tectonic setting. The host intrusions are alkaline syenite, alkaline monzonite, subalkaline granite, and lesser calc-alkaline granite. The Au deposits are assocated with potassium metasomatism. The intrusions in the belt are controlled by major east-west-trending faults. These intrusions may have formed from the remelting deep crust (Zhou Kun, 1995), or from mantle-derived magma (Song Guorui, Zhao Zhenhua, 1996). Shi Zhunli and Xie Guangdong (1998) interpret the magmatism and deposits are related to a mantle plume and formed in a tensile tectonic setting. There are many ages the mineralization. Reliable isotopic data suggest a Late Triassic and Early Jurassic age (Shi Zhunli and Xie Guangdong, 1998; Nie Fengjun and others, 1989).

REFERENCES: Nie Fengjun and others, 1989; Zhou Kun, 1995; Song Guorui and Zhao Zhenhua, 1996; Shi Zhunli and Xie Guangdong, 1998.

Fanshan Metallogenic Belt of Magmatic-Metasomatic Apatite Deposits (Belt FS) (North China)

This Late Triassic metallogenic belt is related to mafic-ultramafic plutons that occur along a major fault that cuts Sino-Korea platform sedimentary cover and the West Liaoning-Hebei-Shanxi terrane of the Sino-Korean Craton. The belt occurs in the western Hebei Province, trends east-west, is about 30 km long, and ranges up to 15 km wide. The significant deposit is Fanshan.

Fanshan Magmatic-Metasomatic Apatite Deposit

This deposit (Mu, Baolei and others, 1988) consists of stratiform and circular igneous masses that occur at the intersections of two huge fracture zones in cratonal rocks. The deposits is related to an alkalic, stratiform ultramafic-syenite complex. The ore assemblages are apatite, magnetite-apatite, and biotite-apatite. The rich assemblages are apatite and biotite-apatite intercalated with biotite gabbro and pyroxenite. Grade ranges from 25% to a maximum of 38.69% P_2O_5. The ore minerals occur in masses, bands, and disseminations. A Rb-Sr isochron isotopic age for ore is 218.8± 8 Ma. The deposit is large with an average grade of 10-45% P_2O_5.

Origin and Tectonic Controls for Fanshan Metallogenic Belt

The subalkaline mafic-ultramafic intrusions hosting the belt are interpreted as forming during Late Triassic and Early Jurassic intraplate plutonism related to the subduction of Kula plate under the Eurasian Plate. A major east-west fault is an important control for the mafic-ultramafic plutonic intrusions.

REFERENCES: Mu Badei and others, 1998.

Gyeonggi Metallogenic Belt of Mafic-Ultramafic Related Ti-Fe, Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork, Metamorphic Graphite, and W±Mo±Be Skarn Deposits (Belt GA) (South Korea)

This Late Triassic and Early Jurassic (230 to 187 Ma) metallogenic belt is hosted in the Proterozoic Gyeonggi Group (Gyenggi granulite-paragneiss terrane that is part of South China Craton), and the Jurassic Daebo Granite belt. The belt contains mafic-ultramafic related Ti-Fe, polymetallic Pb-Zn-Ag vein and stockwork, and W±Mo±Be skarn deposits. The Gyeonggi Group consists of a migmatitc gneiss complex, including biotite schist, quartzite, hornblende schist, quartz-hornblende-biotite schist, and augen gneiss. The group is intruded by the Jurassic Daebo Granite belt that consists of quartz porphyry, fine-grained granite, and lamprophyre. The major deposits are at Soyounpyong-do (Fe, Cr, Ti), Chilbo (W, Fe), and Bupyung (Ag, Pb).

Chilbo W±Mo±Be Skarn Deposit

This deposit (Koo and Kim, 1966) consists of tungsten and magnetitie skarn exposed at six prospecting sites in a zone that is 600 m long and 100 m wide. The ore minerals are scheelite, powellite, and magnetite, with lesser chalcopyrite, pyrite, pyrrhotite, bismuthinite, and arsenopyrite, and very sparse molybdenite and covellite. Gangue minerals are garnet, epidote, tremolite, diopside, zoisite and quartz. The deposit is hosted in Precambrian metasedimentary rock, including amphibole schist, quartz schist, and dolomitic marble that is intruded by younger hornblende-biotite granite, and microgranite, felsite, and pegmatite dikes. The deposit is small and grades from 0.2-3.4% WO_3 48.89% Fe, 0.15% Cu.

Soyounpyong-do Mafic-Ultramafic Related Ti-Fe (V) Deposit

This deposit (Lee and others, 1965) consists of magnetite, ilmenite, and a small quantity of hematite in a roof-pendant form developed between Precambrian mica schist, limestone, hornblende schist, and lamprophyre of unknown age. The pendant occurs above the hornblende schist formation and is concordant with the schistosity of hornblende schist. The body is seperated by a fault extending NS and the body in the W side is displaced down about 90 m. Main body hardly contains gangue minerals and is high grade titaniferous Fe. Gangue minerals are hornblende, chlorite and hercynite. Chlorite is altered from hornblende. The ore minerals generally exhibit granular texture, with a grain size of 0.0017-0.5 mm, but average grain size is 0.1 mm. Most ilmenite is fresh and does not contain other minerals, and magnetite tends to occur in parallel intergrowth with ilmenite. Ilmenite and magnetite showing granular texture can be separated, because the grain size is 0.1 mm. But the size of ilmenite grain showing parallel intergrowth in magnetite is 1-0.03 mm, so it is hard to separate ilmenite from magnetite. It is thought to be magma differentiated deposit. The average grade is Fe 50.82%, TiO_2 17.75%, S 0.02%, P 0.07%. Grade of drill core is Fe 46.77%, TiO_2 16.17%, Cr 0.26%, and trace V. Estimated ore reserves are: East side body; 2,888,757 tonnes; West side body, 991,485 tonnes; and total ore reserves, 3,880,000 tonnes.

Bupyung Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Mine

This mine (Park and Chung, 1968) is hosted in Precambrian gneiss, and Cretaceous or Tertiary rhyolite, granite, and dikes. The ore minerals are mainly galena, sphalerite, chalcopyrite, marcasite, argentite, tetrahedrite, and pyrargirite. The ore minerals occur in masses and disseminatons and are interpreted as forming from hydrothermal fluids that migrated along fissures, joints, and shears in rhyolite. Three main outcrops occur on the surface. The largest trends north, is 20 to 30 m wide and 330 m long.

Origin and Tectonic Controls for Gyeonggi Metallogenic Belt

The belt is related to magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment. The Ti-Fe deposits in the belt are interpreted as forming during intrusion of mafic and ultramafic plutons associated with Late Jurassic to Early Cretaceous Daebo orogeny. The polymetallic vein deposits are interpreted as forming during hydrothermal fluid activity, and skarns are interpreted as forming during contact metasomatism along contact zones of hornblende biotite granite and dikes.

REFERENCES: Koo, and Kim, 1966; Park, and Chung, 1968; Duk Hwan Hwang, this study.

Eungok Metallogenic Belt of Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork and Ni-Co Arsenide Vein Deposits (Belt EU) (South Korea)

This Late Triassic and Early Jurassic (230 to 187 Ma) metallogenic belt occurs in the Yeongnam Metamorphic Complex (Yeongnam granulite-paragneiss terrane, part of Sino-Korean Craton), Gyeongsang Supergroup, Pyeongan Supergroup, and the Late Jurassic to Early Cretaceous Daebu Granite belt that consists of biotite granite, granite porphyry, and and quartz porphry. The major deposits are at Eungok and Yungchang.

Eungok Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (**Moon, 1966**) consists of lenses and veins in the Permian and Carboniferous sedimentary rock of the Pyongan Supergroup, Hongjom Formation, Sadong Formation, Kobang Formation, and Nokam Formation that are intruded by granite porphyry. The deposit formed during hydrothermal replacement in lenses and lenticular along contacts between the crystallized limestone and sedimentary rock. Five outcrops of the veins occur the surface, strike northeast, dip northwest, and range from 40 to 160 cm wide. The ore minerals are galena, sphalerite, and chalcopyrite, and the gangue minerals are garnet, quartz, calcite, feldspar, fluorite, pyrite, and limonite. Four veins are intersected by the main crosscut have lengths of from 30-40m. The veins are lenticular and discontinous. The other two or three veins intersected by the crosscut consist of quartz and calcite veinlets with pyrrhotite and pyrite. The deposit is small with an average grade of 3.37% Pb,5.66% Zn, 0.42% Cu, 0.4 g/t Au, and 388 g/t Ag.

Yungchang 2 Ni-Co Arsenide Vein Deposit

This deposit (Seo and others, 1981) is hosted in Precambrian granitic gneiss and Cretaceous shale, sandstone and tuffaceous rocks of Young Dong Series. The deposit is related to a Cretaceous quartz porphry that intrudes the granitic gneiss and a mafic dike tht intrudes quartz porphyry. The deposit formed during hydrothermal filling of a fault shear in granitic gneiss, quartz porphyry, and mafic dike. Ore minerals are mainly chalcopyrite, and azurite, and minor magnetite, specularite, and pyrite. Gangue minerals are quartz, chlorite, pyroxene, and fault clay. The deposit is small with an average grade of 60 ppm Co, 12-16 ppm Ni, 42-46 g/t Ag, 1.3-4.1% Cu, and 300-580 ppm Sn.

Origin and Tectonic Controls for Eungok Metallogenic Belt

The belt is related to magmatic rocks that intruded along transform micro plate boundaries and in a within plate (plume) environment. The belt formed during intrusion of granitoids associated with Late Jurassic to Early Cretaceous Daebo orogeny and intrusion of Cretaceous biotite granite, granite porphyry, and quartz porphyry into granitic gneiss. The belt is hosted in Archaean to Proterozoic granite gneiss and Carboniferous and Permian sedimentary rock of the Pyongan Supergroup.

REFERENCES: Moon, 1966; Seo and others, 1981; Duk Hwan Hwang, this study.

North Kitakami Metallogenic Belt of Volcanogenic-Sedimentary Mn and Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposits (Belt NK) (Japan)

This Triassic to Early Cretaceous metallogenic belt is related to stratiform units in the Mino Tamba Chichibu accretionary wedge terrane. The belt occurs in the northern Kitakami mountains, trends approximately north-south for more than 150 km, ranges up to with a 75 km wide, and occurs north of the Hayachine tectonic line. The metallogenic belt may extend further northwest onto southwestern Hokkaido island. In the northern Kitakami mountains, two tectonic units are defined, the Kuzumaki-Kamaishi and Akka-Tanohata belts (Okami and Ehiro, 1988) that are separated by Iwaizumi tectonic line. The Kuzumaki-Kamaishi belt consists of chert, limestone, and clastic rock. The chert and limestone form olistoliths in the clastic rocks. The olistolith age ranges from Permian to Early Jurassic, and the age of clastic rock is Middle Jurassic to Late Cretaceous. The units form a typical Jurassic accretionary complex. The Akka-Tanohata belt consists of Middle Jurassic to Early Cretaceous shale, sandstone, mafic pyroclastic rock, limestone, and abundant Triassic to Jurassic chert. Early Cretaceous siliceous tuff, black shale, and andesitie occur in the eastern Akka-Tanohata belt, and host the Kuroko Taro deposit. Manganese deposits occur in or adjacent to the chert. The belt contains a large number of stratiform Mn deposits, and one Kuroko massive sulfide deposit occurs in the belt. Tsuboya and others (1956) defined Chichibu geosyncline Fe-Mn metallogenic province that contains the Mn deposits of the North Kitakami metallogenic belt. The significant deposits are at Nodatamagawa and Taro.

Nodatamagawa Volcanogenic-Sedimentary Mn Mine

This mine (Mining and Metallurgical Institute of Japan, 1968; Hayashi and Ohmoto, 1996) consists of three major stratiform ore bodies hosted in Jurassic chert. The ore bodies are stratiform or lenticular and are controlled by folding in the host chert. Cretaceous granite occurs near and contact metamorphose the deposit with formation of biotite and cordierite in the slate around the deposit. The ore bodies are 600 m long and 1m thick. The ore minerals are rhodonite, tephroite, pyrochroite, hausmannite, rhodochrosite, and brounite. Gangue mineral is quartz. The ores are typically zoned with a central pyrochroite-haumannite, medial tephroite, and the outermost rhodonite that is adjacent to wall rock chert. The deposit is medium size with production of 311,600 tonnes Mn grading 30-35% Mn.

Taro Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai type) MIne

This mine (Mining and Metallurgical Institute of Japan, 1965; Yamaoka, 1983) consists of seven main bodies that strike northwest direction with dip southwest at 60-70 degrees. The main body extends 500 m along strike, and ranges up to 12 m thick. The main ore minerals are chalcopyrite, pyrite, galena, sphalerite, pyrrhotite, magnetite, and chalcocite. Gangue minerals are chlorite, calcite, and quartz. Host rocks are Mesozoic shale and sandstone. Mining started in 1854. The deposit is small with production of 36,857 tonnes Cu, 18,942 tonnes Zn, 5,825 tonnes Pb grading 0.8% Cu.

Origin and Tectonic Controls for North Kitakami Metallogenic Belt

The Mn deposits are interpreted as forming in a syngenetic setting on the ocean floor. The Kuroko deposits are interpreted as forming in an island arc. Deposits and host rocks were subsequently incorporated into an accretionary wedge.

REFERENCES: Tsuboya and others, 1956; Okami and Ehiro, 1988.

Sannae Metallogenic Belt of Au in Shear Zone and Quartz Vein and Ni-Co Arsenide Vein Deposits (Belt SA) (South Korea)

This Late Triassic and Early Jurassic (230 to 187 Ma) metallogenic belt is hosted in the Proterozoic Yeongnam Metamorphic Complex, (Yeongnam granulite-paragneiss terrane that forms part of Sino-Korean Craton), Gyeongsang Supergroup, and the Jurassic Daebo Granite. The Yeongnam Metamorphic Complex consists of leucogranite gneiss, hornblende-plagioclase gneiss, and biotite gneiss and schist. The Daebo granite consists of biotite granite, granodiorite, anorthosite, and porphyry, and felsic and quartz porphyry dikes. The Gyeongsnag Supergroup terrane consists of Cretaceous sandstone and shale. The major deposits are at Dongjin and Sannae.

Dongjin Au in Shear Zone and Quartz Vein Mine

The deposit (Kim, 1964) consists of a fissure-filling Au-Ag quartz vein that occurs along the faults in conglomerate in the Maisan Formation. In addition to gold, the other minerals are pyrite, chalcopyrite, arsenopyrite, sphalerite, galena, calcite, and tetrahedrite. The deposits can be grouped into two kinds; the one is Au-Ag bearing quartz vein, and the other is sulfide vein with less quartz. The quartz vein is averages 20 cm wide. Average grades are 35.7 g/t Au, 187.6 g/t Ag, 0.76% Cu, and 45% Zn. A sulfide vein ranges from 15 to 60cm wide, and the average grades are 7.99% Cu, 25.5 Au g/t, and: 359.53 g/t Ag. The mine is developed in sandstone and shale in the Sansoo-dong Formation that is underlained conglomerate of the Maisan Formation. These units are intruded by Late Cretaceous hornblende-biotite granite. The deposit is small.

Sannae Au Ni-Co Arsenide Vein Deposit

The deposit (Kim and Park, 1959) consists consists of sulfides diseminated and in veinlets in ultramafic rock. The ultramafic rock intrudes gneiss and the deposits occur exclusively rock near the contact zone. The ultramafic rock consists of olivine, pyroxene and plagioclase with some hornblende replacement particularly in the minralized zone. Deposits are rather irregular and grade into barren ultramafic rock. Pyrrhotite with subordinate pentrandite and chalcopyrite occurs predominently along small cracks and faults associated with calcite and quartz. Two stages of deposition are apparent: (1) magmatic segregation during that the disseminated sulfides formed and (2) deuteric and (or) hydrothermal replacement during that sulfides with calcite and quartz precipitated along the cracks and faults. These cracks and faults were probably formed by contraction during cooling. The deposit is small with a grade of 0.29-1.1% Ni, 0.36-0.77% Cu.

Origin and Tectonic Controls for Sannae Metallogenic Belt

The belt is hosted in the Proterozoic Yeongnam Metamorphic Complex, Gyeongsang Supergroup, and the Jurassic Daebo Granite. The belt interpreted as forming during intrusion of Late Triassic to Early Jurassic granitoids during the Songrim orogeny. The deposits consist of fissure-filling Au quartz veins along faults in conglomerate in the Cretaceous Maisan Formation that is intruded by Jurassic hornblende biotite granite.

REFERENCES: Kim, and Park, 1959; Kim, 1964; Duk Hwan Hwang, this study.

Hongcheon Metallogenic Belt of Ta-Nb-REE Alkaline Metasomatite(?) Deposits (Belt HO) (South Korea)

This Jurassic metallogenic belt is hosted in the Proterozoic Gyeonggi Group and Proterozoic Kyeonggi Gneiss Complex (both parts of Gyenggi granulite-paragneiss terrane, South China Craton,), and the Jurassic Daebo Granite. The Jurassic Daebo Granite consists of schistose granite, biotite granite, syenite, and felsite porphyry. The major deposit is at Hongcheon-Jaun.

Hongcheon-Jaun Ta-Nb-REE Alkaline Metasomatite(?) Deposit

This deposit (Kim and others, 1965; Park and Hwang, 1995) consists of magnetite and monazite in chlorite-sericite-quartz schist in the Proterozoic Kyeonggi Gneiss Complex that is intruded by schistose granite and felsite porphyry, and hornblendite dikes. The deposit is about 900 m long, 250 m deep, and 25 m wide. The deposit consists of mainly magnetite and calcite. Associated minerals are hematite, limonite, chalcopyrite, pyrite, siderite, rhodochrosite, apatite, and chlorite. The deposit is interpreted as forming during hydrothermal replacement of Fe ore in argillaceous sedimentary rock during regional metamorphism. Drill hole grades range from 19.34 to 32.70% Fe. Carbonate rock contains anomalous P, Sr, Nb, La, Ce, Nd, Sm, and Ba. REE monazite occurs in dolomite and strontianite, generally in myrmekitic intergrowths with strontianite. Also occurring are apatite in carbonate, barite in dolomite, and minor chalcopyrite and molybdenite in the deposit and host carbonate rock. Magnetite and monazite grains are generally fractured. The deposit is medium-size with an average grade of 25% Fe, 1.86% SrO, 2.79% R_2O_3 and reserves of 8,132,800 tonnes Fe ore.

Origin and Tectonic Controls for Hongcheon Metallogenic Belt

The Ta-Nb-REE alkaline metasomatite deposits are interpreted as forming during intrusion of syenite of the Jurassic Daebo granite belt.

REFERENCES: Kim and others, 1959; Kim and others, 1965; Park, and Hwang, 1995; Duk Hwan Hwang, this study.

Sambagawa-Chichibu-Shimanto Metallogenic Belt of Besshi Cu-Zn-Ag Massive Sulfide (Cu, Zn, Ag), Volcanogenic-sedimentary Mn, and Cyprus Cu-Zn Massive Sulfide Deposits (Belt SCS) (Japan)

This Early Jurassic and to Albian metallogenic belt is related to stratiform units in the Shimanto and Mino Tamba Chichibu accretionary-wedge terranes and the Sambagawa metamorphic terrane. The belt occurs in the outer zone of the Southwestern Japan, trends approximately northeast-southwest for about 800 km, ranges up to 70 km wide, and occurs in the Chubu district and Kii Peninsula on Honshu, Shikoku, and Kyushu Islands. The belt contains a large number of Besshi and Cyprus Cu-Zn massive sulfide deposits, and stratabound Mn deposits. Most of the Besshi deposits occur in the Sambagawa terrane in the northern part of the belt. The Besshi deposit occurs on the Shikoku Island. The Besshi deposits and host rocks in the Sambagawa terrane are generally metamorphosed to epidote-amphibolite facies, high-pressure greenschist facies, or pumpellyite-actinolite facies metamorphism (Watanabe and others, 1998). The age of peak metamorphism is interpreted at about 110 Ma, and the age of submarine basalt volcanism and formation of related Besshi deposits is interpreted as between 200 Ma and 140 Ma (Watanabe and others, 1998). Geochemical characteristics of basalt associated with the deposits suggest submarine volcanism occurred in an oceanic intra-plate setting or in a constructive plate margin (Watanabe and others, 1998). Several Besshi deposits occur in the Chichibu terrane south of the Sambagawa terrane, but most of them are small and not of economic value. The Shimanto terrane, south of the Chichibu terrane, hosts several Besshi deposits, including the Makimine deposit that occurs in the Mikabu greenstone zone of the Chichibu terrahe. Manganese deposits in the metallogenic belt occur mainly in the Chichibu terrane with lesser in the Sambagawa and Shimanto terranes. The deposits are stratiform volcanic and sedimentary deposits and occur in or adjacent to chert. Three metallogenic provinces, a Besshi metallogenic province, the Chichibu Fe-Mn metallogenic province, and outer zone of Southwest Japan pyrite and Fe-Mn metallogenic province, were defined by Tsuboya and others (1956) for the area of the Sambagawa-Chichibu-Shimanto metallogenic belt in this study. The significant deposits in the belt are at Besshi Ananai, and Okuki.

Besshi Besshi Cu-Zn-Ag Massive Sulfide (Cu, Zn, Ag) Mine

This Mine (Mining and Metallurgical Institute of Japan, 1965; Suyari and others, 1991; Watanabe and others, 1998) consists of four srtratiform ore bodies. The Main Motoyama body extends 1,600 m along strike and 2,000 m down dip, and has dimensions of 3,000 by 11,000 m. Average thickness is 2.4 m with a maximum thickness of 15 m. The ain ore minerals are pyrite, chalcopyrite, bornite, and magnetite. Gangue minerals are chlorite, hornblende, glaucophane, and quartz. Deposit hosted in pelitic schist of Cretaceous Sambagawa Metamorphic Rocks. Mafic schist and piedmontite schist occur the ore zone. Geochemistry indicates mafic schist derived from basalt that formed in an oceanic intra-plate or constructive plate margins. Age of peak of metamorphism is 110 Ma according to Rb-Sr and K-Ar isotopic studies. Possible age for submarine basaltic volcanism and deposit formation is 200 Ma (Late Triassic) to 140 Ma (Jurassic). Deposit was discovered in 1690. The deposit is large with production of 706,000 tonnes Cu, reserves of 8,000,000 tonnes Cu, and average grades of 1.0-1.8% Cu, 0.1-1.4% Zn, 11.9-40% S, 0.3-0.7 g/t Au, and 7-20 g/t Ag.

Ananai Volcanogenic-Sedimentary Mn District

This district (Shikoku Bureau of International Trade and Industry, 1957; Yoshimura, 1969; Suyari and others, 1991) contains more than eleven small ore bodies andis also named the Amatubo district. The ore bodies are hosted in Paleozoic and Mesozoic greenstone and sandstone of Chichibu belt. The main Ananai deposit which produced about 300,000 tonnes ore and consists of seven ore bodies that trend east-west for 4 km. Thickness of the deposit is typically 2 to 12 m. Ore minerals are rhodochrosite, braunnite, and bementite. The deposit is medium size with production of 300,000 tonnes of Mn ore.

Okuki Cyprus Cu-Zn Massive Sulfide Mine

This mine (Mining and Metallurgical Institute of Japan, 1965; Watanabe and others, 1970; Suyari and others, 1991) consists of Cu sulfide and pyrite massive sulfide that occurs conformably in metamorphosed mafic volcanic and pyroclastic rock associated with a gabbro body and thin chert beds in the Mikabu ophiolite. The deposit consists of the Honko and Otoko ore zones. Each ore zone contains several small ore bodies typically occur at hinges of anticlines. Hanging wall of the deposits is mafic volcanic rock and red chert, and foot wall is phyllite. The red chert markes the ore horizon. The Honko ore zone is 1,500 by 400m. The main ore minerals are pyrite, chalcopyrite, sphalerite, and native gold, and minor bornite, tetrahedrite, and cobaltite. Gangue minerals are chlorite, quartz, and calcite. The deposit is medium size with production of 50,000 tonnes Cu, 2 tonnes Au, and 7 tonnes Ag grading 2.14% Cu, 4 g/t Au, and 60 g/t Ag.

Origin and Tectonic Controls for Sambagawa-Chichibu-Shimanto Metallogenic Belt

The Mn deposits in the belt are interpreted as forming in a syngenetic, ocean floor setting. The Besshi and Cyprus deposits are interpreted as forming during submarine volcanism related along a spreading ridge. The deposits were subsequently incorporated into and accretionary wedge.

REFERENCES: Tsuboya and others, 1956; Watanabe and others, 1998.

MIDDLE JURASSIC THROUGH EARLY CRETACEOUS (175 to 96 Ma) METALLOGENIC BELTS

Tari-Bigai Metallogenic Belt of Carbonate-hosted Hg-Sb Deposits (Belt TB) (Taimyr Peninsula, Russia)

This Early Cretaceous or older metallogenic belt is related to veins that occur along a major fault cutting the South-Taimyr fold belt in the North Asian Craton Margin. The belt occurs in the western Taimyr Peninsula in the Byrranga Ridge. The Hg-As deposits in the belt occur along a major fault zone that extends sublatitudinally for more than 350 km. Two similar occurrences are located along the flanks of this belt (Ravich, 1959). The more important is the Izvilistaya River occurrence.

Izvilistaya River Carbonate-Hosted Hg-Sb Occurrence

This occurrence (Ravich, 1959) is hosted in fractures in Ordovician and Early Carboniferous limestone and dolomite Permian terrigenous sedimentary rock in the core of anticline. The occurrence consists of quartz-carbonate veins, lenses, nests, disseminations, and stockworks that occur along contacts between sedimentary rock and lamprophyre dikes. The occurrence extends several hundred meters and 20 m thick. The ore minerals are cinnabar, stibnite, pyrite, and orpiment, and gangue minerals are quartz, calcite, and ankerite. Wall-rocks are altered to kaolinite and silica. The occurrence is small.

Origin and Tectonic Controls for Tari-Bigai Metallogenic Belt

The belt is interpreted as forming during intraplate rifting and generation of alkali basalt (Ravich, 1959; Vernikovskiy, 1996). The age of deposits is interpreted as pre-Early Cretaceous because pebbles of pre-ore lamprophyres occur in Early Cretaceous conglomerate (Ravich, 1959; Smirnov and others, 1976).

REFERENCES: Ravich, 1959; Smirnov and others, 1976; Vernikovskiy, 1996.

Verkhoyansk Metallogenic Belt of Au in Shear Zone and Quartz Vein Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Sn-W Greisen, Stockwork, and Quartz Vein, and Au in Black Shale Deposits (Belt VK) (Russia, Verkhoyansk-Kolyma orogenic region)

This Late Jurassic to Early Neocomian metallogenic belt is related to veins and replacements in the Verkhoyansk fold and thrust belt (unit NSV). The age of the belt is interpreted as late Late Jurassic and Early Neocomian. The Verkhoyansk belt extends as a narrow (up to 100 km) band for 1200 km along the western margin of the northern and central sectors of the Verkhoyansk fold and thrust belt. It is made largely of Carboniferous and Permian clastic rocks metamorphosed at greenschist facies. Metamorphism is thought to be related to thrust zones, regional metamorphism or to unexposed granitoid plutons. Early authors proposed the relation of Au deposits with high-grade metamorphism of greenschist facies. Later on it was established that Au content is low in higher-grade rocks of the biotite subfaces and that best Au values occur in the muscovite-chlorite subfacies. Metamorphism consists of flow cleavage, recrystallization blastic and thorny structures of the rocks, and by the presence of metamorphogenic quartz, muscovite, and albite. The main deposits of the belt are concordant veins complicated by cross veinlets clustering into stockworks in sandstone beds. The major Au shear zone deposit is at Djandi.

Djandi Au in Shear Zone and Quartz Vein Deposit

This deposit consists of stockworks, veins, and mineralized breccias controlled by sublongitudinal high-angle faults. The stockworks are up to 900 m long and 100 m wide (avg. 20 m). Concordant and cross-cutting veins are present, ranging up to 80 m long and 3 m wide. The veins and stokworks are companion by mineralized breccias. The highest Au values occur in the stockworks-up to 4.3 g/t. Ag content of the stockworks is up to 1 g/t. The Au is 700 to 900%0 fine and occurs as grains up to 2 to 3 mm in size. The structure of the deposit area is determined by linear overturned folds and thrusts. Flow cleavage is clearly defined, is parallel thrusts.

REFERENCES: Parfenov and others, 2001; Prokopiev and others, 2001; Fridovsky and Prokopiev, 2002.

Nikolaevskoe and Otkrytoe Au in Shear Zone and Quartz Vein Deposits

The Au quartz vein deposits at Nikolaevskoe and Otkrytoe (Abel and Slezko, 1988) consist of conformable and cross-cutting quartz veins with gold, galena, arsenopyrite, pyrite, tetrahedrite, sulfosalts, carbonates, and albite that are hosted in Early Permian sandstone beds. The veins occur in anticlinal hinges, are up to 1 km long, and range from 0.2 to 1 m thick, sometimes up to 10 m thick. Sulfides comprise up to 5% the veins. The Au quartz vein deposits are not economic, but the source for the placer Au mines of the Verkhoyansk district.

Kuolanda Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (Ivensen and others, 1975; V. Tseidler, written commun., 1985) consists of a breccia with abundant veins and stringers of massive and disseminated galena and sphalerite that are hosted in Early Carboniferous siltstone and sandstone. Main ore mineral is sphalerite with lesser galena and chalcopyrite. Subordinate minerals are siderite, arsenopyrite, glaucodot, pyrite, melnikovite, pyrrhotite, and native silver. Veins are divided into sulfide and quartz-sulfide types. Some veins range up to 20 m long and 0.2-0.3 m thick. Vein zones range up to up to 280 m long and from 1.5 to 10 m wide. The deposit occurs along axis of an anticline. The deposit is large with reserves of 15,000 tonnes Pb, 120,000 tonnes Zn. Average grade of 20-30% Zn, 2% Pb, 1.3% Cu, up to 953 g/t Ag.

Imtandzha Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Ivensen and Proschenko, 1961; Indolev and Nevoisa, 1974) occurs in a fissure zone that ranges up to 500 m wide, 2 km long, and occurs along the axis of an anticline. Intruding the sedimentary rock are granodiorite porphyry dikes that areassociated with deposit. The dikes cut polymetallic veins and in turn are cut by Sn-sulfide veins. Early-stage Ag-polymetallic veins are mostly conformable. Later-stage veins are mostly cross-cutting, but are less common. Veins range from 0.01 to 0.85 m thick. Major ore minerals are galena, sphalerite, and siderite. Lesser vein minerals are quartz, tetrahedrite, pyrite, arsenopyrite, and boulangerite. Later-stage veins contain quartz, chlorite, pyrite, arsenopyrite, galena, cassiterite, tourmaline, and stannite and range from 0.1-0.6 m thick. Stringers range 2 to 3 m thick and up to 1 km long.

Mangazeika 2 Au in Black Shale Deposit

This deposit (Indolev and Nevoisa, 1974;Kostin and others, 1997) consists of high-angle veins that have a variable dip and strike, and thin or branch into closely-spaced veinlets. The veins range from tens of centimeters to 2 to 2.5 m thick (in swells) and extend from a few meters to tens of meters to 700 to 1000 m long. Stock-like swells in veins range up to 25 to 30 m thick. Crush zones and closely spaced vein systems also occur. Deposit is discontinous in an area 3 km across and 19 km long and is hosted in Late Carboniferous and Early, Early Permian clastic rock. The deposit contains native Ag, Sb Ag minerals, animikite, allargentum, acanthite, Pb-acanthite, Cu-acanthite, Ag2S-Cu2S sulfide series, galena, sphalerite, chalcopyrite, stannite, pyrite, arsenopyrite, bismuthinite, and stibinite. Also occurring are sulfosalts, including fahl, pyrargyrite, miargyrite, diaphorite, owyheeite, polybasite, stephanite, canfieldite, freieslebenite, geocronite, bournonite, boulangerite, gustavite, and Ag-Bi-sulfotelluride. The deposit is interpreted as forming during Devonian rifting. Metals are interpreted as having been leached from Devonian basalt by sea water that circulated along faults. The deposit is large.

Origin and Tectonic Controls for Verkhoyansk Metallogenic Belt

The belt is interpreted as forming during collision of the Kolyma-Omolon superterrane and the North Asian Craton and associated regional metamorphism during the Late Jurassic to early Neocomian. The belt is hosted mainly in Carboniferous and Permian clastic rocks that are metamorphosed to greenschist facies. Metamorphism is interpreted as related to thrust zones, regional metamorphism, and (or) unexposed granitoid plutons

REFERENCES: Amuzinsky, 1975; Ivensen and others, 1975; Parfenov and others, 1999, 2001.

Kular Metallogenic Belt of Au in Shear Zone and Quartz Vein, Granitoid-Related Au Vein, and Sn-W Greisen, Stockwork, and Quartz Vein Deposits (Belt KU) (Russia, Verkhoyansk-Kolyma Region)

This Late Jurassic and Early Neocomian metallogenic belt is related to veins and replacements in the Kular-Nera terrane. The belt occurs on the northwestern flank of the Kular-Nera (slate belt) terrane, extends northeastward for 150 km, and ranges from 30 to 40 km wide. The belt is hosted in Permian to Triasssic deep-marine black slate that is intruded by granite with a $^{40}Ar/^{39}Ar$ of 103 Ma by. Early studies interpreted the belt as forming in a uplifted fault-fold complex with simple box and slit-shap folds. Subsequent, detailed structural studies reveal a complex fold and thrust zone with numerous refolded, recumbent isoclines. The host rocks are metamorphosed to greenschist facies (muscovite-chlorite and biotite subfacies). The metamorphic Au in shear zone and quartz vein deposits in the Solur, Ulakhan-Sis, and Magyl-Khayata districts occur along crests of antiforms formed in Permian slate. The mineral assemblage is quartz, carbonate (ankerite and calcite), chlorite, muscovite, and albite. An early pyrite-arsenopyrite assemblage is succeeded by a productive Au pyrrhotite-chalcopyrite-sphalerite-galena assemblage. The major deposits are at Emelyanovskoye, Novoe, and the Tirekhtyak district (Nagornoe, Podgornoe, Poputnoe).

Emelyanovskoye Au in Shear Zone and Quartz Vein Deposit

This deposit (Parfenov and others, 2001) consists of concordant, stratabound saddle, lenticular, and sheet veins. High density veins and veinlets form concordant stockworks. Most of the veins and veinlets parallel cleavage with some occurring in S-shaped shears and fractures. Up and downdip, the veinlets grade into concordant veins or are truncated by decollement faults. The deposits extend up to a few hundreds of meters long, range up to 1.5 m thick and consist mainly of quartz and carbonate, along with subordinate pyrite, galena, sphalerite, Au, pyrrhotite, arsenopyrite, fahl, and chalcopyrite. Gold grains are 3 to 4 mm long.

Novoe Granitoid-Related Au Vein Deposit

This deposit (Ivensen and others, 1975) consists of steeply-dipping, cross-cutting shear zones and lenticular veins that occur in tension gashes. The shear zones strike northeast and dip northwest or southeast at 15-60°, commonly range up to several meters thick, locally to 10-12 m thick, and up to 1.5 km long. The lenticular veins range from 0.1-2 m thick and up to 50-100 m long. Major minerals are quartz, wolframite, arsenopyrite, carbonates minerals, cassiterite, and gold. The deposit hosted in Late Permian sandstone and shale near the dome of the Central-Kular anticline. The deposit is small with an average grade of 0.2-6.8% W03, 0.03-0.16% Sn, 0.5-5% As.

Tirekhtyak district (Nagornoe, Podgornoe, Poputnoe) Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Ivensen and others, 1975) consists of veins of tourmaline-quartz and cassiterite-scheelite-quartz; and cassiterite stringers. The major minerals are beryl, pyrrhotite, arsenopyrite, muscovite, sphalerite, and galena. Veins and stringers range from 0.01-1.2 m thick and up to 100 m long. Veins and stringers strike northeast and occur near the contact of the Early Cretaceous Tirekhtyak granite pluton. Veins and stringers intrude aplite dikes and granites and adjacent Triassic clastic rock that is contact metamorphosed. The deposit is small with up to 5% Sn, up to 1% W03 ; up to 0.6% Pb, and up to 1% As

Origin and Tectonic Controls for Kular Metallogenic Belt

The belt is interpreted as forming during collision of the Kolyma-Omolon superterrane to the North Asia Craton and associated regional metamorphism in Late Jurassic to early Neocomian. The belt occurs on the northwestern flank of the Kular-Nera slate belt.

REFERENCES: Fridovsky, 1996; Parfenov and others, 1999, 2001.

Erikit Metallogenic Belt of Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposits (Belt ER) (Russia, Verkhoyansk-Kolyma Region)

This Late Jurassic metallogenic belt is related to stratiform units in the Uyandina-Yasachnaya volcanic belt and and Ilin-Tas back arc basin in the Kolyma-Omolon superterrane. The Erikit belt contains the Chersky-Garmychan and Yasachnaya metallogenic zones (Shpikerman, 1998). The Uyandina-Yasachnaya volcanic belt is interpreted as a subduction-related magmatic arc that formed on the southwestern margin of the Kolyma-Omolon superterrane. The Khotoidokh Ag pyrite-polymetallic deposit is the largest and the best studied in the belt.

Khotoidokh Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Deposit

The Khotoidokh deposit (E. Naumov, written commun. 1987; Danilov and others, 1990; Shpikerman, 1998) is hosted in Late Jurassic siliceous and calcareous shale interbedded with tuff, tuffaceous sandstone, andesite, ignimbrite, and rhyolite and rhyodacite lava. The volcanic and sedimentary rocks are deformed into a sublatitudinal syncline, are intruded by two small-sized subvolcanic rhyolite bodies, and are altered to carbonate and chlorite propylite grade northward into albite alteration. varieties. The deposit is bounded by a major fault that is exposed for for 3 to 4 km and can in the subsurface along topographic lows and a rusty surface rocks caused by oxidation of pyrite. The deposits consists of a lenticular body of quartz, barite, and pyrite that occurs at the base of a rhyolite unit in silica-clay rock. The deposit is about 12 m thick and 400 m long and is surrounded by quartz-sericite-pyrite metasomatite. The metasomatite contains quartz, sericite, barite, and pyrite with up to 10% barite, greater than 15% pyrite, 50 g/t Ag, and 2 to 5 g/t Au. The principal ore minerals (>10%) are pyrite, chalcopyrite, sphalerite, galena, barite, and quartz in various mineral assemblages. (1) The oldest assemblage is quartz, sphalerite, and barite with mainly sphalerite and barite. In weakly-altered areas, barite ususally forms large prismatic crystals, sphaliterite occurs in equigranular quartz aggregates. (2) A younger assemblage of tetrahedrite, chalcopyrite, bornite, and galena is enriched in Ag. Ag content in galena ranges up to 3500 g/t. Also occurring are native Ag and Au, matildite, and andorite. Ag deposits are extensive and average 150 to 200 g/t Ag. Distribution of Au is irregular, with a maximum of 12 g/t and an average of 1 to 2 g/t Au in electrum (fineness of 482 to 780). During regional metamorphism, early assemblages were transformed into fine-to coarse layers with spiral, lenticular, and concentric structures. (3) A youngest assemblage of calcite and dominant pyrite metasomatically replaces the older two assemblages. The parts of the deposit that are not regionally metammorphosed exhibit stable Au/Ag ratios ranging from 1:100 to 1:300. A quartz-sericite-pyrite metasomatite with contrasting Zn, Pb, and Ag geochemical anomalies serves as a criterion for search for blind deposits. The deposit is large with resources of 180,000 t Pb, 900,000 Zn, 150,000 tonnesCu, about 1,000 tonnes Ag. Average grade is 5.15% Pb, 14.9% Zn, 0.7% Cu, and more than 100 g/t Ag.

Origin and Tectonic Controls for Erikit Metallogenic Belt

The belt is interpreted as related to a subduction-related magmatic arc formed on the southwest margin of the Kolyma-Omolon superterrane. Belt hosted in Uyandina-Yasachnaya volcanic belt.

REFERENCES: Bychok and Popov, 1975; Danilov and others, 1990; Shpikerman, 1998; Parfenov and others, 1999, 2001.

Chybagalakh Metallogenic Belt of Sn-W Greisen, Stockwork, and Quartz Vein, Sn-B (Fe) Skarn (ludwigite), and Granitoid-Related Au Vein Deposits (Belt CH) (Russia, Verkhoyansk-Kolyma Region)

This Late Jurassic to Early Neocomian metallogenic belt is related to veins and replacements in the Main granite belt. The belt extends for 250 km, ranges up to 75 km wide, and coincides spatially with the Main batholithic belt (Trunilina, 1992). The northwestern part of the belt contains the Burgavli-Chalba Sn-W and Upper Tirekhtyakh B-Sn districts. The Burgavli-Chalba Sn-W district extends sublatitudinally for 70 km, ranges up to about 10 km wide (Flerov and others, 1979), and contains complexly-deformed Jurassic flysch in the Inyaly-Debin synclinorium that is intruded by Early Neocomian granitoid. In the subsurface, contact-metamorphic zones occur adjacent to granitoid plutons. The deposits are related to granite and leucogranite and contains cassiterite-quartz and cassiterite-wolframite-quartz veins and stockwork. The Upper Tirekhtyakh B-Sn district occurs to the northeast of the Burgavli-Chalba district and is hosted in a homogeneous granodiorite and granite pluton (Trunilina, 1992). The district extends northwesternerly for 40 km and ranges up to 10 to 15 km wide. B-Sn and magnetite skarn deposits occur along the margins of the granodiorite in Paleozoic carbonate rock. Granitoid-related Au-REE deposits also occur in the belt. The major deposits are the Kere-Yuryakh Sn-W greisen, stockwork, and quartz vein deposit, the Titovskoe Sn-B (Fe) skarn (ludwigite) deposit, and the Chuguluk and Nenneli granitoid-related Au vein deposits.

Kere-Yuryak Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Flerov and others, 1979) occurs in the apical portion of a granite pluton that intrudes an anticline formed in Middle Jurassic sandstone. The deposit consists of stockwork veins and stringers that occur along the upper contact of the pluton. The veins and stringers are 0.1 to 2 m thick and range up to 100 m long. Outcrops of vein and stringer zones vary from 50 to 150 m wide. Major minerals are quartz, tourmaline, muscovite, arsenopyrite, cassiterite, and wolframite. Rare minerals are topaz, apatite, scheelite, tetrahedrite, pyrite, molybdenite, and bismuthine. Deposit exhibits intense greisen alteration. Average grade is 0.6% Sn; 0.487% As; and 0.62% W.

Titovskoe Sn-B (Fe) Skarn (ludwigite) Deposit

This deposit (Dorofeev, 1979) consists of forty bodies that of Mg skarn that occur along the contact between the quartz monzonite phase of an Early Cretaceous granitoid intrusion and Silurian and Devonian dolomite and limestone. The skarn range from 5 cm to 20 m thick and ranges from 50 to 1,000 m long. Main ore mineral is ludwigite that forms up to 70 to 80% some deposits. The skarn also contains ascharite, kotoite, datolite, harkerite, monticellite, fluoborite, clinohumite, calcite, periclase, forsterite, diopside, vesuvianite, brucite, garnet, axinite, tourmaline, biotite, phlogopite, serpentine, spinel, hornblende, pyroxene, feldspar, quartz, and magnetite. Sn occurs as an isomorphous admixture in ludwigite. Ludwigite is often replaced by sulfides, including pyrrhotite, sphalerite, pyrite, arsenopyrite, and chalcopyrite. Kotoite ore veins occur along margins of ludwigite bodies. Contact between the intrusion and carbonate is highly irregular. Most skarn bodies occur in embayments into the intrusion. The deposit occurs in an area 3 by 6 km, is medium-size to large, and has an average grade of 9.5% B_2O_3 and 0.3% Sn.

Origin and Tectonic Controls for Chybagalakh Metallogenic Belt

The belt is interpreted as forming during collision of the Kolyma-Omolon superterrane and the North Asian Craton and generation of anatectic high-alumina granitoids. The collision was companion by deformation, metamorphism, and formation of the high-alumina granitoid Main batholithic belt.

REFERENCES: Rozhkov and others, 1971; Flerov, 1976; Flerov and others, 1979; Dorofeev, 1979; Shoshin and Vishnevsky, 1984; Trunilina, 1992; Parfenov and others, 1999, 2001.

Adycha-Nera Metallogenic Belt of Au in Shear Zone and Quartz Vein, Sn-W Greisen, Stockwork, and Quartz Vein, and Granitoid-Related Au Vein Deposits (Belt AN) (Russia, Verkhoyansk-Kolyma Region)

This Late Jurassic to Early Neocomian metallogenic belt is related to veins in the Kular-Nera terrane. The belt occurs in the central and southwestern Kular-Nera terrane (slate belt) that consists of Permian and Triassic deep-water black slate, and in the adjacent Verkhoyansk fold and thrust belt that consists of Late Triassic and local Early Jurassic shelf deposits. The belt extends northwesterly for 600 km, is 150 km wide, and contains several hundreds Au quartz vein deposits and occurrences with various morphologies. A long history of ore deposition is interpreted, starting with accumulation of disseminated Au in the late Paleozoic and early Mesozoic black slate units in distal parts of the Verkhoyansk passive continental margin, and subsequent mobilization during metamorphism and emplacement of granitoid during Late Jurassic and Early Neocomian collision between the northeastern margin of the North Asia Craton and the Kolyma-Omolon superterrane. The major deposits are at Badran, Imtachan Uchui, Sokhatinoe, and Delyuvialnoe.

Badran Au in Shear Zone and Quartz Vein Deposit

This deposit (Amurzinskiy and others, 1989; Anisimova, 1993; Fridovskiy, 1999) occurs along the Badran-Egelyakh strike-slip fault, that also has a minor reverse fault component. The horizontal displacement is 800 m. The footwall consists of Norian clastic rocks and the hanging wall consists of mainly Carnian rock (Fridovskiy, 1999). There is no apparent relation of the deposit to igneous units, and the nearest granitoids occur 30 km southeast of the deposit. The deposit consists of quartz veins and veinlets that tend to occur in crush zones along the fault plane and that extend for 6 km along the surface and to a depth of 800 m (Fridovskiy, 1999). The quartz veins range up to 200 m long and up to 4.2 m thick in swells, and are accompanied by thin quartz veinlets that are most abundant in ares of pinching of the veins. Along with the veins and veinlets, disseminated Au occurs in boundins and cataclastic rock. Maximum Au concentration occurs in the massive quartz veins. The ore minerals are mainly pyrite, goetite, arsenopyrite, galena, sphalerite, and tetrahedrite, along with minor (< 1%) chalcopyrite, antimonite, bournonite, antimonite, and free gold. The gangue minerals are mainly quartz, calcite, and dolomite. (Amuzinsky and others, 1989; Anisimova, 1993). Gold is lumpy and interstitial. Fineness ranges from 689 to 1000 (Anisimova, 1993). The deposits is large.

Imtachan Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Indolev and Nevoisa, 1974) consists of Sn polymetallic veins that occur in a linear, steeply-dipping fault zone that cuts Late Permian sandstone and shale. Main ore minerals are pyrrhotite, pyrite, and sphalerite with lesser galena, arsenopyrite, maracasite, cassiterite, and stannite. Gangue minerals are quartz, siderite, and mangananankerite. The deposit occurs in the dome of a plunging brachyform anticline in the contact metamorphic aureole of an unexposed granitoid intrusion. The deposit is small.

Uchui Au in Shear Zone and Quartz Vein Deposit

This deposit (Rozhkov and others, 1964) consists of quartz veins in thin sandstone beds. The veins are short and cross-cutting, have a complex morphology, and range up to 250 m long and 26 m thick. The veins locally grade into sheet stockworks that ranges from 10 to 20 m thick and up to 150 m long. Six major veins occur. The major vein minerals are quartz, albite, carbonates, and sericite, and lesser arsenopyrite, pyrrhotite, sphalerite, tetrahedrite, chalcopyrite, galena, pyrite, and gold. Disseminated arsenopyrite commonly occurs in Wallrocks that exhibit silica, albite, and carbon alteration. The deposit hosted in Late Triassic shale that is folded into a major anticline. The deposit is small.

Delyuvialnoe Granitoid-Related Au Vein

This deposit (Rozhkov and others, 1964; Flerov and others, 1979; V. Vladimirtseva, written commun.,1985) consists of shear zones and quartz stringers that occur in a brachyanticlinal dome formed in contact metamorphosed Late Triassic (Norian) sandstone and siltstone. The deposit area is 500 by 1,500 m. The shear zones range from 1 to 20 m thick, and stringers occur in zones up to 100 m thick. Shear zones and stringers occur in an areas that is 250-300 m long, trends east-west, and dips 50-70°. An unexposed part of the neighboring Chenkelenyn intrusion is interpreted to occur at depth. The ore minerals are arsenopyrite and pyrite, and lesser galena, chalcopyrite, scheelite, wolframite, bismuthine, native gold (fineness 600-700), and cassiterite. Gangue minerals are mainly quartz and less common chlorite and carbonate minerals. Wallrocks exhibit chlorite and sulfide alteration. The deposit is medium size and grades from 0.1-75.8 g/t Au, average grade of 5 g/t Au, 0.1-3% WO_3; 0.01-1.1% As.

Origin and Tectonic Controls for Adycha-Nera Metallogenic Belt

The belt is interpreted as forming in two stages: (1) initial accumulation of disseminated Au in late Paleozoic early Lower Mesozoic black slate; and (2) mobilization during regional metamorphism and intrusion of collisional granitoids during accretion of Kolyma-Omolon superterrane to northeastern margin of the North Asian Craton. The belt extends over the central and southwestern sectors of the Kular-Nera slate belt that contains Permian and Triassic deep-water black slate, and in the adjacent part of the Verkhoyansk fold and thrust belt that contains Late Triassic and local Early Jurassic shelf deposits.

REFERENCES: Indolev and Nevoisa, 1974; Fridovskiy, 1998; Goryachev, 1998; Parfenov and others, 2001; Nokleberg and others, 2003.

Polousny Metallogenic Belt of Cassiterite-Sulfide-Silicate Vein and Stockwork, and Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposits (Belt PO) (Russia, Verkhoyansk-Kolyma orogenic region)

This Neocomian to Aptian (120 to 130 Ma) metallogenic belt is related to granitoids in the Northern granite belt. The metallogenic belt extends sublatitudinally for 200 km along the western margin of the Northern batholithic belt, ranges up to 70 km wide, and crosses the northern block of the Omulevka terrane and the Polousnyy synclinorium. The Northern batholithic belt has $^{40}Ar/^{39}Ar$ ages of 120 to 130 Ma. In the western part of belt are the Marya-Khaya, Mamyandzhu, and Talannakh occurrences, and in the eastern part is the Egekit deposit and other occurrences. The major deposits are at Mamyandzhu, Marya-Khaya, Talannakh, and Egekit.

Ulakhan-Sala Cassiterite-Sulfide-Silicate Vein and Stockwork Deposit

This deposit (V. Arsky and others, written commun., 1963) consists of four quartz-tourmaline and tourmaline-chlorite-quartz veins that range from 320 to 1400 m long and 0.2 to 3.6 m wide. Major minerals are cassiterite, pyrrhotite, arsenopyrite, sphalerite, chalcopyrite, galena, wolframite, scheelite, and calcite. Veins are brecciated. Sn decreases with depth. Wallrocks altered to silica and sulfides. Veins hosted in Late Jurassic sandstone and shale are display minor contact metamorphism. Host rocks form monocline that strikes from north to east. The deposit is small with an average grade of 0.84% Sn.

Aragochan Polymetallic Pb-Zn ± Cu (±Ag, Au) vein and stockwork Deposit

This deposit (V. Shpikerman in Nokleberg and others, 1997) consists of seven sheet-like veins. Veins range from 120 to 700 m long and 0.4 to 1.13 m thick. Major minerals are quartz, calcite, siderite, galena, sphalerite, pyrite, and rare cassiterite. Veins hosted in Upper Jurassic sandstone and shale that dip 60-65° N. The deposit is small with an average grade of of 5.28% Pb, 3.6% Zn.

Origin and Tectonic Controls for Polousnyy Metallogenic Belt

The belt is interpreted as forming during collision of the Kolyma-Omolon superterrane and the North Asian Craton and associated regional metamorphism and generation of anatectic granitoids.

REFERENCES: Bakharev and others, 1988; Trunilina, 1992; Parfenov and others, 2001; Nokleberg and others, 2003.

Yana-Adycha Metallogenic Belt of Cassiterite-Sulfide-Silicate Vein and Stockwork and Sn-W Greisen, Stockwork, and Quartz Vein Deposits (Belt YAd) (Russia, Verkhoyansk-Kolyma Region)

This mid-Cretaceous metallogenic belt (130 to 123 Ma) is related to replacements in the Transverse granite belt. The host Transverse granite belts radiates from the southwestern warp of the Kolyma-Omolon superterrane boundary, and crosscuts at a high angle older folds and faults of the Verkhoyansk fold and thrust belt. The belt contains the Ege-Khaya, Tirekhtyakh, and Derbeke-Nel'gese districts each of which is hoted in part of the Transverse granite belt that bears the same name. The districts strike northeast for 150 to 200 km and range from 10 to 30 km wide. Each district contains several tens of Sn deposits and various occurrences. The major deposits are cassiterite-sulfide-silicate vein and stockwork atEge-Khaya, Ilin-Tas, and Burgochan deposits, and a Sn-W greisen, stockwork, and quartz vein deposit at Kester.

Ege-Khaya Cassiterite-Sulfide-Silicate Vein and Stockwork Deposit

This deposit (Flerov, 1974; V. Spomnor and others, written commun., 1985; Shur, 1985) consists of shear zones, stringers, and less common veins that occur in zones that range from 0.7 to 4 m thick, extend for up to 1 km long, dip steeply, and extend downdip for about 500 m. Host rocks are weakly contact metamorphosed Late Triassic shale and interbedded sandstone. Major minerals are quartz, chlorite, cassiterite, sphalerite, pyrrhotite, pyrite, marcasite, siderite, and calcite. Subordinate minerals are arsenopyrite, galena, stannite, chalcopyrite, wolframite, bismuth, tourmaline, and albite. Sulfides are predominant at depth. Wallrocks exhibit chlorite, silica, and sulfide alteration. Average grades are 0.1 to 3% Sn and 0.1 to 3% Zn. Limited production has occurred. The deposit is medium size.

Kester Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Flerov, 1974; V. Spomnor and others, written commun., 1985; Shur, 1985) consists of greisen with major minerals of quartz, muscovite, albite, K feldspar, molybdenite, zinnwaldite, tourmaline, topaz, amblygonite, apatite, cassiterite, wolframite, and tantaloniobate, and lesser stannite, arsenopyrite, and Pb sulfosalts. Host granite exhibits intense greisen alteration for occurrence of local tourmaline and sulfides. Deposit is irregularly shaped and occurs along the margin of a stock of subalkalic alaskite granite that intrudes the Arga-Ynnakhai granodiorite pluton. Deposit is 80 by 1,200 m in plan view, and extends to a depth of 60 m thick. The deposit is small and is partly mined. Average grades are 0.3% Sn, up to 0.5% Nb_2O_5, and up to 0.35% Li20.

Origin and Tectonic Controls for Yana-Adycha Metallogenic Belt

The belt is interpreted as forming during collision of the Kolyma-Omolon superterrane and the North Asian Craton and occurrence of associated regional metamorphism and generation of anatectic granitoids to form the Transverse granite belt.

REFERENCES: Flerov and others, 1971, 1979; Flerov, 1976; Shour, 1985; Trunilina and others, 1985; Parfenov and others, 1999, 2001; Nokleberg and others, 2003.

Tompo Metallogenic Belt of W±Mo±Be Skarn and Sn-W Greisen, Stockwork, and Quartz Vein Deposits (Belt TO) (Russia, Verkhoyansk-Kolyma Region)

This Neocomian(?) metallogenic belt is related to replacements in the Transverse granite belt that intrudes the southeasterrn part of the Verkhoyansk fold and thrust belt. The belt is about 30 km long, 20 km wide, and occurs the east of the southern termination of the Verkhoyansk metallogenic belt. The occurs along a sublatitudinal zone of high-angle faults, with probable strike-slip components, that crosscut Permian to Middle Jurassic sandstone and shale that occur in sublatitudinal folds. The major granitoid plutons, with surface areas of less than 2 km^2 at at Sosukchan and Erikag. Associated with the granitoid plutons are granitoid dikes swarms and contact metamorphism. The belt major deposits are the Agylky Cu-W±Mo±Be skarn deposit, the largest in the belt, the Erikag and Dzhuptagan cassiterite-silicate-sulfate deposits.

Agylky Cu-W±Mo±Be Skarn Deposit

This deposit (Flerov and others, 1974) consists of pyroxene-garnet-scheelite skarn that occurs in layers of metamsomatized limestone in contact metamorphosed Early Triassic argillite and siltstone. Layers range up to 3 to 5 m thick. Three successive metasomatic mineral assemblages ocur: (1) scheelite-quartz; (2) sulfide; and (3) calcite. Most W occurs in scheelite and rarely in wolframite. Main sulfide minerals are pyrrhotite and chalcopyrite. Subordinate minerals are pyrite, arsenopyrite, stannite, sphalerite, galena, native bismuth, and bismuthine. Contact metamorphosed argillite does not contain ore mienrals. Deposit occurs on limbs of a brachyform anticline in the thermal aureole of an unexposed granitoid intrusion with numerous apophyses of granodiorite porphyry dikes. Deposit dips 20 to 35° on anticline limbs. The deposit is medium size.

Erikag Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Flerov and others, 1974) consists of sulfide-quartz veins and stringers in a zone that occurs parallel to bedding. Veins and stringers extend east-west-trending band that dips steeply south. Major minerals are quartz, pyrite, and stannite. Subordinate minerals are arsenopyrite, lщllingite, cassiterite, bismuthine, bismuth, chalcopyrite, and sphalerite, and minor pyrargyrite and tetrahedrite. Wallrocks exhibit intense chlorite, sericite, and tourmaline alteration. Deposit is hosted in steeply-dipping, contact metamorphosed sandstone and shale in the contact aureole of the Erikag granodiorite pluton that has a K-Ar isotopic age of 125 to 130 Ma.

Origin and Tectonic Controls for Tompo Metallogenic Belt

The belt is interpreted as forming during collision of the Kolyma-Omolon superterrane and the North Asian Craton and associated regional metamorphism and generation of anatectic granitoids in the Transverse granite belt. The belt occurs along sublatitudinal high-angle, probable strike-slip faults that cut Permian to Middle Jurassic sandstone and shale.

REFERENCES: Flerov and others, 1974; Shour, 1985; Parfenov and others, 1999, 2001.

Allakh-Yun' Metallogenic Belt of Au in Shear Zone and Quartz Vein, Cu (±Fe, Au, Ag, Mo) Skarn, and Au in Black Shale Deposits (Belt AY) (Russia, Verkhoyansk-Kolyma Region)

This Late Jurassic metallogenic belt is related to veins that cut the southern Verkhoyansk fold and thrust belt in the North Asian Craton Margin. The belt extends longitudinally for 300 km in the Minorsk-Kiderikinsk zone of highly deformed Late Carboniferous and Permian sedimentary rock in the western South Verkhoyansk synclinorium. The Au in shear zone and quartz vein eposits, that are characteristic in the belt, are relatively older than large anatectic granitic plutons of the South Verkhoyansk synclinorium that have a $^{40}Ar/^{39}Ar$ isotopic age of 120 to 123. The main deposits are concordant and crosscutting veins that occur in hinges and limbs of minor folds. The concordant thin outward into concordant stockworks. Also occurring are tabular deposits along tension fractures. The major deposits are at Yur, Muromets, and Svetly.

Yur Au in Shear Zone and Quartz Vein Deposit

This deposit (Strona, 1960; Kobtseva, written commun., 1988) consists of four interbedded quartz veins that occur along a zone of meridional faults in Middle Carboniferous sandstone and shale. Veins range from 0.3 to 0.4 m thick and are 100 to 500 m long. The main ore minerals are gold, arsenopyrite, galena, pyrite, and sphalerite and comprise up to 2% veins. Gangue minerals are quartz, ankerite, and albite. Wallrock alteration is insignificant and consists of sericite, silica minerals, and arsenopyrite. The deposit is small with an average grade of 3.5 to 5.7 g/t Au.

Muromets Cu (±Fe, Au, Ag, Mo) Skarn Deposit

This deposit (Krasny and Rasskazov, 1975; Nikitin and Rasskazov, 1979) is hosted in Middle Cambrian dolomite along the contact with an Early Cretaceous quartz monzodiorite. Deposit consists of a band skarn bodies that are 1 km long and dip gently (20-40°) under the intrusion. The bodies range from 6 to 12 m thick, and occur in disseminations, stringers, and rare masses. Minor magnesian skarn consists of spinel, forsterite, phlogopite, tremolite, diopside, and serpentine. Predominant limestone skarn consists of salite, diopside, scapolite, grossular, and andradite. Ore minerals are magnetite, chalcopyrite, molybdenite, scheelite, pyrrhotite, bornite, pyrite, galena, and sphalerite. Skarn formed several stages: (1) magnesian skarn with magnetite; (2) calcareous pyroxene-garnet skarn with magnetite and scheelite; and (3) metasomatic quartz-feldspar rock with molybdenite and Cu sulfides. Disseminated Cu sulfides also occurs in adjacent altered quartz monzodiorite is a skarn-related porphyry Cu deposit. The deposit is medium size and grade ranges up to 10% Cu, up to 0.92% WO_3, up to 0.3% Mo.

Origin and Tectonic Controls for Allakh-Yun' Metallogenic Belt

The belt is interpreted as forming during accretion of the Okhotsk terrane to the North Asian Craton. The belt occurs in the Minorsk-Kiderikinsk zone of highly deformed Late Carboniferous and Permian sedimentary rock in the western South Verkhoyansk synclinorium. The deformation associated with formation of the Allakh-Yun' belt occurred in the Late Jurassic and is interpreted as forming during accretion of the Okhotsk terrane to the North Asia Craton.

REFERENCES: Konstantinov and others, 1988; Fridovsky, 1998; Parfenov and others, 1999, 2001.

Chara-Aldan Metallogenic Belt of Au Potassium Metasomatite, U-Au, Au in Shear Zone and Quartz Vein, Au-Ag Epithermal Vein, Au Skarn, Charoite Metasomatite, and Felsic Plutonic U-REE Deposits (Belt CA) (Russia, Aldan-Stanovoy Shield)

This Jurassic to Early Cretaceous metallogenic belt is related to replacements and granitoids in the South Yakutian subalkaline and alkaline igneous belt that intrudes the North Asian Craton and Central Aldan superterrane in the southeastern part of North Asian Craton. The belt consists of Au sheets, veins, crush zones and U-Au zones that are related to the Jurassic and Early Cretaceous subalkaline and alkaline granitoids. The belt contains several districts of Mesozoic subalkaline and alkaline plutons, stocks, and sills of alkali syenite, monzonite, granosyenite, alkali gabbro, and volcanic analogues, and as zoned alkalic ultramafic plutons. These magmatic rocks intrude the Early Precambrian crystalline basement and Vendian and Early Cambrian sedimentary cover of the Aldan-Stanovoy shield. The belt is promising for undiscovered REE and U deposits. The major deposits are at Kuranakh, Klin, Krutoy, and Murunskoye.

Kuranakh Au Potassium Metasomatite (Kuranakh type) Mine

This mine (Benevolskiy, 1995; Fredericksen, 1998; Fredericksen and others, 1999) consists of Au-bearing potassium metasomatite that occurs along horizontal Cambrian calcareous rock and Jurassic sandstone where intruded by lamprophyre dikes emplaced along high-angle fault and especially bedding. Host rocks are Jurassic arkose, Early Cambrian limestone and dolomite, underlying Precambrian metamorphic basement, and abundant Mesozoic plutonic rock. Deposit occurs in subhorizontal sheets that range from a few meters to a few tens of meters thick, and extend for several kilometers along sublongitudinal faults and Mesozoic dikes. Deposit formed during Jurassic and Early Cretaceous intrusion of dike swarms and (or) small plugs and sills of bostonite, microgabbro, and minette. Gold deposits are spatially related to dikes that range from pre-mineral to post-mineral in relative age. Several sub-horizontal deposits occur in blankets or ribbons, range up to a few dozen meters thick, and are located mainly along and (or) above, or under the contact between Cambrian calcareous footwall and overlying Jurassic clastic rock in a long narrow zone that is bounded by several north-south-trending faults. The two types of metasomatite are quartz-adularia and quartz replacing adularia. The main metasomatite minerals are quartz, pyrite, marcasite, gold, Ag, bismuth, pyrrhotite, chalcopyrite, arsenopyrite, galena, sphalerite, carbonate, and barite. The main part of the Au deposits contain pyrite, arsenopyrite, sphalerite, and galena with sulfide comprising only a few percent of rock volume. The deposit is thoroughly oxidized and only a few traces of arsenopyrite and pyrite occur. The Au occurs primarily as grains less than 5 microns in size and usually contains friable porous goethite. Fluid inclusion homogenization temperatures range from 80°C to 220°C but generally averaging 110°C to 160°C. Metasomatite is controlled by interplate rift structures. Local parts of complicated by formation of karst cavities with deposition of secondary rubble ore, and by surficial weathering of ore minerals and replacement of Au. The Kuranakh deposit was discovered in 1947 and modest production began in 1955. Large scale open pit mining began in 1965 and continues to the present. The Kuranakh mine is one of the largest lode gold mines in Russia. Gold recovery averages 83% using resin columns. The deposit is large with production of 7.1 million ounces of gold through 1997 from 74.1 million tonnes of ore grading 3.57 g/t Au.

El'kon Group of Au in Shear Zone and Quartz Vein Deposits

The El'kon group of Au in shear zone and quartz vein deposits (Naumov and Shumilin, 1994; Boitsov and Pilipenko, 1998) occurs on the eastern margin of the Central Aldan ore district that contains several hydrothermal deposits that occur along northwestern striking Mesozoic faults that cut the crystalline basement of the Aldan-Stanovoy shield. These deposits contain the largest U reserves in Russia. Three types of deposits occur, Au-brannerite, Au-uraninite, and Au-Ag brannerite. Au-brannerite deposits consist of metasomatite zones that extend up to 20 km long, range from1.0 to 40 m thick, and formed from replacement of host gneiss, schist, metadiorite, and blastomylonite. The sequence of mineral assemblages is: (1) pyrite, ankerite, and K-feldspar; (2) pyrite, dolomite, K-feldspar; and (3) calcite and adularia. Au grade in pyrite of the first assemblage is 60 to 90 g/t. The third assemblage contains native gold and ranges up to 40 to 100 g/t. Brannerite is the only U mineral in the metasomatite and occurs in a matrix of microbreccia and veinlets. Typical U ore shoots extend for 20 km and form distinct deposits (Druzhnoye, Kurung, El'kon Plato, El'kon). Au-uraninite deposits occur in the northwestern part of the belt (Nadezhnoye and Interesnoye deposits) and consist auriferous pyrite-carbonate-K-feldspar metasomatite with superposed U. Brannerite-Au-Ag deposits are characteristic of the Fedorovskoye deposit in the southern area that consists of a metasomatite zone that ranges from 8 to 30 km thick and, is 10 km long, contains U minerals. The metasomatite and brannerite deposits are overprinted by a late-stage mineral assemblage of quartz, carbonate, native gold, native silver, and acanthite. Grades range from 3 to 10 g/t Au, 15 to 200 g/t (up to 1400 g/t) Ag, and 0.02 to 0.5% U.

Murunskoe-Tokski Group of Charoite Metasomatite Deposits

The Murun-Tokski group (Konev and others, 1996) occurs in western Northern Tranabaikalia along the margin of the West-Aldan cratonal terrane, and is related to magmatic complexes of the overlap Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt. The major deposit is at Murunskoye. The group of deposits occurs in the extreme northeastern of Baikal-Patom highland, extends northeast for 200 km, and ranges up to 75 km wide. The Middle to Late Jurassic igneous rocks of the Transbaikaliaian sedimentary and volcanic-plutonic belt consist of minor ultrapotassic and alkaline intrusions (stocks and laccolith), and subvolcanic rock of the Aldan Complex. The igneous rocks occur at intersections of large faults that trend northeast, northwest and submeridional (Atbastakh-Torgoy and others) that cut the periphery of the Archean Chara block. The main igneous rock types are Ka-Na nepheline syenite, alkaline syenite, quartz syenite, alkaline granite, biotite pyroxenite, lamproite, ijolite, leucite fergusite, and shonkinite. Zones of alkaline metasomatite occur along margins of alkaline intrusions. The deposit-hosting Murun laccolith is a zoned intrusive complex composed of syenite, alkaline syenite, and fenite, and is surrounded by alkaline ring dikes (Alekseev, 1984; Konev and others, 1996). Comagmatic trachyte lavs occurs in separate volcanic structures that are mostly eroded. This laccolith contains a wide spectrum of high- and medium-temperature hydrothermal deposits (Th-Ti, Th-U, U) and metasomate that contain charoite as the major useful mineral. This deposit is the only global occurrence of charoite. The charoite bodies occur in veins and irregular shapes in metasomatite.

Origin and Tectonic Controls for Chara-Aldan Metallogenic Belt

The belt is interpreted as forming in a back-arc region of an Andean-type continental margin arc that formed along the Early Cretaceous margin of the North Asian Craton. The belt is hosted in subalkaline and alkaline plutons, stocks, and sills of syenite, monzonite, granosyenite, and alkali gabbro, and volcanic analogues, and in zoned alkalic ultramafic plutons.

REFERENCES: Kazarinov, 1969; Alexeev, 1984; Naumov and Shumilin, 1994; Konev and others, 1996; Vetluzhskikh and Kim, 1997; Miguta, 1997; Boitsov and Pilipenko, 1998; Parfenov and others, 1999, 2001; Fredericksen and others, 1999; S.M. Rodionov, this study.

Kondyor-Feklistov Metallogenic Belt of Zoned Mafic-Ultramafic Cr-PGE Deposits (Belt KDF) (Russia, Far East)

This Early Cretaceous metallogenic belt is related to several zoned mafic-ultramafic intrusions that occur along a northwest-trending, major, buried fault that cuts the southeastern Stanovoy block of the North Asian Craton and the northeastern part of Galam terrane. The belt contains the large zoned mafic-ultramafic Kondyor Cr-PGE deposit at and the Chad (Mokhovoy) and Feklistov (Shantar Islands) deposit. The major deposit is at Kondyor.

Kondyor Zoned Mafic-Ultramafic Cr-PGE Deposit

This deposit (Marakushev and others, 1990; Zalishchak and others, 1993; Bundtzen and Sidorov, 1998; Bakulin and others, 1999) is hosted in the Kondyor pluton and consists of two types: (1) short lenses, veins, and disseminations that areabout 2 to 50 m long and range up to few m thick that occur in the central part of a dunite stock; and (2) oval-shaped, roughly equidimensional metasomatite with dimensions of about 200 by 300 m. The first type contains PGE minerals in intergrowths with chromite and olivine; and in small inclusions. Isoferro Pt is the major PGE mineral. The second type consists of PGE minerals that form intergrowths with magnetite, pyroxene, and rarely with metasomatic phlogopite, chrome diopside, and magnetite. This type of deposit is intruded by alkalic igneous veins and dikes including nepheline syenite, lujavrite, ijolite, and urtite. In addition to isoferro Pt and tetraferro Pt, the deposit contain up to 5 to 8% sulfide and As minerals. Controversy exists about the age and tectonic environment for the host mafic and ultramafic rock. The host rocks were originally interpreted as an integral part of the Neoproterozoic and older cratonal rock of the Stanovoy block of the North Asian Craton. However, A.I. Khanchuk (written commun, 1994) interprets the mafic and ultramafic rock as Jurassic because the intrusions are similar in composition to other Jurassic plutons of the Ariadny igneous belt. This igneous belt is interpreted as forming possibly immediately before Late Jurassic accretion in the region, or possibly in the mid-Cretaceous. Unpublished K-Ar isotopic ages for the zoned mafic-ultramafic intrusions in the Kondyor metallogenic belt range from 110 to 160 Ma (A.M. Lennikov, written commun., 1993). An Ar-Ar isotopic age of 127 Ma (Early Cretaceous) was recently obtained for the alkalic mafic and ultramafic igneous rocks at Ingagli (Dalrymple and others, 1995) that may be part of the same igneous belt that hosts the Kondyor metallogenic belt. The deposit is medium size with about 13.5 tonnes PGE produced from 1984-1993. Annual production of about 2.5 to 3.0 tonnes PGE since 1993. In 1999, approximately 2.9 tonnes PGE were produced.

Origin and Tectonic Controls for Kondyor-Feklistov Metallogenic Belt

The belt is interpreted as forming during interplate intrusion of mafic-ultramafic plutons along a major fault that formed along the North Asian Craton margin during collision and accretion of outboard terranes during the Early Cretaceous.

REFERENCES: Nokleberg and others 1997, 1998, 2003; Marakushev and others, 1990; A.I. Khanchuk, written commun, 1994; Dalrymple and others, 1995.

Mavrinsk Metallogenic Belt of Clastic Sediment-Hosted Hg Deposits (Belt MV) (Salair Range, Russia, Eastern Siberia)

This Early Jurassic or younger metallogenic belt is related to replacements along a major fault between the Salair terrane and Kuznetsk orogenic basin. The belt extends northwest for about 150 km along the eastern slope of Salair Range and contains two en-echelon branchs that contain the Mavrinsk-Matveevsk and Orlinogorsk districts. Spatial distribution of Hg deposits is determined by the en-echelon fault and fissure systems. The more important Mavrinsk-Matveevsk district occurs in the northern belt. The deposits are the barite-cinnabar mineral type (Kuznetsov and others, 1978) with typical association of Hg, barite, and fluorite. The major deposits are at Mavrinskoye and Orlinogorskoye.

Mavrinskoye Clastic-Sediment-Hosted Hg Deposit

This deposit (Kuznetsov and others, 1978) consists of Hg minerals in a fracture zone related to a fault that curs a graben of Devonian volcanic and sedimentary rock from Cambrian limestone, sandstone, and quartzite. The Hg deposits occur in crush zones along the margin of, and in quartzite.Ore minerals occur in breccia and disseminations. Main ore minerals is cinnabar, and accessory mineals are pyrite, barite, fluorite, quartz, and calcite. The deposit is small.

Orlinogorskoye Clastic-Sediment- Hosted Hg Deposit

This deposit (Kuznetsov and others, 1978) occurs along a fault zone between the Middle Cambrian volcanic and sedimentary rock and Late Cambrian calcareous sandstone. The Hg minerals occur beneath stratified Fe-quartzite and hematite that serve as structural and lithologic screen. Ore minerals occur in disseminations, streaks, masses, lenses, and nests. Main ore minerals are cinnabar, schwazite, pyrite, and hematite, and gangue minerals are quartz, barite, dickite, and calcite. Host porphyry, tuff, and sandstone are generally hydrothermally altered to argillite, partly silica, and barite. The deposit is small.

Origin and Tectonic Controls for Mavrinsk Metallogenic Belt

The belt and other Hg belts in the Altai-Sayan region are interpreted as forming during intraplate rifting and interblock strike-slip faulting during the Late Paleozoic to Early Mesozoic (Kuznetsov and others, 1978; Obolenskiy and others, 1999). Rifting was accompanied by diabase and alkali basalt intrusions in dike swarms. A K-Ar isotopic age for lamprophyre dikes is 190 to 200 Ma, and establishes a minimum age for the Hg deposits (Obolenskaya, 1983; Obolenskiy, 1985).

REFERENCES: Kuznetsov and others, 1978; Obolenskaya, 1983; Obolenskiy, 1985; Obolenskiy and others, 1999.

Kuznetsk Metallogenic Belt of Volcanic-Hosted Hg and Carbonate-Hosted Hg-Sb Deposits (Belt KE) (Russia, Eastern Siberia)

This Middle to Late Jurassic metallogenic belt is related to replacements along major faults that cut the Kuznetsk orogenic basin, Altai volcanic-plutonic belt, and Telbes-Kitat island-arc terrane. The belt extends from north-south for about 150 km along the boundary of the Kuznetsk Alatau fold belt and the Kuznetsk Basin in the southwestern Altai-Sayan region. The major deposits are the Kupriyanovskoye and Belo-Osipovskoye volcanic-hosted Hg deposit and the Pezass carbonate-hosted Hg deposit (Obolenskiy and others, 1968).

Belo-Osipovskoye Volcanic-hosted Hg Deposit

This deposit (Kuznetsov and others, 1978; Obolenskiy and others, 1968) consists of a steeply-dipping crush zone that strikes strike and occurs along the contact between a andesite-basalt porphyry dike and volcanic and Middle Devonian sedimentary rock. The zone is 800 m long and ranges from 0.5 to 1.5 m thick. Ore minerals are irregularly spaced and occur mainly in disseminations streaks, and breccia. Main ore minerals are cinnabar, pyrite, and marcasite, and lesser Hg-sphalerite. Gangue minerals are kaolinite, dickite, and quartz, and rare dolomite and calcite. Host rocks are altered to argillite. The deposit is partly mined and is small.

Pezass Carbonate-hosted Hg-Sb Deposit

This deposit (Kuznetsov and others, 1978) consists of Hg minerals in feathering fracture zones along the the Kuznetsk fault that cuts Riphean marble. Fracture zones extend up several hundreds of meters length, and range up to 10 m thick in swells. Hg minerals occur in small nests, veinlets and disseminations, and in breccia cement. The major ore minerals are cinnabar and pyrite, and gangue minerals are calcite, quartz, and Fe-carbonate. Cinnabar occurs along a 40 m strike interval, extends downdip to 40 to 70 m, and pinches out. The deposit is small.

Origin and Tectonic Controls for Kuznetsk Metallogenic Belt

The belt is interpreted as forming during intraplate rifting and interblock strike-slip faulting during the Late Paleozoic to early Mesozoic. The belt occurs along the Kuznetsk fault (Kuznetsov and others, 1978; Berzin and others, 1994; Obolenskiy and others, 1999). The deposits are controlled by the feathering branches of the Kuznetsk fault. The host rocks are Riphean and Cambrian carbonate and metamorphic rock, and overlapping Devonian volcanic and sedimentary rock, and late Paleozoic age and younger Mesozoic rock in small blocks along major fault zone. The deposit-controlling fault is a steeply-dipping structure and is not a favorable structures for ore minerals (Kuznetsov and others, 1978).

REFERENCES: Obolenskiy and others, 1968, 1999; Kuznetsov and others, 1978; Berzin and others, 1994.

Sistigkhem Metallogenic Belt of Clastic-Sediment-Hosted Hg Deposits (Belt SS) (Russia, Tuva)

This Middle to Late Jurassic. metallogenic belt is related to replacements that occur along and adjacent to the Khemchic-Kurtushiba fault and related conjugate faults between the Kurtushiba and Alambai terranes in northeastern Tuva. The belt extends northwest, and most of the ocurrences are hosted in Ordovician sandstone and shale and occur in fracture zones among a Paleozoic granitoid. The Kukshinskoye Hg occurrence is hosted in Middle Devonian volcanic and sedimentary rock. The belt contains several small occurrences as at Kukshinskoye and Oktyabrskoye.

Kukshinskoye Clastic-Sediment-hosted Hg Occurrence

This occurrence (Kuznetsov and others, 1978) consists of small mineralized fracture zones in Middle Devonian volcanic and sedimentary rock (Kuznetsov and others, 1978). The occurrence consists of cinnabar in thin veinlets and disseminations in hydrothermally-altered tuff and sandstone. Argillic alteration is typical. The deposit is small.

Oktyabrskoye 2 Clastic-Sediment-hosted Hg Occurrence

This occurrence (Kuznetsov, 1981) consists of a fracture zone in plagiogranite intruding Early Cambrian volcanic rock (Kuznetsov, 1981). Cinnabar occurs as fillings and thin coatings The occurrence is poorly studied. Average grade is 0.1% Hg.

Origin and Tectonic Controls for Sistigkhem Metallogenic Belt

The belt is interpreted as related to magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment.

REFERENCES: Kuznetsov, 1981; Kuznetsov and others, 1978

Eravninsky Metallogenic Belt of Cassiterite-Sulfide-Silicate Vein and Stockwork and Carbonate-Hosted Fluorspar Deposits (Belt Era) (Russia, Western Transbaikalia)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to replacements and volcanic complexes in the Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that intrudes and overlaps the Orhon-Ikatsky terrane, the Barguzin-Vitim granitoid belt, and the Selenga sedimentary-volcanic plutonic belt. The belt occurs in Western Transbaikalia in the Ikatsky Range and Vitim lowland along Kydzhimit River, a tributary of Vitim River. The belt extends for 375 km and ranges from 25 to 115 km wide. The age of the Transbaikalia sedimentary and volcanic-plutonic belt Middle Jurassic through Early Cretaceous. The major deposits are at Kydzhimitskoye and Egitinskoye.

The major varieties of cassiterite-sulfide-silicate vein and stockwork deposits in the belt are: (1) a Sn-sulfide deposit at Kydzhimitskoye, Sn-sulfide-polymetallic and Sn-polymetallic deposits at Khortyakskoye, Zhirondinskoye, and Malo-Yarovoy, and Sn-skarn deposits at Levo-Kydzhimit, Vysotnoye, and Ara-Zazinskoye; (2) cassiterite-quartz, greisen and quartz-vein deposits; and (3) Sn pegmatite. The second and third varities are not economically significant. Also occurring are local carbonate-hosted fluorspar deposits ast at Egitinskoye, Kluchevskoye, and Gorsonskoye. The deposits are controlled by the major Turka-Vitim fault that trends east-west. The cassiterite-sulfide-silicate vein and stockwork and stockwork deposits along the the axial part of the fault, and cassiterite-quartz and pegmatite occurrences are along the fault periphery. A spatial combination of Sn-sulfide, Sn polymetallic and Sn skarn deposits occurs along some structures. For example, Sn-polymetallic deposits occurs in upper levels and , Sn sulfide deposits occur in lower levels, and Sn-skarn deposits are hosted in carbonate rock. The Sn sulfide and Sn sulfide-polymetallic deposits are usually hosted in quartz-tourmaline rock and cassiterite is the main mineral. The Sn sulfide deposits contain arsenopyrite, pyrrhotite, chalcopyrite, and the Sn sulfide-polymetallic deposits contain galena, sphalerite, pyrite, and arsenopyrite. Host rocks are metamorphosed clastic and carbonate and volcanic rock, stocks of Paleozoic syenite, diorite, leucocratic granite and granosyenite. The deposits are closely related to Mesozoic diorite porphyry, microdiorite, and lamprophyres dikes.

The carbonate-hosted fluorspar deposits occur in the large Eravna xenolith of carbonate rock in a late Paleozoic granitoid adjacent to a fault that separates a horst and intermontane basin (Korotaev and others, 1986; Bulnaev, 1995). The deposits are related to Middle to Late Jurassic diabase, basalt, trachyrhyolite, and trachydacite porphyry dikes in a subvolcanic complex. The deposits are most closely associated with the latter two lithologies. Numerous deposits occurring in layers and lensoids define several districts. The deposit occur in breccia, layers, veinlets, and disseminations, and consist quartz, fluorite, and calcite.

Egitinskoye Carbonate-Hosted Fluorspar Deposit

This deposit (Popov, 1981; Korotaev and others, 1986; Bulnaev, 1995) consists of 23 bodies and a series of small lenses in three deposits (600-1000 x 400 x 230 x 270 m) that extend for 200-400 m. Three gently-lying, bedded, metasomatic occurrences (100-760 x 4-12 x 50-310 m) consist of breccia with clasts of limestone and argillite cemented by quartz-fluorite aggregate. Also occurring are massive and poorly-consolidated bodies. The major minerals are quartz, fluorite, calcite; minor-clay minerals, feldspars, Fe hydroxides (goethite and hematite), fluorine-apatite; and local magnetite, ilmenite, rutile, sphene, pyrite, chalcopyrite, galena, and sphalerite. $CaCO_3$ grade ranges up to 5-15%; $Si0_2$ about 15%; Al_20_3 about 5.4%; P_20_5 0.7%. Local average and high grades. Deposit is confined occurs at SE termination of a small xenolith (4 sq.km.) of Early Cambrian carbonate rock in middle Paleozoic granitoids. The deposit is large with an average grade of 53.2% CaF_2, and reserves of 4.2 million tonnes ore.

Kydzhimitskoye Cassiterite-Sulfide-Silicate Vein and Stockwork Deposit

This deposit (Komarov and others, 1978; Shobogorov and others, 1983; Ignatovich and Martos, 1986; Belogolov and Sizykh, 1988) consists of veins and layers in four zone fractures that strike sublatitudinally, and are two km long and up to 30-40 m thick. The veins and layers consist of brecciated quartz-tourmaline metasomatite with sizes of 1500 by 220 by1-128 m and that occur in metamorphosed Early Carboniferous sandy shale and volcanic rocks. The main ore minerals are tourmaline, quartz, cassiterite, arsenopyrite, chlorite, galena, and sphalerite; minor rutile, ilmenite, scheelite, pyrrhotite, pyrite, chalocopyrite, magnetite, hematite, lollingite, and bismuth. Economically important are en-echelon lenses (with dimensions of 20 by 45 m) of arsenopyrite and cassiterite in the zones. The deposit contains dikes of Mesozoic diorite porphyry, microdiorite, spessartite that intrude the flanks of Triassic granite plutons and middle and late Paleozoic stocks of syenite, diorite, leucoratic granite, and granosyenites. The host rocks are altered to K-feldspar, greisen, and chlorite. The deposit is small.

Origin and Tectonic Controls for Eravninsky Metallogenic Belt

The belt is interpreted as related to magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment.

REFERENCES: Belichenko, 1969, 1977; Korotaev and others, 1986; Bulnaev, 1995.

Karengskiy Metallogenic Belt of Porphyry Mo (±W, Sn, Bi) Deposits (Belt Krg) (Russia, Eastern Transbaikalia)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to granitoids and volcanic complexes related to Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that intrudes and overlaps the West Stanovoy terrane, the Barguzin-Vitim granitoid belt, and the Selenga sedimentary-volcanic plutonic belt. The belt occurs on the northwestern branches of the Chersky Range in the Eastern Transbaikalia where it extends northeast along Kirenga River covering the midstream of Vitim River. The belt is 350 km long and 70 km wide. The host Mesozoic intrusions consist of coarse-, medium-and fine-grained biotitic granite porphyry in the Amanan and Amudzhikan complexes that are intruded by numerous granite porphyry, andesite, diabase, microdiorite, pegmatite, and fine-grained granite dikes. The belt is fairly promising for undiscovered porphyhry Mo deposits, and Au and fluorite deposits.The porphyry Mo (±W, Bi) deposits in the belt are related to Mesozoic intrusions and associated dikes. Deposits at Orekitkanskoye, Saivakinskoye, Orogochinskoye and Yablonovskoye occur along northeast-striking faults zones. The deposits consist of stockwork and veinlets with quartz and molybdenite, and rare pyrite, quartz, and beryl, and quartz and wolframite (Pokalov, 1972; Ignatovich and Scheglov, 1968; Bulnaev, 1995).

Orekitkanskoye Porphyry Mo (±W, Sn, Bi) Deposit

This deposit (Yablokov, 1963; Ignatovich and Scheglov, 1968; Bulnaev, 1995) consists of an intricate stockwork (with dimensions of 2100 by 1600 m) that forms three bodies with 0.03% Mo. The stockwork consists of a dense network of quartz-molybdenum and sparse pyrite-quartz-beryl, molybdenum, and quartz-wolframite veinlets and rare quartz veins. The main ore minerals are molybdenite, pyrite, pyrrhotite, and magnetite and minor galena, sphalerite, chalcopyrite, wolframite, beryl, and bismuth. Gangue minerals are quartz, calcite, muscovite, and fluorite. The stockwork occurs along the southeastern exocontact of the Early and Middle Jurassic Orekitkan granitoid massif that occurs along a shallowly-dipping fault that is traced to a 500 m depth. The host rocks are coarse-grained early Paleozoicgranite that is intensely altered to greisen composed of quartz, feldspar, muscovite, wolframite, molybdenite, pyrite, ilmeno-rutile, and fluorite. Molybdenum contains about 20-30 ppm of Re, Se, and Te. The deposit contains low grade W, Be, F, Pb, Zn, Cu, Bi, and Nb. The deposit is large and grades 0.15%-0.40% Mo

Origin and Tectonic Controls for Karengskiy Metallogenic Belt

The belt is interpreted as related to magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment.

REFERENCES: Ignatovich and Scheglov, 1968; Pokalov, 1972; Bulnaev, 1995.

Nerchinskiy Metallogenic Belt of Granitoid-Related Au Vein, W-Mo-Be Greisen, Stockwork, and Quartz Vein, and Fluorspar Vein Deposits (Belt Ner) (Russia, Eastern Transbaikalia)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to granitoids and volcanic complexes related to Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that intrudes and overlaps the Western Stanovoy terrane, Barguzin-Vitim granitoid belt, and theSelenga and Transbaikalia sedimentary and volcanic-plutonic belts. The northeast-to east-trending belt occurs in the Chersky Range in the watershed of the Uruljunguy and Nercha Rivers and the upper Olekma River. The belt is 1025 km long and 85 km wide. The host Mesozoic intrusions consist of coarse-, medium-and fine-grained biotitic granite porphyry in the Amanan and Amudzhikan complexes that are intruded by numerous granite porphyry, andesite, diabase, microdiorite, pegmatite, and fine-grained granite dikes. The major deposits are at Darasun, Teremkinskoye, Talatuyskoye, Muoklokanskoye, and Usuglinskoye.

The the major deposits in the belt are: (1) major granitoid-related Au vein type deposits at Darasun, Teremkinskoye, and Talatuyskoye, and numerous small deposits); (2) W-Mo-Be greisen, stockwork, and quartz vein deposits at Muoklokan W and elsewhere; and (3) fluorspar vein deposits at Usuglinskoye, Uluntuy, and elsewhere. All deposits contain numerous components formed in multiple stages. The Au deposits occur in zoned volcanic-tectonic structures (Seminsky and others, 1987, 1994; Zorina, 1993; Zorina and others, 1989), and are related to Mesozoic subvolcanic bodies of mainly granodiorite porphyry, and rare granite and diorite porphyry (Tauson and others, 1987). The vein form of deposits and a distinct relationship to local extrusive domes and volcanic basins structures is common. Also occurring in the belt are Wo-Mo hydrothermal deposits and W hubnerite-sulfide deposits in quartz veins, vein zones, and stockworks that are related to Mesozoic granitoid plutons. The fluorite deposits occur in basins filled with Late Jurassic and Early Cretaceous sedimentary and volcanic rock and occur near margins of widespread Late Jurassic granodiorite and granosyenite porphyry plutons that contain numerous Paleoproterozoic metamorphic rock xenoliths with granitic gneiss, schist, and migmatite. The deposits consist of quartz-fluorite veins (Soloviev and Struve, 1959; Yakzhin, 1962; Kotov, 1995). The belt is prospective for undiscovered Au,W, fluorite, and associated deposits.

Darasunskoye Granitoid-Related Au Vein Deposit

This deposit (Zvyagin and Sizikov, 1971) consists of over 120 steeply-dipping quartz-sulfide veins that extend along strike for 1.0-1.2 km. The zone of veins ranges from 100 to 1000 m thick and individual veins range from 5-20 cm thick. A zone of wall rock marginal to the veins is about 0.6-1.5 m thick and contains disseminated sulfides. The ore minerals comprise the complex Darasun sulfide-sulfosalt type with up to 40-60% sulfides. The main ore minerals are pyrite, arsenopyrite, chalcopyrite, pyrrhotite, galena, sphalerite, Pb, Cu, Ag, Bi, As, Sb sulfosalts, tellurides, native gold, quartz, carbonates, and tourmaline. The principal economic gold-bearing mineral assemblages are: chalcopyrite-gray ore, chalcopyrite-pyrrhotite, pyrite-arsenopyrite, and sphalerite-galena. Gold occurs in arsenopyrite, pyrite, chalcopyrite, pyrrhotite, and gray ore, and is finely dispersed. The deposit ocurs along the Mongol-Okhotsk suture high Middle and late Cretacous K granodiorite-porphyry that intrudes a volcanic dome. The porphyry is accompanied by dikes of diorite and granodiorite porphyry, and explosive breccia. The deposit occurs both in the intrusion and in the enclosing early Paleozoic gabbro, middle Paleozoic granodiorite, and in late Paleozoic and Triassic granite. Host rocks are altered to propylite. The deposit is large with grades up to a few to 300 ppm Au and an average grade 6.5 ppm Au

Muoklakanskoye W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Sizykh and others, 1985; Skursky, 1996) consists of two subparallel zones that host 30 steeply dipping quartz-hubnerite-sulfide veins (with dimensions of 300-600 by 0.5 by 2.0 m). The first zone contains a series veinlets and about 1.0% WO_3, up to 1400 ppm Ag, and to 3.4 ppm Au. The second zone contains three large quartz veins and several small ones and grades 0.45% WO_3. The ore minerals are quartz, hubnerite, muscovite, native gold, molybdenite, sphalerite, galena, chalcopyrite, and calcite. Host rocks are altered to K-feldspar, beresite, and silica. The deposit is hosted in Archean granitic gneiss, plagiogneiss, amphibolite, and diopside quartzite along the exocontact of the Middle and Late Jurassic Dzhekdachinsky granite massif that intrudes the Archean Muoklakan block. The deposit is small with an average grade of 0.8% WO_3.

Usuglinskoye Fluorspar vein Deposit

This deposit (Soloviev and Struve, 1959; Yakzhin, 1962; Kotov, 1995) is hosted in seven fault zones that strike northwest and occur in an area from 1-3 km wide. The zones contain extensive, steeply-dipping veins that extend from 800-3000 m, range from 0.3-1.8 m thick, and extend to a depth of100-400 m. The deposits occur in pillars that range form 8-45 m thick. The ore minerals are fluorite and quartz (90%), minor kaolinite, and rare dikkite, narkite, hydromicas, barite, calcite, pyrite, apatite, rutile, sphene, calcite, and sericite. The deposits occur in masses, layers, breccia, and veinlets. The vein texture is symmetrically banded with a variable color for fluorite. The main mineral assemblage is quartz-fluorite. Sulfur grade is about about 0.12% with 0.01-0.16% P_2O_5. The deposit is hosted in Neoproterozoic and early Paleozoic granite and granodiorite along the northern edge of a late Mesozoic basin filled with Middle Jurassic through Early Cretaceous terrigenous, volcanic, and sedimentary rock. The deposit is medium size with resources of 2.9 million tonnes CaF_2 grading 64% CaF_2.

Origin and Tectonic Controls for Nerchinsky Metallogenic Belt

The belt is interpreted as related to magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment. The belt is related to granitoids in the Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt.

REFERENCES: Struve, 1959; Yakzhin, 1962; Seminsky and others, 1987; Soloviev, Tauson and others, 1987; Zorina and others, 1989; Zorina, 1993; Seminsky and others, 1994; Kotov, 1995.

Shilkinsko-Tukuringrskiy Metallogenic Belt of Granitoid-Related Au Vein, Porphyry Au, Au Skarn, Au-Ag Epithermal Vein, Porphyry Mo (±W, Bi), W-Mo-Be Greisen, Stockwork, and Quartz Vein, Cassiterite-Sulfide-Silicate Vein and Stockwork, Ta-Nb-REE Alkaline Metasomatite, Polymetallic (Pb, Zn ± Cu, Ba, Ag, Au) Metasomatic Carbonate-Hosted, Au-Ag Epithermal Vein, and Fluorspar Vein Deposits (Belt ShT) (Russia, Eastern Transbaikalia)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to granitoids, volcanic rocks, and replacements related to Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that intrudes and overlaps the West Stanovoy, Ononsky, and Argunsky terranes and adjacent units. The belt occurs in Eastern Transbaikalia along the Onon River, the Borschovochny Range, and the Shilka River. The belt extends for 1000 km and varies from 50 to 125 km wide. The belt contains numerous major deposits at Ukonikskoye, Itakinskoye, Aleksandrovskoye, Kluchevskoye, Kariyskoye, Aprelkovskoye, Baleiskoye, Sredne-Golgotaiskoye, Fatimovskoye, Shunduinskoye; Delmachik; Andryushkinskoye; Taseyevskoye; Davendinskoye, Zhirekenskoye; Belukhinskoye, Bukukinskoye; Sherlovogorskoye; Etykinskoye; Yekaterininskoye; Kalanguyskoye, Tamenskoye, Zhetkovskoye, Kirovskoe, Berezitovoe.

The Au, Mo, W, Sn, Pb, Ta, Nb and F deposits are related to Middle and Late Jurassic and Early Cretaceous granitoids that occur along the Mongol-Okhotsk suture. The Au, Mo, and polymetallic deposits are related to Middle and Late Jurassic, and Early Cretaceous granitoids. The Jurassic granitoids are mainly granite and granodiorite with rare granosyenite and diorite. Also occurring are granite, granodiorite, and diorite porphyry subvolcanic bodies. Associated extrusive rocks are rhyolite, dacite, latite, andesite, shoshonite, and basalt. The deposits and occurrences are commonly located in domes, dome rings, and basins and are spatially and temporally related to minor stocks, sills, and dikes of granodiorite, granite, diorite, and felsite porphyry. Vein deposits are concentrated around stocks and dikes, inside stocks, and in explosive breccias. Stocks are surrounded a zoned, decreasing temperature mineral assemblages (Seminsky, 1980; Zorina, 1993; Seminsky and others, 1994; Spiridonov, Gnilusha, 1995; Tauson and others, 1987; Jurgenson, Grabeklis, 1995). The belt contains major Au deposits (Fogelman, 1968; Geology and regularities…, 1970; Zorin and others, 1998; Zorin, 1999).

Granitoid-related Au vein deposits are dominant in the belt and consist of low-sulfide (Fatimovskoye, Shunduinskoye), medium-sulfide (Kluchevskoye, Sredne-Golgotaiskoye, Kirovskoe, Berezitovoe) and high-sulfide (Uonikskoye, Itakinskoye, Aleksandrovskoye, Karyiskoye, Aprelkovskoye) deposits. The center of the Au deposits is intersection of the Onon fault with the main Mongol-Okhotsk suture. This area also contains low-and medium-sulfide (Sredne-Golgotaysky), Au skarn (Andryushkinskoye), porphyry Au (Delmachik), and Au-Ag epithermal vein (Baley and Taseevsky) deposits that formed in Early Cretaceous rifting during formed the Baley graben. The characteristics of Au deposits evolve along the suture from the center to the northeast. Along this direction, the granitoid-related Au vein deposits exhibit an increase of sulfides (pyrite, arsenopyrite, chalcopyrite, galena, sphalerite), occurrence of sulfide deposits, and intense occurrence of tourmaline (Kluchevskoye), and Sb deposits (Itakinsky) tp the extreme northeast. This part of belt also includes large porphyry Mo (±W, Sn, Bi) deposits (Davendinsky, Zhirekensky), and rare polymetallic (Pb, Zn±Cu, Ba, Ag, Au) metasomatic carbonate and hosted deposits (Yekaterininsky).

The belt also contains various Sn-W greisen, stockwork, and quartz vein (Belukhinsky, Bukukinsky) deposits, cassiterite-sulfide-silicate vein and stockwork deposits (Sherlovogorsky, Bolshaya Sopka, Tourmaline Otrog, Vostochny), Ta-Nb-REE alkaline metasomatite deposits (Etykinsky), and fluorine vein (Kalanguysky, Tamensky, Zhetkovsky) deposits. These deposits occur along the southwestern flank of the belt in the Onon fault that cuts the Aginsky terrane. The deposits are related to Middle and Late Jurassic granite porphyry stocks, Late Jurassic leucocratic and amazonite granite plutons, and Early Cretaceous diorite, granodiorite, and granite porphyry dikes. This area contains greisen with silica and tourmaline alteration. The belt is promising for undiscovered Au, Mo, W, Sn, Ta, Ni, and fluorite deposits.

Baleyskoe Au-Ag Epithermal Vein Deposit

This deposit (Petrovskaya and others, 1961; Yurgenson and Grabeklis, 1995) consists of quartz veins and zones of small veinlet and stockwork mineralization. Ore bodies are located in concentric gently-lying zones and in steeply dipping ruptured fractures. The former represent lenticular short and thin quartz veins,. the latter have complicated morphology. In the northern part of the deposit differently oriented veins in granitoids produce stockwork (about 1 sq.km) extended over vertical line. In places ore pillar are the case. Mineralization is penetrated by boreholes to 0.8-1 km depth. Ore is composed of adular, chalcedony, quartz, kaolinite, carbonate, pyrite, chalcopyrite, arsenopyrite, markasite. In places there are gold-enriched stibial sulphosalts Cu, Pb, Ag, the most predominant are pyrargyrite and grey ore. Sulfides make up 0.5-1.5%. Finess of gold 680-780, finely dispresed, high silver (to electrum), quartz-associated. The enclosing rocks are granodiorites, volcanics of dacite-andesite somposition, conglomerates, sandstones, aleurolites. Dykes of diorite porphyrites. Near-ore alterations - propilitization, beretization, argillitization. The deposit formed in the Early Cretaceous epoch of rifting and is located in the Baley graben in the zone of Mongol-Okhotsky suture.

Berezitovoe Polymetallic Pb-Zn±Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (A.K. Ivashchenko and A.A. Kuzin, written commun., 1982; Vakh, 1989) consists of massive Pb-Zn sulfides that occur in a lenticular, northwest-striking, steeply-dipping (75-85°) zone that ranges up to 1000 m long and 100 to 160 m thick. The deposit hosted in Early Proterozoic gneissic granite. The sulfidesare metamorphosed and galena-sphalerite aggregates contains younger andradite and gahnite (zinc spinel). Host muscovite-quartz-potassium feldspar rock also contains metamorphic garnet. Adjacent Mesozoic igneous rocks are not metamorphosed, indicating pre-Mesozoic mineralization. The deposit occurs in narrow northeast-trending fracture zones. Gold mineralization is later than polymetallic sulfide mineralization. Thin Au-bearing zones, associated with quartz-sericite altered rock, occur beyond the polymetallic sulfide deposit in gneissic granite. The deposit is medium size and contains an estimated 42.3 tonnes Au, 201.0 tonnes Ag, 131.0 thousand tonnes Zn, 80 thousand tonnes Pb. Average grade is 3.3 g/t Au, 14.3 g/t Ag, 0.93% Zn , 0.57% Pb. Contains an estimated 42.3 tonnes Au, 201.0 tonnes Ag, 131.0 thousand tonnes Zn, 80 thousand tonnes Pb.

Kalanguyskoye Fluorspar Vein Deposit

This deposit (Kotov and others, 1968; Kormilitsyn, 1973; Ivanov, 1974) consists of a series of fluorspar veins and zones of crushing with three commercial deposits. 80% resources occur in one vein with dimensions of 1300 by 0.7-3.6 to 600 m). The vein contains three ore pillars with swells about 15-20 m thick. The major ore minerals are fluorite, quartz, and pyrite (2-10%). Minor ore minerals are kaolinite, gearksutite, and marcasite, and rare ore minerals are galena, molybdenite, arsenopyrite, calcite, galluasite, and sphalerite. At depth sulfides increase to 15-

25% and fluorite decreases from 80% to 45%. The upper parts the veins exhibit a symmetric-zonal structure and at the are brecciated. Yellowi-honey fluorite is most common with lesser porcelaneous fluorite, and violet and green fluorite. The deposit contains kidney-shaped, concretionary and boulder types of ores and is interpreted as an epithermal sulfide-quartz-fluorite deposit type. The vein occurs in a large, steeply-dipping fault zone with submeridional strike and is hosted in Late Jurassic sandstone and shale. The adjacent host rocks are altered to kaolinite or silice to a depth 10-20 m. The deposit is large with resources of 6.3 million tonnes fluorspar grading 60% CaF_2.

Ukonikskoe Granitoid-Related Au Vein Deposit

This deposit (Fedchul and Lukin, 1995) consists of two zones that range from 300 1.5 km long and contain quartz-carbonate-sulfide veins, lenses, and streaks, and disseminations. The zones varies from 0.15 to 4.5 m thick, extend 300-400 m downdip, and from 40 to 220 m along strike, with an average 80-100 m. The zones occur in gneiss and schist that altered into quartz-sericite metasomatite and beresite near the bodies. The ore minerals are moderate sulfide assemblages and grades rangefrom 10 to 40% with an average of about 30%. The main ore mineral are quartz, carbonates, pyrite, arsenopyrite, galena, sphalerite; and native gold. Secondary minerals are chalcopyrite, bismuth, bismuthin, and silver. Two varieties of gold occur: finely dispersed old in pyrite and arsenopyrite of quartz-pyrite and pyrite-arsenopyrite-quartz bodies; and native (free) gold in polymetallic sulfides. Gold particles range from from 0.5 to 200 mm and the fraction of coarse gold ranges up to 5%. Formation of the deposit is linked with numerous (about 45 per 1 km^2) dikes of mafic, intermediate, and siliceous porphyry granitoids. The deposit is medium size with a range of 1-170 ppm Au.

Zhirekenskoye Porphyry Mo (±W, Sn, Bi) Deposit

This deposit (Melnikova and Sudarikov, 1970; Pokalov, 1978; Sotnikov and others, 1995) consists of isometric stockwork (with surface dimensions of 1200 by 100 m) with a central pipe-like body (120 by 60 m) of explosive breccia that extends to a depth of 600 m. Ore minerals occur in disseminations, veinlets, and breccia, and occur in a quartz-K-feldsparr-molybdenite assemblage with varying amounts of chalcopyrite, rare molybdenite, scheelite, magnetite, arsenopyrite, fluorite, and tourmaline. Also occurring are younger, thin veinlets of quartz, pyrite, sphalerite, galena, chalcopyrite, pyrrhotite, grey ore, bornite, and chalcocite with molybdenite, pyrite and charlcopyrite comprising about 90-95% and occurring in equal amounts. The deposit also contains up to 5-20 ppm Te, 20-900 ppm Se, 10-80 ppm Re, and 380 ppb PGE. The upper part of the deposit contains up to 0.008-0.4% WO_3. The deposit occurs adjacent to a zone of intersecting shears and late Mesozoic granite-porphyry dikes that occur along the margin of a Middle and Late Jurassic granite porphyry stock with a surface area of 8 km^2. The host rocks are intensely altered to K-feldspar, argillite, and sericite. The deposit is large with annual production of 2.4 million tonnes ore grading 0.08% Mo, 0.03-0.15%Cu.

Origin and Tectonic Controls for Shilkinsko-Tukuringrskiy Metallogenic Belt

The belt is interpreted as related to magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment. The belt occurs in basins with continental sedimentary rocks and alkaline magmatic plutonic and volcanic rocks that occur along the Mongol-Okhotsk suture that separates various terranes and the North Asian Craton and the Sino-Korean Craton.

REFERENCES: Fogelman, 1968; Seminsky, 1980; Tauson and others, 1987; Zorina, 1993; Seminsky and others, 1994; Jurgenson and Grabeklis, 1995; Spiridonov and Gnilusha, 1995; Zorin and others, 1998; Zorin and others, 1998; Zorin, 1999; Zorin, 1999; L.G. Stepanov, this study.

North Stanovoy Metallogenic Belt of Granitoid-Related Au Vein and Au-Ag Epithermal Vein Deposits (Belt NSt) (Russia, Far East)

This Early Cretaceous metallogenic belt is related to granitoids in the Stanovoy granite belt that intrude the Tynda terrane. The deposits generally consist of quartz and quartz-carbonate veins that are spatially related to Jurassic to Early Cretaceous granite and granodiorite that are generally interpreted as forming in a collisional setting. The one large Au-Ag epithermal vein deposit is at Bamskoe. Also occurring in the area are numerous related placer Au mines that are some of the largest placer Au mines in the west-central part of the Russian Far East.

Bamskoe Granitoid-related Au Vein Deposit

This deposit (A.V. Lozhnikov and others, written commun., 1989; Kurnik, 1992) consists of thirty-five zones of listwenite and beresite hydrothermal alteration that occur in granite and gneiss. The altered zones contain eight Au prospects with abundant veins, pods, and small quartz and quartz-carbonate veinlets. Prospects range from 140 to 960 m long and have an average thickness of about 3 m. The deposits are related to, and occur around the periphery of an Early Cretaceous subvolcanic rhyolite and rhyodacite stock that intrudes Neoproterozoic granite and biotite-amphibolite gneiss of the Tynda terrane.

Burindinskoe Au-Ag Epithermal Vein Deposit

This deposit (V.A. Taranenko, written commun., 1991; G.P. Kovtonyuk, written commun., 1993) occurs in steeply-dipping quartz and quartz-carbonate gold-bearing veins. The veins range up to 200 m lon, with an average thickness of about 10 m. The veins are hosted in an Early Cretaceous volcanic sequence overlying the Gonzhinsky terrane of the Burea-Khanka superterrane. The deposit is medium size with reserves of 6,230 kg gold and 38,200 kg silver grading 9.5 g/t Au and 42.6 g/t Ag.

Origin and Tectonic Controls for North-Stanovoy Metallogenic Belt

The belt is interpreted as forming during late-stage accretion of the Bureya superterrane to the south with the North Asian Craton to the north, during final closure of the Mongol-Okhotsk ocean. The lode Au and related large placer deposits occur in the southern part of the metallogenic belt, near a major fault between Precambrian gneiss of the Tynda terrane to the north and the Paleozoic rocks of the Tukuringra-Dzhagdi subduction-zone terrane to the south. The latter is metamorphosed to greenschist facies. The Paleozoic rocks contain beds of Au-bearing, pyrite-bearing graphitic shale.

REFERENCES: Gurov, 1978; Parfenov, 1995; Nokleberg and others 1997, 1998, 2000, 2003; Sukhov and others, 2000; L.G. Stepanov, this study

Djeltulaksky Metallogenic Belt of Granitoid-Related Au Vein Deposits (Belt Dlt) (Russia, Far East)

This Early Cretaceous metallogenic belt is related to granitoids in the Stanovoy granite belt that intrude the Tynda terrane and the Dzugdzur anorthositic belt. The deposits generally consist of quartz and quartz-carbonate veins that are spatially related to Jurassic to Early Cretaceous granite and granodiorite that are generally interpreted as forming in a collisional setting. Also occurring in the area are numerous placer Au mines that constitute some of the largest placer Au mines in the west-central part of the Russian Far East. The major deposit is at Zolotaya Gora.

Zolotaya Gora Granitoid-related Au Vein Deposit

This deposit (Mel'nikov, 1984) consists of quartz veins and zones of hydrothermally altered metamorphic rock that are conformable to host rock layering. Alteration assemblages are predominantly sericite and quartz, and chlorite, amphibole, and quartz. The main mineral assemblages are mainly: sulfide, biotite, and quartz; sulfide, sericite, and quartz; and biotite, quartz, amphibole, and chlorite. Less common is and assemblage of amphibole, quartz, and feldspar. Four successive stages of deposition are identified: (1) magnetite, chalcopyrite, pyrrhotite, and quartz; (2) gold, carbonate, and sulfide; (3) zeolite; and (4) supergene. Gold occurs both in early and late quartz, and in hydrothermally-altered rock. Gold generally occurs in films and fine plates in fractures, and is concentrated in selvages of quartz and quartz-pyrite veins. Gold fineness is high (985). The deposit is hosted in gneissic granite, granulite, calcareous shale, and quartzite of the Tynda terrane. The deposit is small and average grade is about 52 g/t Au. The deposit was intermittently mined from 1917 to 1948 with production of 2.5 tonnes gold.

Origin and Tectonic Controls for Djeltulaksky Metallogenic Belt

The belt is interpreted as forming during late-stage accretion of the Bureya superterrane to the south with the North Asian Craton to the north, during final closure of the Mongol-Okhotsk Ocean. The Paleozoic rocks contain beds of Au-bearing, pyrite-bearing graphitic shale.

REFERENCES: Mel'nikov, 1984; Nokleberg and others, 2000; 2003; L.G. Stepanov, this study

North Bureya Metallogenic Belt of Au-Ag Epithermal Vein and Granitoid-Related Au Vein Deposits (Belt NB) (Russia, Far East)

This Early Cretaceous metallogenic belt is related to veins and granitoids in Early Cretaceous felsic and intermediate volcanic rock in the Umlekam-Ogodzhin volcanic-plutonic belt that intrudes and overlaps the Malokhingansk terrane, Turan terrane of the Bureya superterrane, Gonzha terrane, Nora-Sukhotin-Duobaoshan terrane, and Tukuringra-Dzhagdy terrane. The host volcanic rock extends along the boundary between the Tukuringra-Dzhagdi terrane and the North Asia Craton. Several poorly-explored Carlin type deposits, that consist of layers of disseminated gold in jasper beds, occur in the area, but are unexplored. Numerous related placer Au mines occur in the metallogenic belt. The Au in the placer mines is interpreted as being mainly derived from Au-bearing quartz veins in Late Jurassic to Early Cretaceous sedimentary and volcanic rock. The major Au-Ag epithermal vein deposit is Pokrovskoe and granitoid-related Au vein deposit is at Pioneer.

Pokrovskoe Au-Ag Epithermal Vein Deposit

This deposit (Mel'nikov, 1984; Khomich, 1990;V.D. Mel'nikov, written commun., 1993) is hosted in a sequence of Early Cretaceous andesite, dacite andesite, and tuff that overlies a Jurassic coal-bearing sequence of sandstone, siltstone, and argillite. The deposits consist of gently-dipping quartz veins and zones of hydrothermal alteration. The main alterations are propylitic (albite, sericite, calcite, chlorite, and pyrite), berezite (quartz, sericite, and hydromica), and argillite (kaolinite, montmorillonite, hydromica, carbonate, quartz, and pyrite). The largest part of the deposit is a gently-dipping zone of altered rock that occurs near the lower contact of an andesite sequence with a granodiorite porphyry sill. Hydrothermally altered rock consists of quartz (25 to 85%), carbonate (2 to 5%), hydromica (5 to 12%), adularia (up to 5%), kaolinite (5 to 7%), and sulfides (less than 1%, mostly pyrite). Gold is fine-grained (0.0005 to 0.032 mm), is associated with quartz, and is rarely or not associated with sulfides. Silver grains (0.002 to 0.016 mm) occur in Fe-hydroxide alteration. The deposit is interpreted as forming in the Early Cretaceous. The deposit is medium size with reserves of 15 million tonnes grading 4.4 g/t Au and 15 g/t Ag.

Pioneer Granitoid-Related Au Vein Deposit

This deposit (N.E. Malyamin and V.E. Bochkareva, written commun., 1990; V.N. Akatkin, written commun., 1991) occurs near the margin of an Early Cretaceous granodiorite intrusion in both the intrusion, and in adjacent country rock that consists of contact-metamorphosed Jurassic sandstone and siltstone. The deposit consists of veins of quartz, quartz-feldspar, quartz-tourmaline, and quartz-carbonate, and altered zones of quartz, K-feldspar, sericite, and albite. The veins and zones vary from 1 to 50 m thick, and in branch plan view with variable trends. The deposit is large, is low grade, and has no visible boundaries. The extent of deposit is determined by geochemical sampling. Gold and Au-sulfide ores identified. The Au ore type consists of quartz-adularia-carbonate veins, and the Au-sulfide type consists of quartz veins with pyrite, galena, stibinite, and Ag-sulfosalts. The deposit is small, with estimated reserves of 17.1 tonnes Au, 20.1 tonnes Ag, and average grades of grade 2.7 g/t Au, and 5.2 g/t Ag.

Origin and Tectonic Controls for North Bureya Metallogenic Belt

The belt is interpreted as forming during formation of Umlekan-Ogodzhin continental-margin arc that formed during subduction of part of ancestral Pacific Ocean plate that is now preserved as tectonically interwoven fragments of the Badzhal, Khabarovsk, and Samarka terranes. This tectonic pairing is based on: (1) occurrence of the accretionary-wedge terranes outboard (oceanward) of the Umlekan arc; (2) formation of melange structures during the Jurassic and Early Cretaceous; and (3) where not disrupted by extensive Cretaceous and Early Cenozpic movement along the Central Sihote-Aline strike-slip fault, dipping of melange structures and bounding faults toward and beneath the igneous units of the arc. Subduction is generally interpreted as ending in the Early Cretaceous when extensive sinstral faulting occurred along the subduction zone.

REFERENCES: Melnikova, 1974; Gurov, 1978; Khomich and others, 1978; Mel'nikov, 1984; Khomich, 1990; V.D. Mel'nikov, written commun., 1993; Khanchuk and others, 1996; L.G. Stepanov, this study

Kerbi-Selemdzha Metallogenic Belt of Au in Shear Zone and Quartz Vein, Granitoid-Related Au Vein, and Cassiterite-Sulfide-Silicate Vein and Stockwork Deposits (Belt Ksl) (Russia, Far East)

This Late Jurassic and Early metallogenic belt contains quartz veins in Late Cretaceous granitoids and that cut the Tukuringra-Dzhagdy and Badzhal terrane. The terranes are overlain or intruded by the Cretaceous Umlekan-Ogodzhinsky volcanic-plutonic belt and by Late Cretaceous and early Tertiary Khingan-Okhotsk volcanic-plutonic belt. The major Auin shear zone and quartz vein deposits are at Tokur and Malomyr, and the major granitoid-related Au vein deposit is at Poiskovoe.

Tokur Au in Shear Zone and Quartz Vein Mine

This mine (Mel'nikov and Fat'yanov, 1970; P.H. Layer, V. Ivanov, and T.K. Bundtzen, written commun., 1994) consists of Au-bearing veins. Ore minerals comprise 3% the veins and consist of pyrite, arsenopyrite, gold, sphalerite, galena, chalcopyrite, pyrrhotite, tetrahedrite, tennantite, and scheelite. Gangue minerals are quartz, adularia, sericite, chlorite, and calcite. Gold fineness ranges from 650 to 800. Sphalerite and arsenopyrite increase with depth. Carbonaceous material occurs along vein margins. Vein zones normally range from 25 to 90 m thick. Veins commonly are conformable to bedding of host rocks, but are are locally discordant. Veins range up to 800 m long and vary from 0.2 to 0.7 m thick. Maximum depth of deposit is 500 m. Diorite dikes and stocks intrude the veins. Ar-Ar adularia isotopic age is 114 Ma. Veins are hosted in a structurally-deformed middle Paleozoic sequence of sandstone, shale, and quartzite. The deposit is medium size with production of 27.1 tonnes Au. The deposit was mined from 1933 to 1940.

Malomyr Au in Shear Zone and Quartz Vein Deposit

This deposit (S.G. Parada, written commun., 1984; B.D. Melnikov, written commun., 1993) consists of quartz veins and local stockworks, with an area of 12 km^2. Most of gold reserves occur in the gently-dipping Diagonalnaya zone that extends about 3 km along strike and ranges from 30 to 150 m thick. The zone has average grade of 1 to 2 g/t Au and consists of ten, gently-dipping deposits ranging from1.0 to 28 m thick and 50 to 400 m long with an average grade of 5 to 12.4 g/t Au. Assemblages in deposit formed during five successive stages: (1) quartz breccia with abundant disseminated pyrite; (2) quartz-sulfide veinlets; (3) veinlets of chalcedony-like quartz; (4) monomineral pyrite veinlets; and (5) quartz-carbonate veinlets with pyrite. The second and third stages are separated by the intrusion of dikes of Early Cretaceous granodiorite porphyry and diorite porphyry. Only pre-dike mineral assemblages contain gold. Dikes occur in districts and are controlled by the same fractures as deposits. Gold is fine-grained and ranges up to 0.02 mm. Shape of gold grains is predominatly lumpy, less commonly platy. Gold fineness ranges from 700 to 820. Typical admixtures are Fe, Ti, Cu, and Hg. The deposit hosted in early Paleozoic quartz-mica rock, shale, slate, and metasandstone of the Tukuringra-Dzhagdi terrane. The deposit is medium size with resources of 30-50 tonnes gold grading 5.0-12.4 g/t Au.

Origin and Nectonic Controls for Kerbi-Selemzha Metallogenic Belt

The belt is interpreted as forming during collision of the Bureya and Khanka continental-margin arc superterrane with the North Asian Craton. The belt is interpreted as forming in two stages: (1) Middle Triassic deposition of disseminated Au in sedimentary rock; and (2) tectonic reactivation during the Late Jurassic and Early Cretaceous to form the gold deposits. During the Late Jurassic collision, the middle to late Paleozoic passive continental-margin clastic rocks of the North Asian Craton to the north were thrust over the Bureya superterrane to the south. The Paleozoic clastic rocks and the lesser oceanic tholeiite, chert, limestone, and black shale of the Tukuringra-Dzhagdi and Galam subduction zone-accretionary-wedge terranes form nappes. During collision and regional thrusting, these rock units were regionally metamorphosed to greenschist facies with late-stage formation of Au vein deposits. Local higher-grade metamorphism occurred in metamorphic domes.

REFERENCES: Kirillova and Turbin, 1979; Natal'in and others, 1985; Kozlovsky, 1988, 1985; Martynyuk 1990; Natal'in, 1993; Nokleberg and others, 1998, 2000, 2003.

Sarasinsk Metallogenic Belt of Carbonate-Hosted Hg-Sb and Fluorspar Vein Deposits (Belt SR) (Gorny Altai Mountains, Russia)

This Middle to Late Jurassic metallogenic belt is related to replacements in the Anui-Chuya terrane and occurs in the northern part of Gorny Altai region along the border between the Katun and Anui-Chuya island arc terranes. The belt extends along the large Sarasinsk-Kurai sublongitudinal fault and adjacent basin containing Devonian clastic sedimentary rock. The belt contains small Hg deposits and occurrences that generally occur in breccia zones in Riphean and Cambrian carbonate rock. Carbonate and cinnabar are the main deposit minerals. The major deposit is at Sarasinskoye.

Sarasinskoye Carbonate-Hosted Hg-Sb Deposit

This deposit (Kuznetsov and others, 1978) consists of cinnabar in lenses in Proterozoic limestone that is overlapping by Middle Devonian volcanic rock. The lenses occur along steeply-dipping, stepwise shears in an overthrust. As minerals also occur in the deposit that consists of lenses of coarse-grained orpiment and realgar in disseminations, streaks, and stockwork. Main ore minerals are cinnabar, realgar, orpiment, pyrite, and marcasite, and rare stibnite. Gangue minerals are calcite, dolomite, and quartz, and rate barite, dickite, and fluorite. Host limestone is altered to dolomite and silica, and the volcanic rock is intensely altered to argillite. The deposit was mined from 1941 to 1945. The deposit is small.

Origin and Tectonic Controls for Sarasinsk Metallogenic Belt

The belt is interpreted as related to magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment. Transtension occurred during interblock strike-slip faulting along the major Sarasinsk-Kurai fault. (Kuznetsov and others, 1978; Obolenskiy, 1985; Obolenskiy and others, 1999).

REFERENCES: Kuznetsov and others, 1978; Obolenskiy, 1985; Obolenskiy and others, 1999.

Kurai-Tolbo Nuur (Belt KTN) Metallogenic Belt of Carbonate-Hosted Hg-Sb, Silica-Carbonate (listvenite) Hg, Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu), Clastic Sediment-Hosted Hg±Sb, Ag-Pb Epithermal Vein, Au-Ag Epithermal Vein, Ni-Co Arsenide Vein, and Ag-Sb Vein Deposits (Gorny Altai Mountains, Russia and Mongolia)

This Early and Middle Jurassic metallogenic belt is related to replacements in the West Sayan and Hovd terranes and occurs in southeastern of the Gorny Altai region of southeastern Siberia and innorthwestern Mongolia. The belt trends northwest for about 300 km and ranges from 20 to 60 km wide. The belt contains significant Hg deposits, including the Aktashskoye and Chagan-Uzunskoye Hg deposits in Russia, and the large Askhatin Ag-Sb deposit in Mongolia (Kuznetsov and others, 1978; Obolenskiy, 1985; Borisenko and others, 1992, 1999). The belt occurs along the complex major Kuznetsk-Altai fault that forms the southwestern boundary of the West Sayan terrane. This suture consists of a system of large regional faults and feathering branches that separate early Paleozoic island arc, sea-mounts, and ophiolite terranes, and overlapping Middle and late Paleozoic near-fault basins, and Mesozoic and

Cenozoic intermontane basins. Distribution of Hg deposits is controlled by the interblock faults. The main deposit-controlling structures are the major Kurai-Kobdinsk fault and conjugate Aktash and Chagan-Uzun thrust faults.

The Ag-Sb deposits occur generally in the southeastern part of the metallogenic belt in the Delyuno-Yustyd Basin and are hosted in contact-metamorphosed Middle and Late Devonian black-shale. The controlling Kurai-Kobdinsk fault borders the north basin. Feathering the fault host the deposits and cause a vein shape and irregular ore distribution. The major Yustid, Tolbonur, and Sagsay districts occur in the belt (Borisenko and others, 1992, 1999). The high-grade Aktashskoye deposit is a world-class deposit. (The significant deposits are at Aktashskoye, Ozernoye, and Chagan-Uzunskoye. The Aktashskoye deposit has been mined.

Asgat Ag-Sb Vein Deposit

This deposit (Borisenko and others, 1992; Jargalsaihan and others, 1996) consists of 5 mineralized zones hosting siderite veins that occur along a quartz-siderite stockwork. Host rocks are Middle to Upper Devonian black-grey siltstone intruded by Carboniferous granite massif. The siltstone is intensively contact metamorphosed, and altered to graphite and pyrite. Widely distributed diabase, diorite-porphyrite, dolerite and lamprophyry dikes occur ahnd are related to Mesozoic interplate magmatism. The veins are mostly 0.5-1.0 m thick with some veins ranging up to 12 m thick. Ore minerals occur mostly in veins mainly in stockwork. The amount of sulfides is mostly 5-10%, sometimes up to 50-60% in ore bodies. Zone 1 hosts a 0.2-12.0 m thick siderite-sulfide vein in stockwork. The zone extends downdip to 500 m and extends on surface for 2.5 km. Main ore minerals are tetrahedrite (1.0-2.5% Ag) and chalcopyrite. Rare minerals are chalcostibnite, zincenite, bismuthinite, arsenopyrite, and pyrite. Zone 2 is 1100 x 0.3 - 12 m and hosts 0.1 - 0.15 m to 6.0 m thick siderite veins. Chalcostibnite dominates in veins of zone 2. Tetrahedrite is dominate in zone 2a. Sulfides are oxidized weakly and siderite is intensively oxidized. Malachite, azurite, Fe-oxides, Mn oxide, jarosite, chalcocite, and covellite are widely developed in oxidized zone, along with rare native silver and akantite. The deposit is large with an average grade of 384 g/t Ag, 0.5% Sb, 0.58% Bi, and 1.02% Cu. Reserves are 7,700 tonnes Ag, 12,200. tonnes Bi, 106,600 tonnes Sb, and 238,200 tonnes Cu.

Aktashskoye Carbonate-hosted Hg-Sb Mine

This mine (Kuznetsov and others, 1978; Obolenskiy, 1985) consists of steeply-dipping columns and lenses in Cambrian limestone altered to dolomite and silica. The deposit is controlled by fracture zones and fissures related to large overthrusts. The columns and lenses form an en-echelon-like system that extends to a depth 450 m in an limestone that varies from 80 to 250 m thick. Ore minerals occur in dissiminations, streaks, and masses. Main ore minerals are cinnabar and pyrite. Accessory minerals are stibnite, realgar, orpiment, aktashite, and Hg-fahl. Rare ore minerals are sphalerite, chalcopyrite, chalcostibite. Gangue minerals are calcite, quartz, dolomite, rare dickite, sericite, chlorite, and graphite. Wall rock alterations are sandstone and shale altered to argillite; limestone altered to dolomite, silica, and calcite. Rare lenses of serpentinite are altered into silica-carbonate rock (listvenite). The deposit is exhausted and produced 5,500 tonnes with an average grade of 0.4% Hg.

Chagan-Uzunskoye Silica-Carbonate (listvenite) Hg Deposit

This deposit (Kuznetsov and others, 1978; Obolenskiy, 1985) consists of a steeply-dipping listvenite zone with Hg minerals that extend for about 5 km along a large overthrust. Hg minerals occurs in schistose listvenite along a contact zone between the plate-like body of serpentinite and Cambrian sandstone, greywacke, and limestone. Cinnabar and pyrite, and gangue minerals occur in brecciated (and local mylonite) listvenite, serpentinite, dolomite, silicified limestone, and sandstone. The main district is 1700 m long, varies from 0.3 to 0.5 to 6 m thick with an average thickness of 2.5 m. Deposit extends to 800 m depth. The main ore mineral is cinnabar, and subordinate minerals are pyrite, stibnite, realgar, and orpiment. Gangue minerals are dolomite, ankerite, quartz, calcite, and dickite. Rare minerals are millerite, gersdorffite, bravoite, sphalerite, galena, chalcopyrite, pyrrhotite, arsenopyrite, native As. Ore minerals occur in streaks, dissiminations, breccia, stockwork, and incrustates. Hydrothermal alteration consists of listvenite replacing serpentinite, dolomitie and silica replacing limestone, and argillite and carbonate replacing sandstone. The deposit is medium size with an average grade of 0.17% Hg.

Ozernoye 1 Volcanogenic-Hydrothermal-Sedimentary Massive Sulfide Pb-Zn (±Cu)Deposit

This deposit (Borisenko and others, 1984, 1986, 1992) consists of siderite-sulfosalt veins and vein zones in an alternating sequence of Middle to Late Devonian sandstone, siltstone, and shale, and diabase dikes. About 20 veins and zones occur and range from 45 to 540 m long, 0.1 to 2.5 m thick, and extend to more than 500 m depth. Veins are composed of brecciated wall rock cemented by siderite, quartz, and ore minerals. Vein zones consist of a siderite stockwork with burnonite, tetrahedrite, semseyite, pyrite, arsenopyrite, chalcopyrite, galena, and native Bi and Sb. The deposit is medium size.

Tolbonuur Group of Ag-Sb Vein Deposits

This Permian and Late Jurassic to Early Cretaceous group of deposits (Obolenskii, 1985; Borisenko and others, 1986, 1991 and 1992) occurs in the southeastern part of the belt and is related to gabbro diabase and lamporphyry dikes that cut the Altai, Hovd terranes, and and the Deluun overlapping assemblage. The group contains Ag-Pb epithermal vein, clastic sediment-hosted Hg, and silica-carbonate (listvenite) Hg deposits. The major deposits are the Asgat Ag-Sb deposit, Sharbuureg Ag-Sb occurrence, Boorj and Tolbonuur Pb-Ag occurrences, Teht and Tsagaangol Co (Cu, Bi, Au, Ag) occurrences, and Ulaanhus and Olgii Hg occurrences.

The Tolbonuur group occurs mostly along the north-south middle Paleozoic Deluun-Yustyd basin that extends approximately 400 km, overlies the early Paleozoic Altai and Hovd turbidite terranes, and is closely related to Permian gabbro and diabase and Mesozoic lamprophyre dikes. The major deposits occur in the Hovd and the Tolbonuur faults that bound the Deluun-Yustyd basin. The Terekt fault is the continuation of the Tolbonuur fault zone, and the Kurai fault is the continuation of the Hovd fault. The Deluun-Yustyd basin consists of an approximately 9-km-thick sequence of volcanic and sedimentary rock, including Lower and Middle Devonian rhyolite, andesite, dacite, tuff, volcanic breccia, tuffaceous sandstone, tuffaceous gravelstone, conglomerate, and a Middle and Late Devonian sequence of approximately 5-km-thick clastic rock and flysh, including black to gray siltstone, shale, and quartz-feldspar sandstone. The main deposit types are epithermal Ag-Sb vein, Co-sulfoarsenide, As-Sb-Hg, Ni-Co arsenide deposit types that formed in the Permian and Mesozoic.

Origin and Tectonic Controls for Kurai-Tolbo Nuur Metallogenic Belt

The belt is interpreted as forming during interplate alkaline basalt magmatism related to a mantle plume.. The belt occurs along the complex, major Kuznetsk-Altai fault. Basalt and alkali basalt occurs in dike swarms that are controlled by the same faults that control the deposits. The K-Ar isotopic age of lamprophyres is 210 to 190 Ma and the age of altered rocks adjacent to deposits is 150 to 180 Ma (Obolenskaya, 1983; Obolenskiy, 1985). The spatial and temporal similarity of alkali basalt magmatism and epithermal deposits indicates a co-genetic relationship, and a mantle origin for hydrothermal ore-forming systems.

REFERENCES: Obolenskaya, 1971, 1983; Kuznetsov and others, 1978; Borisenko and others, 1982, 1988, 1991, 1992, 1999; Obolenskii, 1984, 1985; Byamba, and Dejidmaa, 1999.

Hovdgol Metallogenic Belt of Au-Ag Epithermal Vein, Granitoid-Related Au Vein, and Hg-Sb-W Vein and Stockwork Deposits (Belt Hov) (Western Mongolia-Northwestern China)

This Late Jurassic(?) metallogenic belt is related veins related to gabbro, diabase, and lamprophyre dikes that intrude the Altai terrane and Altai volcanic-plutonic belt. The belt is too small to show at 5 M scale. The belt occurs in western margin of Mongolia and in the upper Hovdgol River. The Hovdgol metallogenic belt, that was first defined by Dandar and others (1999), occurs in a weak northwest-striking fault zone between the Mongol Altai turbidite and Olgii island arc terranes, extends approximately 250 km, and ranges up to 30 km wide. Movements on the fault zone occurred several times from the Devonian to the late Mesozoic. The fault zone contains Early to Late Devonian volcanic and sedimentary rock, late Paleozoic gabbro and diabase, and late Mesozoic lamprophyre complexes. Part of the metallogenic belt is interpreted as closely related to late Mesozoic(?) diabase and lamprophyre dikes. The southeastern part of the belt cotains granitoid-related Au vein deposits and occurs in the northeastern Xingjian Province of Northwestern China. This part of the belt trends northwest, and is about 120 km long and 15 km wide. The significant deposit in the metallogenic belt in China at Aketishi.

Aketishi Granitoid-related Au Vein Deposit

This major deposit (Rui Xingjian, 1993) occurs in northwestern China. The deposit occurs in layers and veins in a zone about 100 to 200 m long and 1.5 to 2 m wide. The ore minerals are pyrite, chalcopyrite, galena, and sphalerite. Gangue mineral is mainly quartz. Other rare minerals are argyrithrose, native silver, corundum, celestite, and barite. The deposit is probably related to Jurrassic granitoid and occurs along the Hongshan fault that is closely related to the deposit. The host rocks are Late Devonian dacite, phyllite, and slate of the Mangdaqia Formation, and Early Carboniferous siliceous and intermediate continental volcanic rock, fine-grained marine clastic rock, bioclastic limestone of the Hongshan Formation. The Hongshan fault trends west-northwest, dips north, is about 200 m wide, and contains intensely fractured rock, and mylonite, phyllite, and local breccia. The deposit is medium size.

Hovdgol Au-Ag Epithermal Vein Deposit

This deposit (Kempe and others, 1993) occurs in the middle part of the metallogenic belt and is hosted in Middle and Late Cambrian shale intruded by Ordovician granodiorite, Early and Middle Devonian granite, and Early Permian granite. Widely distributed are plagiogranite, granite, diorite, granodiorite porphyry, aplite, microgranite, felsite, microdiorite, and diabase porphyry dikes of the Late Jurassic Chui intrusive complex. The deposit (Demin and others, 1990) consists of 23 quartz-wolframite and quartz-wolframite-stibnite veins in granite stock with surface dimensions of 350 to 800 m. The veins range occur along a gently-dipping thrust and fractures, range from 100 to 1000 m long, and from 0.1 to 0.7 m thick. The oore minerals are ferberite (10-90%), scheelite (0.0-15%), and stibnite (0-50%), and rare pyrite, chalcopyrite, galena, Fe oxides, and native gold. Stibnite cuts ferberite and is associated with scheelite. Gangue main minerals are quartz, siderite, calcite, and sericite. Host rocks are altered to sericite, argillite, and rare greisen. Grades from: 0.01-50.0% W, 0.00-20.0% (mostly 0.01%) Sb, 0.01-1.0% Li, up to 0.5% As, up to 0.01-0.2% Ba, 0.001-1.0% Cu, up to 1.0 g/t Ag and 0.2-1.0 g/t Au (94 g/t in 1 sample).

Origin and Tectonic Controls for the Hovdgol Metallogenic Belt

The belt is interpreted as forming during interplate alkaline basalt magmatism related to a mantle plume.

REFERENCES: Kempe and others, 1974; Dandar and others, 1990, 1999; 1994; Rui Xingjian, 1993.

Terligkhaisk Metallogenic Belt of Volcanic-Hosted Hg, and Clastic-Sediment-Hosted Hg Deposits (Belt TR) (Tuva Region, Russia)

This Middle to Late Jurassic metallogenic belt is related to replacements between and along margins of the Khemchik-Sistigkhem basin and Kurtushiba terrane in the Western Tuva region. The deposits occur along the major Khemchik-Kurtushiba fault zone that extends northwest for about 400 km. The fault zone contains feathering faults in an en-echelon system that strikes sublatitudinally (Kuznetsov and others, 1978). The main deposit-controlling structure of the belt is the Peloruk fault zone that consists of several subparallel faults, and contains individual blocks of early Paleozoic, Devonian, and Early Carboniferous volcanic and sedimentary rock, and local Jurassic sedimentary rock. The Terligkhaiskoye and Arzakskoye Hg deposits occur in Early Devonian volcanic and sedimentary rock whereas the Tora-Sairskoye deposit occurs in diabase porphyry dikes cutting Early Devonian sandstone and argillite. The significant Terligkhaiskoye deposit is partly mined (Kuznetsov, 1981; Kuznetsov and others, 1978).

Terligkhaiskoye Volcanic-Hosted Hg Deposit

This deposit (Kuznetsov and others, 1978) consists of steeply-dipping lenses in a Early and Middle Devonian volcanic and sedimentary sequence that occur in en-echelon-like fracture zones connected with faults that bound the Kyzil-Khasch graben. Six Hg occurrences are in the Kyzil-Khasch graben, and one economic deposit has been mined in an open-pit. The deposit extends along strike for 1 km and is 200 m thick. Ten lenses were occur to 300 m depth. Ore minerals occur in disseminations, streaks, disseminations, breccia, and rare masses. Main ore minerals are cinnabar and pyrite, and accessory chalcopyrite and fahl. Gangue minerals are quartz, dickite, barite, chlorite, sericite, and chalcedony. The deposit is partly mined, and small with reserves of 1,650 tonnes grading 0.2% Hg.

Origin and Tectonic Controls for Terligkhaisk Metallogenic Belt

The belt is interpreted as related to magmatism along transextension zones along transform micro plate boundaries and within plate (plume) environment. Deposits occur along major Khemchik-Kurtushiba fault zone (Kuznetsov, 1974; Obolenskiy and others, 1999).

REFERENCES: Pavlov, 1971; Kuznetsov, 1974; Kuznetsov and others, 1978; Kuznetsov, 1981; Obolenskiy and others, 1999.

Karasug Metallogenic Belt of Fe-REE Carbonatite Deposits (Belt KA) (Tuva, Russia)

This Early and Late Cretaceous metallogenic belt is related to replacements between and along margins of the Khemchik-Sistigkhem and Tuva molasse Basins. The belt occurs along the sublatitudinal Chadan-Karasug fault, and other similar structures that form a feathering system along the major Khemchik-Kurtushibinsk fault zone. These deposit-controlling faults also occur in the basement below the Tuva Basin and are interpreted as controls for distribution of magmatic rocks and mineral deposits. The geological structure of the belt consists of tectonic blocks of Cambrian volcanic and sedimentary rock, Silurian sandstone and argillite, and Early and Middle Devonian volcanic and sedimentary sedimentary rock. Gabbro intrusions of the Early Carboniferous Torgalyk Complex occur in the fault zone. The Karasugskoye Fe-REE deposit is the largest the belt (Mitropolskiy, 1959, 1972; Ontoev, 1966).

Karasugskoye Fe-REE Carbonatite Deposit

This deposit (Mitropolskiy, 1959, 1972; Ontoev, 1966; Kalugin and others, 1981; Sinyakov, 1988) consists of pipes and nests of fluorite, barite, hematite, and siderite that occur in a zone of brecciated Silurian sandstone and siltstone. The deposit ranges from 130 to 700 m long, is 30 to 100 m thick, and extends to a depth of 800 m. Primary ore minerals are siderite, fluorite, barite, and hematite, and lesser quartz, pyrite, and magnetite. Fluorite, barite, and siderite are the most widespread. The average grades are 7-45% Fe (28% average), up to 20% fluorite (9% average), and 1.4-30% barite (15% average). An oxidizied zone extends from 100 to 300 m depth. Oxidizied ore minerals are hematite and goethite, and hydrohematite. Average grade in oxidizied ore is 30 to 33% Fe. A K-Ar isotopic age for hydrothermal ore-formation is 112 to 122 Ma. The deposit is large with reserves of 270,000,000 tonnes grading 25.75% Fe in primary ores and 30-33% Fe in oxidizied ores.

Origin and Tectonic Controls for Karasug Metallogenic Belt

The belt is interpreted as related to magmatism along transextension zones related to transform microplate boundaries and within plate (plume) environment with intrusion of alkali-ultramafic magmatic rocks along mantle-related faults. Belt occurs along sublatitudinal Chadan-Karasug fault. Mantle-related faults and alkalic ultramafic magmatism, that are typical for hot-spots, are interpreted as forming the Karasug metallogenic belt (Distanov and Obolenskiy, 1994). A U-Pb isotopic age for the Karasugskoye deposit is 115 to 75 Ma (Mitropolskiy and Kulik, 1975).

REFERENCES: Mitropolskiy, 1959, 1972; Ontoev, 1966; Mitropolskiy, Kulik, 1975; Distanov and Obolenskiy, 1994.

Uuregnuur Metallogenic Belt of Au-Ag Epithermal Vein, Cassiterite-Sulfide-Silicate Vein and Stockwork, and Sediment-Hosted Cu Deposits (Belt UN) (Western Mongolia)

This late Mesozoic(?) metallogenic belt is related to veins and replacements in gabbro, diabase, and lamprophyre dikes of Kharig dike complex (too small to at 5 M scale) in two tectonic zones between the Hovd and Lake terranes.

The belt extends north-northwest for approximately 200 km and is approximately 90 km wide. The eastern boundary of the belt is the major Tsagaanshiveet fault zone and the western boundary is a north-northwest-striking weak fault zone that is located approximately 90 km west of, and parallel to the Tsagaanshiveet fault. Obolenskii (1984, 1985) first defined this metallogenic belt as the Tsagaanshiveet metallogenic zone that controlled by the Tsagaanshiveet fault zone, and by the Harig and Namiriingol Mesozoic grabens that occur in the fault zone.

Various epithermal Ag-Sb vein and Cu-Ag vein and replacement occurrences occur in the Tsagaanshiveet zone. The Mergen bulag Ag-Sb occurrence is located in the northern part of the belt Early Jurassic sedimentary rock of the Harig graben. The Namiriingol Cu-Ag vein and replacement occurrences are located south of Mergen bulag in a northeast-trending thrust fault in the Tsagaanshiveet fault zone, and are hosted in Carboniferous granite and in Early and Middle Jurassic sedimentary rock of the Namiriingol graben. Cu-Sn-Ag vein and replacement occurrences are located mostly in western part of the bounding fault zone, mainly in Ordovician and Devonian volcanic and sedimentary and carbonate rock. The belt continues into Russian where it contains mainly Ni-Co-As and Cu-Co-As deposits (Borisenko and others, 1992).

Various cassiterite-silicate-sulfide replacements and skarn deposits and occurrences are located in the Otor Uul district that occurs along the western boundary fault. Cu-Sn-Ag replacement deposits are associated with a late Paleozoic ore complex composed of W, Mo, Sn vein and greisen, and Cu-Co-W, Sn-S and Ni-Co-As deposits (Borisenko and others, 1992).

Namiryn gol Au-Ag Epithermal Vein Deposit

This deposit (Ushakov et. al., (1964) Tseveennamjil. and others, 1981; B.N. Podkolzin and others, written commun., 1990) consists of several zones with altered with Cu sulfides that occur in the hanging wall of a northwest-trending thrust fault in Devonian Kharkhiraa cataclastic granite. The zone is 200-500 m wide and 8000 m long. Host rock is altered to argillite, silica, and albite. The ore minerals are hematite, chalcopyrite, chalcocite, bornite, native copper, covellite, cuprite, tenorite, malachite, and azurite. The zones strike northwest to EW, range up to 1 m thick, and from 10 to 15 m long. Most zones dip steeply to west and northwest. Channel samples contained: up to 1.0% Cu, 0.1% Zn+Pb, and up to 20.0 g/t Ag with local 400.0 g/t Ag and up to 0.5% Bi. Footwall of thrust fault consists Early to Middle Jurassic mylonitic red sandstone and conglomerate that is cut by rare calcite stringers with malachite. A complex soil anomaly along the thrust fault grades up to 0.01% Cu, Pb, Zn, Ba with up to 1.0 g/t Ag.

Origin and Tectonic Controls for Uuregnuur Metallogenic Belt

The belt is interpreted as forming during intraplate rifting and associated alkaline basaltic magmatism related to a mantle plume. Triassic and Jurassic alkaline explosive basalt dike complexes occur in the Khovd complex in the Hovd terrane, and are interpreted as similar to the Chui alkaline basalt (lamporphyre) complex in the Altai terrane (Vochkovich and Leontyev, 1990). Alkaline basalt dikes in the Hovd terrane occur mostly in western Uureg nuur belt, near the vicinity of Otor Uul ore-knot that contains Cu-Sn-Ag replacement and skarn type occurrences.

REFERENCES: Obolenskii, 1984, 1985; Vochkovich and Leontyev, 1990; Borisenko and others, 1992.

Dzid-Selenginskiy Metallogenic Belt of W-Mo-Be Greisen, Stockwork, and Quartz Vein, Granitoid-Related Au Vein, Au Skarn, Porphyry Mo (±W, Bi) (+W, Sn, Bi), Fluorspar Vein; and Magmatic, and Metasomatic Apatite Deposits (Belt DSe) (Russia, West Transbaikalia, Mongolia)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to veins, replacements, and plutons related to the Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that overlies and intrudes the Dzhida, Hamar-Davaa, and Orhon-Ikatsky terranes, the Selenga sedimentary-volcanic plutonic belt, the Barguzin-Vitim granitoid belt, and adjacent units. The belt occurs in the Selenga and Dzhida River basins and extends from

Mongolia northeast to southern Lake Baikal in Russa. The belt extends for 725 km long and 85 to 175 wide. The Transbaikaliaian sedimentary and volcanic-plutonic belt occurs in numerous rift basins in two sequences: (1) Middle and Late Jurassic shoshonite and latite; and (2) Late Jurassic and Early Cretaceous trachybasalt. Basalts in the second is part of a bimodal sequence. Plutonic rocks occur in several intrusive Jurassic complexes: (1) the Kyrinsky complex with large plutons of calc-alkaline biotite, biotite-amphibole diorite, granodiorite, granite, leucogranite; (2) Sokhondinsky complex with subvolcanic dacite and rhyolite bodies; (3) Asakan-Shumilovsky complex of biotite and biotite-amphibole granite, granite, leucogranite; (4) Kharalginsky complex of high alkaline biotite leucogranite, syenite porphyry, leucogranite, and alaskite); (5) gabbro and syenite and local carbonatite. Within the belt are deposits and occurrences various districts. The most widespread are W and Mo deposits of different model types (Reif and others, 1982; 1982; Petrovskaya and others, 1977; Dzhida ore region, 1984, Khodanovich, 1995). The major deposits are in the Dzidinskoye district, and at Malo-Oinogorskoye, Arsentievskoye, Naranskoye, and Oshurkovskoye. The belt is promising undiscovered deposits.

Dzhidinskoe District of W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposits

This district (Mokhosoev, 1984, Gordienko, 1987; Khodanovich, 1995; Skurskiy, 1996) occurs in three areas in the apical part of a small Triassic granite massif. The Pervomayskoye stockwork Mo deposit (620x540 m) is mushroom-shaped, and extends to a depth of 240-250 m. Ore consists of molybdenite, pyrite, sphalerite, chalcopyrite, bismuthine, fluorite, aud beryllium. Gangue minerals are quartz, K-feldspar, and muscovite. Ore contains 0.1-0.15% Mo, 0.018% BeO , 0.031% W205. Kholtosonkoye vein W deposit consists of economic hubnerite-sulfide-quartz veins (500-2000x0.8x500-600 m). Ore consists of: hubnerite (14.5-0.4%), scheelite (3.5-0.1%), galena (11.9-0.1%), sphalerite (3.5-0.1%), pyrite (7,6-0.2%), chalcopyrite (0.8-0.001%), fluorite (7.6-0.2%). The grade of WO_3 varies from 1.10 to 0.42%. The Inkurskoye stockwork W deposit (1700x400-600x300-400 m) consists a network of quartz, quartz-feldspar, quartz-muscovite and quartz-sulfide veinlets with hubnerite and scheelite. The major minerals are hubnerite and scheelite. Less widespread are pyrite, galena, sphalerite, chalcopyrite, and gray ore. The average grade in stockwork is 0.147% WO_3; 0.019% Pb; 0.045% Zn; 0.0035% Cu; 0.046% BeO; 0.7 ppm Au, and 6 ppm Ag. Many veins occur along the dike belt with diorite porphyry, microdiorite, aplite, syenite porphyry, and lamprophyre. The early and middle Paleozoic host granitoid rock is altered to berisite, sericite, and greisen. The deposit is large with a grade in stockwork ores of 0.16-0.18% WO_3, in vein bodies 0.5-1.0% WO_3. Average grade is 0.1-0.15% Mo, 0.3-0.5% Pb, 0.3% Cu, up to 2,8 ppm Au, up to 315 ppm Ag. Prospected to 700 m depth.

In northern Mongolia, the district is related to granitoids intruding the Vendian to early Paleozoic Dzida island arc terrane. The district contains W-Mo-Be greisen, stockwork, and quartz vein, W-Mo-W±Mo±Be skarn, granitoid-related Au vein, and Au skarn deposits. The major deposits are the Bulagtai vein and stockwork W-Mo deposit, Sohatinh W-Mo skarn occurrence, the Baruunhujirt granitoid-related vein Au occurrence, Tavt granitoid-related vein Au (Cu, Ag) deposit, and Teshig group Au (Cu, Fe) skarn deposit and occurrences. These deposits and occurrences are related to Mesozoic intrusive rocks and occur mainly in Russia and in the Teshig district in Mongolia. The granitoid-related deposits are closely related to Late Jurassic leucogranite stocks of the Gudjir Complex that also contains REE granite stocks. Isotopic ages for granitoids in the Gudjir complex are 180 to 170 Ma and 145 to 140 Ma (Shermet and Kozlov, 1981). The related granitoids in the district consist of small stocks of granite porphyry and leucogranite, and dikes of aplite, aplite porphyry, fine-grained granite, syenite, syenite porphyry, and granite porphyry.

Tavt (Ereen) Granitoid-Related Au vein Deposit

This deposit (Tsyba, 1990; Jargalsaihan and others, 1996) is hosted mainly in early Paleozoic gabbro and granitoids with xenoliths of Vendian to Lower Cambrian limestone that are intruded by Late Permian granitoids of the Selenge complex, and by early Mesozoic granitoid stocks and dikes of the Orkhon intrusive complex. Abundant quartz veins occur and contain gold and sulphides mostly in the early Paleozoic gabbro and gabbro-diorite, and in the first phase granitoids of the Selenge complex. About 100 gold-sulfide-quartz veins occur in mainly ten zones that range from 2.0 to 7.5 km long and 50.0 to 800.0 m wide, and strike northwest, and dip steeply southwest. The length of individual veins ranges from 100 to 250 m and rarely up to 800 m, and range from 6.0-8.0 m wide with an average thickness of 0.5-1.5 m. Ore minerals are native gold and silver, pyrite, chalcopyrite, galena, molybdenite, and sphalerite. Sulphides are replaced by carbonates and hydroxides in an oxidized zone. Grade ranges from 0.1 to 230.0 g/t Au, and rarely up to 1.5 kg/t. Au. The average grade is 21.2 g/t Au in 0.7 m average thickness of vein.

High grade of Cu and Ag also occurs with average grade of 61.2 g/t Ag, and 1.94% Cu. Drilling shows deposit extends 300.0 m below surface with decreasing in grades and thickness. The deposit is large with resources of 12 million tonnes ore.

Teshig 1 Au Au Skarn Deposit

This deposit (Alaev and others, 1985) is hosted in Vendian to Early Cambrian volcanic and sedimentary rocks of the Buuraltai Unit that is intruded by gabbro, quartz syenite of the Late Permian Selenge Complex, and by various early Mesozoic dikes and stocks. The deposit consists of a Cu-Au magnetite-garnet-epidote skarn that occurs along the contact between the Vendian to Lower Cambrian limestone and the early Mesozoic diorite-granite intrusive stock. The contact is cut by a northwest-trending fault zone that contains vein magnetite Cu and Au, and and post-deposit intermediate dikes. The magnetite bodies dip steeply northeast, are intensely altered to limonite and Fe hydroxides. The skarn is 1500.0 m long and varies from 25.0 m to 80.0 m wide. The same Cu and Au minerals occur in skarn, magnetite, and limonite-magnetite bodies. The ore minerals are mainly malachite, rare azurite, chalcopyrite, pyrite, bornite, covellite, and gold. Au grains varies from 0.001 to 0.7 mm and average size 0.05-0.2 mm. The deposit is divided in to three parts. The skarn contains 0.1-1.0 g/t Au with average grade of 0.5 g/t Au. Magnetite bodies average 0.3% Cu, up to 0.5 g/t Au (average 0.1 g/t Au). Average grade of 0.12% Cu in skarn without magnetite.

Naranskoye Fluorspar Vein Deposit

This deposit (Kozhemyachenko and others, 1971; Bulnaev, 1995) consists of 17 steeply-dipping veins, 9 of these are largest (600-1200 x 1.0-4-6x170-300 m). The deposit occurs in both veins crush zones with major quartz and fluorite in variable proportions (10-85% CaF_2 with an average of 31%), and lesser kaolinite, montomorillonite, hydromuscovite, and pyrite, and very rare galena and sphalerite. The minerals occur in breccia and masses. S, P, Fe range up to about 0.01%.. The host rocks are diverse and include mainly Middle Triassic granosyenite, and lesser Mesoproterozoic sedimentary-metamorphic,Early Triassic to Early Jurassic volcanic and sedimentary, and Middle Triassic to Middle Jurassic granitoids. Peripheral alterations are weak to absent. Deposit occurs in a highly-deformed tectonic block (about 8 sq.km.) that occurs along a local fault. The deposit is large with an average grade of 31% CaF_2.

Oshurkovskoye Magmatic and Metasomatic Apatite Deposit

This deposit (Litvinovsky and others, 1998) consists of apatite in plutonic sheeted complex and occurs in concordant, lenses, plates and dikes of coarse- and medium-grained alkaline gabbro and syenite. Apatite is disseminated in alkaline gabbro with average grade of 4%. P_2O_5. There are a number of proximal site of 100-400 m wide, 300-600 m long, with 5-6% P_2O_5 and locally 10-20% P_2O_5. Apatite forms tabular, short prismatic, and rare spicular crystals in cumulates, in poikillitic inclusions in pyroxene and amphibole, in phenocrysts in microgabbro dikes, in variably-trending lenses and nests with dimensions of 0.2-2.0 m that are composed of 80-90% tabular apatite grains with minor hornblende and titanic magnetite. Gabbro includes hornblende-feldspar pegmatoid spots with numerous apatite inclusions. Deposit includes fracture and hydrothermal alteration alteration zones that range from 5-20 m thick and 50-80 m long that are enriched in carbonate, chlorite, local apatite (about 35%), and ceolite. The host rock is granite and gneiss. The deposit formed in Early Cretaceous rifting, is large, has an average grade of 4.1% P_2O_5.

Origin and Tectonic Controls for Dzid-Selenginskiy Metallogenic Belt

The belt is interpreted as forming during subalkaline and alkaline granitoid magmatism associated with extensional or back arc rifting related to the Orhon-Selenge continental margin arc. The metallogenic belt is hosted in the Transbaikalia sedimentary-volcanic-plutonic belt. The main characteristics of the granitoid-related Au vein and Au skarn deposits and occurrences in the Tseshig district are: (1). complex major metals of Au, Ag and Cu; (2) a close relation to a high alkaline syenite-diorite and monzonite-granite sequence; (3) a close relation of W, Mo vein, greisen and skarn, granitoid-related Au vein deposits and occurrences with siliceous and leucocratic granite; and (4) a relation of Au-Ag-Cu vein and skarn deposits to intermediate intrusives and melanocratic granitoid sequences that intruded during continental rifting.

REFERENCES: Tsyba, 1990; Bulnaev, 1995; Khodanovich, 1995; Litvinovsky and others, 1998; Geological Map of Mongolia, 1999; Dondovyn, 1999.

Khilokskiy Metallogenic Belt of Sn-W Greisen, Stockwork, and Quartz Vein Deposits (Belt Khl) (Russia, Western Transbaikalia)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to veins, replacements, granitoids, volcanic complexes related to the Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that overlies and intrudes the Barguzin-Vitim granitoid belt and Selenga sedimentary-volcanic plutonic belt. The belt occurs in the southwestern part of Eastern Transbaikalia in the Khilok River Basin, and is about 375 km long and 60 km wide. Sn-W greisen, stockwork, and quartz vein deposits deposits are the major deposits in the belt. Only one W deposit and small Au, Mo, and rare Cu occurrences are known. The major deposit is at Bom-Gorkhonskoye. The belt is promising for undiscovered W and partly Mo deposits.

Bom-Gorhonskoye W-Mo-Be greisen, Stockwork, And Quartz Vein Deposit

This deposit.(Ageev and others, 1975; Barabanov, 1975; Belogolovkin, 1977; Ontoev, 1974; Sizykh, 1995; Skursky, 1996) consists of a series of gently-dipping quartz-hubnerite veins that occur in three extended subparallel areas. The veins contain quartz (to 85 to 95%), large-tabular hubnerite (to 5 to 10 cm), muscovite, molybdenite, and fluorite. Less widespread are pyrite, sphalerite, chalcopyrite, and kozalite. The deposit is hosted in the southeastern endocontact of a Late Triassic to Early Jurassic granitoid pluton. Granite that forms the first phase the pluton hosts the deposit. The granite exhibits alteration to greisen, K-feldlspar, muscovite, and silica. The three areas consist of: (1) a central area with quartz-hubnerite and numerous dikes of Early Jurassic granite, diorite and quartz porphyry; (2) the Cheremshansky area that in addition has a quartz-molybdenite deposit; and (3) the Kluch area with a Mo-W stockwork deposit. The deposit is medium size with an average grade of 0.5-1.0% WO_3.

Origin and Tectonic Controls for Khilokskiy Meyallogenic Belt

The belt is interpreted as related to magmatism that occurred transpression zones related to transform micro plate boundaries and within plate (plume) environment.

REFERENCES: Ontoev, 1974; Ageev and others, 1975; Barabanov, 1975; Belogolovkin, 1977; Sizykh, 1995; Skursky, 1996.

Onon-Chikoiskiy Metallogenic Belt of W-Mo-Be Greisen, Stockwork, and Quartz Vein, and Sn-W Greisen, Stockwork, and Quartz Vein Deposits (Belt OCH) (Russia, East Transbaikalia)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to veins, replacements, volcanic complexes, and granitoids in the Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that overlies and intrudes the Hangay-Dauria terrane, Zag-Haraa turbidite basin, and Selenga sedimentary-volcanic plutonic belt. The belt occurs in the southern Transbaikalia area in the Chikoy River Basin, is isometric shaped, and trends northeast. The belt extends for 240 km and is 170 km wide. The Late Mesozoic rocks of Transbaikalia sedimentary-volcanic-plutonic belt are calc-alkaline and subalkaline granitoids of the Sokhondinsky, Kyrinsky, Asakan-Shumilovsky and Kharalginsky Complexes. The associated overlap volcanic and sedimentary units occur in scattered fault-controlled fields. The major deposits are at Kunaleyskoye and Shumilovskoye. The belt is promising for discovery large objects with W, Sn and partly Au and Mo deposits.

The major deposits in the belt consist of W-Mo-Be greisen, stockwork, and quartz vein stockwork, and quartz vein deposits, and Sn-W greisen, stockwork, and quartz vein deposits with similar features. The W greisen, quartz-wolframite and quartz-wolframite-cassiterite vein deposits occur along exocontact of Early to Middle Jurassic granite and granite porphyry stocks (Levitsky, 1964; Getmanskaya and others, 1976; Skursky, 1996). Most greisen bodies occur at the surface, but some occur in the subsurface, and dip gently at depths of 70 to 140 m in domal zones above granite stocks. Short quartz-wolframite and quartz-wolframite-cassiterite veins occur at depths of 40 to 60 m, and dip gently over peripheries of granitoid domes. The veins have a variable strike and range from 0.05 to

1.2 m thick (Omelyanenko and others, 1973). The major ore minerals are wolframite and scheelite, and minor minerals are molybdenite, cassiterite, pyrite, chalcopyrite, pyrrhotite, sphalerite, and galena. Gangue minerals are quartz, topaz, fluorite, apatite, Li-mica, beryl, and muscovite. Anomalous Rb, Ta and Nb occur. No large deposits occur in the belt.

Gold deposits are moderately abundant in the belt; however, are not economic deposit. The deposits are mainly Au quartz veins and zones, and Au-quartz low-sulfide stockworks (Petrovskaya, 1973). The gold deposits occur only in middle Paleozoic metasedimentary rock and schist, and are associated with granite and granodiorite plutons of the Middle Jurassic Asakan-Shumilovsky complex.

Shumilovskoe Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Omeljanenko and others, 1973; Getmansky, Chernov, 1976; Skursky, 1996) contains 30 W greisen bodies and 50 quartz-wolframite-cassiterite veins with dimensions of 10 by 700 by 0.2 m. The greisen body has dimensions of 600 by 500 m, is concealed, and dips gently to 70 to 140 m depth. The greisen occurs in a superdomal zone that covers an area of 2.5 km^2 and contains a stockwork in Early and Middle Jurassic Li-F granites. Other greisens occur on the surface and have dimensions of 1-280 by 5-10 m. Most widespread are mica-quartz, mica-topaz-quartz, and topaz-quartz greisen. The main ore mineral is wolframite with lesser cassiterite and molybdenite, pyrite, and sphalerite, and lesser chalcopyrite and galenite.Non-metalliferous minerals are quartz, Li mica (0.85% Li_2O) topaz, fluorite (3.7-4.6% F). Also occurring is anomalous Rb, Ta, Ni, Mo, Bi, and Cu. Short quartz veins (40-60 m length) occur along the periphery of the dome, dip gently, and range from 0.05 to 0.6 m thick. These veins contain wolframite and cassiterite and lesser scheelite, molybdenite, arsenopyrite, pyrite, chalcopyrite, bismuthite, galenite, and fluorite. Gangue minerals are quartz, muscovite, and fluorite, and rare topaz. The deposit is medium size with an average grade of 0.28% WO_3 in greisen, 0.85% WO_3 in quartz vein.

Upper Kumyr W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Khasin, 1977, Jargalsaihan and others, 1996) consists of quartz-wolframite, quartz-wolframite-cassiterite, and quartz-molybdenite-beryl veins that occur at the contact of and in a granite pluton. The veins occurring in the granite pluton are bordered by a greisen zone that ranges up to 5-7 cm thick and contains molybdenite, cassiterite, and basobismutite. Fragments of quartz and silicified breccia with wolframite also occur in the host rocks. The deposit is small and has produced 877 tonnes Sn and 1,022 tonnes WO_3.

Origin and Tectonic Controls for Onon-Chikoiskiy Metallogenic Belt

This belt is interpreted as related to magmatism that occurred transpression zones related to transform micro plate boundaries and within plate (plume) environment.

REFERENCES: Levitsky, 1964; Omelianenko and others, 1973; Petrovskaya, 1973; Getmanskaya and others, 1976; Skursky, 1996.

Verkhne-Ingodinsky Metallogenic Belt of Cassiterite-Sulfide-Silicate Vein and Stockwork Deposits (Belt VIG) (Russia, Central Transbaikalia)

This Middle Jurassic to Early metallogenic belt is related to veins, volcanic complexes, and replacements related to Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that overlies and intrudes the Hangay-Dauria terrane and Selenga sedimentary-volcanic plutonic belt. The belt extends for 175 km, varies from 25 to 50 km wide, and trends northeast. The Late Mesozoic Trans-Baikalian-Daxinganling belt is composed of calc-alkaline and subalkaline volcanic rock of Sokhondinsky and Dzhargalantuy Suites, and calc-alkaline and subalkaline granitoids of the Sokhondinsky, Kyrinsky, Asakan-Shumilovsky, and Kharalginsky. The granite porphyries in these suites hot the Sn-W deposits (Ingodinsky and Sokhondinsky deposits). The major deposits are at Ingodinskoye and Levo-Ingodinskoye.

Large cassiterite-sulfide-silicate vein and stockwork deposits occur at Ingodinskoye and Levo-Ingodinskoye. Small deposits occur at Novoye, Sokhondinskoye, Uljurtuoye, Perevalonoye, Ozernoye and, Bukukunskoye. The deposits are controlled by the Ingodinsky fault. The deposits are hosted in brecciated hornfels and siltstone. The deposits consists of: (1) a thick network of veins and veinlets filled with cassiterite, arsenopyrite, chalcopyrite, quartz, fluorite, topaz, and muscovite (as at the Ingodinskoye and Levo-Ingodinsoye deposits); (2) pipes of granite porphyry with quartz-cassiterite veins and veinlets; (3) scattered, disseminated pyrite, arsenopyrite, cassiterite, and scheelite; and (4) local areas of a gradation from granite porphyries into veins (Sokhondinskoye deposit). The zones deposits range from 200 m to 1 km wide (Semenjuk and Donenko, 1964).

Origin and Tectonic Controls for Verkhne-Ingodinsky Metallogenic Belt

Belt interpreted as related to magmatism that occurred transpression zones related to transform micro plate boundaries and within plate (plume) environment. The belt is prospective for undiscovered Sn, W, and As deposits.

REFERENCES: Semenjuk and Donenko, 1964.

Onon-Turinskiy Metallogenic Belt of Porphyry Au, Granitoid-Related Au Vein, and Cassiterite-Sulfide-Silicate Vein and Stockwork Deposits (Belt OT) (Russia, Central Transbaikalia and Mongolia)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to veins, volcanic complexes, and replacements related to Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that overlies and intrudes Selenga sedimentary-volcanic plutonic belt, and Ononsky terrane. The belt occurs along the Onon and Ingoda Rivers, trends east-northeast along the western boundary of the Argunsky terrane for 300 km, and ranges from from 50 to 70 km wide. The Late Mesozoic Transbaikalia sedimentary-volcanic-plutonic belt consists of calc-alkaline and subalkaline volcanic rock of the Sokhondinsky and Dzhargalantuy Suites, calc-alkaline and subalkaline granitoid of the Sokhondinsky, Kyrinsky, Asakan-Shumilovsky Kharalginsky Complex, diorite and granodiorite of the Shakhtaminsky Complex, and REE granite of the Kukulbey Complex. They volcanic rock units are lava, pyroclastic, extrusive, and subvolcanic varieties that occur in volcanic domes, pluton-related domes, and basins that are controlled by longitudinal and transverse faults (Seminsky, 1980). The Mongolian part of the belt occurs in the Hentii subterrane of the Hangay-Dauria terrane adjacent to Russia, and consists of Sn-W greisen, stockwork, and quartz vein, and stockwork deposits. The belt contains a few cassiterite-wolframite-quartz and wolframite-cassiterite-beryl-quartz veins that are related to small plutons composed of biotite, two-mica, and muscovite fluorite leucogranite that is intensely altered to greisen, and tp leucogranite porphyry with K-Ar isotopic age of 146 Ma (Koval, 1998). The major deposits are at Ara-Ilinskoye, Khapcheranga, Lubavinskoye, and Tarbaldzhiskoye.

The major deposits in the Onon-Turinskiy belt occur in two districts that strike northeastern and are controlled by crossing northwest-striking faults. The deposits are related to Jurassic and Cretaceous magmatism and faulting the define the districts. The largest district is at Lubavinsky-Tarbaldzhey and contains the Lubavinsky granitoid-related Au vein deposit. This deposit contains simple and saddle-like Au-quartz veins (Shubin, 1984). The Tarbaldzhey deposit with cassiterite-sulfide-silicate veins and stockwork contains feldspar-fluorite-quartz veins with cassiterite and sulfides (Ontoev, 1960). The Ara-Ilinsky porphyry Au deposit occurs in a cryptovolcanic diatreme and consists of an Au stockwork (Fogelman, 1964).

Khapcheranga Cassiterite-Sulfide-Silicate Vein and Stockwork Deposit

This deposit (Ontoev, 1974; Gongalsky and Sergeev, 1995; Skursky, 1996) consists of 20 extensive (to 1100 m) veins with thickness of 0.4-0.5 m, in swells 1.5-2.0 m in steeply-dipping shears with a NWN strike, and 50 small, variably-trending veins on the southern flank of the deposit. Major minerals are cassiterite, arsenopyrite, sphalerite, pyrrhotite, and galena; less common are chalcopyrite, pyrite, stannite, ferebrite, and marcasite; minor molybdenite, lellingite, magnetite, bismutine, gray ore, and argentite; and very rare hydrothermal kavalerite, tantalite, hematite, and monazite. Non-metalliferous mlnerals are quartz, muscovite, topaz, chlorite, microcline, albite, biotite, fluorite, calcite, tourmaline, and epidote. Vein occurs along southern exocontact of a stock (2 sq.km. area) of Middle Jurassic granite porphyry with greisen in apical part. The veins are multi-staged, and have a mineral zonation defined by the distance from the contact of the granite stock: zone 1 has apical Sn-W greisen; zone 2 contains quartz-feldspar with arsenopyrite, pyrite, pyrrhotite, cassiterite, and sphalerite; zone 3 contains sulfate-cassiterite-chlorite with pyrrhotite and sphalerite,an economic assemblage; and zone 4 has carbonate-sphalerite-galena with cinnabar and antimonite. The enclosing rock consists of quartz-altered and chlorite-altered sandstone and shale of Early and Middle Triassic age that is sheared in a sublatitudinal anticlinal fold. The deposit is medium size with a grade of 0.75% Sn, 0.3-25% Pb, 1-25% Zn, 0.01-0.17% Cd, 11-600 ppm Ag . Over 10,000 tonnes of metal has been produced. The deposit is prospected to the depth 475 m; developed to 400 m depth.

Lubavinskoye Granitoid-Related Au Vein Deposit

This deposit (Kitaev, 1977; Shubin, 1984) consists of saddle-shaped gold-quartz veins, mineralized dikes, and local stockworks. The veins are subdivided into extensive veins that extend some hundred meters that dip steeply, and short brecciated veins that extend tens of meters and dip gently. The former occur in shears often parallel to layering of hosting rock, whereas the latter occur rupture fractures, Thickness of both types ranges from a few centimeters to 1-5.2 m in swells. Deposit is hosted in weakly metamorphosed sandstone and shale that is intruded by intermediate and siliceous granitoids dikes and stocks. The highest concentration of veins occur adjacent to small granitoid stock. Gold occurs in veins in columns. The veins consist of quartz with minor (0.5-4.0%) sulphides with lesser ankerite, siderite, and barite. The primary ore minerals are gold, arsenopyrite, and pyrite with lesser galenite, sphalerite, chalcopyrite, grey ore, Pb and Sb sulfosalts, pyrrhotite, Pb, Bi, and Bi meneginite and sulfoantimonite, and local scheelite, cassiterite, molybdenite, and cinnabar. Gold occurs as free gold in quartz (70%), in intergrowths with sulfides, and dispersed. The ore minerals occur in breccia, layeres, and disseminations. Main alterations are beresite and silica. The deposit is located along the Mongolo-Okhotsk suture. The deposit is medium size with an average grade from a few to several hundred ppm Au.

Ara-Ilinskoe Porphyry Au Deposit

This deposit (Fogelman, 1964, 1968; G.V.Shubin, 1984) consists veinlets and stockwork that are hosted in a cryptovolcanic diatreme that contains extrusive units (trachyliparites), subvolcanic bodies (dikes of quartz porphyries, diorite porphyry, and diorite stock), and explosive units (breccia with clasts of fragmented granite). All units in diatreme are altered to beresite. Gold occurs in cement of breccias as phenocrysts and in veinlets along with quartz, carbonate, and minor sulfides (3%). The sulfides arearsenopyrite and pyrite with lesser chalcopyrite, sphalerite, galenite, and tetrahedrite. The granite contains tourmaline. Gold is ditributed irregularly, 80% as free state in quartz grains, 20% in sulfides. Fineness of gold is 784-880. The deposit occurs along the Mongolo-Okhotsk suture. The deposit is small.

Tarbaldzheiskoe Cassiterite-Sulfide-Silicate Vein and Stockwork Deposit

This deposit (Smirnov, 1937; Radkevich, 1941; Ontoev, 1960) consists of three stockworks and a series of veins. The largest stockwork is 350-400 m wide and 400-800 m long. The stockworks consists of: thin subparallel veinlets with quartz, cassiterite, and arsenopyrite, and rare fluorite, topaz, muscovite, pyrite, wolframite, beryl; and bodies of explosive breccias with quartz, orthoclase, and fluorite, rare wolframite. The deposit is interpreted as a complicated cassiterite-sulfide body that is overprinted by Sn greisen. The veins have dimensions of 50 by 600 by 0.1-0.5 m, and contain assemblages of feldspar-fluorite-quartz (quartz, orthoclase, fluorite, galenite, sphalerite, arsenopyrite, cassiterite), polymetallic (quartz, chlorite, galenite, sphalerite, chalcopyrite, cassiterite, stannine, pyrite, pyrrhotite, arsenopyrite), and quartz (quartz, fluorite, galenite, sphalerite, native gold) composition. The veins occur in the superdomal part of a hidden Mesozoic granitoid stock that occurs along a regional fault. The host rocks are metamorphosed Middle Permian through Early Tertiary sandstone and shale on the southern side of the fault, and by Silurian to Early Evonian sedimentary rocks on the southern side that are altered to greisen, K-feldspar, silica, and sulfides. Middle Triassic through Late Jurassic quartz porphyry, lamprophyre, and porphyry dikes are widespread. The deposit contains anomalous Pb, Zn, As, Ag, W, Cu, Bi, Au, Be, Li, and CaF_2. The deposit is medium size with an average grade of 0.75% Sn, 0.5-16% Pb; 1.6-24% Zn; 0.05-0.3% WO_3.

Origin and Tectonic Controls for Onon-Turinskiy Metallogenic Belt

The belt is interpreted as related to magmatism that occurred transpression zones related to transform micro plate boundaries and within plate (plume) environment. The belt and related host rocks occurs along sub-meridional Onon-Tura fault that strikes east-northeast, and companion northwest-striking faults. These major structures as associated with the tectonic origin of the intricate Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt.

REFERENCES: Zonenshain and others, 1990; Kovalenko and others, 1995; Koval, 1998; Gerel and others, 1999; Cluer and others, 2000; Tomurtogoo, 2001.

Aginskiy Metallogenic Belt of Sn-W Greisen, Stockwork, and Quartz Vein, REE-Li Pegmatite, Ta-Nb-REE Alkaline Metasomatite, and Hg-Sb-W Vein and Stockwork Deposits (Belt AG) (Russia, Eastern Transbaikalia)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to veins, volcanic complexes, and replacements related to Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that overlies and intrudes the Argunsky terrane. The belt occurs along the the Aga and Onon Rivers, extends northeast for 300 km, and ranges from 50 to 70 km wide. In this area, the Transbaikaliaian belt consists of diorite and granodiorite of the Shakhtaminsky Complex and REE granite of the Kukulbey Complex. The major deposits are at Spokoininskoye, Barun-Shiveinskoye, Malo-Kulindinskoye, and Orlovskoye.

The major districts in the belt are at Uronaysky, Spokoininsky, Taptanay, and Durulguevsky, and are related to plutons of Kukulbey granite or are hydrothermal deposits that occur in or adjacent to the plutons. The largest Spokoininsky district is associated with the Khangilay-Shilinsky pluton and contains the Orlovskoye Ta-Nb-REE alkaline metasomatite deposit that occurs in the apical part over a plutonic dome. The deposit consists of lepidolite- and amazonite-albite granite and quartz-topaz greisen with columbite, tantalite, and microlite (Grebennikov and others, 1995). The Spokoininsky deposit in this district is a Sn-W greisen and stockwork and quartz vein deposit and consists of quartz-wolframite veins and stockworks. The Durulguevsky district contains quartz-wolframite deposits in plutonic rock. In this district is the Barun-Shiveinsky wolframite-stibnite-cinnabar deposit that consists of a Hg-Sb-W vein and stockwork (Borovkov and Gaivoronsky, 1995). The metallogenic belt contains scattered minor Late Jurassic intrusions in stocks, laccoliths that are associated with domal uplifts roof rock over late magmatic phases. The late phases consist of hypabyssal dikes of leucocratic granite, granite porphyry, and granosyenite (Kozlov and others, 1977) that are oversaturated in alumina. K predominates over Na, and Sn, W, Ni, Ta, Li, and Be occur.

Spokoininskoye Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Scheglov and Butkevich, 1978; Reif and others, 1982; Grebennikov, 1995) consists of a greisen stockwork with a surface area of 600 by 320 m with a saddle shape, and an apical thickness of 50 to 100 m. The stockwork occurs in the apex of Late Jurassic two-mica granite that is altered to albite. The deposit dips gently to a depth of 200-320 m. Thre stockwork contains: (1) tungsten-bearing quartz-muscovite greisen (major types) with high-grade blocks of quartz and feldspar; and (2) 17 veins and streaks with wolframite in steeply dipping shear fractures with dimensions of 600 by 0.10-2.0 m. The major minerals are wolframite, quartz, muscovite, and fluorite, and minor minerals are pyrrhotite, sphalerite, chalcopyrite, bismuthine cassiterite, scheelite, tourmaline, and tantalite-columbite. Also occurring locally is apatite, zircon, garnet, topaz, and pyrite. Wolframite contains from 0.5 to 1.0% Ta+Nb The granite stock contains two-mica amazonite granite that intrudes Mesoproterozoic sericite, chlorite-quartz and quartz-biotite shale and sandstones. The deposit occurs in the site of intersection of northeast and northwest striking faults. The deposit is medium size with an average grade 0.27% WO_3 (range of 0.1-0.9% WO_3).

Malo-Kulindinskoye REE-Li Pegmatite Deposit

This deposit (Grebennikov, 1995) consists of a series of extensive pegmatite veins that strike northwest strike and are hosted in biotite shale, sandstone, and conglomerates. The pegmatite bodies are platy, lenticular, saddle-like, and irregular. The bodies range from 1 to 18 m thick and extend several hundred meters along strike. The bodies consist of replaced and partly replaced types. The replaced pegmatites consist mainly of albite, quartz, muscovite, and are economic for Ta and Be. The main ore minerals are tantalum-columbite andberyl and grade ranges up to 0.048% Ta_2O_5 and 0.104% BeO. Also occurring is anomalous Nb, Sn, and Li. The partly replaced and non-replaced pegmatite bodies consist mainly of K-feldspar, plagioclase, quartz, muscovite, tourmaline, and garnet. The pegmatite veins are related to Late Mesozoic two-mica pegmatite granite. The deposit is small.

Barun-Shiveinsky Hg-Sb-W Vein and Stockwork

This deposit (Scheglov and Butkevich, 1978; Borovkov and Gaivoronsky, 1995) consists of a linear lenticular stockwork with surface dimensions of 800 by 80-250 m that strikes northwest direction extendes to a depth of 200 m. The deposit consists of two types bodies: (1) lenticular breccia with dimensions of 10-80 by 1-2 m with ferberite, stibnite, and cinnabar; and (2) veins in steeply-dipping shear fractures with dimensions of 20-100 by 0.05-1.0 m that contain wolframite and stibnite composition. The major ore minerals are ferberite, cinnabar, and stibnite, and rare wolframite, pyrite, chalcopyrite, sphalerite, arsenopyrite, siderite, magnetite, pyrrholusite, quartz, and carbonate. The stockwork occurs in the hanging wall of an anticline fold, dips gently, and extends along strike for 2 km. Wall rocks are lasted to silica, hydromica, and sericite. Host rocks are Mesoproterozoic chlorite and quartz-chlorite schists and quartzite. The deposit is small, mined out, and on the edges contains resources of up to 5,000,00 tonnes WO_3 with an average grade of 0.8% WO_3, 0.2% Hg, 0.05% Sb

Origin and Tectonic Controls for Aginskiy Metallogenic Belt

The belt is interpreted as related to magmatism that occurred transpression zones related to transform micro plate boundaries and within plate (plume) environment. The major structural control is the Central Aginsky fault zone that controls the loci of deposits and related host rock. The belt is prospective for undiscovered of Ta, Nb, REE, W, and Sn deposits associated with plutons of the Kukulbey Complex, particularly in the subsurface.

REFERENCES: Kozlov and others, 1977;Borovkov and Gaivoronsky, 1995; Grebennikov and others, 1995.

Tuanjiegou Metallogenic Belt of Granitoid-Related Au Vein Deposits (Belt TJ) (Northeastern China)

This Late Jurassic to Early Cretaceous metallogenic belt is related to granitoids in the Jilin-Liaoning-East Shandong volcanic-plutonic belt (too small to be shown on 10 M scale) that intrudes the Heilongjiang terrane and Zhangguangcailing superterrane. The belt trends north-south, and is about 90 km long and 30 km wide. The significant deposit is at Tuanjiegou.

Tuanjiegou Granitoid-related Au Vein Deposit

This deposit (Xu, Enshou and others, 1994) consists of vein, composite vein and pod-like deposits in the inner contact zone of a granodioritic porphyry (K-Ar age: 100 to 112.6 Ma) and in the altered fracture zones in the schist of Paleoproterozoic Heilongjiang group. Marcasite is the main ore mineral and pyrite, stibnite, native Au, galena, chalcopyrite, cinnabar, realgar, and orpiment are minor. The finness of native Au is up to 930. The deposits occur in breccia, vein, vugs, and crustiform structures. The largest boby is more than 900 m long. Wallrock alterations are planar and superimposed and consist of hydromica, kaolinite, silica, sericite, and bersite alterations. Ore-forming temperatures range from 150° to 350° and three stages are recognized. The deposit occurs at the intersection of Wulaga fault zone and Taipinggou anticlinorium in the northern part of the Variscan Jilin-Heilongjiang orogenic belt, north of the Jiamusi pluton and Zhangguangcai orogenic belt. The deposit is large with reserves of 80 tonnes grading 2-10 g/t Au

Origin and Tectonic Controls for Tuanjiegou Metallogenic belt

The belt is interpreted as forming during intrusion of post-accretionary granitoids associated with interplate magmatism along major faults. The belt and host plutonic rocks are related to subduction of Pacific plate under the Euroasian continent.

REFERENCES: Xu Enshou and others, 1994; Wu Shangquan, 1995.

East Mongolian-Priargunskiy-Deerbugan Metallogenic Belt of Polymetallic Metasomatic Carbonate and Volcanic Hosted, Zn-Pb (Ag, Cu, W) Skarn, Au Skarn, Au-Base-Metal Metasomatic Volcanic Hosted, W-Mo-Be Greisen, Stockwork, and Quartz Vein, Porphyry Cu-Mo (±Au, Ag), Porphyry Mo (±W, Bi) (W, Sn, Bi), Granitoid-Related Au Vein, Carbonate-Hosted As-Au Metasomatite, Au-Ag Epithermal Vein, Sedimentary Siderite Fe, Sn-W Greisen, Stockwork, and Quartz Vein, Carbonate-Hosted Hg-Sb, Sb, Fluorspar Vein, and Volcanic-Hosted U Deposits (Belt EMA) (Russia, Eastern Transbaikalia; Central and Eastern Mongolia, Northeastern China)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to Middle Jurassic to Early Cretaceous veins, volcanic complexes, replacements, and granitoids in the Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that overlies and intrudes the Argunsky terrane, Idermeg terrane, Gazimur sedimentary basin, Gobi-Khankaisk-Daxinganling volcanic-plutonic belt, Lower Borzja fore-arc basin, Upper Borzja marine molasse basin. The belt extends from central Mongolia to northeastern Mongolia, and into Russian and China. This metallogenic belt is one of the largest in NE Asia and contains about 80 mines, deposits, or occurrences.

The Russian part of the belt occurs in the Priargunsky passive continental margin terrane that is overlapped by the Gazimur sedimentary basin, Lower Borzja fore-arc basin, Upper Borzja basin, and Transbaikaliaian sedimentary and volcanic-plutonic belt. The Mongolian part the belt is related to granitic and volcanic units on the Paleoproterozoic Ereendavaa and Idermeg terranes. In Russia, the belt extends nearly for 500 km, ranges from 100 to 150 km wide, and occurs along the Gazimur, Urov, Uryumkan, and Argun Rivers. The belt is the largest and richest in Central Asia.

In Mongolia, the belt extends approximately 2000 km and varies in width from 100 km in southwestern part to 550 km in northeastern part (Dobrolyubov, and Filippova, 1990). The eastern Mongolian part of the metallogenic belt is overprinted on the Hangay-Dauria accretionary wedge, Onon accretionary wedge, Ereendavaa passive continental margin, Herlen ophiolite, Idermeg passive continental margin, Govi-Altay turbidite, and Mandal Ovoo island arc terranes (Tomurtogoo and others, 1999).

In Northeastern China the belt contains Deerbugan group of porphyry Cu-Mo (±Au, Ag), granitoid-related Au vein, and Au-Ag epithermal vein occurs in the western side of the Daxinganling Mountain ranges in Northeast Inner Mongolia of Northeastern China. The tectonic setting and metallogenic features of the group are similar to those in Russia and Mongolia (Hu Shaokang, Yan Hongquan, Ye Mao and others, 1998).

In China, the metallogenic belt is locally-named the Deerbugan metallogenic belt that is controlled by the northeast-trending Deerbugan fault. The belt extends for 800 km and ranges from 50 to 100 km wide, and is related the Middle Jurassic to Early Cretaceous Daxinganling volcanic-plutonic belt that formed after accretion of the Argun terrane. The multiple units of continental volcanic rock in the Daxinganling belt consist mainly of calc-alkalic felsic volcanic rock, including basalt, andesite, trachyandesite, dacite, and rhyolite. The associated plutonic rocks are diorite, granodiorite, biotite granite, granite porphyry, quartz monzonite, monzonite, and quartz monzonite porphyry. The metlalogenic belt contains several Cu, Mo, Au, and Ag deposits with great economic potential. The significant deposits are at Wunugetushan, Jiawula, and Erentalegai.

Akatuevsky and Blagodatskoye District-Transbaikalia

The Akatuevsky and Blagodatskoye districts contain widespread polymetallic (Pb, Zn, Ag) carbonate-hosted metasomatite deposits (Ekaterino-Blagodatskoye, Vozdvizhenskoye). The sphalerite-galena deposits contain significant Ag, CD, and local Au.

Au Deposits and Occurrences - Mongolia

Various Au deposits and occurrences (Dejidmaa, 1996) are at Dochiin gol, Turgen gol, Narsyn hondlon, Onon-Berh, Herlen, Dornot, Tsav, and Bulgan (Dejidmaa, 1996). Au deposits and occurrences in Dochiin gol, Dornot and Tsav districts (Mironov and Solovyev, 1993; Mironov and Trofimov, 1993) are subdivided into various age groups. Many deposits are related to diorite, granodiorite, monzonite, granite that occur in hypabyssal stocks and have K-Ar isotopic ages of 190 to 180 Ma and 165 to 175 Ma. Other deposits areclosely related to a Late Jurassic to Late Cretaceous basalt and rhyolite bimodal sequence (Mironov and Solovyev, 1993; Mironov and Trofimov, 1993).

The two major deposit types are granitoid-related Au deposit and granitoid-related Au-Ag-Sb-As and Au-Ag-Cu deposits. The granitoid-related vein and replacement Au (Tsagaanchuluut and others) occurrences are related to multiphase stocks of gabbro, diorite, granodiorite and granite that are cut by abundant granodiorite and granite porphyry and diorite dikes. Granitoid-related-vein and replacement Au-Ag-Sb-As occurrences (Borondor, Ovorhooloi and others) occur mostly in the northeastern Mongolian part of the belt in the exocontacts of granodiorite stocks in the Middle and Late Jurassic Yamalh complex that intrudes clastic rock. Granitoid-related vein and replacement Au-Te (Dagai, Harguit and Urliin ovoo and others) deposits and occurrences are closely related to microsyenite, lamprophyre, and diabase dikes with K-Ar isotopic ages of 190 to 220 Ma (Mironov and Solovyev, 1993; Mironov and Trofimov, 1993). The granitoid-related vein and stockwork and replacement Au-Ag-Cu occurrences (Nomint and Soyo Ondor) are related to the Avdar tolgoi deposit porphyry Cu-Mo (±Au, Ag) (W, Au, Ag) deposit located at the intersection of the Ulz gol and Doch gol Rivers. The Avdar porphyry Cu-Mo (±Au, Ag) tolgoi deposit is small and is Mo dominated. Granitoid-related Au (Il turuut) and Ag-Pb-Zn (Lutaagiin) occurrences are closely related to the Avdar tolgoi deposit.

Au-Ag Epithermal Vein Occurrences-Mongolia

Various poorly-studied Au-Ag epithermal vein occurrences are located mostly along the Onon and Ulz faults in the norther part and along major Mongolian and Nariin hiid faults in the southeastern part of the Mongolian part of the belt. The Au-Ag epithermal vein occurrences in the Turgen gol, Dornot, and Onon-Berh Au districts (Dejidmaa, 1996), that are in the northern part of thebelt, consist of vein and linear stockworks composed mostly of chalcedony and quartz in breccia with minor fluorite. The major occurrences are at Tsagaanchuluut khudag II in Turgen gol district, Ugtam occurrence in Dornot district, and the Tenuun gol, Tsagaan, Bayanzurh, and others in the Onon-Berh district. The Au-Ag epithermal vein occurrences are located mostly along the southeastern margin of the belt, are mainly related to a large hydrothermal-metasomatite that exhibits mainly argillic alteration. Potential deposits of this type occur along the border between Mongolia and China, between the Mongolian Ma lineament and the Nariinhiid fault, in China.

Baga Gazar Polymetallic (Pb, Zn, Ag) Carbonate-Hosted Metasomatite Deposit

This deposit (Smirnov, 1961; Polyakova, 1963; Sanin and Zorina, 1980) consists of a series of veins and stockworks. Large Kadainsly vein is characterized by varying thickness, presence of gentle bends over strike, and dipping branches and pinches. Occurs in carbonate rock along the contact with a thick, extensive dike of lamprophyre. The vein extends over 360-560 m, downdip to 180 m, and thickness varies from 0.4 to 6 m (average 1.7 m). Deposit occurs in breccia, veinlets, and disseminations, and consists of rare massive sphalerite, pyrite, and galena. The deposit is intensely oxidized to a depth of 150 m. The large Osinovsky stock is wedge -shaped. The upper horizon has an area of 3000 sq.m, the lower one has an area of 100 sq.m. The inner structure of the stock is complicated by non-metalliferous limestone and abundant, intricately branching bodies of lamprophyre. The stock contains rich galena and sphalerite. The ore minerals occur in veinlets and disseminations. Gangue minerals are quartz, ankerite, calcite, dolomite, sericite, and rare tourmaline. Depth of zone of oxidation is 20-25 m. At the pre-deposit stage, the host limestone was altered to skarn, dolomite, serpentinite, and silica, and shale to pyrite. At the pre-deposit stage also formed Fe-Mn metasomatite. The syn-deposit stage consists of quartz-dolomite-ankerite metasomatite. Dikes of lamprophyre and granite porphyry are altered to beresite. The deposit is small with an average grade of 3.5% Pb, 5.6% Zn.

Bayan uul 1 Granitoid-Related Au Vein Deposit

This deposit (Yu. B. Mironov and others, written commun.,1993; Jargalsaihan and others, 1996.) contains higher grade (up to 250 g/t Au). The deposit consists of a few quartz veins that range up to 5.0 by 1500 m that occur in a weak fault zone that ranges from 7.7 to 15.95 m wide. The deposit contains 9.36-123.0 g/t Ag, 0.11-1.46% Pb, 0.05-1.06% Zn, and 0.01-0.1% Cu. Heavy mineral concentrates grade up to 30.0-50.0 g/t Au in pyrite, up to 10.0-30.0 g/t Au in sphalerite and chalcopyrite, and 0.4-2.0 g/t Au in galena. Also occurring is lower fineness gold that ranges from one micron to 0.1-0.2 mm. High grade Au associated with rich polymetallic mineral concentrations. Also occurring are zones of berisite alteration that range from 1.0-2.0 m thick with abundant pyrite and that contain from 8.0 to 20.0 g/t Au. Quartz in stringers, from 0.1-5.0 mm thick and along with pyrite, galena, sphalerite, and chalcopyrite, grades up to 100.0 g/t Au. Microprobe analyse of gold grains shows composition of 28.7-66.65% Au, 32.0-67.35% Ag, 0.2-2.5% Bi, and 0.3-3.8% Cu. The deposit is medium size with reserves of 7 tonnes Au with an average grade of 9.36-123.0 g/t Ag, 0.11-1.46% Pb, 0.05 -1.06% Zn, 0.01-0.1% Cu.

Bayandun Fe-Zn Skarn Deposit

This deposit (D. Dorjgotov, written commun., 1990; Jargalsaihan and others, 1996) consists of numerous, steeply-dipping lenticular bodies of Fe Zn skarn that occurs along the contact between Devonian limestone and early Mesozoic subalkaline granite. The size of skarn bodies ranges from 40 by 100m to 100 by 800m. The bodies extend 100 m downdip. The sulfide-bearing skarn ranges from 100 to 300 m wide and extends for several hundred meters. The major ore minerals are sphalerite and magnetite. Gangue minerals are garnet, pyroxene, amphibole, quartz, and calcite. The deposit is medium size with reserves of 240,000 tonnes ore grading 25% Fe and 4-7.1% Zn.

Erentaolegai Au-Ag Epithermal Vein Deposit-China

This deposit (Li, Henian and others, 1994) consists of layers, veins, and pods hosted in Late Jurassic volcanic rock, mainly Mesozoic Yanshanian adamellite and rhyolite porphyry. The deposits are strongly controlled by fractures. Two ore mineral assemblages recognized, Mn-Ag and Ag quartz-vein minerals. The Mn-Ag assemblage consists of chlorargyrite and psilomelane with minor argentite, iodargyrite, cryptomelane, coronadite, pyrolusite, manganite, and limonite. The Ag quartz-vein assemblage consists of argentite and freibergite with minor polybasite, miargyrite, and jalpaite. Alterations are sericite, chlorite, silica, adularia, and carbonate. The deposit occurs in a Variscan orogenic belt between the Siberian and North China Platforms. The deposit is large.

Fluorspar Vein Deposits-Transbaikalia and Mongolia

In Transbaikalia, widespread development fluorspar vein deposits occur at the Abagaituiskoye and Solonechnoye, and nearby areas. The richer deposits occur in the southwestern end of the belt. The deposits consist of quartz-fluorite veins in hosted in variable rocks in the southern (Abagaituiskoye) and central (Solonechnoye, Shakhmatnoye) parts of the belt. In Mongolia, the fluorite vein deposits occur in northern and southern fluorite zones (Khrapov, 1977) that were first named the North Herlen, South Herlen, and Har Airag-Buyant fluorite zones (Kandinov and Dobrolyubov, 1984).

Jiawula Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Deposit-China

This deposit (Pan, Longju and Sun, Enyu, 1992; Li, Henian and others, 1993) consists of more than 40 vein-like bodies that occur along northwest-striking fractures. The wall rocks are a complicated sequence of Late Permian volcaniclastic rock of the Laolongto Formation, intermediate to mafic volcanic rock of the Late Jurassic Tamulangou Formation, intermediate to siliceous volcanic rock of Late Jurassic Shangkuli Formation, Variscan granite and Mesozoic diorite porphyry, feldsparphyre, quartz porphyry, and beschtauite. The main ore minerals are galena, sphalerite, pyrite, marcasite, pyrrhotite, and chalcopyrite. The minor ore minerals are magnetite, hemalite, bornite, and arsenopyrite. Alterations are silica, chloritication, carbonate, sericite, fluoritie, epidotie, and hydromica. The deposit occurs in a Variscan orogenic belt between the Siberian and North China Platforms. The deposit is large with reserves of 236,300 tonnes Pb and 379,000 tonnes Zn grading 130-173 g/t Ag, 3.16% Pb, 5.24% Zn.

Kadainskoye Polymetallic (Pb, Zn, Ag) Carbonate-Hosted Metasomatite Deposit

This deposit (Smirnov, 1961; Polyakova, 1963; Sanin and Zorina, 1980) consists of a series of veins and stockworks. Large Kadainsly vein is characterized by varying thickness, presence of gentle bends over strike, and dipping branches and pinches. Occurs in carbonate rock along the contact with a thick, extensive dike of lamprophyre. The vein extends over 360-560 m, downdip to 180 m, and thickness varies from 0.4 to 6 m (average 1.7 m). Deposit occurs in breccia, veinlets, and disseminations, and consists of rare massive sphalerite, pyrite, and galena. The deposit is intensely oxidized to a depth of 150 m. The large Osinovsky stock is wedge -shaped. The upper horizon has an area of 3000 sq.m, the lower one has an area of 100 sq.m. The inner structure of the stock is complicated by non-metalliferous limestone and abundant, intricately branching bodies of lamprophyre. The stock contains rich galena and sphalerite. The ore minerals occur in veinlets and disseminations. Gangue minerals are quartz, ankerite, calcite, dolomite, sericite, and rare tourmaline. Depth of zone of oxidation is 20-25 m. At the pre-deposit stage, the host limestone was altered to skarn, dolomite, serpentinite, and silica, and shale to pyrite. At the pre-deposit stage also formed Fe-Mn metasomatite. The syn-deposit stage consists of quartz-dolomite-ankerite metasomatite. Dikes of lamprophyre and granite porphyry are altered to beresite. The deposit is small with an average grade of 3.5% Pb, 5.6% Zn.

Klichkinskoye District (Transbaikal)

The Klichkinskoye district contains polymetallic (Pb, Zn, Ag) carbonate-hosted metasomatite (Klichkinskoye) and Zn-Pb (Ag, Cu, W) skarn (Savinskoye-5) deposits. The deposits are hosted in early Paleozoic dolomite, carbonaceous shale, and shale with interbedded limestone, sandstone, conglomerate. These sedimentary rocks are intruded by late Mesozoic stocks and dikes of diorite, leucocratic granite and porphyry. The host rocks and deposits are cut by faults and deformed into folds that control the location of bed, vein, and pipe-shaped deposits.

Klichkinskoye Polymetallic (Pb, Zn, Ag) Carbonate-Hosted Metasomatite Deposit

This deposit (Arkhangelskaya, 1963; Sanin and Zorina, 1978, 1980) consists of a series of thin and discontinuous plates, veins, and pipes with sphalerite and galena in dolomite with thin beds of shale. The deposit occurs in the same tectonic zone as Savinsky-5 deposit to the south. The bodies strike for a few hundred meters, extend downdip for tens of meters, and range from 0.1 to 1.,1 m thick with an average thickness of 0.2-0.3 m. The major ore minerals are pyrite, galena, sphalerite, and arsenopyrite, and minor pyrrhotite, chalcopyrite, and tetrahedrite, and rare bulanzherite, cassiterite, and scheelite. Major gangue minerals are quartz and calcite. The main ores assemblages are: pyrite-arsenopyrite, sphalerite-galena, and pyrite-arsenopyrite-sphalerite-galena. Sulfide bodies are cut by the quartz-fluorite (and local barite) veins and streaks. Oxidized ore minerals are limonite, cerussite, smithonite, kalamine, anglesite, skorodite, jarosite, galena, and quartz. The host dolomite is intruded by Late Jurassic granite, diorite stock, and rare granite porphyry dikes. Deposit and host rocks are altered to dolomite, serpentinite, silica, skarn, greisen, and beresite. The deposit is small with grade ranging from tens of fractions to 50% Pb (average 12%), from fractions to 17% Zn, and about 400 ppm Ag.

Novo-Shirokinskoye Volcanic-Hosted Au-base-Metal Metasomatite Deposit

This deposit (Kormilitsyn and Ivanova, 1968; Sanin and Zorina, 1980; Tauson and others, 1987) consists of a thick metasomatic zone of listvenite-beresite and sulfides that occurs in en-echelon branching bodies. The zone is hosted in trachyandesite latite volcanic rock that is intruded by small stocks and dikes of diorite porphyry, granodiorite porphyry and lamprophyre. The host rock is propiliticaly-altered to quartz, chlorite and dolomite. The zone extends for over 6 km, varies from 20 to 300 m thick and has no clear outlines. The sulfide bodies occur in pipes, nests, lenses and veins, extend along strike for 1500 m and range from 1.5 to 30 m thick. The sulfides occur in layers, streaks and disseminations. Sulfide bodies consist of 60-80% pyrite, galena and sphalerite with local sulphosalt, quartz and dolomite. The sulfide body structures are massive, banded, dense disseminations, spots and coliform. Streaks and disseminations form haloes around massive sulfides, but commonly form independent bodies with irregular distribution of sulfides. Several assemblages occur: tourmaline; pyrite with Au (pyrite, rare aresonpyrite and chalcopyrite); polymetallic with Au (pyrite, galena, sphalerite, quartz, carbonates); sulphosalt with Au (gray ore, tetrahedrite, shwartzite, tennatite, cleiophane, dolomite); and realgar-antimonite with Au and Hg-barite-antimonite. Gold is fine-grained and occurs in sulfides. Oxidation zone occurs to a depth of 16 m. The deposit is medium size with an average grade of 3.53% Pb, 1.35% Zn, 3.11 ppm Au, 62 ppm Ag ; 0.25% Cu, 3.47 ppm Cd, 9.77 ppm In, 3.75 ppm Se, 6.44 ppm Te.

Savinskoye-5 Zn-Pb (Ag, Cu, W) Skarn Deposit

This deposit (Arkhangelskaya, 1963; Lobanova and Sanin, 1963; Sanin and Zorina, 1978, 1980) consists of lenses, veins, nests, and pipes that occur in a thick (150-200 m) and extensive (over 2 km) zone. The zone contains skarn, propylite, , relict of host limestones, schist, diorite, rare dolerite dikes, and fluorite and zeolite veins and nests. The deposit occurs in a tectonic zone and is boundedby the western and eastern bodies of quartz diorite of the Paleozoic Savinsky stock. The skarn bodies extend for80-500 m and locally up to 960 m, extend down dip for 100-500 m, and range from 0.7 to 17 m thick. The major ore minerals are pyrite, pyrrhotite, galena, and sphalerite, and lesser arsenopyrite, chalcopyrite, bulanzherite, markasite, and melnikovite. The major gangue minerals are quartz and calcite. Pyrite-galena in aksinite and diopside skarn occur in the upper and middle layers, and pyrrhotite-sphalerite occur in garnet skarns in lower layers. Oxidation zone extends to 80 m depth. Oxidized minerals include limonite, cerussite, smithsonite, kalamine, anglesite, skorodite, jarosite, residual galena, and quartz. The deposit age is interpreted as Late Jurassic. The deposit is medium size with an average grade of 2.45% Pb, 4.5% Zn.

Sediment-Hosted Hg and Sb Occurrences - Mongolia

Sediment-hosted Hg (Obolenskii, 1985) and sediment-hosted Sb occurrences are located in the northeastern part of the metallogenic belt, and are hosted in Late Permian and Triassic marine sedimentary rock in central part of the Doch gol district. The major occurrences are at Harzat Hg, Tagiinburd Sb, Gorhit bulag Sb, Baruun bulag Sb, and Huts Ondor Sb. These and other occurrences are located close to, or along a weak northeast-striking fault zone. Vocanic-rock-hosted Hg occurrences, such as at Dalai Am gol and Hotol and others, occur in the northeast-striking Ulz fault that occurs between Cretaceous grabens and pre-Cretaceous horsts. The Hg deposits consist of Hg-quartz-carbonate and barite vein and stockworks and curt early Paleozoic and Permian granite. The occurrence of barite vein deposits is similar to volcanic-jpsted Hg occurrences.

Shakhtaminskoye Porphyry Mo (±W, Sn, Bi) Deposit

This deposit (Kormilitsyn, 1973; Sidorenko, 1961; Sotnikov and others, 1995) consists of over 300 steeply-dipping veins (30-800 x 0.2-0.5 m) having low-grade stockwork inbetween. Three types deposit mineral assemblages occur: early-quartz-tourmaline with rare disseminations of large-scaly molybdenite; average-fine-grained quartz with small-scaly molybdenite and rare pyrite; late one with pyrite, sphalerite, chalcopyrite, pyrite, galena, tetrahedrite, bismuthite, pyrarhyrite, gray ore, antimonite and native gold. Assemblages are zonally combined in the veins of complex composition. Stock-and veins of pre-deposit explosive breccia with dimensions of bodies to 500 x 600 m. The deposit minerals contain impurities (ppm): 10-70 Re; 10-30 Se and Te; 0.1-1.6 Au; 17.0 Ag; as well as Cd, In, Ga, Ge. Deposit occurs in the southern part of the multi-phase Shakhtaminsky massif (135 sq. km) of biotite-hornblende granite and granodiorite (Middle and Late Jurassic) cut by late Mesozoic dikes produicing the zone of 40 x 7 km. Granitoids are altered to K-feldspare, sericite, beresite and argillite. The deposit is medium size with a grade of 0.03-1-2% (average 1%) MoS2, 0.5-0.7% Cu, about 0.8% Pb, about 0.9% Zn.

Solonechnoye Fluospar Vein Deposit

This deposit (Pavlenko and Grachev, 1972; Kormilitsyn, 1973; Ivanova, 1974; Pavlenko, 1975) consists of an intricate zone that extends ENE for 1.5 km along strike and dips steeply northwest. The zone contains two bodies. The main body is a linear stockwork (with dimensions of 350 by 25-30 x 200 m) that contains a series of closely-spaced, subparallel feathering veins that are cut by a network of small and variably-oriented veinlets. The eastern vein (with dimensions of 300 by 1.5-3,0 m) is a gash vein. All veins and veinlets display a symmetrically-zoned structure and consist quartz and fluorite (90%), minor adularia and hydromicas, and sporadically disseminations of calcite, pyrite, and arsenopyrite. Fluorite is mainly green and rarely violet. Structures are massive and rare bands, and texture is coarse-crystalline. The hosting middle Paleozoic biotite-hornblende granite (PZ2) is altered to silicified and chlorite adjacent to the deposit. The deposit is small with an average grade of 67% CaF_2. Surrounding area contains a resource of 2.8 million tonnes CaF_2.

Tsagaanchuluut khudag II Au-Ag Epithermal Vein Deposit

This deposit (Togtokh and others, 1974; Schekin and others, 1985) occurs along a sub-latitudinal weak fault zone that occurs between Proterozoic basement and a late Mesozoic graben. The deposit consists of a zone of quartz breccia, veinlets, and crystalline and porcelain quartz veins. The veins and breccia are variably oriented, and are extensively developed in early Paleozoic cataclastic granite and form a stockwork. The zone ranges from 0.1-3.0 m wide and 10 to few hundreds m wide. Grade ranges up to 0.1-0.5 g/t Au and altered zones range up to 10.0-30.0 g/t Au. Altered zones consist of limonitie and are intensely deformed. Samples with high grade Au contain high grade of Pb, Zn, Mo, As, and Ag.

Tsav and Bayan Uul Granitoid-Related Au Vein Deposits - Mongolia

Various granitoid-related Au vein(Bayan uul 1 deposit), Ag-Pb-Zn vein (Tsav deposit) deposits and occurrences occur extensively in the Tsav-Delgermonh and Dochiin gol districts and are closely related to Late Jurassic monzodiorite, granodiorite, and granite stocks (Batjargal and others, 1997; Dorjgotov, 1996; Bat-Ulzii, 1996 and 1999). Similar deposits occur to the southeast in China (Ke-Zhang Qin and others, 1995).

Tsav Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (D. Dorjgotov, written commun., 1990; Jargalsaihan and others, 1996) consists of quartz-sulfide and quartz-carbonate-sulfide veins in NW-trending, steeply-dipping altered zones hosted in Jurassic diorite, granodiorite and granite porphyry intruding Proterozoic metamorphic rock. The alteration consists of beresite (quartz-sericite-pyrite metasomatite). The width of alteration zone is 10-20 m. Metasomatic alteration has a zonal, internal structure, a central part that contains an assemblage of quartz-sericite-pyrite and peripheral gradual reduction of pyrite and sericite with chlorite and carbonate. Bodies are 700-1900 m long, 0.5-1.2 m thick and 125-500 m down dip. Deposit minerals are sphalerite, galena, pyrite, magnetite,chalcopyrite, pyrrhotite, arsenopyrite and Ag minerals. Major gangue minerals are quartz, sericite, muscovite, eligonite, rhodochrosite, chlorite and calcite. In the area are also numerous occurrences of polymetallic vein deposits. The deposit is medium size with a grade of 6.48% Pb, and 3.53% Zn, and a resource of 420,000 tonnes.

Tumentsogt W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Khasin, 1977; Kovalenko and others, 1986) consists of wolframite and molybdenite related to a Mesozoic granite pluton that consists of coarse-grained porphyritic granites and fine- and medium-grained leucocratic granite. The deposit occurs in granite porphyry and fine-grained granite that intrude porphyritic granites. Greisen formed during alteration of coarse-grained porphyritic granites and rarely in fine-grained granite. Greisen bodies are irregular and extend to a depth of 150 m. Quartz-muscovite and muscovite form the core of greisen bodies along with assemblages of muscovite, fluorite-muscovite, molybdenite-muscovite, and rare beryl-muscovite. Pyrite and scheelte also occur. Muscovite contains anomalous Li, Rb, and Cs. Also occurring are pegmatite, veins, and albitite. The deposit is small with resources of 1043 tonnes WO_3 in the main deposit. In the West Tumentsogt deposit are resources of 2302 tonnes WO_3.

Urliin Ovoo Granitoid-Related Au Vein Deposit

This deposit is hosted in Proterozoic gneiss intruded by early Paleozoic granite and by Mesozoic microdiorite, microsyenite, and lamprophyry dikes. The depoist contains three zones with over 20 quartz veins. The zone occurs in a northwest-trending area with dimensions of 10.0 km by 3.0 km. Veins are 80-160 m long and 0.1-1.0 m thick. Quartz veins extend for 100-200 m along four areas. Grade ranges from 0.5 g/t to 30.0 g/t Au in quartz veins and from 0.5 g/t to 20.0 g/t Au in altered host rock. The three mineral associations are: (1) medium-grained, white quartz, rare pyrite, chalcopyrite (3-5%) with a grade of 1.0-3.0 g/t Au; (2) chalcopyrite, rare galena, sphalerite, tellurides (gessite, veissite, silvanite, crennerite, and rikkardite), bornite, rare tetrahedrite in quartz-carbonate viens with up to 0.1% Te and 10-30 g/t Au; and (3). post-deposit carbonate veinlets with up to 4.2% Ag, up to 0.11% Cu, up to 0.09% Hg, and trace of Te. The deposit is medium size with an average grade of 0.5-30.0 g/t Au, 4.2% Ag, 0.11% Hg, 0.09% Cu.

Vozdvizhenskoye Polymetallic (Pb, Zn, Ag) Carbonate-Hosted Metasomatite Deposit

This deposit (Smirnov, 1961; Kulagashev, 1963; Sanin and Zorina, 1980) consists of sulfide bodies that occur in two parallel pseudo-layers spaced 10 to 40 m apart. The layers extend for over 600 m along the strike and 400 m downdip. Individual sulfide bodies occur in flattened pipes, nests, and layers. The dimensions along strike vary from 80 to 200 m, downdip from 20 to 200 m, and from 0.97 to 6.2 m thick. The main ore minerals are pyrite, galena, and sphalerite, and localy arsenopyrite, bulanzherite, burnonite, chalcopyrite, grey ore, and geokronite. Vein minerals are dolomite, quartz, and calcite. Sulfides occur in masses and disseminations. An oxidation zone extends to a depth 160 m and is consists of Fe oxides, cerussite, smithsonite, anglesite, calamine, plumbojarosite, skorodite, and psilomelane, and local malachite and azurite. Host rocks are carbonaceous limestone and dolomite with local coal shale, and dikes of felsite-porphyry, quartz porphyry, and lamprophyre. The main sulfide bodies occur in dolomite, locally close to or along the contact with lamprophyre and shale. Host rocks are altered to dolomite, silica, serpentine, sericite, sericite, chlorite, and argillite. Sulfide bodies formed along with quartz-dolomite-ankerite metasomatite. The deposit is medium size with an average grade Pb 6.3% Zn 8.5% Ag 106 ppm.

W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposits - Mongolia

This type of deposit occurs mainly in small uplifts bedrock that is intruded by granitoids and (or) overlain by a Late Jurassic to Early Cretaceous basalt and rhyolite bimodal sequence. Major W-Mo deposits are related to Late Jurassic leucogranite, granite porphyry stocks in the Chuluunhoroot REE complex in northeastern Mongolia. These deposits occur in veins and stockworks in the Chuluunhoroot, Ondor-tsagaan, Tumentsogt, Burentsogt, and Ikh Nartynhiid deposits. Most deposits were exhausted before 1970, but the Ondortsagaan W-Mo and Tsagaanchuluut Mo stockwork and greisen deposits are new discoveries.

Wunugetushan Porphyry Cu-Mo (±Au, Ag) Deposit - China

This deposit (Weishi, 1994) occurs at the intersection place between the northeast-trending Manzhouli-Dalaidong thrust and strike-slip fault with a secondary northwest-striking Hanigou fault normal fault that is a secondary structure of the northeast-striking Deerbugan major fault zone. The deposit is hosted in the Yanshannian granodiorite porphyry that is exposed over an area of 0.12 km^2. A K-Ar age for the porphyry is 164 Ma. The wallrock alteration forms circular zoned pattern, with an inner quartz-K-feldspar zone, a middle quartz-sericite-hydromica zone, and an outer illite-hydromica zone. There are 33 Cu and 13 Mo bodies in the deposit that are controlled by the porphyry body and the contact zone. From the center of the porphyry outward, the zonation pattern is a pyrite-molybdenite zone, apyrite-chalcopyrite zone, and a pyrite-galena-sphalerite zone. Cu and Mo minerals occur mainly in disseminatins and networks. The temperatures of formation of the porphyry intrusion and deposits are 1003 to 12O5, and 140 to 500°C, respectively. The ore-forming fluids exhibit high salinity (51 wt% NaCl) and high density (1.12 g/cm3). The deposit is large with resources of 2.232 million tonnes grading 0.4% Cu, and resources of 0.412 million tonnes grading 0.05%Mo.

Zapokrovskoye District-Transbaikalia

The Zapokrovskoye district contains carbonate-hosted As-Au metasomatite deposit (Gurulevskoye, Oktyabrskoye, Zapokrovskoye) that occur in vveins, pillars, nests and lenses. The deposits ae hosed in faulted carbonate rock that is intruded dikes and stocks of granite, diorite, and monzonite porphyry (Volfson, 1963). The Shakhtaminskoye porphyry Mo (±W, Sn, Bi) deposit occurs in the Shakhtaminskoye granodiorite and granite pluton (Sotnikov and others, 1995). The deposits consist of typical quartz-Mo veins that occur in the southeastern margin of an eroded subvolcanic structure (Seminsky, 1980).

Zapokrovskoye Carbonate-Hosted As-Au Metasomatite Deposit

This deposit (Smirnov, 1961; Zavorotnykh and Titov, 1963) consists of various bodies As-Au minerals that occur in fractured veins, pillars, pipes, nests, and lenses that are hosted in carbonate rock, primarily along the contacts between marble and schists and other sedimentary rock. The bodies occur along faults and have sharp and folded contacts. The bodies extend along strike for about 20 to 250 m, and 300 down dip. The main gangue minerals are quartz, calcite, and dolomite. In swells, the bodies are banded with alternating bands of grey quartz with rare disseminations of arsenopyrite and bands with massive arsenopyrite that contains nests of quartz and inclusions of host rock. Along faults that bound veins is local serpentine. An oxidation zone occurs from 5-20 m depth. Oxidized ore minerals are scorodite and red-brown ochres. Limestone in the southern part of the deposit is intruded by the Zapokrovsky monzonite intrusion that also contains metasomatic hybride quartz syenite with local skarn along contacts. The deposit is cut by numerous dikes of quartz porphyry, granodiorite porphyry, granodiorite porphyry, and lamprophyre. Alterations consist of zones of dolomite, serpentine, silica, ankerite, chlorite, sericite, and kaolinite. The deposit is medium size with an average grade of 6.93% As in primary ore, from 2.2-9.65% As in oxidized ore.

Zn-Pb (±Ag, Cu) Skarn Deposits-Mongolia

Various Zn-Pb (±Ag, Cu) skarn deposits and occurrences are in the Bayandun district and are hosted in Proterozoic gneiss and carbonate rock, Devonian carbonate and clastic rock, and in Permian volcanic and sedimentary rock. The deposits and occurrences are closely related to Middle and Late Jurassic granodiorite and granite stocks.

Origin and Tectonic Controls for East Mongolian-Priargunskiy Metallogenic Belt

The belt is interpreted as forming during Middle Jurassic to Early Cretaceous extensional tectonism associated with generation of the Trans-Baikalian-Daxinganling volcanic-plutonic belt that was related to the back arc of a continental margin arc. The metallogenic belt is controlled by major, regional northeast-and northwest-trending faults. The northeast-striking faults (Byrkinsky-Urovsky, Gazimur-Urjumkan, Argunsky) control the magmatic and hydrothermal activity and internal structure of the belt.

In Russia, the related major volcanic units are basalt, rhyolite, and andesite (Shadoronsky, Berjozovsky, Ust-Kara, and Argunsky Suites), and co-magmatic hypabyssal and subvolcanic units (Shakhtaminsky, Samudzhikan and Akatuevsky complexes) The volcanic units occur in grabens, paleo-calderas, volcanic comes, plutonic domes, and volcanic basins. Cassiterite-silicate-sulfide vein and stockwork occurrences (Shalz and Narsyn khondlon) and granitoid-related Au-magnetite vein and stockwork occurrences (Delberhei bulag and Salhit) are related to Middle Jurassic diorite stocks in the Narsynhondlon district. Cassiterite-silicate-sulfide vein occurrences are mainly in the central part of the belt, and granitoid-related Au-magnetite-hematite vein and stockwork occurrences are in the north-northwest and in southeastern marginal parts of the belt.

In Mongolia, the metallogenic belt contains the Early Cretaceous Onon graben that is interpreted as an extensional feature superimposed on the Hentii megadome. The Onon graben contains Early Cretaceous basalt and arkose (Enkhtuvshin, 1995) that are down-faulted against post-collisional Mesozoic intrusions (Gerel, 1998). The Au deposits in the Onon graben are interpreted as forming during early Mesozoic, post-orogenic back-arc volcanism-plutonism that occurred along a late Paleozoic suture zone between the North China Plate and the North Asian Craton. During collision, some terranes were consumed in a subduction zone that dipped toward the North Asian Craton prior to transpressional tectonism and continental magmatism. Various Au hydrothermal systems formed during the transpression and were subsequently downdropped into the Onon graben. (Cluer and others, 2000). An alternative interpretation is that the Onon graben is related to the Mongol-Okhotsk system of northeast-trending, Late Jurassic and Early Cretaceous grabens that formed after collision between the North Asian Craton with microcontinents (Zonenshain and others, 1975).

In China, several different interpretations exist for the origin of the metallogenic belt. (1) Some studies discuss the effect of Argun terrane during the closing of the Mongolia-Okhotsk ocean on structural patterns of Late Mesozoic period is emphasized in some studies (Hu Shaokang and others, 1998). (2) Some studies suggest that the distance between the Late Mesozoic volcanic belts and the subduction zone of the ProtoPacific plate would be more than 1000 km and a plate subduction model is regarded as difficult. Instead, the Late Jurassic to Creaceous Daxinganling volcanic belt is interpreted in some studies as a ring-shaped volcanic belt related to uprising of deep hot mantle plumes in the ancient Asian Ocean (Lin Qiang and others, 1998). (3) Continental plume tectonics are also employed in some studies to interpret the region (Deng Jifu and others, 1996). During the Jurassic, to the east was the Zianagi Ocean, and to the north was the Mongolia-Okotsk Ocean that was subducted under east China with de-rooting and thinning of lithosphere and upwelling of asthesnosphere. The upwelling is interpreted as the cause of intense Jurassic magmatism and formation of large and superlarge deposits from mantle plumes (Hu Shaokang and others, 1998). (4) In this study, the Nariinhiid fault is interpreted as the direct continuation of northeast-striking Ergun-Hulun fault that controlled the distribution of Middle Jurassic to Late Cretaceous volcanic and plutonic rocks and related porphyry Cu-Mo (±Au, Ag), Ag-Au-Pb-Zn vein deposits, epithermal Ag(Au) deposits, hot spring Au-Ag occurrences (Ke-Zhang Qin, 1995), and the new intrusion-related Zalaa Uul sediment hosted Au+(As ± Sb) Au occurrence (Cluer and others, 2000).

REFERENCES: Koshelov, 1985; Kovalenko and others, 1988; Mironov and others, 1989; Mironov and Solovyev, 1993; Sotnikov and others, 1995; Mironov and Trofimov, 1993; Bat-Ulzii, 1996, 1999; Batjargal and others, 1997; Deng Jifu and others, 1996; Dejidmaa, 1996, 1998;Hu and others, 1998; Lin Qiang and others, 1998.

Ikh-Hairhan Metallogenic Belt of W-Mo-Be Greisen, Stockwork, and Quartz Vein, and Ta-Li Ongonite Deposits (Belt IH) (Mongolia)

This Late Jurassic to Early Cretaceous metallogenic belt is related to veins, replacements, and granitoids related to Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that overlies and intrudes Hangay-Dauria terrane. The belt contain numerous W vein and W-Sn deposits that are related to Late Jurassic and Early Cretaceous granite and leucogranite, and Ta, Nb and Li deposits that are related to ongonite, Ta granite, and and pegmatite. The Late Triassic and Early Jurassic granitoids have K-Ar isotopic ages of 158 Ma and 130 Ma that host the Ikh Khairkhan metallogenic belt form are variable size and morphology and consist of hypabyssal and shallow intusions. The granitoids consist of an older biotite granite phase and a younger leucocratic granite and granite porphyry phase that also contains albite granite and ongonite (Kovalenko and Kovalenko, 1976). Ta and Li REE pegmatite deposits are related to the late Mesozoic Unjuul pluton and to ongonite in the Ongon Khairkhan pluton that occur along a northwest-elongated transverse uplft. This uplift is bordered by the Orkhon, Bayangol and North Gobian fault systems, and is divided the Hentii and Hangai faults. The Mesozoic intrusions occupy area of about 1000 km^2 (Koval and others, 1982). The major W deposits are at Ikh Khairkhan and Ongon Khairhan and a number of vein and stockwork occurrences also are known.

Ikh Khairkhan W-Mo-Be Greisen, Stockwork, and Quartz Vein Mine

This mine (Khasin 1977; Jargalsaihan and others, 1996) consists of quartz-wolframite veins related to the late Mesozoic Baga Kharikhan pluton. The deposit occurs along the contact zone and contains four zones that trend mainly north-east to sublatitudinal for 290 to 3 km long and vary from 2 to 5 m wide. The deposit contains 14 quartz-wolframite veins and ore shoots that extend to a depth of 200 m. Five stages occur: (1) beryl, quartz, muscovite, fluorite, and wolframite; (2) quartz, feldspar, fluorite, muscovite, wolframite, scheelite, and cassiterite; (3) sulfides, molybdenite, bismuthite, pyrite, chalcopyrite, galena, and sphalerite; (4) quartz, feldspar, fluorite, muscovite, scheelite, and wolframite; and (5) pyrophylite and calcite. The stages are named muscovite-fluorite, quartz-muscovite-wolframite, sulfide, quartz-wolframite, and pyrophylite-carbonate. Alterations are mainly silica, sericite, pyrite, and greisen. A K-Ar muscovite isotopic age for a quartz-wolframite vein is 126 ± 5 Ma and is very close to the age of the granite. The deposit is medium size with production of 8,435 tonnes WO_3. The deposit is mined out.

Origin and Tectonic Controls for Ikh-Hairhan Metallogenic Belt

The belt is interpreted as related to magmatism along transpression zones along transform micro plate boundaries and within plate (plume) environment**.**

REFERENCES: Ivanova, 1976; Kovalenko and Kovalenko, 1976; Marinov and others, 1977; Koval and others, 1982.

Mushgaihudag-Olgiihiid Metallogenic Belt of REE (±Ta, Nb, Fe) Carbonatite and Be Tuff Occurrences (Belt MH) (Southern Mongolia)

This Late Jurassic to Early Cretaceous metallogenic belt is related to stratiform units in the Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that overlies and intrudes the Govi Altai, Mandan, Mandalovoo-Onor, and Gurvansayhan terranes. The major deposits are at Mushgai Khudag, Dorvont Dort, Teg uul, and Olgii hiid.

Fe-REE Carbonatite Deposits

Fe-REE carbonatite, REE-Sr carbonatite, and REE-apatite deposits are related to alkaline volcanic-plutonic complexes, Be-tuffs, volcanic ongonite. The major Mushgai Khudag REE deposit, and the Bayan Khoshu, Khotgor, and Olgii hiid occurrences are located along a major east-west trending fault. Three types of REE deposits occur. One type consists of REE deposits related to alkaline volcanic-plutonic complex of a K-rich alkaline sequence that is dominated by melaleucitite, melanephelinite, latite and trachyrhyodacite, nepheline syenite, syenite, and quartz syenite, and companion carbonatite dikes. REE is concentrated in apatite. A second type occurs in carbonatite breccia and REE is concentrated in bastaenesite. The breccia is cemented by carbonate, fluorite, barite, and celestine, or magnetite and apatite. And a third type is magnetite-apatite rock with REE. This rock consists of apatite, magnetite, and phlogopite, and local celestine as at the Bayan Khoshu occurrence. Also is cerussite rock.

Mushgai hudag REE (±Ta, Nb, Fe) Carbonatite Deposit

This deposit (Jargalsaihan and others, 1996, Munkhtsengel and Iizumi, 1999) is spatially and genetically related to a Late Jurassic volcanic-plutonic complex with a Rb-Sr isochron age of 139.9 Ma,. The complex intrudes late Paleozoic granite and middle and late Paleozoic carbonate and terrigenous sedimentary rocks. The volcanic rocks consists of nepheline melleucetite-melanephelinite, subalkaline trachyte, trachyte-trachyrhyodacite, and trachyte-latite. The intrusive rocks consist of shonkynite dike, and nepheline and quartz-bearing syenite. Seventeen minor bodies spaced 100-1200 m apart occur in stocks, pillars, pipes, lenses, and veins that extend to 50-150 m downdip. The bodies consist of REE minerals with anomalous Sr, Ba, P, F, F, and Fe. REE assemblages are: apatite-bastnasite carbonatite and apatite carbonatite. The carbonatites consist of eruptive breccias with carbonate cement that comprises 15-30% the rock and consists of calcite, fluorite, celestine, and apatite. Ore minerals correlated with volume of cement. Vein carbonatites have a similar composition. Carbonate-fluorite and fluorite veins are REE-rich. Apatite veins are low in REE. Veins occur in stockes or large bodies of magnetite-apatite, apatite, phlogopite-apatite, feldspar-apatite, and syenite-apatite. Grade ranges from 1.0-13.5% TR_2O_3 and averages 2.1% TR_2O_3 in rich apatite masses. The deposit is large with reserves of 200 million tonnes grading 1.5% REE, 441,000 tonnes grading 0.88-14% P_2O_5, 223,000 tonnes grading 0.95% BaSO4, and 220,000 tonnes grading 0.9% Sr, and resources of 1.2 million tonnes Fe, and 5.2 million tonnes of gypsum and anhydrite.

Be Tuff Occurrences

Be tuff and ongonite with Ta (Rb, Nb) occurrences are located in the belt along with Sr deposits in celestine. Carbonatite dikes occur in a alkaline volcanic-plutonic complex and form thick linear zones, up to several tens of m wide, veins, and stocks bodies. The major Be tuff occurrences are at Dorvon dert (with a Rb-Sr isotopic age of 125 Ma and a K-Ar age of 115 to 118), and at Teg Uul (with a Rb-Sr age of 107 Ma) (Samoilov and others, 1986).

Teg uul Be Tuff Deposit

This deposit (Kovalenko and others, 1977, Kovalenko and Koval, 1984) consists of Be in late Mesozoic tuffs that contains fragments of rhyolite, ongorhyolite, quartz, feldspar, and rare fluorite. Tuff underlying ongonites is white, layered, and covers an area of 1 km^2. Be content ranges from 0.01% to 0.5% BeO. The deposit is small with an average grade of 100 g/t Be.

Origin and Tectonic Controls for Mushgaihudag-Olgiihiid Metallogenic Belt

The belt belt is interpreted as formed in Late Mesozoic rift in post-collisional setting.

REFERENCES: Samoilov and Kovalenko, 1983; Samoilov and others, 1986; Tomurtogoo, 2001.

Govi-Tamsag Metallogenic Belt of Sediment-Hosted U, Evaporate Sedimentary Gypsum, Sedimentary Celestite, and Volcanic-Hosted Zeolite Deposits (Belt GT) (Southern Mongolia)

This Late Jurassic to Early Cretaceous metallogenic belt is related to stratiform units in the Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that overlies and intrudes the Dzhida, Govi Altai, and Mandalovoo-Onor terranes. The major sediment-hosted U deposits is at Haraat, Narsyn, and the major evaporate sedimentary gypsum deposits are at Taragt, Unegt, and Modonus.

Sediment-Hosted U Deposits

The sediment-hosted U deposits at Haraat and Narst, and various occurrences are hosted in an Early Cretaceous sedimentary graben and Late Cretaceous sedimentary basin in the Late Mesozoic Eastern Mongolian continental rift. Some deposits are interlayered with coal deposits that contain high grade U. The U deposits and occurrences consist of U-bearing sandstone beds and and lenses (Ochirbat, 1998).

Haraat Sediment-Hosted U Deposit

The deposit (Jargalsaihan and others, 1996; Ochirbat, 1998; Wetz and others, 1999) is hosted in the Early Cretaceous Choir graben. The deposit surface area is over 100 km^2. The host rocks are intercalated sandstone and siltstone ranging from 0.2-20.0 m thick. The deposit bed is approximately horizontal, 20 km long, 0.5-2.0 km wide, ranges from 1.0 to 30.0 m thick, and is covered by 0.5 m to 45 m of barren rocks. Two explored bodies are 400 m and 2500 m long, range from 50-300 m wide, and from 1.0 to 12.0 m thick. Ore minerals are nasturan (pitchblende), autunite, and torbernite. The average grade of uranium ranges from 0.01-0.04% U to 0.05-0.2% U, partly 1.2-4.0% U. Uranium ore contains 0.02-0.3% CE, 0.017-0.17% La, 0.7-60 g/t Sc, 25-30 g/t Y, 2-12 g/t Yb, 0.1-8 g/t Re, 10-90 g/t Ge, and up to 0.03% Mo, up to 0.01% Se, and up to 3.0 g/t Ag. In siti leach mining method has been successfully tested. The deposit is medium size with an average grade of 0.01-0.2% U and reserves of 22,700 tonnes U.

Evaporate Sedimentary Gypsum Occurrences

Evaporate sedimentary gypsum deposits are extensive and occur mainly in sandstone and shale in a Late Cretaceous and local Paleogene basin (Ganbaatar, 1999). The occurrences are related to continental evaporate basins. The. Unegt and Shiree Uul (Taragt-2) deposits are in operation at the present.

Shiree Uul (Taragt-2) Evaporate Sedimentary Gypsum Mine

This mine (Shaandar and others, 1992; D. Begzsuren, written commun., 1999; Ganbaatar, 1999) consists of gypsum and calcite concretions that occur in Tertiary sedimentary rock. The gypsum thickness is 1 m. The size of gypsum concretions range from 30-40 cm. The deposit age interpreted as middle and late Oligocene. The deposit is small with production and reserves of 4.5 million tones grading 83-84% gypsum.

Sedimentary Celestite Occurrences

Sedimentary celestite occurrences are hosted in Early Cretaceous sandstone, siltstone and mudstone. Sandstone beds contain thin (1 to 5 cm) layers or roses of celestite (Goldenberg and others, 1978). Sedimentary celestite is poorly studied, and occurrences are mainly in southern part of metallogenic belt.

Horgo uul Sedimentary Celestite Deposit

This deposit (V.I. Goldenberg and others, written commun.,1978) consists of 1.0 -5.0 cm thick layers of celestite in Early Cretaceous sandstone. Celestite also occurrs as isometric black concretions with a diameter 0.3-0.4 cm, and as celestite roses. These concretions contained up to 6.56% Sr. The thickness of celestite-bearing beds with concretions ranges from 10 m to 50 m. The beds are intercalated with barren sandstone (up to 0.07% Sr) beds that range from 50 to 100 m thick. The average grade is 45.59% Sr.

Tsagaantsav Volcanic-Hosted Zeolite Deposit

This deposit (P.Shaandar and others, written commun., 1992; Petrova and Amarjargal, 1996) consists of zeolite beds and layers in siliceous tuff, tuffaceous sandstone, and argillite of the Early Cretaceous Tsagaantsav Formation. The deposit has a surface area of 1.5 by 3 km with a thickness of 200 m. The zeolite beds are elongate and strike east-southeast and dip gently The maximum zeolite content (60-90%) occurs adjacent to an underlying siliceous vitreous tuff that. The main zeolite mineral clinoptilolite. The deposit is large with resources of 179.0 million tonnes grading 10-80% zeolite.

Origin and Tectonic Controls for Govi-Tamsag Metallogenic Belt

The belt is related to Aptian-Albian (Late Cretaceous) and local Paleogene sedimentary rocks deposited in grabens and depressions that overlap the Mesozoic Eastern-Mongolian-Preargune continental rift belt that developed on the Idermeg passive continental margin, Govi-Altai turbidite, and Mandal-Ovoo island arc terranes. The sedimentary U deposits and occurrences formed in the latest stage of a late Mesozoic continental rift. The gypsum deposits and occurrences formed in continental evaporite basins.

REFERENCES: Goldenberg and others, 1978; Ochirbat, 1998; Ganbaatar, 1999.

Daxinganling Metallogenic Belt of Zn-Pb (±Ag, Cu) Skarn, Sn Skarn, Cassiterite-Sulfide-Silicate Vein and Stockwork, Polymetallic Pb-Zn, Cu (Au, Ag) Veins and Stockwork, Peralkaline Granitoid-related Nb-Zr-REE, and Au-Ag epithermal Vein Deposits (Belt DX) (Northeastern China)

This Late Jurassic and Early Cretaceous metallogenic belt is related to veins, replacements, and granitoids in the Daxinganling part of the Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt. The belt overlies and intrudes the Gobi-Khankaisk-Daxinganling volcanic-plutonic belt. The belt occurs in the central and southern Daxingaling region (Great Khingan Mountains), southeastern Inner Mongolia. The belt consists of three northeast-trending, subparallel zones. The middle zone is the largest, and is 500 km long and 100 km wide. The Daxinganling volcanic-plutonic belt contains very thick, multiple stages of volcanic rock that range up to 2000 to 3000 m thick, and consists mainly of basalt, andesite, trachyandesite, trachyte, and dacite. Felsic volcanic rock is dominant. The volcanic rocks are calc-alkalic with slightly high alkaline content. The associated plutonic rocks occur in a batholith, stocks, and dikes, and consist mainly of granodiorite, granite, tonalite diorite porphyry, granite porphyry and quartz monzonite, orthoclase granite and alkaline granite. The plutonic rocks intrude Permian oceanic volcanic and sedimentary rocks that are interpreted as forming in an island arc in a residual oceanic basin (Xu Zhigang, 1993). The island arc assemblage forms an overlap assemblage that formed after accretion of the Xilinhot, Solon and Hegenshan terranes. The metallogenic belt includes a variety of deposits and metals. The major cassiterite-sulfide-silicate vein and stockwork deposit is at Maodeng), the major polymetallic Pb-Zn, Cu (Au, Ag) veins and stockwork deposits are at Meng'entaolegai and Aonaodaba; the major peralkaline granitoid-related Nb-Zr-REE deposit is at Baerzhe, and the major Au-Ag epithermal Vein deposits is at Guandi.

Baiyinnuoer Zn-Pb (±Ag, Cu) Skarn Deposit

This deposit (Li Henian and others,1993) occurs in the central part of Huanggangliang-Wulanhaote polymetallic belt. The deposit occurs in a secondary anticline of the Sifangcheng-Baiyinwula anticlinorium. Northeast-striking faults control the formation and distribution of igneous intrusions and deposit. The strata consist of Early Permian low-grade metamorphic rock and late Jurassic siliceous and intermediate volcanic rock. The Early Permian strata host most of the deposit, are composed of sandy slate, carbonate, and pelitic slate, and occur in the central and southeast parts of the associated district district. The Yanshannian granitoids consists of granodiorite, granodioritic porphyry, quartz syenite porphyry, and granite porphyry. The deposit occurs mainly in skarn along a contact zone between granodioritic porphyry and country rock. The main ore minerals are sphalerite and garnet, and the minor ore minerals are chalcopyrite, pyrite, pyrrhotite, and stannite, and Ag minerals. The main gangue minerals are hedenbergite, epidote, andradite, actinolite, diopside, wallstonite, quartz, and calcite. The deposit is large with reserves of 2.4 million tonnes of Pb+Zn grading 3.24% Pb and 5.46% Zn.

Maodeng Cassiterite-Sulfide-Silicate Vein and Stockwork Deposit

This deposit (Liu Yuqiang, 1996) occurs in the western contact zone of the Alubaogeshan granite porphyry with a Rb-Sr isotopic age of 149 Ma. The deposit is hosted in a Jurassic bimodal volcanic sequence, including a lower basalt and upper rhyolite unit, in the Maoding volcanic basin. The deposit occurs in veins controlled by a northwest-trending fault system. The major ore minerals are cassiterite, chalcopyrite, arsenopyrite, sphalerite, and molybdenite. The minor ore minerals are pyrite, galena, magnetite, hematite, wolframite, bornite, scheelite, and bismuthine. Nonmetallic minerals are quartz, fluorite, K feldspar, biotite, calcite, tourmaline, topaz, and muscovite. The ore minerals are of idiomorphic to hypidiomorphic granular and occur in, some metasomatic fillings, disseminations, masses, veins, veinlets, stockwork, and breccia. In the magnetite, cassiterite, and sulphide deposits, respectively, are three types of main alteration: potassic silicates, greisen, and silica. The deposit is interpreted as forming during hydrothermal conditions at a moderate depth of 1.6 to 2 km, and moderate temperature of 450 to 200°C. The deposit is medium size.

Meng'entaolegai Polymetallic Pb-Zn, Cu (Au, Ag) Vein and Stockwork Deposit

This deposit (Li, Henian and others, 1993) occurs along the west junction between the Daxinganling orogenic belt and the Songliao basin. The main part of the deposit is controlled by east-west-and northeast-trending faults. The deposit is hosted in Permian and Jurassic rocks tuffaceous sandstone, slate, tuffaceous clastic rock, marble, arkose, pelitic siltstone, lava, and bioclastic limestone. Both Hercynian and Yanshannian-age granitoids occur. The Mengentaolegai granite covers an area of 240 km^2 and has a K-Ar isotopic age of 286 Ma and a U-Pb age of 235 Ma. The Duerji granite complex consists of coarse-grained biotite-plagioclase granite, granodiorite, moyite, alaskite, and fine-grained biotite granite. The complex covers an area of 150 km^2 and has a U-Pb zircon age of 150 Ma. Forty-four sizes of veins occur. The main wall-rock alterations are sericite, Mn siderite, silica, and chlorite. The main ore minerals are sphalerite, galena, and Ag minerals, and the minor minerals are chalcopyrite, pyrite, pyrrhotite, arsenopyrite, chalcocite, and cassiterite. The deposit formed at temperatures are 140 to 340°C, and the deposit is closely related to the Yanshannian Duerji granite. The deposit is large with reserves of 84,300 tonnes Pb, 2,300 tonnes Zn. Average grade of 84 g/t Ag, 1.02% Pb, 2.30% Zn.

Baerzhe Peralkaline Granitoid-Related Nb-Zr-REE Deposit

The deposit (Lin, Chuanxian and others,1994) is hosted in a riebeckite granite intrudes Middle Jurassic volcanic rock and occurs in two areas. The western part of the intrusion covers an area of 0.11 km^2, the eastern part covers an area of 0.24 km^2, and at the depth, the two parts merge. A Rb-Sr isotopic age is 125 Ma. The main minerals are barbierite, quartz, and riebeckite, the minor minerals are aegrite and albiteoligoclase, and accessory minerals are zircon, monazite, bunsite, fluorite, calcite, galena, sphalerite, pyrrhite, and ferrothorite. In the eastern intrusion, from the surface to depth, successive zones of pegmatitic granite, albite-altered granite and porphyritic riebeckite granite occur. Weak alterations are silica, chlorite, carbonate, aegrute and sulphides. K+Na/Al of is greater than 1, and SiO_2 content is high. REE distribution patterns dip slightly right, approaching horizontal. The rocks are rich in HREE, and Eu is intensely depleted. The main economic minerals are bunsite (500 to 800 g/t), monazite (79 to 2000 g/t), pyrrhite (80 g/t), titano euxenite (20 to 80 g/t), Xinganite (600 to 7000 g/t) and niobite(94 to 5000 g/t). The initial $^{87}Sr/^{86}Sr$ is 0.689±1. The deposit is large with an average grade of 0.051% BeO, 0.258% Nb_2O_5 .

Ag-Sn Deposits

Various Ag-Sn deposits(Meng'entaolegai, Aonaodabaand others), mainly polymetallic Pb-Zn ± Cu (±Ag, Au) vein and stockwork deposits (Li Henian et al.,1994) occur in the middle section of part of the metallogenic belt in the southeast part of the Hercynian Daxinganling orogenic belt. The main structures are a north-northeast-trending syncline and northeast-striking faults. The host rocks are Early Permian low-grade metamorphosed sandstone, graywacke, sericite slate, and knotted slate. The igneous intrusion is mainly the Yanshannian granite porphyry that occurs at the core of the syncline and is intruded by slightly younger granodioritic porphyry and quartz syenite porphyry. The granite porphyry has a Rb-Sr whole-rock isochron age of 148.31 Ma. The main alterations are silica, topaz beresite, K-feldspar and chlorite. The deposits in veins and locally in lenses. The main ore minerals are pyrite, chalcopyrite, arsenopyrite, sphalerite, and pyrrhotite, and the minor ore minerals are loelingite, garnet, and tetrahedrite. Rare argentite, molybdenite, and marcasite also occur. The deposit-forming temperatures are 160 to 426°C.

Aonaodaba Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (Li Henian and others,1994; Zhang Dequan and others, 1994) occurs in the southeastern part of the Daxinganling Hercynian orogenic belt that is hosted in Early Permian, low-grade metamorphosed sandstone, graywacke, sericite slate, and knotted slate. The Yanshannian granite porphyry, that intrudes the core of a syncline, is intruded by slightly younger granodiorite porphyry and quartz syenite porphyry.The granite porphyry has a Rb-Sr whole-rock isochron age of 148.3 Ma, and is altered to silica, topaz-beresite, K-feldspar, and chlorite. The dposit occurs in veins and rare lenses. The main ore minerals are pyrite, chalcopyrite, arsenopyrite, sphalerite, and pyrrhotite, and minor loelingite, garnet, and tetrahedrite, along with very minor argentite, molybdenite, and marcasite. The deposit formed at temperatures of 160-426 C. The deposit is large.

Guandi Au-Ag Epithermal Vein Deposit

This deposit (Zhou Gang, 1997) consists of several Ag veins in a volcanic rock belt. The ore mineral textures range from hypidiomorphic to xenomorphic to varied metasomatic. The ore minerals occur in disseminations, masses, veins and stockwork. Ag minerals are freibergite, Ag tetrahedrite, vitreous Ag, stromeyerite, and electrum. Other metallic minerals are sphalerite, galena, pyrite, chalcopyrite, tetrahedrite, cerusite, and magnetite. Gangue minerals are quartz, rhodochrosite, calcite, dolomite, sericite, chlorite, siderite, and fluorite. The deposit is large and grades 60-1500 g/t Ag, locally up to 2,400 g/t Ag, and with a range of 0.68-4.4 g/t Au.

Origin and Tectonic Controls for Daxinganling Metallogenic Belt

The belt is interpreted as forming during interplate extensional tectonism. The extension is interpreted as occurring during Late Jurassic in a back-arc setting with formation a series of volcanic and sedimentary basins and sub-alkaline to alkaline granite. The basins and granitoids are controlled by northeast-north-northeast and east-west striking regional faults that to certain degree reflect the pre-Mesozoic structures (Xu Zhigang, 1993, Zhang Dequan and others, 1994). The extension is interpreted as occurring during subduction of the Eurasian plate. The granitoids related to W and Sn deposits are mainly K potassic feldspar granite, whereas the granitoids related to Pb, Zn and Cu deposits are granodiorite and quartz syenite. The two types of granite differ greatly in petrochemical and geochemical features (Zhang Dequan and others, 1994). The Permian volcanic and sedimentary rock may be the main source for Sn, Pb, Zn and Ag (Li Henian, 1993; Zhang Dequan and others, 1994).

REFERENCES: Li Henian, 1993; Xu Zhigang, 1993, Zhang Dequan and others, 1994.

Bindong Metallogenic Belt of Zn-Pb (±Ag, Cu) Skarn W±Mo±Be Skarn, Cu (±Fe, Au, Ag, Mo) Skarn, and Fe-Zn Skarn Deposits (Belt BD) (Northeastern China)

This Late Jurassic to Early Cretaceous metallogenic belt is related to replacements in small granitoids in the Mesozoic Jihei volcanic and plutonic belt that intrudes and overlies the Zhangguangcailing superterrane, Zhangguangcailing sedimentary overlap assemblage, and adjacent units. The belt occurs in the Zhangguangcailing Mountains in the East Heilongjiang Province, and is hosted in a Late Jurassic and Early Cretaceous plutonic belt that intrudes various units of the Paleoproterozoic Zhangguangcailing continental margin arc superterrane and younger overlap sedimentary assemblages (Shi Lindao, 1994). The skarn deposits occur at contacts between the Devonian and Permian limestone strata and granitoid intrusions. The significant deposits are at Erguxishan, Chuihongshan, Goupengzi, and Wudaling.

Ergu-Xishan Zn-Pb (±Ag, Cu) Skarn Deposit

This deposit occurs (Xu, Enshou and others, 1994) occurs in the axial part of the Ergu-Xujiugou anticline in the Zhangguangcailing fold belt that contains Early Permian siltstone and marble that in xenoliths in Hercynian medium-grained biotite plagiogranite, porphyritic biotite granite, and granodiorite. The deposit is controlled by the east-west-trending, north-dipping fractures and the contacts. The main wallrock alteration is skarn. The deposit is small with reserves of 129,800 tonnes Pb, 221,300 tonnes,Zn grading 2.55-3.37% Pb, 3.23% Zn.

Chuihongshan Fe Skarn Deposit

This deposit (Cao, Jingxian, 1993a, b) consists of several skarn lenses that occur concordant to the bedding of host rocks and trend northwest along the contact between the alaskite granite and dolomite. The skarns occur mainly in masses, layers, stockworks, and veinlets. The ore minerals are magnetite, cassiterite, molybdenite, scheelite, galena, sphalerite, chalcopyrite, and pyrrhotite. The gangue minerals are diopside, phlogopite, garnet, actinolite, wollastonite, clino-humite, and fluorite. Horizontal zoning in the main deposit occurs and consists from inward to outward of Mo W-Fe, Mo-W-Fe, Fe-Zn-Cu, and Pb-Zn ore minerals. At the contact zone, are contact metasomatic scheelite, cassiterite, and magnetite, and younger , and hydrothermal deposits of molybdenite and Cu-Pb-Zn sulphides. The host strata are Middle to Late Carboniferous slate, marble, and metamophosed sandstone and dolomite. Late Permian tuffeous pebble sandstone and intermediate to siliceous volcanic rock occur but do not contain skarn. Both sequences are intruded by granite. The deposit is medium size with reserves of 531,000 tonnes Cu, 121,600 tonnes WO_3, 194,300 tonnes Pb, and 478,600 tonnes Zn. Average grades are 40-50% Fe, 0.45% Cu, 0.32% WO_3, 3.30% Pb, and 2.43% Zn.

Wudaoling W±Mo±Be Skarn Deposit

This deposit (Huang, Dianhao and others, 1994) consists of irregular masses at a contact zone between quartz porphyry and intermediate and siliceous volcanic rock of Late Permian Wudaoling Formation. The quartz porphyry is silica-rich with >75% SiO_2), has K_2O+Na_2O of 7.97%-8.04%, K_2O/Na_2O of 1.21 to 1.31, and has whole rock K-Ar isotopic age of 157.8 Ma. Both the porphyry and W±Mo±Be skarn bodies are controlled by an east-west striking fault. Ore minerals are mainly molybdenite, pyrite, and magnetite, with lesser hematite, specularite, chalcopyrite, galena, sphalerite, bornite, chalcocite, tetrahedrite, and bismuthinite. Mo bodies occur in disseminations and minor veins. Wallrock are altered to skarn, silica, beresite, and carbonates. The deposit occurs at the southeast part of Yuquan-Sandaogang anticlinorium in the Variscan Jilin-Heilongjiang orogenic belt. The deposit is medium size.

Origin and Tectonic Controls for Bindong Metallogenic Belt

The belt is interpreted as forming during interplate extensional tectonism and sub-alkaline to alkaline volcanism and and related sedimentation. The belt occurs along northeast and east-west-trending regional faults, consists of various skarn zones and deposits that occur at contacts between some small intrusions of granodiorite, biotite granite, granite porphyry, quartz porphyry and Devonian limestone and clastic rock and Early Permian marble, sandstone, shale, and the Late Permian felsic volcanic rock. Previously, the belt was interpreted as forming during the Triassic (Indosinian Orogeny); however, new isotope data indicate the belt is the Middle Jurassic and Early Cretaceous (Shi Lindao, 1994). The skarns contain numerous metals, including Fe, Cu, Pb, Zn, W, Sn, and Mo. Like other Middle Jurassic and Early Cretaceous metallogenic belts in Northeastern China, the magmatism and deposits in this belt are interpreted as forming in a tensile tectonic setting along north-northeast-trending regional faults (Tanlu fault system or fracture zone). The origin of the Mesozoic magmatic and related deposits in Northeastern China is a controversial topic. Some authors relate the magmatism and deposits to the subduction of Pacific Oceanic plate under the Eurasian plate. However, this interpretation may be too simple.

REFERENCES: Shi Lindao, 1994.

Laozhuoshan Metallogenic Belt of Granitoid-Related Au Vein Deposits (Belt LZ) (Northeastern China)

This Late Jurassic to Early Cretacenous metallogenic belt is related to granitoids related to the Mesozoic Jihei volcanic and plutonic belt and occurs in the eastern Heilongjiang Province. The belt trends northeast and is about 40 km long and 20 km wide. The granite belt intrudes the Jiamusi terrane. The significant deposit is at Laozhuoshan.

Laozhuoshan Granitoid-Related Au Vein Deposit

This deposit (Liu, Fu and others, 1996) is related to both the Hercynian granitoids and the Mesozoic intermediate and siliceous stocks and dikes, including diorite, quartz diorite, diorite porphyry, granite porphyry, and felsite. Two types of Au deposits occur: (1) mainly Au veinlets and stockworks; and (2) lesser Au altered rock. The deposit occurs along faults that occur along the external contact zone of granite intrusions, and consists of layers, lenses, and irregular masses. The ore minerals are mainly arsenopyrite, chalcopyrite, pyrrhotite, and pyrite, and minor galena and sphalerite. Gangue minerals are quartz, calcite, sericite, diposide, and garnet. Gold occurs mainly in arsenopyrite and chalcopyrite. Two main depositional stages are interpreted, a magmatic hydrothermal stage, and a volcanic-hydrothermal stage. The first stage is related to large Hercynian granite and occurs in a contact skarn in veins and layers. The second stage is related to diorite porphyry and granite porphyry. High-grade gold occurs where the two stages are overprinted. The deposit is large with reserves of 20 tonnes of gold, grading 6.85 g/t Au.

Origin and Tectonic Controls for Laozhuoshan Metallogenic belt

The belt is interpreted as forming during generation of post-accretionary granitoids along major faults during interplate magmatism related to subduction of Pacific Oceanic Plate under the Eurasian Plate.

REFERENCES: Liu Fu and others, 1996.

Ariadny Metallogenic Belt of Mafic-Ultramafic Related Ti-Fe (±V) and Zoned Mafic-Ultramafic Cr-PGE Deposits (Belt AR) (Russia, Far East)

This Middle Jurassic and Early Cretaceous metallogenic belt is related to mafic-ultramafic plutons intruding the Samarka accretionary-wedge terrane. The zoned intrusions that host the Ariadny metallogenic belt consist of Late Jurassic ultramafic and gabbroic plutons with K-Ar isotopic ages of about 160 Ma age. The complexes are interpreted as syn-volcanic intrusives that intruded the turbidite deposits of the Samarka accretionary-wedge terrane immediately before accretion of the terrane in the Early Cretaceous. Intrusion of the Samarka terrane may have occurred in the final stages of accretion during seaward migration of the subduction zone.

The major deposits are at Katenskoe, Ariadnoe, and Koksharovskoe. The deposits consist mainly of disseminated to massive ilmenite that is hosted in layers in gabbro and pyroxenite. Titanium-magnetite and apatite are rare. The deposits also contains sparse PGE minerals, and sparse PGE minerals also occur in stream-sediment samples. The host plutonic bodies are several tens of m thick and several hundred m long. K-Ar isotopic ages are 160 to 170 Ma. The petrochemical features and mineral composition of the gabbro and pyroxenite intrusions hosting the mafic-ultramafic related Ti-Fe (+V) deposits are similar to those hosting the Kondyor PGE deposit.

Katenskoe Zoned Mafic-Ultramafic Cr-PGE Deposit

This deposit (Shcheka and others, 1991) consists of disseminated ilmenite in Early Cretaceous pyroxene-hornblende gabbro and olivine gabbro. The deposit consists of lenticular bodies that are several tens of meters thick and at least 1 km long. The deposit is large.

Ariadnoe Mafic-Ultramafic Related Ti-Fe (+V) Deposit

The deposit (Shcheka and Vrzhosek, 1985) consists of abundant disseminated ilmenite that occurs in layers in pyroxene-hornblende gabbro and pyroxenite in layered intrusions. The ilmenite layers are several tens of m thick and several hundred m long. A K-Ar isotopic age for the host intrusion is 160 to 170 Ma. Ilmenite contains rare PGE inclusions. The deposit is large, and the average grade is 1.0 to 11.8% TiO_2 and 0.086% V_2O_5.

Koksharovskoe Mafic-Ultramafic Related Ti-Fe (+V) Deposit

This Koksharovskoe deposit (Shcheka and others, 1991) consists of disseminated ilmenite, magnetite, and apatite that occur in a hornblende and biotite pyroxenite with a K-Ar isotopic age of 160 Ma. Minor PGE minerals also occur. Intrusive rocks are weathered and weathered pyroxenite may have economic concentrations of vermiculite. The deposit is large, and the average grade is 1.0 to 10% P_2O_5; 3.3 to 4.5% TiO_2.

Origin and Tectonic Controls for Ariadny Metallogenic Belt

The belt is interpreted as forming during generation of ultramafic and gabbroic plutons during underthrusting of the Kula oceanic ridge and formation of bimodal igneous rocks along a transform continental margin. The Middle and Late Jurassic clastic matrix of the Samarka terrane consists of parautochthonous turbidite and olistostrome with fragments of mainly Middle and late Paleozoic ophiolitic rock and greenstone, Middle Triassic chert, Early Jurassic schist and shale, and Triassic to Jurassic clastic rock. Olistostromes, particularly in the northern terrane, contain large fragments of Carboniferous to Early Permian limestone. A fragment of the terrane occurs near the town of Bikin, where meimechite and picrite flows occur in a Late Jurassic(?) matrix. The Samarka accretionary-wedge terrane and correlative subduction zone units in Japan are tectonically linked to Jurassic granitoids in Korea, and with a major Jurassic to Cretaceous volcanic-plutonic belt in southeastern China. These subduction-related units are interpreted as offset from their tectonically-linked igneous arcs by left-lateral movement during the Cretaceous and Cenozoic.

REFERENCES: Shcheka and Vrzhosek, 1985; Philippov, 1990; A.I. Khanchuk, written commun., 1992; Nokleberg and others 1997, 1998, 2003; Khanchuk and Ivanov, 1999.

Samarka Metallogenic Belt of Porphyry Cu-Mo (±Au, Ag), Porphyry Mo (±W, Sn, Bi), and W±Mo± ±Be Skarn Deposits (Belt Sam) (Russia, Far East)

This Early to mid-Cretaceous metallogenic belt is related replacements and S-type granitoids in the Khungari-Tatibi granitic belt (too small to depict at 10 M map) that intrudes Samarka accretionary-wedge terrane. The belt occurs in Early to mid-Cretaceous aluminous, mainly S-type granitoids that intrude the Samarka terrane. The host granitic rocks are mainly granodiorite porphyry, granite, gabbro, and diorite. The olistostrome that host the Samarka belt consists of limestone caps of guyots that are enclosed in a matrix of highly deformed Jurassic sedimentary rock. The skarns are hosted in limestone along contacts between calcareous and alumosilicate clastic rock. The belt contains a major W±Mo±Be skarn deposit at Vostok-2, and small porphyry Cu-Mo (±Au, Ag) deposits at Khvoshchovoe, Kafen, and Malakhitovoe. The major deposits are at Malakhitovoe, Vostok-2, and Lermontovsky.

Malakhitovoe Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Petrachenko and Petrachenko, 1985) occurs in a circular aureole of hydrothermally-altered rock with dimensions of 200 x 200 m. The aureole occurs over an intrusive dome. Successive mineral assemblages are: (1) quartz-biotite-actinolite with pyroxene and epidote; (2) quartz-biotite-actinolite; (3) quartz-biotite-sericite (± chlorite); and (4) quartz-hydromica with carbonate. A stockwork contains the first three facies and consists of a thick network of quartz-epidote-actinolite veinlets and lenses that range up to 2-3 cm thick and contain chalcopyrite, bornite, and pyrite. Heavily fractured and brecciated chert and siltstone in breccia zones were prospected by and rare holes to a depth of 100 m. Ore minerals in breccia zones are chalcopyrite, bornite, molybdenite, and pyrite, rarely pyrrhotite, cubanite, arsenopyrite, galena, and sphalerite. Carbonate veinlets with chalcopyrite also occur. Deposit occurs at northwest margin of a volcanic-tectonic depression that contains a lower structural stage of Early Cretaceous sandstone interlayered with siltstone and shale that grades upwards into conglomerate and sandstone that is overlain by Paleogene andesite and basaltic andesite lava and lava breccia. Local intrusive rocks consist of dikes of calc-alkaline andesite porphyry that is interpreted as tongues of a dome-like subvolcanic intrusion. The deposit is small with an average grade of 0.1-1.6% Cu in stockwork, and up to 0.5% Cu in breccia zone

Vostok-2 W±Mo±Be Skarn Deposit

This major deposit (Stepanov, 1977; Rostovsky and others, 1987) consists of skarn in veins and sheets that formed in several stages. From older to younger the stages are: (1) skarn composed mainly pyroxene, plagioclase, amphibole, and garnet; (2) greisen alteration of skarn and granitoid with formation of quartz, feldspar, and muscovite, along with lesser chlorite and biotite with scheelite and apatite, and minor arsenopyrite, pyrrhotite, and chalcopyrite; (3) scheelite and quartz; and (4) low temperature scheelite and arsenopyrite. The deposit occurs along flat to steeply-dipping contacts of granitoid plutons that intrude an olistostrome consisting of Carboniferous and Permian limestone and calcareous-shale. Successive skarn and greisen alteration of limestone preceded deposition of scheelite, gold, and apatite that range up to a few tens of percent. A plagiogranite with an approximate K-Ar isotopic age of 110 Ma is interpreted as coeval with the deposit. The deposit is large with an average grade of 0.65% W_2O_3 and 1.64% Cu, and has been mined since the 1980's.

Lermontovsky W±Mo±Be Skarn Deposit

This deposit (Gvozdev, 1984) consists of skarn in lenses, sheets, and nests that occur at the top contact of an Early Cretaceous granitic stock that intrudes bedded limestone. Skarn ranges from 40 to 640 m long and 1 to 78 m thick. Deposit formed in three stages: (1) skarn (diopside, hedenbergite, hornblende, wollastonite, and garnet) replacement of limestone and of biotite hornfels derived from sandstone; (2) hydrothermal alteration of granitoid, hornfels, and skarn to greisen; and (3) deposition of sulfide minerals. Two types of greisen occur: (1) quartz-albite-muscovite; and (2) scheelite-muscovite-apatite-mica-quartz. Pyrrhotite is the major sulfide, and arsenopyrite, pyrite, marcasite, and scheelite are minor. Sulfide minerals are either superimposed on scheelite greisen or occur separately in veins. Deposit also contains Ag-telluride-bismuth (polymetallic) and Au-telluride-bismuth (pyrrhotite) zones. W occurs in all parts of deposit, although the most abundant scheelite occurs in muscovite and lesser biotite, and phlogopite greisen, quartz veins, and a metasomatic feldspathic rock. The host Early Cretaceous granitoid is highly aluminous, low in alkalies and Ca, and contain elevated levels F and P. The deposit is large with an average grade of 0.67-3% W_2O_3.

Origin and Tectonic Controls for Samarka Metallogenic Belt

The belt is interpreted as forming during generation of S-type grantitoid plutons during underthrusting of the Kula oceanic ridge and formation of bimodal igneous rocks along a transform continental margin. K-Ar isotopic ages for host granitoids are 110 to 115 Ma.

REFERENCES: Stepanov, 1977; Gvozdev, 1984; Rostovsky and others, 1987; A.I. Khanchuk, written commun., 1997; Nokleberg and others 1997, 1998, 2003; Khanchuk and others, 1998.

Hartolgoi-Sulinheer Metallogenic Belt of Au-Ag Epithermal Vein, Ag-Pb Epithermal Vein, Porphyry Mo, W±Mo±Be Skarn, Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Carbonate-Hosted Hg-Sb, and Silica-Carbonate (Listvenite) Hg Deposits (Belt HS) (Southern Mongolia, Northwestern China)

This Late Jurassic to Early Cretaceous metallogenic belt is related to veins and replacements in latite and lamporphyre dikes in the Trans-Baikalian-Daxinganling sedimentary-volcanic-plutonic belt that intrudes and overlies the Tsagaan Uul-Guoershan and Solon terranes, and the Lugyngol volcanic and sedimentary basin. The belt extends approximately 1200 km along southern and southeastern border part of Mongolia with China. The major deposits are the Hartolgoi carbonate-hosted Ag-Pb, Biluut Ag-Pb vein-replacement deposits, and the Zuuntogoo Uul, Baruuntogoo Uul carbonate and hosted Sb (Au, Ag, As) occurrences, the Hotoltolgod, Barjin uul Au-Ag epithermal vein occurrences, and the Hangi Ovoo silica-carbonate Hg occurrence. The Ag-Pb vein and replacement, carbonate and hosted Ag-Pb deposits and occurrences in the Biluutiin and Ulaan Uul districts are located in the western part of the belt and were first assigned to the South Govi-Nuhetdavaa metallogenic belt (Yakovlev, 1977; Batjargal and others, 1997). Various carbonate-hosted Sb (Au, Ag, As), Au-Ag epithermal vein, and listvenite Hg occurrences are located along an east-west-trending thrust fault in the Sulinheer accretionary wedge terrane, and were discovered in result of detailed geological mapping and prospecting in the last 10 years. The significant deposits are at Biluut, Harmorit, Hartolgoi, Khartolgoi, Khoit Barjin, Qiyishan, Ulaan Uul, and Zuun Togoo.

The metallogenic belt displays the following features. (1) The vein and replacement Ag-Pb, carbonate-hosted Ag-Pb, carbonate-hosted Sb (As, Au, Ag), epithermal Au-Ag and silica-carbonate Hg deposits and occurrences all occur in the southern, border part of Mongolia, and are controlled by east-west trending thrust faults. (2). The deposits are closely related to monzonite, quartz porphyry and diabase stocks and dikes that intrude Late Triassic to Early Jurassic granite porphyry and granite stocks with local REE deposits. (3) The thrust fault is a part of the east-west trending Yenshan thrust zone. The western part of this metallogenic belt of Qiyishan W-Mo-W±Mo±Be skarn occurs in the western Inner Mongolia (Northwestern China) It trends east-west and is about 170 km long and 30 km wide. And (4) the Tsagaantolgoi fault in Mongolia, that controls the Buluutiin and Ulaan Uul districts, is the western continuation of the Sulinheer thrust fault that may be a part of the Yenshan thrust zone in China (Geological and Mineral Resources Maps of China). These east-west trending thrust faults closely control the Late Mesozoic vein and replacement deposits and occurrences in the belt. The post-accretionary Late Jurassic granite, that is related to the deposits in the metallogenic belt, intruded the volcanic and sedimentary units of the Archean Alashan terrane.

Khartolgoi Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (Khasin, 1977; Jargalsaihan and others, 1996; D. Dorjgotov, written commun., 1990; Geology and mineral resources of Mongolia, 1999) consists of Pb-Ag veins and lenticular bodies in Proterozoic metamorphic rock intruded by Triassic granitoid. Bodies have dimensions of 100x400 mx2-29x120 m. Wallrock hydrothermal alteration consists of carbonate and silica alteration. Ore minerals are galena, pyrite, antimonite, arsenopyrite, and Ag minerals. Major gangue minerals are chalchedony, siderite, quartz, and calcite. The deposit is large with an average grade of 1,8-13.4% Pb and 2,6% Sb. The deposit has a resource of 60,000 tonnes Pb, 30,000 tonnes Sb, 138 tonnes Ag.

Biluut Ag-Pb Epithermal Vein Deposit

This deposit (Yakovlev, 1977) and other occurrences in the Biluutiin district are located along in the western margin of the belt in a zone with quartz veins containing galena, pyrite, and chalcopyrite. The zone occurs along a weak east-northeast-striking fault that cuts Silurian sandstone and is closely spatially related to quartz porphyry dikes that also contain ore minerals. Some occurrences also contain anglesite and cerussite and are hosted in Proterozoic carbonate and Silurian sedimentary rocks, and in Devonian granitoid.

Ulaan Uul District

This district (Yakovlev, 1977) occurs in south of Dalanzadgad city, and contains Hartolgoi and Hormorit carbonate-hosted Ag-Pb deposits and related occurrences. The bedrock is Proterozoic marble, Carboniferous granodiorite and granite, Permian sandstone and shale, Late Triassic to Early Jurassic granite stocks, and Late Cretaceous basalt (Yakovlev, 1977). The deposits and occurrences arecontrolled by the east-northeast-striking Tsagaantolgoi fault that bounds the Hashaat Tsagaan Uul and Sulinheer terranes.

Hartolgoi Carbonate-Hosted Ag-Pb Deposit

The deposit (Yakovlev, 1977) is hosted in Proteozoic marble that is thrust over a Carboniferous granitoid pluton composed of gabbro, diorite, granodiorite, granosyenite, and granite. Also occurring close to the deposit are extensive Late Triassic and Early Jurassic(?) stocks and dikes of monzonite, quartz monzonite, and quartz-porphyry (Yakovlev, 1977). The deposit is mainly hosted in marble and to a lesser degree in monzonite and quartz porphyry. Individual bodies occur along a major north-northwest-striking, north-dipping thrust and parallel faults, and also in northwest-striking, steeply-dipping faults associated with the major thrust. Ore minerals occur mainly in thrust faults and veins in steep-dipping faults. Ore mineral assemblagess are siderite-sulfide, massive sulfide, and sulfide-magnetite. Main sulfides are pyrite, galena, and arsenopyrite. In addition to high Pb are high contents of Ag, Sb, As, Cd, Cu, and Zn. The deposit is intensely oxidized and leached on the surface. In addition to the Hartolgoi deposit, extensive Fe-oxides zones occur along the Tsagaantolgoi fault and branches.

Harmorit Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This polymetallic deposit (Khasin, 1977; Yakovlev, 1977) is hosted along a weak fault in Permian sandstone and shale that are intruded by a Late Triassic to Early Jurassic granite porphyry stock that also hosts a Sn vein and greisen deposit. Diabase and diabase porphyry dikes are extensive and are closely related to the polymetallic veins. Cassiterite-quartz veins and cassiterite-topoz-fluorite greisens occur in the granite porphyry stock, and in adjacent, contact metamorphosed Permian sandstone and shale. Polymetallic vein are are altered to sericite, chlorite, and limonite, and contain pyrite, arsenopyrite, galena, and chalcopyrite. The veins occur in Permian shale mostly to the southwest of the granite porphyry stock. Gangue minerals are quartz, feldspar, and calcite. The polymetallic veins, diabase, and diabase porphyry dikes intrude the granite porphyry stock and related Sn vein and greisen. Pb grade ranges from 01% to 11% at the surface. Khasin (1977) and Yakovlev (1977) interpret that the polymetallic veins are closely related to the granite-porphyry stock and related Sn vein and greisen deposits, but formed in separate stages. This study interprets that polymetallic veins are closely related to diabase and diabase porphyry dikes, and are younger than granite porphyry stock and associated Sn deposits.

Carbonate-Hosted Hg-Sb Deposits

Various carbonate-hosted Sb (Au, Ag, As) deposits and occurrences (Burenhuu and Gotovsuren, 1995), as at Zuun Togoo Uul and Baruuntogoo Uul, are hosted in in Carboniferous limestone that is thrust over Permian sedimentary rock. The major ore mineral is stibnite. The deposits consist of thin veins with stibnite, quartz, and carbonate that range up to 10 cm wide and form a stockwork in limestone. The occurrences contains high Au, Ag, and As. Diabase dikes are widespread.

Zuun Togoo Uul Carbonate-Hosted Hg-Sb Deposit

This deposit (A. Gotovsuren and others, written commun., 1995; Burenhuu and Gotovsuren, 1995) has a surface ares of 7 km^2 and is hosted in Carboniferous limestone thrusted over Permian volcanic and sedimentary rock and serpentenitized ultramafic rock that occur along a sub-latitudinal fault zone. The rocks are intensively altered to stibnite, and are cut by a quartz vein stockwork with stibnite and other sulfides.NEE-trending quartz veins and veinlets are also abundant. Limestone is intensively altered to silica. Soil samples show a complex anomaly of Sb, W, Ni, As, Cr, Ba, Ag, Mo, and Au. Grab rock and chip samples containe0.01-1.0% and more Sb, 0.01-1.0% As, 0.001-0.01% W, 0.005-0.02% Ni, 0.07-0.3% Cr, 0.002-0.02% Co, 0.0005-0.001% Mo, 0.007-1.0 g/t Au and 0.3-1.0 g/t Ag. A complex hard rock geochemical anomaly occurs in a 1.2. km^2 area with average grade of 0.12% Sb, 0.19% As, 0.06% Ni, and 0.14% Cr. 0.94-1.41% Sb. The anomaly coincides with the Zuun Togoo uul peak. Ore minerals are stibnite, marcasite, pyrite, chromite, nickeline, native silver, native gold, and Fe oxides and various secondary minerals. The deposit is small with resources of 15,000 tonnes Sb and grades up to 1.41% Sb.

Au-Ag Epithermal Vein Occurrences

Various Au-Ag epithermal vein occurrences (Altangerel, 1998) are closely related to a Late Cretaceous basalt and rhyolite sequence. The Barjin Uul occurrence occurs along the Sulinheer thrust zone and consists of silicified and brecciated andesite and chalcedony-like quartz veins that are hosted in Cretaceous andesite.

Khoit Barjin Au-Ag Epithermal Vein Deposit

This occurrence (N. Aizawa and others, written commun., 1996; Altangerel and others, 1998) occurs in the eastern part of an Early Cretaceous siliceous subvolcanic en-echelon bodies that occur along a sub-latitudinal fault zone. The Khoit Barjin hill subvolcanic body is cut by northeast and sublatitudinal quartz veins that range up to 1.0 m thick and up to 50 m long. A northeast-trending quartz vein zone contains parallel veins and contains coarse-bladed quartz that is partly fractured, brecciated, and and altered to limoniteA NNE-trending breccia zone occurs in silicesous volcanic rock and contains abundant disseminated fine-grained pyrite. Rock chip samples contained up to 1.0-3.0 g/t Au. Grade ranges up to 3.0 g/t Au.

Qiyishan W±Mo±Be Skarn Deposit

This deposit (Editorial Committee of the Discovery History of Mineral Deposits, 1996) consists of 71 small lensoid bodies that strike east-west orientation and dip 50 to 65^{o}. The largest body is 700 m long, extends 300 to 500 m downdip, and ranges from 80 to 150 m wide. The bodies occur predominately in the contact-metamorphosed tuffaceous sandstone, and andesite in the exocontact zone and partly in the granite intrusion. The bodies consist of veinlets and disseminations and are complicated. The main ore minerals are wolframite, scheelite, colloform Sn-minerals, molybdenite, cassiterite, lepidolite, and quartz. Rb lepidolite ocurs. The deposit is closely related to a Jurassic biotite granite and granitic porphyry that was previously interpreted as a Rb-Li granite deposit. The deposit is not mined because of difficulty in ore dressing. The deposit is medium size.

Origin and Tectonic Controls for Hartolgoi-Sulinheer Metallogenic belt

In northwestern China, the belt interpreted as forming during generation of post-accretionary granite during subduction of Pacific Plate under the Eurasian Plate. In southern Mongolia, the belt is interpreted as forming in result of back arc extension of a late Mesozoic continental margin arc.

REFERENCES: Khasin, 1977; Obolenskiy, 1985; Compilation Committee, 1992; Batjargal and others, 1996; Mineral Resources (Metals) Map of China, 1992; Editorial Committee of the Discovery History of Mineral deposits of China, Inner Mongolia, 1996; Tomurtogoo and others, 1999.

Yanshan Metallogenic Belt of Cu (±Fe, Au, Ag, Mo) Skarn, W±Mo±Be Skarn, Porphyry Mo (±W, Bi), Granitoid-Related Au Vein, Polymetallic Pb-Zn±Cu (±Ag, Au) Vein and Stockwork, and Au-Ag Epithermal Vein Deposits (Belt YSH) (Northeast and North China)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to veins, replacements, and granitoids related to the Jurassic and Cretaceous Yanliao volcanic-sedimentary basin and plutonic belt that overlies and intrudes the Sino-Korean Craton, West Liaoning-Hebei-Shanxi terrane, Sino-Korea platform sedimentary cover, and adjacent units. The belt occurs in the Yanshan Mountains in North Hebei Province and in an eastern continuation in the West Liaoning Province. The volcanic-plutonic belt consists of Early Jurassic basalt and andesite, Middle Jurassic andesite, dacite, and trachyandesite, Late Jurassic rhyolite and pyroclastic rock, and Early Cretaceous andesite and rhyolite. Most of the volcanic rocks in the belt are calc-alkaline and or alkaline. Plutonic rocks in the belt consist of monzograntie, granodiorite, granite, K-feldspar granite, granite porphyry, and quartz porphyry, and are mostly calc-alkaline. The metallogenic belt trends east-west and is about 600 km long and 200 to 250 km wide. The belt forms a shield-shaped area consisting of northeast and north-northeast-trending zones and districts. The contains numerous large, superlarge deposits of various types and is one of the most economic regions in North China. The significant deposits in the belt are at Shouwangfen, Yangjiazhangzi, Jinchangouliang, Xiaosigou, Dazhuangke, Caijiaying, and Niujuan.

Shouwangfen Cu (±Fe, Au, Ag, Mo) Skarn Deposit

This deposit (Xu, Qidong and others, 1993) occurs at the contact zone of the Mesozoic granodiorite and the Neoproterozoic dolomite of the Wumishan Formation. The deposits are lenticular and lensoid in skarn and are stratiform shaped in metasomatized dolomite. Seven skarn zones occur along the contact: granodiorite zone, altered granodiorite zone, garnet-epidote-vesuvianite skarn zone, diopside zone, magnetite-humite-diopside skarn zone, wollastonite skarn zone, and serpentinized dolomite zone. The main ore minerals are molybdenite, pyrrhotite, pyrite, sphalerite, galena, chalcopyrite, magnetite, hematite, and scheelite. The ore minerals comprise five types: magnetite, pyrite-bearing magnetite, pyrrhotite and Co-bearing chalcopyrite, pyrite-bearing chalcopyrite, and veined chalcopyrite. The ore minerals occur in masses, disseminations, veins, and veinlets, and and display idiomorphic, xenomorphic, crashing, colloid textures. Four skarn stages are recognized: (1) a scapolite stage with scapolite, wollastonite, vesuvianite, garnet and diopside; (2) amagnetite stage with magnetite, humite, phlogopite, sericite, tremolite, and actinolite; (3) a quartz-sulphide stage with sulphides, chlorite, and sericite; and (4) a carbonate stage with calcite and fluorite. The deposit is medium size with reserves of 155,300 tonnes Cu grading 0.65% Cu.

Yangjiazhangzi W±Mo±Be Skarn Deposit

This deposit (Huan, Dianhao and others, 1994) consists of tabular skarns that occur along the contact zone between the coarse-grained Hongluoshan granite (with a K-Ar isotopic age of 178 to 186 Ma) and Middle Cambrian to Middle Ordovician limestone. The deposit is 500 m long, 220 m wide and extends 600 m downdip. The main skarn body, is 300 to 800 m long, 3 to 10 m thick, and extends 200 to 350 m downdip. The ore minerals are mainly molybdenite and pyrite, with lesser sphalerite, galena, and chalcopyrite. Molybdenum occurs in disseminations, veinlets, and networks. Skarn is an important alteration and skarn exhibits late stage pyrite, chlorite, carbonate, and silica alterations. Molybdenum deposition is closely related to silica alteration. Like Lanjiagou porphyry Mo deposit, this deposit also occurs in the Proterozoic Yanshan basin zone along the northern edge of the Sino-Korean Plate. The deposit is medium size with reserves of 32,145 tonnes Mo grading 0.141% Mo.

Jinchanggouliang Granitoid-Related Au Vein Deposit

This deposit (Zhou, Kun, 1995) occurs in the northwestern outer contact zone of a Mesozoic granodiorite stock. More than 50 Au-bearing altered zones occur in gneiss and amphibolite of the Archean Xiaotazhigou Formation. The zones are generally several hundred meters long and 1 to 5 m wide, and are mostly trend northwest and dip steeply southwest or northeast. The deposit occurs discontinously in these altered zones in layers or lenses. The ore minerals occur mainly in masses and dense disseminations and consist mainly of pyrite, quartz, sericite, chalcopyrite, sphalerite, and galena. Sulphur isotopes of ores are of features of meterorite and are narrowly concentrated around 0. Homogenization temperatures for fluid inclusions in quartz range from 250 to 370°C. A K-Ar isotopic age for a related dike is about 120 Ma. The deposit is large with reserves of 17.67 tonnes Au. Grade is 13.09 g/t Au.

Caijiaying Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (Zhang, Changjiang, 1990; Huan, 1991; Quan, Heng,1994) consists of swarms of dense veins that range from 300 to 1000 m long, 1 to 18 m thick, and extend 400 to 500 m downdip. The ore minerals occur in masses and disseminations and are sphalerite, galena, pyrite, arsenopyrite, magnetite, hematite, gold, siliver, and electrum, and minor molybdenite, chalcopyrite, and bornite. Gangue minerals are sericite, quartz, and chlorite and sparse barite and calcite. Host rocks contain chlorite, sericite, silica, pyrite, and carbonate alterations. Early chlorite alteration was replaced by later sericite alteration. Form the deposit outwards the host rocks display successive wide belts of sericite and chlorite alteration. Fluid inclusion temperatures range from 200 to 350 C. The host rocks for the deposit are fine-grained amphibole gneiss derived from Paleoproterozoic volcanic and sedimentary rock that are metamorphosed to amphibolite facie. The host rocks occur along a limb of an overturned fold and the deposit is controlled by faults. The deposit is related to a Jurassic and Cretaceous granite porphyry and quartz porphyry dikes and Late Jurassic volcanic rock. The deposit rerpresents a Mesozoic magmatic hydrothermal system (Huan, 1991). The deposit is large with reserves of 1.44 million tonnes Zn grading 4.26% Zn and 2.73% Pb.

Dazhuangke Porphyry Mo (±W, Bi) Deposit

This deposit (Huan, Dianhao and others, 1994) consists of veins and stockworks in explosive breccia pipes. The main part of the deposit occur in a pipe that is 350 to 400 m long and 40 to 90 m thick. Ore minerals occur in disseminations and veinlets. The main ore mineral is molybdenite with minor magnetite, pyrite, chalcopyrite, sphalerite, and scheelite. Gangue minerals consitute the breccia and are mainly plagioclase, K feldspar, quartz, biotite, fluorite, and sericite. Host rocks are altered to K feldspar, biotitie, silica, pyrite, beresite, zeolite, and propylite. The deposits is related to a Jurassic quartz diorite and quartz monzonite (with a K-Ar isotopicage of 146 to 168 Ma.) and is controlled by east-west-trending fault zones. The deposit is medium size and average grade is 0.10% Mo.

Niujuan Au-Ag Epithermal Vein Deposit

This Ag deposit (Liu, Fengshan, and Zhang, Guohui, 1997) is hosted in metamorphic rock of the Proterozoic Hongqiyingzhi Group and the Late Jurassic volcanic rock that are intruded by the medium-to coarse-grained Gangou granite, fine-grained Dongtai, granite and Yushugoumen quartz diorite. The granitoids have a U-Pb zircon isotopic age of 245.1 Ma. The main deposit occurs in veins in siliceous breccia controlled by faults. The breccias are very complicated and contain fragments of various granite, quartz veins, feldspar, and quartz. The breccia cement is chalcedony and has an isotopic age of 120.66 Ma. The deposit exhibits seven stages: sericite, siliceous rock (chalcedonite), suphide, pyrite-quartz, purple fluorite, white fluorite, and kaolinite. The second stage is the most important. The main ore minerals are sericite, chlorite, pyrite, quartz, adularia, galena, sphalerite, arsenopyrite, marcasite, chacopyrite, magnetite, native silver, Ag tetrahedrite, fluorite, kaolinite, and quartz. Deposit-forming temperatures range from 220 to 350°C and pressures from about 12.6 to 26.0 Mpa. These data suggest a hot spring origin. The deposit is medium size with an average grade of 281 g/t Ag.

Origin and Tectonic Controls for Yanshan Metallogenic Belt

The belt is interpreted as forming during interplate magmatism associated with extensional tectonism related to oblique subduction of the Pacific Oceanic Plate beneath Eurasian Plate. Related volcanism and plutonism is interpreted as extending from the Late Triassic to the Early Cretaceous. The Au deposits in the belt are herein interpreted as related to a separate alkaline igneous complex. Some Early Jurassic deposits may occur in the belt, but most of the belt is interpreted as forming during the Middle Jurassic and Early Cretaceous (Shi Lindao, 1994). The metallogenic zones and districts in the metallogenic belt are apparently controlled by the north-northeast and east-west trending major faults. As for other Middle Jurassic and Early Cretaceous metallogenic belts in this region, some authors discuss the origin of the Mesozoic magmatism as related to deep lithosphere processes (Deng Jifu and others, 1996; Lin Qiang and others, 1998; Wu Fuyuan, Sun Deyou, 1999)

REFERENCES: Huan, 1991; Shi Lindao, 1994; Deng Jifu and others, 1996; Lin Qiang and others, 1998; Wu Fuyuan and, Sun Deyou, 1999.

Jiliaolu Metallogenic Belt of Zn-Pb (±Ag, Cu) Skarn, Cu (±Fe, Au, Ag, Mo) Skarn, Granitoid-related Au Vein, Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork, and Volcanic-Hosted Au-Base Metal Metasomatite Deposits (Belt JLL) (Northeastern China)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to replacements and granitoids of the Jilin-Liaoning-East Shandong volcanic-plutonic belt that overlies and intrudes Sino-Korean Craton, Jilin-Liaoning-East Shandong terrane. The belt extends northeast from East Jilin Province, to the Liaodong and Shandong Peninsulas, and is 600 km long, and 100 to 200 km wide. Nearly twenty relatively large volcanic basins overlap the Jilin-Liaoning-East Shandong Archean terrane and Proterozoic-Paleozoic overlap assemblages. The host volcanic rock for the belt include calc-alkalic andesite, dacite, and rhyolite. Plutonic rocks associated with volcanic rock are mainly multiple stages of granite. The belt several types of large deposits. The belt is the important economic resource for Cu, Pb, Zn and Au in China. The significant deposits are at Huanren, Huatong, Ermi, Jiaojia, Liudaojiang, and Xianluwanzhi.

Huanren Zn-Pb (±Ag, Cu) Skarn Deposit

This deposit (Tu Guangzhi and others, 1989) occurs at the contact zone between limestone and diorite. The skarn occurs in a belt that ranges from 30 to 60 m wide and 600 to 800 m long in an external contact zone. The skar forms several complicated-shaped lenses. The skarn belt and alteration ranges up to 200 m wide. The skarn extends more than 300 m downdip. Apparent lateral and vertical zoning occurs. The lateral zonation is: diorite altered to K feldspar-altered diorite, epidote-altered diorite, epidote skarn, garnet skarn, garnet-diopside skarn, Pb Zn sulfides, marble, and limestone. The vertical zonation is: an upper Pb-Zn sulfide zone; a middle Cu and Zn sulfide zone; and a lower are Fe sulfide zone. The ore minerals occur in masses and disseminations, and are mainly magnetite, hematite, pyrite, arsenopyrite, chalcopyrite, sphalerite, galena, garnet, diopside, calcite, quartz, epidote, and actinolite. The exposed area of the diorite intrusion is 12 km^2. The intrusion consists of diorite, granodiorite, and quartz diorite and is intruded by numerous mafic, intermediate, and siliceous dikes. The diorite is Cretaceous and intrudes Precambrian strata and Jurassic volcanic rock. The deposit is large with reserves of 495,900 tonnes Zn grading 0.40% Zn.

Huatong Cu (±Fe, Au, Ag, Mo) Skarn Deposit

This deposit (Deng, Guoquan, and Jia, Dacheng, 1994) occurs at the contact zone between the marble in the Paleoproterozoic Dashiqiao Formation and a giant phenocryst granite. Both magnesian and calcic skarn occurs. Sulphides occur mainly in calcic skarn but overprint both skarn types. Ore minerals are chalcopyrite, magnetite, pyrrhopyrite, and pyrite. Minor and trace minerals are ludwigite, molybdenite, scheelite, chalcocite, bornite, galena, gold, and arsenopyrite. Gangue minerals are skarn minerals, and talc, wollastonite. The deposit shape is very complicated and is controlled by the shape of the intrusion, lithology of host rocks, and fissures in the host rocks. Gold occurs in both skarn types and may comprise a separate resource. The deposit is medium size.

Ermi Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (Feng Shouzhong, 1998) is hosted in a Late Jurassic sedimentary and volcanic sequence, and occurs in the eastern part of a quartz diorite intrusion that formed in a Mesozoic volcanic basin during the Yanshan orogeny. The deposit mainly occurs in the inner and outer contact zone of a granite porphyry intrusion, partly in the contact zone of quartz diorite intrusion, and in andesite. About 8,000 veins are recognized and are concentrated around quartz diorite and granite porphyry in an arc. The economic deposits are divided into gently dipping, steeply dipping, arcuate fractures with massive ore minerals, and steeply-dipping lenses. The ore minerals are chalcopyrite, pyrrhotite, sphalerite, marcasite, pyrite, galena, chalcocite, magnetite and bismuthine. Gangue minerals are quartz and calcite along with minor sericite, kaolinite, and chlorite. Cu mainly occurs in chalcopyrite. The ore minerals display idiomorphic-hypidiomorphic, porphyritic, and metasomatic textures. The ore minerals occur in masses, bands, disseminations, breccia, veins, stockworks, and colloidal masses. The main ore assemblages are chalcopyrite-marcasite, Cu-bearing magnetite, tourmaline, and chalcopyrite-pyrrhotite-arsenopyrite. Main alterations silica, tourmalinie, chlorite, carbonate, pyrite, chalcopyrite, kaolinite, and sericite alterations. Vertical and horizontal zoning occurs in the deposit. The deposit is medium size.

Jiaojia Granitoid-Related Vein Au Deposit

This deposit (Wei, Yongfu, and Lu, Yingjie, 1994; Sun Fengyue and others, 1995) consists of tabular zones in the Mesozoic Yanshanian Linglong granite that intrudes gneiss and amphibolite of the Archean Jiaodong group. Pyrite is the dominant ore mineral with lesser chalcopyrite, sphalerite, galena, gold, and electrum. Gold occurs in altered and fractured rock in networks and disseminations. Extensive alterations are K-feldspar, sericite, silica, beresite, and carbonate alterations. The deposit is controlled by the Jiaojia-Xincheng fracture zone and the main deposits parallels the fracture. The largest part of the deposit ranges up to 800 m long and 70 m wide, with extends downdip more than 1000 m. Four mineralizing stages are recognized. The mineralizing temperatures range from 150 to 450°C and pressures from 60 MPa to 120 MPa. The deposit occurs in the west part of Jiaodong Peninsula. The deposit is large with reserves of 60 tonnes ore grading: 5-8 g/t Au.

Liujiapuzhi Volcanic-Hosted Au-Base Metal Metasomatite Deposit

This deposit (Wu, Shangquan, 1993) is hosted in the limestone in the Neoproterozoic, Cambrian, and Ordovician Wanlong and Badaojiang Formations. The deposit occurs in various branches, dikes and veins of granite, diorite, diorite porphyry, quartz diorite porphyry and syenite porphyry. The deposits are controlled by faults in a steeply-dipping, quartz diorite porphyry intrusion. Sulphide minerals comprise more than 50% deposit minerals. The ore minerals occur in masses and disseminations. Main ore minerals are pyrite, galena, sphalerite, and chalcopyrite, and minor hessite and gold. Gangue minerals are quartz and calcite. Alterations are silica, sericite, pyrite, carbonate, epidote, and zeolite alterations. The deposit is medium size.

Origin and Tectonic Controls for Jiliaolu Metallogenic Belt

The belt is interpreted as forming during interplate magmatism associated with extensional tectonism related to oblique subduction of the Pacific Oceanic Plate beneath Eurasian Plate. The metallogenic belt occurs in about twenty relatively large volcanic basins and east of the famous Tanlu fault zone along a series of northeast-trending regional faults. The volcanic rock and plutonic rocks hosting the belt are interpreted as forming during back-arc extension (Rui Zhongyao, 1994). Some authors suggested that the alkalinity, REE and lithophyle content of volcanic rock in the belt are slightly lower than those of the Daxinganling volcanic belt, but are slightly higher than those of interplate continental volcanic rock. The north-northeast-trending, strike-slip faults, such as the Tanlu fault zone that occurs along the coast are an important control (Lin Qiang and others, 1998). The metallogenic belt contains several very important districts. The belt contains more than 200 granitoid-related vein Au deposits in a district of 23,000 km^2, some large and superlarge, that comprise one quarter of proven Au reserve in China. In addition, the belt contains Zn-Pb (±Ag, Cu) skarn and volcanic rock related polymetallic vein deposits in the Shandong Peninsula. Debate continues about why so much Au was concentrated in a limited area (Yao Fengliang and others, 1990).

REFERENCES: Yao Fengliang and others, 1990; Rui Zhongyao, 1994; Lin Qiang and others, 1998.

North Jilin Metallogenic Belt of Zn-Pb (±Ag, Cu) Skarn, Granitoid-Related Au Vein, Porphyry Au, Porphyry Cu (±Au), Porphyry Mo (±W, Bi), Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite, Au-Ag Epithermal Vein, and Fluorspar Vein Deposits (Belt NJ) (Northeastern China)

This Middle Jurassic to Early Cretaceous metallogenic belt is related to replacements and granitoids in the North marginal plutonic belt of North China Platform that intrudes the Laoling terrane and Zhangguangcailing superterrane in the Sino-Korea Craton in the North Jilin Province. The host igneous rocksformed during multiple stages of volcanism and plutonism mainly in Late Triassic, Late Jurassic and Cretaceous during central and pipe-like eruptions of intermediate volcanic rock. The Mesozoic granite intrusions in the area are the Late Triassic granite (I type), the Early Jurassic granite (I type), and Late Jurassic granite (A type) (Rui Zongyao, 1994). The metallogenic belt is controlled by the structures along the northern margin of the Sino-Korea Craton, and by northeast-, northwest-, and east-west-trending faults. Though irregular, the belt generally trends east-west, and is 500 km long and 50 km wide. The significant deposits are at Tianbaoshan, Haigou, Sanwen, Daheishan, Xiaoxinancha, and Ciweigou.

Xiaoxinancha Porphyry Cu (±Au) Deposit

This deposit (Rui, Zongyao, 1994) is located at the intersection place of Tianshan-Jilin(Heilongjiang) EW-trending Paleozioc accretion zone and Circum Pacific Mesozoic tectono-magmatic zone.The oldest exposed strata are early Paleozoic Qinglong Group,that often occur as xenoliths in late Hercynian granite and diorite and consist of amphibolite, amphibolitic gneiss, biotite schist, graphite schist, andalusite state, sillimanite slate and sandy slate.Dispersed early and Late Permian strata are distributed in the adjacent region,that are composed of intermediate-siliceous tuff,volcanic breccia,lava and sandy slate. Jurassic volcanic rock can be seen in the fault basins S and NW to the deposit. Ingneous intrusives account for more than 60% the deposit area, including Hercynian, Indosinian,Yanshannian and Himalayan igneous bodies. Hercynian intrusives are the dominant ones,that are plagioclase granite, biotite-plagioclase granite, gneissoid biotite granite and diorite.The main host rock is Hercynian diorite. During early Yanshannian stage, many kinds of intrusives formed, including diorite, quartz diorite, granite, diorite porphyry, moyite, admallite and granitic porphyry. They occur as small igneous stocks or dikes of Hercynian granite and Jurassic volcanic rock. Intermediate porphyry,especially diorite porphyry (130.1 Ma), are closely related with Cu and Au minerals. Deposit is controlled by the intersection of NW-and NNE-striking faults. There are 34 bodies in a NNW-trending belt with an area of 2.4-1.8 sq.km. The bodies are composite vein type, single vein type, network type and veinlets and disseminations. Main deposit minerals are chalcopyrite, pyrite, pyrrhotite, native gold and electrum. Quartz, calcite, sericite, chlorite, epidote, actinolite and zeolite are gangue minerals. Wallrock alterations include K-feldspar alteration, biotitization, beresite alteration, propylitic alteration and carbonate alteration. Deposit-forming temperatures are 200-450 C. The deposit is large.

Tianbaoshan Zn-Pb (±Ag, Cu) Skarn Deposit

This deposit (Rui, Zongyao, 1994) occurs at the intersection of the the east-west-trending Tianbaoshan-Madida fault and the major northeast-striking Liang Jiang-Tianqiaoling fault. The host rocks are Cambrian and Ordovician amphibolite, chlorite schist interlayered with siliceous marble, Late Carboniferous marble interlayered with biotite slate, chert, and limestone, Late Trisssic rhyolite, andesite, and Late Jurassic mafic and intermediate volcanic rock. Several periods of igneous intrusives occur in the area: (1) early Hercynian gneissoid granite with a U-Pb zircon isochron age of 326.4 Ma; (2) late Hercynian granodiorite with a U-Pb zircon isotopic age of 245.2 Ma; (3) Indosinian porphyritic adamellite and dacite porphyry with a U-Pb zircon isotopic age of 205 Ma; and (4) Yanshannian andesitic porphyry and granite porphyry. The deposit is related to Yanshannian igneous rocks and is controlled by the intersections of northwest-, northeast-, and north-south-trending faults. The skarn occurs in the contact zone of Indosinian and Yanshanian granodioritic porphyries and marble in metavolcanic rock. The main ore minerals are magnetite, galena, sphalerite, and chalcopyrite. Explosive breccia pipe deposits occur in the western part of the Mesozoic Tianbaoshan volcanic basin. Galena, sphalerite, chalcopyrite, and pyrite are the main ore minerals, and alteration minerals are quartz, calcite, epidote, hydromica, and chlorite. The main sulfide depositional temperatures are 210 to 300 C. The deposit is medium size with reserves of 123,300 tonnes Pb,193,900 tonnes Zn. Average grade of 0.52% Pb, 1.76% Zn.

Sanmen Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Deposit

This deposit (Tian, Weisheng, and Shao, Jianbo, 1992) consists of veins, lenses, and stockwork. The main part of the deposit is 1800 m long. The ore minerals occur in masses, veinlets, and disseminations, and consist of native silver, pyrite, galena, sphalerite, argentite, Cu and Sn sulfides, and quartz. Intense host rock alteration consists of silica, pyrite, beresite alterations. The host rocks are Cambrian and Ordovician intermediate and siliceous volcanic rock, sedimentary clastic and carbonate rock that are intruded by Jurassic and Cretaceous gramotpods. The deposit is controlled by north-northeast-trending faults and fracture zones. The deposit is large with an average grade of 180 g/t Ag.

Daheishan Porphyry Mo (±W, Bi) Deposit

This deposit (Huan, Dianhaoand others, 1994) consists of veinlets and disseminations in the Yanshanian plagiogranite that intrudes the highly metamorphosed Variscan granite of the Devonian Hulan group with a K-Ar biotite isotopic age of 354 Ma. The plagiogranite forms an ellipse with a surface area of 8 km^2. Ore mineral is mainly molybdenite with minor pyrite, chalcopyrite, galena, and sphalerite. From central to ourward, the important proximal alterations are silica, sericite, kaolinite alterations. The deposit occurs at the intersection between north-northeast-trending Panshi and the east-west-trending Huadian-Shuanghe structural zones that occur in the southeastern part of the Jilin Variscan fold belt near the north margin of Sino-Korean Plate. The deposit is large with reserves of 1.09 million tonnes ore grading 0.066% Mo.

Ciweigou Au-Ag Epithermal Vein Deposit

This deposit (Xu, Enshou and others, 1994; Rui, Zongyao, 1995) occurs along the Yanshannian intra-continental volcanic basin along the southeastern Inner Mongolia-Xinganling Hercynian fold belt. The host rocks are Late Jurassic siliceous, intermediate, and mafic volcanic rock with a Rb-Sr isochron age of 147.5 Ma. The deposit is controlled by circular and radial faults around a maar volcano that occurs at the intersection between east-west-trending major faults and northwest-trending faults. The deposit occurs in veins. Wallrocks display silica, carbonate, sericite, and propylitic alterations. Depositional temperatures range from 180 to 240°C and pressures from 20 MPa to 1.48 MPa. Ore minerals are pyrite, chalcopyrite, tetrahedrite, sphalerite, galena, electrum, argentite, gold, calaverite, and sylvanite. The deposit is medium size.

Origin and Tectonic Controls for North Jilin Metallogenic Belt

The belt is interpreted as related to magmatism along transpression zones along transform micro plate boundaries and within plate (plume) environment. The volcanic rocks that host part of the deposits are interpreted as forming during lithosphere extension and are at least controlled partially by the major, north-northeast-trending Tanlu strike-slip fault system. The belt occurs in: (1) the northern margin of the Archean Jilin-Liaoning-East Shandong terrane of the Sino-Korea Craton; (2) plutonic rocks related to early and late Paleozoic accretions; and (3) post-accretionary Early Triassic, Late Jurassic, and Cretaceous volcanic and plutonic rocks. Deposits in the belt may haveformed in multiple stages. Various authors cite different isotopic ages for the same deposit and therefore some deposit age are uncertain. Some deposits probably formed during the Early Jurassic and Late Triassic (Rui Zhongyao, 1994), but most surely formed in the Middle Jurassic and Early Cretaceous. Lin Qiang and others (1998) suggested that the volcanism in the area continued from the Late Triassic to post Early Cretaceous with most intense activity in the Middle Jurassic and Early Cretaceous.

REFERENCES: Rui Zhongyao, 1994; Lin Qiang and others, 1998.

Benev Metallogenic Belt of W±Mo±Be Skarn Deposits (Belt BV) (Russia, Far East)

This Early Cretaceous metallogenic belt is related to replacements associated with Khungari-Tatibi granitic belt that intrudes the Taukha and Sergeevka terranes. The major deposit is at Benevskoe. The belt occurs in the southern Primorie region in the Russian Southeast.

Benevskoe W±Mo±W±Mo±Be Skarn Deposit

The deposit (V.D. Shlemchenko and others, written commun., 1983) consists of two zones containing skarn and hydrothermal alteration that contain approximately 30 ore bodies ranging from a few m to 200 m long and from 0.6 to 6 m thick. The deposit occurs along the margin of an Early Cretaceous biotite, peraluminous granite that intrudes an olistolith composed of Permian shale and interbedded limestone. The skarn occurs in metasomatized limestone. Various mineral assemblages are magnetite, garnet, pyroxene-gamet, garnet-epidote, and garnet-orthoclase. Late-stage quartz-feldspar and quartz-amphibole overgrowths replace the skarn and locally contains disseminated scheelite. Late-stage quartz-sericite and zeolite alterations also occur. The major ore minerals are scheelite with minor magnetite, arsenopyrite, pyrite, and rare cassiterite. Gangue minerals are quartz, feldspar, amphibole, epidote, biotite, and tourmaline. Easily concentrated apatite also occurs. The deposit is small with an average grade of 0.44 to 3.15% W_2O_3.

Origin and Tectonic Controls for Benev Metallogenic Belt

The belt is interpreted as forming during generation of granitoids during underthrusting of the Kula Oceanic ridge and formation of bimodal igneous rocks along a transform continental margin of the Russian Southeast.

REFERENCES: V.I. Shiemchenko and others, written commun., 1983; Nokleberg and others, 1997, 2000, 2003.

Kamuikotan Metallogenic Belt of Podiform Chromite Deposits (Belt KM) (Japan)

This metallogenic belt is related to ultramafic rocks that comprise part of an ophiolite in the Kamuikotan belt (complex) of the Shimanto accretionary wedge terrane. The belt occurs in the central part of the Hokkaido Island, trends north-south for more than 350 km, and ranges up to 30 km wide. The belt occurs immediately west of the Hidaka metallogenic belt. The belt is hosted in a typical ophiolite sequence in a tectonic mélange (Watanabe and Maekawa, 1985), and the host Shimanto terrane contains serpentinite and high-pressure metamorphic rock (Kamuikotan metamorphic rock). Radiolarian fossils from chert overlying the ophiolite range from Late Jurassic to Early Cretaceous and indicate pre-Cretaceous formation of the ophiolite complex (Kito, 1987). The serpentinite and metamorphic rock occur in three north-south-trending discontinuous blocks. Podiform chromite deposits and PGE minerals occur in serpentinite (Nakagawa and others, 1991). Related PGE minerals occur in placer deposits in and around the metallogenic belt (Nakagawa, 1999). Several massive sulfide occurrences also exist in the belt. The Kamuikotan metallogenic belt was defined by Saito (1958) and Saito and others (1967). Tsuboya and others (1956) included this belt in the Hidaka metallogenic province. Deposits in this belt are genetically related to the formation of ophiolite. The significant deposit is at Nitto.

Nitto Podiform Chromite Mine

This mine occurs in serpentinite of the Kamuikotan ohiolite belt that contains 30 bodies in an area 500 m long and 100 m wide. Eleven bodies more than 3,000 tonnes ore. Mine contains massive chromitite with minor porphyritic chromite. Minor uvarovite and clinochlore also occur. Mining started in 1917 and ended in 1959. The mine is medium size with production of 53,000 tonnes and grade ranging up to more than 50% Cr_2O_3.

Origin and Tectonic Controls for Kamuikotan Metallogenic Belt

The belt is interpreted as forming during generation of an ophiolite that was incorporated into an accretionary wedge.

REFERENCES: Tsuboya and others, 1956; Saito, 1958; Saito and others, 1967; Watanabe and Maekawa, 1985; Kito, 1987; Nakagawa and others, 1991; Nakagawa, 1999.

Hanxing Metallogenic Belt of Fe Skarn Deposits (Belt HX) (North China)

This Late Jurassic to Early Cretaceous metallogenic belt is related associated with granitoids in the Taihanshan volcanic-plutonic belt (too small to be shown at 5 M scale) intruding Sino-Korean Craton-West Liaoning-Hebei-Shanxi terrane. The belt occurs in the Taihan Mountains, western Hebei Province and trends northeast and is about 50 km long and 15 km wide. The metallogenic belt of Fe skarn is related to the Late Jurassic and Early Cretaceous granitoid intrusion and the Middle Ordovician carbonate sedimentary assemblages overlapped on the sourthern West Liaoning-Hebei-Shanxi Archean terrane. The significant deposit is Zhongguan.

Zhongguan Fe Skarn Deposit

This deposit (Cheng, Yuqi and others, 1994) occurs in irregular bodies and lenses. The main deposit occurs at the contact zone between a Cretaceous diorite intrusion and Middle Ordovician limestone. Some skarn occurs in the limestone in the external contact zone and consist of diopside skarn, diopside-tremolite skarn and phlogopite skarn. Along the internal contact zone are scapolite, albite, diopside, and phlogopite skarn. Intense metasomatism resulted in formation of scapolite skarn, diopside-albite metasomaitic rock, and albite metasomatic rocks. The metasomatic zoning consists of: (1) diorite and diopside-albite-altered diorite; (2) diopside-albite skarn or albite metasomatic rocks; and (3) diopside skarn overprinted by magnetite; and (4) marble. Fe sulfides correlate with intensity of albite alteration. The ore minerals occur in masses, disseminations, and layers and the ore minerals are magnetite, martite, specularite, chalcopyrite, pyrrhotite, and chalcocite. The gangue minerals are mainly diopside, tremolite, actinolite, phlogopite, serpentine, garnet, dolomite, and chlorite. Magnetite replaces diopside, formed simultaneously with tremolite, actinolite, and phlogopite, and is replaced by pyrite and other sulphides. The deposit occurs in the southern Taihang Mountains with a group of smaller, similar deposits. The deposit is large with an average grade of 46% Fe.

Origin and Tectonic Controls for Hanxing Metallogenic Belt

The belt is interpreted as forming during granitoid plutonism associated with extensional faults related to subduction of Pacific Plate under the Eurasian Plate. The host Middle Ordovician marine carbonate sedimentary assemblages overlap the North China Platform.

REFERENCES: Cheng Yuqi and others, 1994.

Laiwu Metallogenic Belt of Fe Skarn Deposits (Belt LW) (Northeastern China)

This Late Jurassic to Early Cretaceous metallogenic belt is related to replacements associated with Late Jurassic to Early Cretaceous granitoids in the Jilin-Liaoning-East Shandong volcanic-plutonic belt that intrudes the Sino Korean Craton, West Liaoning-Hebei-Shanxi terrane. The belt occurs in the western Shandong Province, trends northeast, is about 50 km long, and is about 30 km wide. The metallogenic belt is related to the Late Jurassic and Early Cretaceous granitoids that intrude Middle Ordovician and Carboniferous carbonate sedimentary assemblages that overlap the southern Archean West Liaoning-Hebei-Shanxi terrane. The belt occurs at the core of the Jilin anticline and exposed in an area of 70 km^2. The significant deposit is at Jinling.

Jinling Fe Skarn Deposit

This deposit (Tang, Xianqing, 1993) is hosted in Ordovician through Carboniferous limestone and shale that are intruded by plutons of the Jinling complex. The sequence of associated plutonic intrusion is: contaminated mafic porphyritic gabbro diorite and intermediate to mafic biotite diorite; hornblende diorite; pyroxene diorite; and-intermediate to alkalic diorite; and varous dikes (quartz syenite, pegmatite, lamprophyre, and diabase). The deposit occurs in the contact zone between carbonate rocks and plutons of the Jinling complex and are mostly lenticular. The ore mineral is mainly magnetite with minor pyrite, pyrrhotite, and chalcopyrite, and trace hematite, limonite, pseudomorphs of hematite, chalcocite, and marcasite. Gangue minerals are diopside, calcite, serpentine, tremolite, garnet, phylogopite, chlorite, epidote, feldspar, quartz, sericite, actinolite, scapolite, biotite, fluorite, sphene, gypsum and apatite. The ore mineral textures are xenomorphic-hypidiomorphic, secondly idiomorphic-hypidiomorphic granular, and metasomatic relics. Ore minerals occur mainly in masses and secondarily in disseminations. Alteration is very intense and external, contact, and internal alteration zones are recognized. The internal zone contains Na and K alteration and is several meters to several tens of meters wide. The contact zone contains skarn and magnetite deposits that range from 5 to 50 meters wide. The external zone consists of marble, partly-metasomatized marble, skarn with marble, hornfels, and metamorphosed sandstone. The deposit is interpreted as a W±Mo±Be skarn that formed during the Yanshan orogeny. Related granitoids have a K-Ar isotopic age of 110 to 128 Ma. The deposit is large with reserves of 166.1 million tonnes Fe, 38,177 tonnes, Cu, and 5,321 tonnes Co. Average grade is 51% Fe, 0.1-3.0% S, 0.02-0.05% P, 0.05-0.512% Cu, and 0.01-0.23% Co.

Origin and Tectonic Controls for Laiwu Metallogenic Belt

The belt is interpreted as forming during granitoid plutonism associated with extensional faults related to subduction of the Pacific Plate under the Eurasian Plate. The granitoids of the Jinling Complex are interpreted as forming during the Yanshan orogeny. The host Middle Ordovician through Carboniferous marine carbonate sedimentary assemblages overlap the North China Platform. The granitoids are controlled by subduction-related extensional faults.

REFERENCES: Cheng Yuqi and others, 1994.

Taebaegsan Metallogenic Belt of Fe Skarn, Fe-Zn Skarn, Zn-Pb (Ag, Cu, W) skarn, W±Mo±Be Skarn, Au in Shear Zone and Quartz Vein, and REE-Li Pegmatite Deposits (Belt Tae) (South Korea)

This Middle Jurassic through Early Cretaceous metallogenic belt is related to the Jurassic Daebo granite that consists of biotite granite, two-mica granite, granophyre, and felsic and quartz porphyry. The Daebo granite intrudes the Yeongnam Metamorphic Complex and Great Limestone Group that is part of Sino-Korean Craton, Yeongnam granulite-paragneiss terrane. The Yeongnam Metamorphic Complex consists mainly of metasedimentary rocks, quartzite and amphibolite and quartz-injection biotite gneiss, and the Cambrian and Ordovician Great Limestone Group that consists of the Pungchon Limestone, Hwajo Formation, Dongjom Quartzite, and Dumugol and Maggol Limestone. The major deposits are at Dongnam, Kangwon, Seojom, Susuk, Soonkyong, Yomisan (Sinyemi), Sangdong, and Wondong.

The metallogenic belt also contains polymetallic (Pb, Zn, Ag) carbonate-hosted metasomatite at Uirim-Samwon, Au skarn at Chulam, Sn-W greisen, stockwork, and a quartz vein deposit at Soonkyong. These deposits are also interpreted herein as related to the Jurassic Daebo granite.

Dongnam Fe-Zn Skarn Deposit

This deposit (Seo and others, 1983) consists of contact metasomatic and porphyry Mo or disseminated molybdenum including stockwork type ore deposits. The host rocks in the deposit are Cambrian slate (Myobong Formation) and Ordovician limestone (Poongchon and Hwajeol Formation), Cretaceous(?) granitic rock, and Quaternary alluvium deposits. The diorite and quartz porphyry units include diorite-tonalite, granite, and monzodiorite-granodiorite, quartz monzonite-granite, K-rich diorite. and potassic granite. The deposit occurs in fissure filling, contact metasomatic, hydrothemal replacement, and supergene enrichment. and include iron, galena, sphalerite, manganese, and molybodenum ore deposits. Diorite and quartz porphyry contains anomalous Mo, Zn, Pb, Zr, and Fe. Ore minerals are mainly magnetite, hematite, Mn oxide, Mn carbonate, galena, sphalerite, and molybdenite. Accessory minerals are pyrite, pyrrhotite, arsenopyrite, chalcopyrite, limonite, scheelite, and fluorite.

Skarn minerals are mainly garnet, epidote, and chlorite, and minor secondary calcite and quartz. Garnet associated with magnetite, epidote, chlorite, and molybdenite. The deposit is medium size with an average grade of 21.47-39.46% Fe, and 1-7% Pb+Zn. Reserves are 1,724,732 tonnes ore.

Kangwon Fe skarn Deposit

This deposit (Kim and Oh, 1968) consists of Fe contact and selective replacement bodies in calcareous beds in Precambrian metasedimentary rock that consists of biotite paragneiss, amphibole schist, limestone, and quartzite in thin beds. Feldspar porphyry and granite porphyry intrude metasedimentary rock. The general strike of eastern body is NS-N10° E and the dip is 70-80° NW; the western body trends N40°E with a dip of 25-30° NW. The length and width of the eastern body is 130-80 m and 10-6 m, and the western is 100 m and 8 m. The average grade of each body is: Eastern body - 29.8-35.49% Fe, 0.56-1.93% S, 0.02-0.06% P; Western body - 49.03% Fe, 5.61% S, 0.01% P. The deposit is small with an average grade of 38.44%Fe, and reserves of 581,000 tonnes Fe.

Susuk Fe Skarn Deposit

This deposit (Chi, 1963) consists of magnetite and pyrite or pyrrhotite skarn in Precambrian amphibolite that is altered to serpentine or silica by regional metamorphism and hydrothermal fluids. The amphibolite is interlayered with quartzite and quartz-biotite gneiss. These rocks are intruded by granophyre, and felsite and quartz porphyry of suspected Mesozoic age. The granophyre is interpreted as the deposit-related igneous body. Limonite occurs on weathered, but is not economic. The deposit contains low-grade zones with 30-35% Fe and locally up to 50% Fe with higher sulfide content. The deposit is small with resources of 717,400 tonnes Fe, reserves of 164,000 tonnes Fe, and grade of 30-50% Fe.

Yomisan (Sinyemi) Fe-Zn Skarn Deposit

This deposit (Kim and others, 1965) consists of the West body, the East body, and the Magnetite body. The West body is layered and the East body is a small lens with high grade that occurs along breccia and fault zone. The Magnetite body forms a contact metasomatic unit in breccia and as massive skarn in limestone.The host rocks the Maggol Limestone of Ordovician Choseon System that is unconformably overlain by the Late Carboniferous Hongjeom Formation. Igneous intrusions of suspected Mesozoic intrude the sedimentary rocks. The average grade of the West ore body is 5.38% Zn. Reserve amounts are range up to about 490,000 tonnes. The Magnetite body has estimated reserves 100,000 tonnes grading 26.16% Fe. The deposit is small with reserves of 590,000 tonnes ore and an average grade of 5.38% Zn, and 26.16% Fe.

Wondong W±Mo±Be Skarn Deposit

This deposit (Hwang, 1997) consists of three types of skarn ore bodies. The skarns occur in Carboniferous-Permian formations and a lesser Cambrrian and Ordovician formations which are intruded by rhyolite. The Weondong thrust fault that occurs in the central part of the mine. A NS fault system cuts the EW thrust. The Pb+Zn, scheelite and iron(magnetite) ore bodies are present. A total of 21 ore bodies which having the cut-off grade of WO 0.10% have been found. Deposit consists of upper and lower ore bodies. The upper Pb-Zn ore body has the thickness of 1.15m, with average grade of 0.56% Pb, 3,76% Zn, 0.13% Cu, 1.03% As, 260 ppm Cd, and 25 ppm Ag. The lower ore body has the thickness of 0.25 m, with the average grade of 0.36% Pb, 4.53% Zn, 0.42% As, 620 ppm Cd, and 60ppm Ag. The Fe ore body ranges up to 3.0 m thick with average grade of 38% Fe. Fe mineralization always associated with scheelite. Skarn type scheelite, lead-zinc, magnetite deposits in the Cambrian limestone formations with the average grade of 0.48% WO_3 and the thickness 2.80 m for three 3 ore bodies. Stockworks and veinlets of porphyry Co-Mo deposit occur in rhyolite with the average grade of 0.51% Cu and minor molybdenite, with a thickness of 23.8 m for 15 ore bodies. The deposit is small with an average grade of 0.10-0.40% WO_3, 0.36-0.56% Pb, 3.76-4.53% Zn, 38% Fe.

Sangdong W±Mo±Be Skarn Deposit

This deposit (Moon, 1987) consists of W-Mo minerals that occur in bedded limestone in the Cambrian Myobong Slate Formation. The common skarn minerals are Ca-garnet and clinopyroxene. Abundant quartz veins in the W-Mo skarn indicate that W and Mo were transported in a silicate-rich fluid. A syncline is interpreted as related to emplacement of granitoids and hidden skarn bodies may occur along the northern limb of the syncline. The deposit, that consists of both skarn and quartz veins, is interpreted as forming during a long period of mineralzation during the Jurassic and Cretaceous. The deposit is large with an average grade of 77.86% WO_3 and 6.49% MoS_2.

Seojom Au in Shear Zone and Quartz Vein Deposit

This deposit (Hwang and Kim, 1963) consists of veins following a fault zone in the Ochon-dong formation. The Ochon-dong formation consists of sedimentary rock of the lower formation of the Shilla series, Kyongsang system, that is overlain comformably by Shinyangdong formation. These rock formations are intruded by andesite extrusive stocks and younger quartz porphyry. The source of the veins may be the andesite porphyry stocks and quartz porphyry. Several veins are distinctively developed in the mine property. The most promising vein has an average width of 20 cm and average grade Au 2.7 g/t, Ag 2.000 g/t, Pb 18%, Zn 9%. The deposit is small with an average grade of 2.7 g/t Au, 2000 g/t Ag, 18% Pb, 9% Zn, and resources 26,150 tonnes and reserves of 5,150 tonnes.

Origin and Tectonic Controls for Taebaegsan Metallogenic Belt

The belt is interpreted as forming during intrusion of granitoids associated with Late Jurassic to Early Cretaceous Daebo granite that intruded during the Daebo orogeny. Granite consists of biotite granite, feldspar porphyry, and granite porphyry that intrude Precambrian metasedimentary rocks. The skarn deposits formed during contact metasomatism of calcareous layers in metasedimentary rock.

REFERENCES: Chi, 1963; Lee, 1959; Kim and others, 1965; Kim and Oh, 1968; Seo and others, 1983; Moon, 1987; Hwang, 1997; Duk Hwan Hwang, this study.

Kitakami Metallogenic Belt of Cu (± Fe, Au, Mo) Skarn and Granitoid-Related Au Vein Deposits (Belt Kit) (Japan)

This Early Cretaceous (Aptian through Albian) metallogenic belt is related to replacements in the Hiroshima granitic belt (too small to show at 10 M scale) that intrudes the South Kitakami and Mino-Tamba-Chichibu terranes. The belt occurs in the Kitakami Mountains and eastern Abukuma Mountains in the eastern part of northeast Japan, trends north-south for more than 350 km, and has a maximum width of 70 km. The rocks units in the Kitakami Mountains are divided into the North Kitakami and South Kitakami provinces. The North Kitakami province consists of an Jurassic accretionary complex and is a part of the Mino-Tamba-Chichibu terrane. The South Kitakami province consists of Paleozoic granite, sedimentary rock, and andesite. These units are intruded by a Cretaceous granitoid, part of the Hiroshima granite belt. K-Ar isotopic ages of the granitoid in the Kitakami mountains range from 120 Ma to 110 Ma, and the granitoid forms about 25% surface exposure. The granitoid consist mainly of I-type tonalite, granodiorite, and granite. The major deposit types in the Kitakami metallogenic belt are Cu skarn and Au-Ag vein deposits and the major deposit is the Kamaishi Cu-Fe skarn deposit that formed during intrusion of Cretaceous granite along with the Au-Ag vein deposits that frequently contain scheerite. Mo skarn and vein deposits occur in the eastern margin of the North Kitakami province, although those deposits are not described in the database. Tsuboya and others (1956) previously defined the Kitakami metallogenic province and Abukuma metallogenic province; however this study limits the Kitakami metallogenic belt to the eastern margin of the Abukuma province. The major mines are at Kamaishi and Oya.

Kamaishi Cu (±Fe, Au, Ag, Mo) Skarn Mine

This mine (Geological Survey of Japan, 1956; Mining and Metallurgical Institute of Japan, 1965; Kawano and Ueda, 1965; Hamabe, 1979; Ichige and others, 1985; Haruna and others, 1990) consists of 12 skarns bodies that occur in iregular masses. The main ore body is 660 m long, 100 m wide, and 450 m deep. The main ore minerals are magnetite and chalcopyrite. Minor minerals are cubanite, pentlandite, pyrrhotite, pyrite, sphlerite, hematite, arsenopyrite, scheelite, and molybdenite. Skarn minerals are hedenbergite,actinolite, diopside, garnet, and epidote. Host rocks are Paleozoic limestone, slate, and sandstone, and Cretaceous granodiorite. Mine is related to a Cretaceous granodiorite with a K-Ar isotopic age 119 Ma. Deposit was discovered in 1727. Mining was started by the government 1874 and completed in 1993. The mine is medium size with production of 200,000 tonnes Cu, and 14,000,000 tonnes Fe grading 30.9% Fe, 0.63% Cu for copper-iron ore.

Oya Granitoid-related Au vein Mine.

This mine (Geological Survey of Japan, 1955; Mining and Metallurgical Institute of Japan, 1968) consists of north-south striking veins with eight main vein systems. Veins occur in an area 3 km by 1.5 km. The main vein is 700 m long with average thickness of 0.3 m. The main ore minerals are arsenopyrite, pyrrhotite, pyrite, sphalerite, chalcopyrite, native gold, galena, argentite, tetradymite, and molybdenite. Gangue minerals are mainly quartz, calcite, hedenbergite, actinolite, epidote, and sericite. Wall rocks are alteted to quartz and calcite. Host rocks are Jurassic sandstone, slate, and granodiorite. Veins are contact metamorphosed. Veins are interpreted as forming during intrusion of Cretaceous granodiorite. The deposit is small with production of 15.6 tonnes Au, and 2.8 tonnes Ag. Average grade is 20-30 g/t Au, 2-8 g/t Ag.

Origin and Tectonic Controls for Kitakami Metallogenic Belt

The belt is interpreted as forming during intrusion of granitoids associated a continental-margin arc and siliceous magmatism. Ishihara (1978) defined the western W-Cu province and eastern Mo-Pb-Zn province in the Kitakami Mountains. The Mo-Pb-Zn province included the Taro Kuroko-type Pb-Zn deposit that is excluded from the Kitakami belt in this study. Granitoids in the Kitakami metallogenic belt are characteristically magnetite-series (Ishihara and others, 1992).

REFERENCES: Tsuboya and others, 1956; Ishihara, 1978; Ishihara, Sasaki, and Sato, 1992.

Cenomanian through Campanian (96 to 72 Ma) Metallogenic Belts

Lower Yana Metallogenic Belt of Ag-Sb Vein and Clastic Sediment-Hosted Hg±Sb Deposits (Belt LY) (Russia, Verkhoyansk-Kolyma Region)

This Aptian to Late Cretaceous metallogenic belt is related to veins and replacements in Kular-Nera terrane. The belt trends northeast for 200 km along the Yana fault and is inferred to occur beneath the Quaternary sedimentary rock in the lower Yana River. The belt is hosted in the southeastern (Kular) part of the Kular-Nera slate belt that consists of complexly and multiply-deformed Triassic deep-water, black slate. The major deposit is at Kyuchus.

Kyuchyus Ag-Sb Vein Deposit

This deposit (Ivensen and others, 1975; Indolev and others, 1980; Konyshev and others, 1993) consists of steeply-dipping, reverse shear zones that range from 0.1 to 1 m thick, and veins that range from 0.1 to 0.5 m thick. The shear zones and veins consist of quartz-stibnite, cinnabar-stibnite-quartz, realgar-quartz and quartz, with varying amounts of ankerite, calcite, kaolinite, dickite, arsenopyrite, pyrite, orpiment, berthierite, sphalerite, galena, bournonite, pyrrhotite, fahl, native Hg (up to 15%), and Au. The ore minerals occur in stringers and disseminations. Veins and shear zones intrude and cut Middle Triassic (Anisian and Ladinian) sandstone and siltstone that are part of a flysch sequence. The shear zones range up to 3 km long and, and, as based on drill data and data from two adit levels, extends 500 to 550 m deep. The alteration minerals are argillite, hydromica, silica, and graphite. The deposit is large, has estimated reserves of 240 tonnes Au, and an average grade of 4.5% As, up to 15% Sb, up to 0.6% Hg, and up to 300 g/t Au.

Origin and Tectonic Controls for Lower Yana Metallogenic Belt

The belt is interpreted as forming during post-accretionary extension related to initiation of opening of the Eurasia basin. The belt occurs along the Yana fault that cuts the southeastern Kular sector of the Kular-Nera slate belt.

REFERENCES: Amuzinsky and others, 1992; Parfenov and others, 1999, 2001.

Chokhchur-Chekurdakh Metallogenic Belt of Cassiterite-Sulfide-Silicate Vein and Stockwork Deposits (Belt CC) (Russia, Verkhoyansk-Kolyma Region)

This Aptian to Late Cretaceous metallogenic belt is related to veins and replacements in the Jurassic Svyatoi Nos volcanic belt (too small to show at 10 M scale). The belt extends longitudinally for 250 km and occurs in a discontinuous chain of small uplifts in Cenozoic deposits of the Primorsk lowlands. The uplifts consist of horizontal Late Jurassic volcanic and sedimentary rock that is intruded by granodiorite, amphibole-biotite granite, and subalkali granite. The granitoids have $^{40}Ar/^{39}Ar$ isotopic ages of 105 to 106 Ma and are classified as intraplate formations that intruded during extension. Small fields of Late Cretaceous dacite and rhyolite are associated with subvolcanic bodies that contain Sn deposits. The metallogenic belt is characterized by cassiterite-silicate-sulfide deposits in the northern part, and by cassiterite-quartz deposits in the southern part. Also occurring are polymetallic and Sb deposits. The major deposits are at Churpunya and Chokurdakh.

Churpunya Cassiterite-Sulfide-Silicate Vein and Stockwork Deposit

This deposit (Zelenova, 1990; Drobot and others, 1993) is the best known in the metallogenic zone and is hosted in Late Cretaceous volcanic and plutonic rocks. At the base of the section are stratabound tuff, lahar breccia, and andesite lava that grade upward into lava breccia, tuff, and tuffaceous sandstone. These units are overlain by lavas of rhyolite and dacite and intruded by explosive breccia veins and a rhyodacite that form the core of a paleovolcano. The deposit is associated with intrusion of steeply dipping, subvolcanic dacite dikes that contain intense quartz-tourmaline metasomatite, intrusion of rhyolite dikes and formation of Sn deposits. The deposit consists of veins, crush zones, veinlets, and disseminations, and occurs along extensive shear zones that strike sublatitudinally. The deposit contains a productive cassiterite-quartz stage, a pyrrhotite-chalcopyrite (sulfide) stage, and a final sulfosalt-carbonate stage. Most of the Sn reserves (about 90%) are in a central zone. Associated ore minerals are wolframite and Bi minerals. A general facies-stage zonation consists of occurrence of the sulfide stage in the central zone. At depth in the western section are areas of voluminous disseminated Cu-Sn minerals and quartz that are not explored. Associated with hypergene alteration of the sulfide minerals is formation of secondary sulfide zones with rich chalcocite.

Origin and Tectonic Controls for Chokhchur-Chekurdakh Metallogenic Belt

The belt is interpreted as forming during post-accretionary extension related to initiation of opening of the Eurasia Basin. The belt occurs along the Yana fault and is hosted in granodiorite, amphibole-biotite granite, and subalkali granite that form part of Svyatoy Nos magmatic arc. Geochemical indicate intraplate formation of granitoids during extension.

REFERENCES: Nekrasov and Pokrovsky, 1973; Parfenov and others, 1999, 2001.

Central Polousny Metallogenic Belt of Cassiterite-Sulfide-Silicate Vein and Stockwork and Sn-W Greisen, Stockwork, and Quartz Vein Deposits (Belt CP) (Russia, Verkhoyansk-Kolyma Region)

This Aptian to Late Cretaceous metallogenic belt is related to veins and replacements related to the Northern granite belt (too small to show at 10 M scale) that intrudes the Polousnyi-Debin accretionary wedge terrane. The metallogenic belt covers an area of 450 km by 150 km in the central part of the Polousnyy synclinorium that contains complexely-deformed Jurassic flysch that is intruded by granitoids in the western part of the Northern granite belt. The granitoids have $^{40}Ar/^{39}Ar$ isotopic ages of 130 to 120 Ma. The deposits are related to a Late Cretaceous REE and similar subalkali granitoids that occur in small stock-like bodies. The belt contains large Sn deposits as at Deputatskoye deposit that is the largest in Russia. The major deposits are at Deputatskoye, Odinokoye, and Polyarnoe.

Deputatskoe Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Flerov, 1974) contains about 150 separate bodies in shear zones, veins, and linear stockworks. The deposit ranges up to 18 m thick and up to 1400 m long. The major minerals are quartz, tourmaline, chlorite, axinite, fluorite, pyrrhotite, cassiterite, chalcopyrite, pyrite, siderite, ankerite, sphalerite, galena, marcasite, wolframite, stannite, franckeite, boulangerite, bismuth, bismuthine, topaz, apatite, scheelite, and sulfosalts. The main part of the deposit is explored to depths of more than 350 m by adits and drillholes. The wallrocks altered to silica, tourmaline, chlorite, and less commonly to greisen and sulfides. The deposit hosted in contact metamorphosed Middle Jurassic shale and in an unexposed granite stock that is penetrated by drilling at 377 m depth. The stock has a K-Ar isotopic age of 108 Ma. Widespread are pre-deposit, coeval,and post-deposit mafic, intermediate, and felsic dikes. Abundant polymetallic veins occur in felsic and intermediate dikes. The deposit is large with an average grade of 0.3 to 0.7 Sn, and locally up to 10% Sn.

Origin and Tectonic Controls for Central Polousnyy Metallogenic Belt

The belt is interpreted as forming during post-accretionary extension related to initiation of opening of Eurasia Basin. The belt is associated with REE and subalkali granitoids that occur in small stocks in the western sector of the Northern granite belt. The deposits are related to Late Cretaceous REE and compositionally similar subalkali granitoids in small stocks that intrude the Polousnyi-Debin accretionary wedge terrane that consists of complexely deformed Jurassic flysch.

REFERENCES: Flerov and others, 1971, 1979; Indolev and Nevoisa, 1974; Parfenov and others, 2001; Nokleberg and others, 2003.

Turukhansk Metallogenic Belt of Volcanogenic-Sedimentary Fe Deposits (Belt TU) (Russia, Eastern Siberia)

This Cretaceous to Paleogene metallogenic belt is related to stratiform units in Northern, Eastern, and Western Siberia sedimentary basins and occurs in the northeastern West Siberian lowland. The belt extends north-south and is a part of the West Siberian Fe basin that covers more than 50,000 km^2 (Shakhov, 1964; Kuznetsov, 1982). The bain contains large reserves of oolitic ironstone that is hosted in Cretaceous and Paleogene marine clastic sedimentary rock. Within an area of 3,500 km^2, are two major strata with total thickness of 150 to 200 m that contain two major, upper and lower Fe horizons at depths of 30 to 330 m, and 270 to 460 m, respectively (Shakhov, 1964; Kashtanov, 1990). The horizons consist of beds and lenses of oolitic ironstone, ferruginous sandstone and siltstone, and leptochloritic glauconite sandstone and siltstone. Rounded fragments of ferruginate trapps occur frequently. The ore minerals are leptochlorite, hydrogoethite, and leptochlorite-hydrogoethite. The total resources of deposits with an average-grade of 23 to 26 wt.% Fe is 40 billion tonnes.

Turukhanskoye Volcanogenic-Sedimentary FeDeposit

This deposit (Shakhov, 1964; Kashtanov, 1990) consists of ferruginous strata that overlie Turonian-Conyacian clay. The strata varies from 35 to 70 m thick, and occurs at 30 to 40 m beneath the surface. Three Fe horizons range from 2 to 16 m thick. Ore minerals are oolitic and consist of leptochlorite, hydrogoethite, and leptochlorite-goethite. The deposit is large with reserves of 3,000,000,000 grading 30.33% Fe, 1% P_2O_5; 0.4% MnO, and up to 0.16% V_2O_5.

Origin and Tectonic Controls for Turukhansk Metallogenic Belt

The belt is interpreted as forming in a nearshore environment during rewashing of laterite crust weathering material in a shallow-water environment. The weathering material is interpreted as derived from trapp basalt of the North Asian Craton (Shakhov, 1964; Kuznetsov, 1982). The oolithic ironstone deposits in the belt were in a near-shore environment during the Cretaceous and Paleogene.

REFERENCES: Shakhov, 1964; Kuznetsov, 1982; Kashtanov, 1990.

Eckyuchu-Billyakh Metallogenic Belt of Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork, Clastic-Sediment-Hosted Sb-Au, Hg-Sb-W Vein and Stockwork, Ag-Sb Vein, and Au-Ag Epithermal Vein Deposits (Belt EB) (Russia, Verkhoyansk-Kolyma Region)

This Aptian to Late Cretaceous metallogenic belt is related to veins and replacements related to the Transverse granite belt (too small to show at 10 M scale) that intrudes the Verkhoyansk fold and thrust belt in the North Asian Craton Margin. The metallogenic belt occurs in the central, deeply-subsided part of the fold and thrust belt in the Sartang synclinorium, extends longitudinally for 350 km, and ranges up to 150 km wide. The belt is hosted in Permian, Triassic, and Early to Middle Jurassic marine clastic rocks that are deformed into large, simple, linear folds that trend longitudinally. The clastic rocks are intruded by granitoid stocks and dikes of various composition that generally occur at the terminations of the Transverse granitoid belt. The granitoids have $^{40}Ar/^{39}Ar$ isotopic ages of no younger than 120 Ma. Along the western margin of the metallogenic belt is the Khoboyatu-Echiy granite pluton with a $^{40}Ar/^{39}Ar$ isotopic age of 97 Ma. The metallogenic contains mainly epithermal deposits that are younger than, and cut the granitoids and adjacent contact-metamorphic rocks. The major deposits are at Prognoz, Billyakh, Zvyozdochka, Mugurus, and Betyugen.

Prognoz Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (E. Vladimirtseva, written commun., 1985; Alekseev and others, 1991) consists of long and thin sulfide-carbonate veins in Triassic clastic rock. The major ore minerals are siderite, galena, pyrargyrite, owyheeite, various Ag minerals, and sphalerite and in granite porphyry dike. The deposit is a large world-class deposit with an average grade of 3% Pb, 1% Zn, and up to 600 g/t Ag, and probable resource of more than 2,000 tonnes Ag.

Zvyozdochka Clastic Sediment-Hosted Hg±Sb Deposit

This deposit (Maslennikov, 1977; Klimov, 1979; V. Maslennikov, written commun., 1985; Shur, 1985) is hosted in intercalated Triassic sandstone and siltstone that is deformed into small folds that strike roughly north-south. The deposit is 0.2 to 11 m thick, dips west at 70 to 75°, and occurs along a fault that cuts an anticlinal axis. The margin of the deposit is not distinct and is defined by geochemical channel sampling. The major host lithology is sandstone along the western limb of an anticline. Cinnabar is the major ore mineral and native Hg occurs at depths greater than 100 m. Other minor ore minerals are metacinnabarite, pyrite, maracasite, galena, sphalerite, chalcopyrite, and arsenopyrite, and rare stibnite, Au, and Ag. Gangue minerals are quartz, ankerite, calcite, dickite, and kaolinite. Wallrocks exhibit intense silica, dickite, and carbon alterations. The deposit is medium size with an average grade of 1.5 to 1.95% Hg, and has reserves of 3,712 tonnes Hg.

Origin and Tectonic Controls for Eckyuchu-Billyakh Metallogenic Belt

The belt is interpreted as forming during post-accretionary extension related to initiation of opening of the Eurasia Basin. The belt hosted in granitoid stocks and dikes of various compositions that occur at the terminations of the Transverse granitoid belt. The metallogenic belt occurs in the central, subsided part of the Verkhoyansk fold and thrust belt along the margins of the Sartang synclinorium. The granitoids intrude Permian, Triassic, and Early to Middle Jurassic marine clastic rock. The granitoids have $^{40}Ar/^{39}Ar$ isotopic ages that are older than 120 Ma. Near the western margin of the metallogenic belt is the Khoboyatu-Echiy granite pluton with a $^{40}Ar/^{39}Ar$ isotopic age of 97 Ma.

REFERENCES: Galkin, 1969; Maslennikov, 1977; Arkhipov, 1979; Klimov, 1979; Indolev and others, 1980; Shur, 1985; Gamyanin and others, 1998; Parfenov and others, 1999, 2001.

Taryn Metallogenic Belt of Clastic-Sediment-Hosted Sb-Au Deposits (Belt Tar) (Russia, Verkhoyansk-Kolyma Region)

This Aptian to Late Cretaceous metallogenic belt is related to veins and replacements in the Kular-Nera continental margin turbidite terrane and Verkhoyansk fold and thrust belt in the North Asian Craton Margin. The belt extends northwest for 500 km along most of the Kular-Neta terrane. The belt contains numerous major Au-Sb deposits at Tan, Maltan, Kinyas'-Yuryakh, Sarylakh, Kyunkugur, Kim, El'gi-Tonor, Tobychan, Lower Tordocha, Kekhtey, Kemyustakh, Byindzha, Aulachan, Dzholakag, Nitkan, Uzlovoye, Burgavliyskoye, Sentachan, and Markovskoye, and lesser Ag and Ag-Sb polymetallic deposits at Kupol'noye and Dichek. The major deposits are at Sarylakh, Senatachan, and Kupol'noe.

Senatachan Clastic-Sediment-Hosted Sb-Au Deposit

This deposit (Berger, 1978; Zharikov, 1978; Indolev and others, 1980; Maslennikov, written commun., 1985; Shur, 1985) consists of two rod-like veins that range from 85 to 200 m long and 0.2 to 3.1 m thick. The veins occur in shear zones that strike northwest, dip 60 to 80° northwest, and extend to a depth of 600 m or more. The main ore minerals are stibnite and quartz, with lesser ankerite, muscovite, pyrite, arsenopyrite, dickite, and hydromica, and rare sphalerite, Au, chalcostibnite, berthierite, tetrahedrite, zinkenite, jamesonite, aurostibnite, and chalcopyrite. Wallrocks exhibit quartz, carbonate, hydromica and dickite alteration. Disseminated pyrite and stibnite occur in aureoles around deposit. The deposit hosted in Late Triassic (Norian and Rhaetian) clastic rock that is deformed into northwest-trending, gently-plunging folds. The deposits occur along the northwest-trending Adycha-Taryn fault and are conformable to folding. Average grade of 3.2 to 40.3% Sb with locally up to 30% Sb and 50 g/t Au. The deposit is medium size, has been mined, and has reserves of 100,000 tonnes Sb.

Origin and Tectonic Controls for Taryn Metallogenic Belt

The belt is interpreted as forming during post-accretionary extension related to initiation of opening of Eurasia Basin.

REFERENCES: Berger, 1978, 1986; Indolev and others, 1980; V.V. Maslennikov, written commun., 1985; Shur, 1985; Gamyanin and Goryachev, 1988; Parfenov and others, 2001.

Selennyakh Metallogenic Belt of Carbonate-hosted Au-Sb-Hg, Volcanic-Hosted Hg, Au-Ag Epithermal Vein, and Ag-Sb Vein Deposits (Belt SE) (Russia, Verkhoyansk-Kolyma Rgion)

This Aptian to Late Cretaceous metallogenic belt is related to veins and replacements in the Omulevka passive continental margin terrane of the Kolyma-Omolon superterrane and adjacent terranes. The belt contains carbonate and hosted Au-Sb-Hg (Gal Khaya, Pologoye, and Arbat deposits), volcanic-hosted Hg (Dogdo deposit), and Ag-Sb vein (Kysylga deposit) deposits. The Selennyakh metallogenic belt was previously named the Uyandina-Yasachnaya Hg-ore belt (Obolenskiy and Obolenskaya, 1972; Indolev and others, 1980). The belt is 80 km wide, extends for 200 km, and is related to igneous rocks in the Late Jurassic volcanic rock of the Uyandina-Yasachnaya volcanic belt that unconformably overlies the Omulevka terrane. In the northwestern of the belt is the Sakyndzha ore district (Au-Hg-Sb) and to the southeast, the Dogdo (Hg-Au-Ag) ore district. In other areas belt are numerous Hg-Au occurrences.

Kysylga Ag-Sb Vein Deposit

This deposit (Shoshin and Vishnevsky, 1984; E. Vladimirtseva, written commun., 1985; Nekrasov and others, 1987; Gamyanin and Goryachev, 1988.) consists of veins in a zone that varies from 0.60 to 1.25 m thick and up to 400 m long. The veins consist of gangue quartz and calcite with about 1 to 5% arsenopyrite, pyrite, Ag-tetrahedrite, pyrrhotite, sphalerite, galena, chalcopyrite, boulangerite, Ag-jamesonite, and Au (fineness of 638). The veins strike roughly east-west to northeast and dip steeply south. The veins exhibit brecciaiated or, less commonly, comb and massive structures, and often grade into stringers. The deposit occurs along feathered fissures in a northwest-striking major fault that cuts Late Triassic sandstone and siltstone. Host rocks are folding and are intensely contact metamorphosed adjacent to a granitic intrusive. Wallrocks exhibit sericite, chlorite, and feldspar alteration. The average grade is 3.0 to 84.5 g/t Au, 1 to 37 g/t Ag; 0.01 to 0.1 As; 0.01 to 0.04% Sb; 0.002% Sn, and 0.03% Pb.

Origin and Tectonic Controls for Selennyakh Metalogenic Belt

The belt is interpreted as forming during post-accretionary extension related to initiation of opening of Eurasia Basin. The belt extends northwest along the Omulevka terrane composed of early and middle Paleozoic carbonate rock that is unconformably overlain by Late Jurassic volcanic and sedimentary rocks of the Uyandina-Yasachnaya volcanic belt.

REFERENCES: Obolensky and Obolenskaya, 1972; Indolev and others, 1980; Shoshin and Vishnevsky, 1984; Parfenov and others, 1999, 2001; Nokleberg and others, 2003.

Khandyga Metallogenic Belt of Ag-Sb Vein, Carbonate-Hosted As-Au Metasomatite, Clastic-Sediment-Hosted Sb-Au, and Clastic Sediment-Hosted Hg±Sb Deposits (Belt Kha) (Russia, Verkhoyansk-Kolyma Region)

This Aptian to Late Cretaceous metallogenic belt is related to veins and replacements in the southern Verkhoyansk fold and thrust belt in the North Asian Craton Margin. The metallogenic belt extends longitudinally for 250 km and ranges up to 30 km wide. The belt occur along the Sette-Daban tectonic zone that contains early to middle Paleozoic carbonate rock, and in the adjacent, eastern Kylakh tectonic zone that contains Riphean clastic and carbonate rock, and in an area of periclinal closure containing Carboniferous, Permian, and Triassic marine clastic rock. The major deposits are at Senduchen, Khamamyt, Svetloe, and Khachakchan.

Senduchen Clastic-Sediment-Hosted Sb-Au Deposit

This deposit (V. Korostelev, written commun., 1963) consists of quartz-carbonate veins composed of orpiment, stibnite, realgar, arsenopyrite, sphalerite, enargite, chalcopyrite, and jamesonite. Individual orpiment concretions range up to 10 tonnes. The veins intrude dark-gray Silurian limestone, range up to 3.5 m thick, and occur in a fault zone that cuts an anticline. The deposit is small with an average grade of 10 to 58% As and 2.9% Sb.

Seikimyan Clastic Sediment-Hosted Hg±Sb Deposits

This deposit (Klimov, 1979; E. Vladimirtseva, written commun., 1987) consists of stringers and disseminations with quartz, dickite, cinnabar, calcite, and pyrite, and rare galena, sphalerite, and arsenopyrite. Deposit hosted in feathered shear and breccia zones in sandstone with dimensions of 0.4-7 by 50-200 m. Deposit occurs on northeastern limb of an anticline formed in Late Triassic sandstone and siltstone. Deposit is bounded by faults that occur parallel to the major, regional Bryungadin fault. Grade ranges up to 0.1-0.5% Hg.

Origin and Tectonic Controls for Khandyga Metallogenic Belt

The belt is interpreted as forming during post-accretionary extension related to initiation of opening of the Eurasia Basin. The belt occurs in veins and replacements in the southern Verkhoyansk fold and thrust alon the Sette-Daban tectonic zone.

REFERENCES: Ozerova and others, 1990; Parfenov and others, 2001; Nokleberg and others, 2003.

South Verkhoyansk Metallogenic Belt of Au in Shear Zone and Quartz Vein, Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein, Stockwork, Granitoid-Related Au Vein, Cu (±Fe, Au, Ag, Mo) Skarn W-Mo-Be Greisen, Stockwork, and Quartz Vein, and Au-Ag Epithermal Vein Deposits (Belt SV) (Russia, Verkhoyansk-Kolyma Region)

This Aptian to Late Cretaceous metallogenic belt is related to veins related to granitoids in the South Verkhoyansk granite belt that intrude the Verkhoyansk fold and thrust belt in the North Asian Craton Margin. The metallogenic belt occurs in the central part of the South Verkhoyansk synclinorium, is bounded to the west by the Minorsk-Kiderikinsk fault and to the east by the Yudoma fault. The belt extends longitudinally for about 300 km from the Yudoma River in the south to the East Khandyga River in the north. The belt is hosted in Late Carboniferous to Middle Jurassic clastic rock that are deformed into folds with gentle crests and smoothly undulating hinges. In the northern part of the belt are northeast-striking strike-slip faults (Suntar system) with horizontal displacements of up to 10 km and vertical displacements ranging up to 1 km. Related magmatic rocks consist of large polyphase plutons (Tarbagannakh, Uemlyakh, and others), and stocks, dikes, and subvolcanic bodies. The belt contains Au in shear zone and quartz vein and crush zones (Nezhdaninka deposit), Au REE deposits that occur in, and above the apices of granitoid plutons (Levo-Dybinsk district), and polymetallic Pb-Zn ± Cu (±Ag, Au) vein and stockwork deposits (Upper-Menkeche deposit). The major deposits are at Nezhdaninka, Upper-Menkeche, and Levo-Dybinsk.

Nezhdaninka Au in Shear Zone and Quartz Vein Deposit

This deposit (Gamyanin and others, 1985; Gamyanin and others, written commun., 1990; Benevolsky and others, 1992) consists of disseminated gold that occurs in: (1) steeply-dipping shear zones up to 40 m thick and 5.4 km long; (2) related tension-gash quartz veins that range up to 200 m long and 1.2 m thick; and (3) quartz lenses in shear zones. The vein minerals are quartz, carbonate, arsenopyrite, galena, sphalerite, scheelite, sericite, albite, chalcopyrite, tetrahedrite, Pb and Cu sulfosalts, stibnite, and gold. Wallrocks display silica, sulfide, and sericite alteration. Quartz Ag polymetallic deposits cross-cut and post-date feathered quartz-veins. The deposit occurs along a major fault that cuts the core of a doubly-plunging anticline in Late Carboniferous to Early Permian sandstone and shale. The deposit extends extends more than 1,000 m vertically, and is explored by boreholes and seven levels of adits. The deposit is large with proven reserves of 475 tonnes Au, and estimated resources of more than 500 tonnes Au. The average minimum grade is 5 g/t Au, with up to 6,748 g/t Au, and up to 8,300 g/t Ag.

Upper Menkeche Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (V. Korostolev, written commun., 1963; Indolev and Nevoisa, 1974) consists of abundant Ag polymetallic sulfide lenses and veins that occur in a linear, steeply-dipping northeast-trending fault zone in Late Permian sandstone, siltstone, and shale. The fault zone is about 10 km long and 1 km wide. The sulfide bodies occur mostly parallel to the fault zone, dip steeply, range from hundred of meters to 3.5 km long, and from 1 to 10 m (average 3 m) thick. The main ore minerals are galena, sphalerite, pyrrhotite, arsenopyrite, and pyrite. Lesser ore minerals are cassiterite, chalcopyrite, magnetite, owyheeite, pyargyrite, tetrahedrite, diaphorite, boulangerite, native silver, and gold. Gangue minerals are quartz, siderite, ankerite, and calcite. Three sulfide assemblages and stages of deposit formation are: (1) sphalerite-quartz-siderite; (2) sulphoantimonite-galena; and (3) sulfide-carbonate. Regional metamorphism occurred between stages 2 and 3. The fault zone occurs along the dome of a plunging brachyform anticline. Part of deposit occurs within the contact metamorphic aureole of a Late Cretaceous granitoid intrusion that forms stocks and numerous dikes of granite-porphyry and granodiorite-porphyry. Lamprophyre and diabase dikes are widespread. The deposit is medium size with an average grade of 2.7-11% Pb, 3.9-7.0% Zn, 138-332 g/t Ag.

Origin and Tectonic Controls for South Verkhoyansk Metallogenic Belt

The belt is interpreted as forming during accretion of the Okhotsk terrane to the North Asian Craton and resultant deformation of the southern Verkhoyansk fold and thrust belt. The belt occurs in the Minorsk-Kiderikinsk zone of highly deformed Late Carboniferous and Permian rock in the western South Verkhoyansk synclinorium. Au quartz veins are relatively older than large granitic plutons that intrude the South Verkhoyansk synclinorium which have ^{40}Ar-^{39}Ar isotopic ages of 120 to 123 Ma.

REFERENCES: Indolev and Nevoisa, 1974; Gamyanin and others, 1985; Bortnikov and others, 1998; Parfenov and others, 2001; Nokleberg and others, 2003.

Upper Uydoma Metallogenic Belt of Cassiterite-Sulfide-Silicate Vein and Stockwork, Polymetallic Pb-Zn±Cu (±Ag, Au) Vein and Stockwork, Sn-W Greisen, Stockwork, and Quartz Vein, and Porphyry Mo (±W, Sn, Bi) Deposits (Belt UY) (Russia, Verkhoyansk-Kolyma Region)

This Late Cretaceous metallogenic belt is related to veins and replacements that are part of the Okhotsk-Chukotka volcanic-plutonic belt that intrudes and overlies the Verkhoyansk fold and thrust belt in theNorth Asian Craton Margin. The metallogenic belt occurs along the western margin of the Okhotsk-Chukotka volcanic-plutonic belt on the eastern limb of the South-Verkhoyansk synclinorium, extends for 200 km, and ranges up to 60 km wide. The igneous rocks cut Permian and Triassic clastic rock that is deformed into folds that trend north to northeast. Typical are small fields of Late Cretaceous, Late Cretaceous horizontal, volcanic and subvolcanic bodies of rhyolite and dacite. The Late Cretaceous igneous and deposits are controlled by longitudinal, northwest-, and northeast-striking faults. Pb, Zn, Sn, Ag, Au, W, and Sb deposits is are widespread and most prevalent are low-sulfide cassiterite-silicate and argentiferous Sn polymetallic deposits (galena-pyrrhotite-sphalerite). The major deposits are at Khoron, Khaardakh, Kutinskoye, and Djatonskoye.

Khoron Cassiterite-Sulfide-Silicate Vein and Stockwork Deposit

This deposit (Andriyanov and others, 1984) occurs on the northeastern side of the metallogenic belt at the intersection of the Khoron and the Pravonitkansk faults. The deposit is hosted in Permian sandstone and siltstone that are simply folded. The sedimentary rock are intruded by pre-ore dikes and a granodiorite porphyry stock. The deposit occurs in crush zones and veins that range up to 100 m long from 1 m to 1.5 m wide. The vertical span is 500 m. The principal minerals are quartz, tourmaline, and muscovite, and local chlorite and pyrrhotite. Accessory minerals are actinolite, axinite, galena, Fe disulfide, sphalerite, cassiterite, chalcopyrite, stannite, and Bi minerals. Minor minerals are stibinite, Ag minerals, teallite, native Bi and gold. Deposit formed in five phases: quartz-tourmaline, cassiterite-quartz with arsenopyrite, greisen, quartz-sulfide, and quartz-carbonate. Most cassiterite formed in the second phase. The deposit is large with an average grade of 1.17% Sn.

Origin and Tectonic Controls for Upper Udoma Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along an active continental margin arc consisting of the Albian to Late Cretaceous Okhotsk-Chukotka volcanic-plutonic belt. Late Cretaceous magmatism and deposits of the belt are controlled by longitudinal, northwest, and northeast faults.

REFERENCES: Andrianov and others, 1984; Flerov, 1984; Parfenov and others, 2001; Nokleberg and others, 2003.

Kukhtuy-Uliya Metallogenic Belt of Au-Ag Epithermal Vein, Porphyry Mo (±W, Sn, Bi), Porphyry Sn, and Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Deposits (Belt Kul) (Russia, Far East)

This Late Cretaceous and to Paleocene metallogenic belt is related to veins that are associated with the Okhotsk-Chukotka volcanic-plutonic belt that intrudes and overlies the Okhotsk terrane. The metallogenic belt occurs in the Uliya volcanic zone of Okhotsk-Chukotka volcanic-plutonic belt and in the overlapped Okhotsk cratonal terrane. The metallogenic belt contains several Au deposits and occurrences. The main deposits are at Khakandzha and Yurievka.

Khakandzha Au-Ag Epithermal Vein Deposit

This deposit (Onikhimovkiy, and Belomestnykh, 1996) occurs in the Uliya volcanic zone that overlaps the Okhotsk terrane is hosted in a large domal volcanic-plutonic structure that overlies a Late Triassic clastic sequence. The lower part of volcanic-plutonic structure is andesite and the upper part is dacite and rhyolite. The subjacent and the volcanic rock are intruded by a Late Cretaceous brecciated latite sill and granosyenite porphyry dikes, and by Paleocene basalt, diabase, and andesite dikes. The deposit consists of a gently dipping (15 to 30^{o} southwest) zone of breccia and silica alteration that ranges from 7 to 52 m thick. The zone is cut by numerous branching veins and veinlets of quartz and quartz-adularia that contain the Au-Ag minerals. The ore is low-sulfide (0.5 to 3.0%), and the main ore minerals are native gold, pyrite, galena, sphalerite, chalcopyrite, electrum, and native silver. Gangue minerals are: quartz, adularia, rodhochrosite, rhodonite, and calcite. Gold fineness ranges from 532 to 774. The deposit contains from 0.1 to 1806 g/t Au (average of 8 to 10 g/t Au), and from 0.1 to 32,676 g/t Ag (average of 350 to 600 g/t Ag). Au/Ag is 1:44. A high Mn content is typical for the deposit.

NOTE: Need latitude and longitude.

Yurievka Au-Ag Epithermal Vein Deposit

This deposit (Onikhimovkiy, and Belomestnykh, 1996) is hosted in the Uliya volcanic zone that consisits of Late Cretaceous andesite, basalt, dacite, rhiolite, and dacite. The deposit occurs along a tectonic zone that strikes sub-latitudinally and dips steeply. The host rocks are altered to propilite. Gold ores are high-sulfide. Average grade is about 10 to 25 g/t Au, and the deposit contains about 7.1 tonnes gold.

NOTE: Need latitude and longitude.

Origin and Tectonic Controls for Kukhtuy-Uliya Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along an active continental margin arc consisting of the Albian to Late Cretaceous Okhotsk-Chukotka volcanic-plutonic belt.

REFERENCES: Korol'kov and others, 1974; Vel'dyaksov and Umitbaev, 1976; Avchenko, 1977; Chikov, 1978; Verzkhovskaya and Krichevets, 1987; Pavlov, 1993; Moiseenko and Eirish, 1996; Onikhimovsky and Belomestnykh, 1996.

Bakcharsk Metallogenic Belt of Sedimentary Siderite Fe, Banded Iron Formation (BIF, Superior Fe), and Sedimentary Fe-V Deposits (Belt BCh) (Russia, Eastern Siberia)

This Cretaceous and Paleogene metallogenic belt is hosted in stratiform units in the Northern, Eastern, and Western Siberia sedimentary basins. The belt extends south to the north and is part of the West Siberian Fe basin that is exposed over an area more than 50,000 km^{2} (Shakhov, 1964; Kuznetsov, 1982). Huge reserves of oolitic brown Fe deposits are hosted in a thick sequence of Cretaceous and Paleogene marine clastic sedimentary rock. The four Fe horizons are recognized and consist of goethite-leptochlorite and hydrogoethite-leptochlorite. The horizons vary from 30 to 45 m thick. Along strike and downward the horizons grade into ferruginous quartz sandstone. The overlying sedimentary section ranges from 150 to 260 m thick. The largest Bakcharsk deposit has been studied in detail by 56 deep boreholes (Orlov, 1998; Roslyakov and Sviridov, 1998)

Bakcharskoye Sedimentary Siderite Fe Deposit

This deposit (Shachov, 1964; Sviridov, 1988; Rosljakov and Orlov, 1998) consists of brown ironstone beds hosted in loosely or weakly cemented marine shallow-water Late Cretaceous and Paleogene sedimentary rock that overlies the Siberian Platform. The deposit covers an area of 1,200 km^2 and occurs in three stratigraphic levels. (1) The Eocene Bakcharsk horizon consists of by dense hydrogoethite with siderite cement with an average thickness of 12.8 m. (2) The Maastrichtian Kolpashevsk horizon consists of brown ironstone and oolitic ferruginous sandstone. The average thickness is 3.1 m. (3) The Santonian-Campanian Narimsk horizon consists of hydrogoethite-leptochlorite oolite and averages 2.3 m thick. The major Fe reserves are in the Bakcharsk horizon. Grades range from 30.32 to 53.48% Fe, up to 0.33% V_2O_5, and 0.055% S. The deposit is large with reserves of 28,000,000,000 grading 37.4% Fe.

Origin and Tectonic Controls for Bakcharsk Metallogenic belt

The belt is interpreted as forming in a nearshore environment during rewashing of laterite crust weathering material during rewashing in a shallow-water, near-shore environment. The laterite crust is interpreted as derived from trapp basalt plateaus of the North Asian Craton (Shakhov, 1964; Kuznetsov, 1982).

REFERENCES: Shakhov, 1964; Kuznetsov, 1982; Orlov, 1998; Roslyakov and Sviridov, 1998.

Verkhoturovsk Metallogenic Belt of Bauxite (Karst Type), Talc (Magnesite) Replacement, andSedimentary Bauxite Deposits (Belt VT) (Yenisei Ridge, Russia, Eastern Siberia)

This Cretaceous to Paleogene metallogenic belt is related to weathering of units in North Asian Craton, North Asian Craton Margin (East Angara fold and thrust belt), and Central Angara terrane. The belt occurs in the southern part of Yenisei Ridge. The bauxite deposits are related to humid hypergenesis during the Cretaceous and Paleogene. The belt occurs in the southern Chernorechensk-Kamensk synclinorium and the Central anticlinorium of Yenisei Ridge. The belt extends latitudinally for about 200 km and ranges from 120 km wide in the west (Sokhatinoe, Murlinoye, Sredne-Tatarskoye deposits) to 40 km wide in the east (Kirgiteiskoye, Verkhoturovskoye, and Porozhninskoye deposits). The majority of deposits occur in karst basins and are derived from diagenetically altered weathering crust. The weathering crust ranges from 60 to 80 m thick and is developed over Proterozic shale, argillite, carbonaceous rock, and limestone. Bauxite fills karst and structural or erosional basins that occur along contact zones between limestone and amphibolite (Tatarsk group deposits, Ivanovskoye deposit), or in argillaceous schist (Kirgiteiskoye, Verkhoturovskoye, and Porozhninskoye deposits). Bauxite basins are valley-shaped and isometric. The bauxite-bearing horizon ranges up to 130 m thick and consists of light or mottled kaolinite and kaolinite-gibbsite clay with admixtures of hydromica, hydrogoethite, and bauxite. The deposits are lensoid or bedded. Grade ranges from 34 to 48% Al_2O_3 and 2 to 6% SiO_2. The bauxite consists of gibbsite with intermixed kaolinite, boehmite, diaspore, and fine-grained corundum. The largest deposits contain mottled clays and occur in deep (up to 250 m) karst cavities. The deeper karst cavities occur in uplifted areas of the anticlinotium (Tatarskoye deposit) (Peltek, 1971). Most of the bauxite deposits are small except for the medium-size Porozhninskoye deposit.

Porozhinskoye 2 Bauxite (karst type) Deposit

This deposit (Peltek, 1967, 1969; Smirnov, 1978) consists of karst bauxite deposits that occur in the contact zone of Proterozoic clastic and carbonate rocks. Bauxite horizon consists of variegated bauxitic clays, earthy and stony clayey bauxite. Ore horizon is 15 km long and 12 to 45 m thick. Separate deposits are from 120 to 1200 m long, 50 to 150 m width, and 12 to 37 m thick. Bauxite are pisolitic, of gibbsite composition, and enriched in Fe oxides. Main ore minerals are gibbsite, kaolinite, corundum, magnetite, hematite, goethite. The deposit is medium size with an average grade of 43.6% Al_2O_3.

Origin and Tectonic Controls for Verkhoturovsk Metallogenic Belt

The belt is interpreted as forming during Cretaceous and Paleogene tropical weathering and regional peneplane formation on the Yenisei Ridge (Kozlovskaya and Adamenko, 1971) in a humid mesothermal climate (Sergeeva, 1971). Bauxite deposits occur in the middle part of a Cretaceous and Paleogene sedimentary sequence. Underlying strata contain mainly hydromica and kaolinite-hydromica clays and weathered fragments of host rocks. The upper bauxite strata consist of kaolinite and kaolinite-hydromica clay and various types of bauxite (Pasova and Spirin, 1970). However, some researchers interpret the bauxite deposits as forming during deposition of lateritic weathering crust that developed on alumosilicate rock (Peltek, 1967; Cykin, 1981, 1994).

REFERENCES: Peltek, 1967, 1971; Pasova and Spirin, 1970; Kozlovskaya and Adamenko, 1971; Sergeeva, 1971; Cykin, 1988, 1994.

Chelasin Metallogenic Belt of Sn-B (Fe) Skarn (ludwigite), Granitoid-Related Au Vein, Cu (±Fe, Au, Ag, Mo) Skarn, Porphyry Cu-Mo (±Au, Ag). And Porphyry Cu (±Au) Deposits (Belt CHL) (Russia, Far East)

This Late Cretaceous to Paleocene metallogenic belt is related to replacements and granitoids that are part of the Okhotsk-Chukotka volcanic-plutonic belt that intrudes and overlies North Asian Craton and Uda volcanic-plutonic belt. The belt contains several types of granitoid-related deposits. The main deposit is at Chelasin.

Chelasin Porphyry Cu (±Au) Deposit

The deposit (S.M. Rodionov, A.A. Cherepanov, and E.V. Kurbatov, written commun., 1994) consists of 42 stockwork zones and some quartz-sulfide veins. The zones occur in a single tract that extends about 2.5 km. One zone was dissected by three trenches and varies from 10 to 28 m thick and extends more than 700 m according to geophysical data. The zone splits into several branches at the flanks. The host rocks consist of dacite and andesite flows and numerous dikes of rhyolite, andesite, diorite porphyry, and granodiorite that display silica and propylitic alteration. A K-Ar isotopic age for the altered rock is 64 to 67 Ma years. The deposit is unexplored. Average grades are 1.0-9.4% Cu, up to 10.0 g/t Au, up to 1,119.0 g/t Ag, up to 3.0% Pb, up to 3.0% Zn.

Origin and Tectonic Controls for Chalasin Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along an active continental margin arc consisting of the Albian to Late Cretaceous Okhotsk-Chukotka volcanic-plutonic belt.

REFERENCES: S.M. Rodionov, this study.

Preddzhugdzhursky Metallogenic Belt of Porphyry Cu-Mo (±Au, Ag), Porphyry Cu (±Au), and Au-Ag Epithermal Vein Granitoid-related Au Vein, and Cu (±Fe, Au, Ag, Mo) Skarn Deposits (Belt PRD) (Russia, Far East)

This Late Cretaceous to Paleocene metallogenic belt is related to granitoids in the Preddzhugdzhur volcanic zone of the Okhotsk-Chukotka volcanic-plutonic belt that intrudes and overlies the Batomga composite terrane of the East Aldan superterrane, the Dzugdzur anorthosite belt, and the Ulkan plutonic belt. Numerous deposit types occur in the belt and almost all of them are poorly studied. The best studied deposit is at Avlayakan.

Avlayakan Au-Ag Epithermal Vein Deposit

This deposit (Moiseenko and Eirish, 1996) occurs along the southern flank of Dzhugdzhur district and is hosted in Late Cretaceous dacite, rhyolite, and andesite that overlie Precambrian gabbro and anorthosite. The deposit consists of quartz and quartz-carbonate veins that occur in several sublongitudinal zones. Two zones are well explored. The Central zone varies from 5 up to 40 m thick, is about 3 km long, and consists of quartz and quartz-carbonate veins and veinlets with disseminated gold. Hosted volcanic rocks are altered up to chlorite, sericite, hydromica, and quartz propilite. The average gold content for two intersections is 34.5 and 72.5 g/t Au. The Northeastern zone occurs 450 m north of the Central zone, ranges from 50 to 120 m thick, is 3 km long, and consists of numerous branching quartz veins and breccias with minor sulfides. The average grade is about 10.8 g/t Au for one intersection. The average for the whole deposit is 18.2 g/t Au and 38.1 g/t Ag. Au:Ag=1:2-4. The deposit is small.

Origin and Tectonic Controls for Preddzhugdzhursky Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along an active continental margin arc consisting of the Albian to Late Cretaceous Okhotsk-Chukotka volcanic-plutonic belt.

REFERENCES: Moiseenko and Eirish, 1996.

Belininsk Metallogenic Belt of Bauxite (Karst Type), Sedimentary Bauxite, Talc (Magnesite) Replacement, and Laterite Ni Deposits (Belt Bel) (Salair Range, Russia, Eastern Siberia)

This Late Cretaceous to Paleocene metallogenic belt is related to weathering of sedimentary rocks in the Salair and Telbes-Kitat island-arc terranes, and ultramafic-mafic bodies in the Alambai accretionary wedge terrane. The belt occurs in the Kuznetsk Alatau and Salair Range and contains several districts. Two types of deposits occur in the belt: (1) karst type bauxite deposits of medium size (Barzasskoye deposit); and (2) laterite Ni deposits of medium size (Belininskoye deposit) (Kuznetsov, 1982). Bauxite deposits are composed of slightly replaced and mottled red beds that are the result of aresidual eluvial weathering crusts. The bauxite formed as a deuterogenic laterite derived from argillic karst. The laterite Ni deposits are related to the ancient weathering crusts developed on serpentinized ultramafic rock.

Barzasskoye Bauxite (Karst Type) Deposit

This deposit (Kuznetsov, 1982) consists of Cretaceous gibbsite bauxite in a contact karst zone developed in Proterozoic marble that is interlayered with amphibolite. Several tens of bauxite layers vary from 50 by 50 to 800 by 1200 m. The layers are separated by bauxite clays and are underlain by variegated kaolinite clay with brown ironstone lenses. Bauxite structures are clayey, earthy, stony, and pisolitic. Bauxite minerals are gibbsite, kaolinite, goethite, and hematite and intermixed chamosite, siderite, magnetite, ilmenite, hydromica, and quartz. Top parts of bauxite layers grade into light kaolinite clays with relics of gibbsite. The deposit is medium-size with an average grade of 41% Al_2O_3.

Belininskoye Lateritic Ni Deposit

This deposit (Minaeva and Bykov, 1974; Kuznetsov, 1982) consists of Ni-bearing weathering crust developed on a ultramafic pluton consists of apodunite, apoperidotite serpentinite, and rare serpentinized pyroxenite.Seventeen layers and funnel-shaped shoots occur. The following deposit types occur: ferruginous-magnesian (1.15% Ni and 0.01% Co); magnesian (1.02% Ni and 0.01% Co); ferruginous-flinty (0.7 to 1.1% Ni and 0.08 to 0.09% Co); and aluminiferous (0.5 to 1% Ni and 0.01 to 0.05% Co). The ore minerals are nontronite, nepouite, serpentine, goethite, hydrogoethite, hematite, kaolinite, Mn oxides and hydroxides, ferrihalloysite, palygorskite, quartz, and chalcedony. The deposit is medium size with an average grade of 15% Ni and 0.01 to 0.09% Co.

Origin and Tectonic Controls for Belininsk Metallogenic Belt

The deposits in the belt are interpreted as a deuteric laterite derived from argillic karst material. Laterite Ni deposits formed from of weathering crust developed on serpentinized ultramafic rock. The bauxite deposits occur along Early Late Cretaceous, Late Cretaceous, and Paleogene stratigraphic levels. The bauxite deposits are hosted in basins of early to middle Paleozoic carbonate and alumosilicate rock cut by faults. Bauxite occur in the upper part of a clayey complex. Kaolinite, hydromica, and montmorillonite zones underly bauxite horizons. Bauxite consists of kaolinite, goethite, and gibbsite. Laterite Ni deposits occur along over the Martynovo-Shalap ultramafic pluton that occurs along a major fault zone early Paleozoic volcanic and sedimentary rock. The weathering crust occurs in areal, linear, and karst zones and has ranges from 5 to 300 and more m thick (Minaeva and Bykov, 1974).

REFERENCES: Minaeva and Bykov, 1974; Kuznetsov, 1982.

Djotsk Metallogenic Belt of Weathering Crust Mn Deposits (Belt DJ) (Russia, Eastern Siberia)

This Late Cretaceous to Paleogene metallogenic belt is hosted in weathered sedimentary rock in the Kizir-Kazir island arc terrane (too small to show at 10 M scale). The metallogenic belt occurs in the East Sayan region and contains several Mn deposits. The major and typical deposit is at Seibinskoye.

Seibinskoye 1 Mn Deposit

This deposit (Cykin, 1972, 1981, 1988; Matrosov, Shaposhnikov, 1988) consists of Mn oxides in weathering crust that developed on Neoproterozoic siliceous and argillacoues shale. The deposit consists of loose and dense pyrolusite, psilomelane, and limonite. The deposit sharply pinches out at depth. The deposit contains layers of loose oxide Mn minerals that range up to 15 m thick. The layers occur in weathered siliceous and carbonaceous shale along a contact with carbonate strata. The deposit contains about 16 bodies with surface dimensions of 100 by 20 m and 10-12 m thick. The bodies contain about 25% Mn, 9% Fe, 0,4% P, and 37% SiO_2. The deposit is medium size with reserves of 110,000 tonnes of ore grading 25% Mn.

Origin and Tectonic Controls for Djotsk Metallogenic Belt

The belt is interpreted as forming from weathering crusts developed on Neoproterozoic Mn-bearing rocks.

REFERENCES: Cykin, 1967; Matrosov and Shaposhnikov, 1988.

Ezop-Yam-Alin Metallogenic Belt of W-Mo-Be Greisen, Stockwork, and Quartz Vein, Sn-W Greisen, Stockwork, and Quartz Vein, Cassiterite-Sulfide-Silicate Vein and Stockwork, and Porphyry Mo (±W, Sn, Bi) Deposits (Belt EYA) (Russia, Far East)

This Late Cretaceous metallogenic belt is related to veins and replacements associated with the Khingan-Okhotsk volcanic-plutonic belt. The deposits occur mainly along the contacts large granite and leucogranite intrusions. K-Ar isotopic ages indicate the Sn deposits and related Sn granite formed between 75 to 100 Ma. The major deposits are at Ippatinskoe, Olgakanskoe, Shirotnoe.

Ippatinskoe Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Ognyanov, 1986) consists of veins and selvages in the northern part of a large granitic body. Sixty-five veins are recognized. The veins range from 2 cm to 2 m wide, extend up to 290 m along strike, and are prospected to a depth of 100 m. The veins occur in a north-south-trending zone that is 3,000 m long and up to 300 m wide. Ore minerals are cassiterite, wolframite, and arsenopyrite, and rare chalcopyrite, pyrite, scheelite, sphalerite, and molybdenite, and very rare bismuthinite and beryl. Gangue minerals are quartz, muscovite, feldspar, fluorite, and rare tourmaline. Deposit contains minor Cu, Ph, Sb, Pb, and Au. Deposit is related to a fine-grained leucogranite with a K-Ar isotopic age of 75 to 90 Ma. The deposit is small with an average grade of 0.31% Sn and 0.19% WO_3 in 6 largest veins.

Lednikovy-Sarmaka W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (A.I. Bukhanchenko, written commun., 1988) occurs in apical portion of a Late Cretaceous granite pluton and granite-porphyry dikes that intrudes sandstone and siltstone. The deposit consists of a linear stockwork that ranges up to 2 km long and about 300 m wide. The stockwork is composed of quartz and fluorite-topaz-quartz veins and veinlets that vary from 1.0-30.0 cm thick and that occur in an altered zone that contains greisen, chlorite-quartz, and sericite-chlorite-quartz metasomatite. The major minerals are quartz, muscovite, wolframite, arsenopyrite, pyrite, and chalcopyrite. The ore minerals comprise 5 to 40% of veins. The deposit is large with resources of 41,000 tonnes WO_3, 28,000 tonnes Cu. Average grade is 0.37% (0.31-0.43%) WO_3, and 0.18% (0.14-0.21%) Cu.

Origin and Tectonic Controls for Ezop-Yam-Alin Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along along the Khingan transform continental-margin arc consisting of the the Khingan-Okhotsk volcanic-plutonic belt. The arc is tectonically linked to oblique subduction of ancestral Pacific Ocean plate. Fragments of this plate are interpreted as occurring in tectonically interwoven units of the Amur River (AM), Khabarovsk (KB) (younger Early Cretaceous part), and Kiselevka-Manoma accretionary-wedge terranes. This tectonic linkage is based on: (1) occurrence of accretionary-wedge terranes outboard (oceanward) of, and parallel to the various parts of the Khinghan arc; (2) formation of melange structures during the Early and Middle Cretaceous; and (3) where not disrupted by extensive Cretaceous movement along the Central Sihote-Aline strike-slip fault, dipping of melange structures and bounding faults toward and beneath the igneous units of the arc. Formation of the Khingan-Okhotsk magmatic arc is related to subduction that is generally interpreted as ending in the late mid-Cretaceous when oblique subduction changed into sinistral-slip faulting along the outboard margin of the arc.

REFERENCES: Natal'in, 1991, 1993; Vrublevsky and others, 1988; Nokleberg and others, 1994, 1998, 2000, 2003; Nechaev and others, 1996; Sengor and Natal'in, 1996.

Pilda-Limuri Metallogenic Belt of Sn-W Greisen, Stockwork, and Quartz Vein,W-Mo-Be Greisen, Stockwork, and Quartz Vein, Ag-Sb Vein, Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork, and Granitoid-Related Au Vein Deposits (Belt PLL) (Russia, Far East)

This Late Cretaceous metallogenic belt is related to veins, replacements, and granitoids related to the Evur zone of the Khingan-Okhotsk volcanic-plutonic belt. The belt occurs at the junction area of the Amgun, Zhuravlevsk-Amur, and Samarka terranes. Several small deposits of different types occur in the belt. The belt contains small deposits at Agnie-Afanasievskoye, Dyapp, and Uchaminskoye.

Agnie-Afanasievskoye Granitoid-Related Au Vein Mine

This mine (Moiseenko and Eyrish, 1996) occurs in a vein system that ranges up 0.5 km wide and up to 1.0 km long. System occurs in a anticline formed in Early Cretaceous sandstone and siltstone. Several diorite dikes occur along joints that cross host rock bedding. Veins range from 200-700 m long and 5-10 cm wide, strike northeast, and dip moderately. The veins contain mainly quartz, carbonate, feldspar, chlorite, and sericite with up to 1% ore minerals. The ore minerals are pyrite, arsenopyrite, antimonite, chalcopyrite, sphalerite, chalcocite, and gold, and rare cassiterite, wolframite, sheelite, and molybdenite. Pyrite is dominant and forms disseminations and thin veinlets in quartz. The amount of arsenopyrite is less than pyrite and occurs in high-grade zones. Gold grains range from 1-6 mm, and occur in bunches, thin veinlets, and rare octahedron crystals in fractured quartz. Gold fineness is 790. Host rocks are altered near the quartz veins and contain up to 2-4 g/t Au. The deposit is small with production of 12 tonnes Au. Average grade is about 25 g/t Au with a maximum grade 1-2 kg/t Au. Mined from 1936 up to 1962.

Dyappe Ag-Sb Vein Deposit

This deposit (Moiseenko and Eirish, 1996) consists of low sulfide quartz veins and lesser vein breccia with pyrite, arsenopyrite, antimonite, magnetite, and gold. Pyrite contains from 40-50 g/t up to 1.5 kg/t Au . Ore gold is fine-grained from 0.01-0.1 mm up to 1.2 mm. Au fineness is 600-650. Ore contains Te up to 50 g/t, but Te mineralogy not investigated. Several veins, dipping at 65° to 85° to SE, are prospected. Veins and breccia range from a 4 to 45 cm thick and from 30 to 800 m long. Deposit occurs in the exo-and endocontact zone of diorite stock that intrudes Late Cretaceous black shale. The deposit is small. Primary ore grades up to 5-6 g/t Au, oxidation zone grades up to 200-300 g/t Au. The deposit was mined from 1935 to1938 for Au, and from 1941 to 1942 for Sb.

Uchaminskoye Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (V. Kochubey, written commun., 1955; Moiseenko and Eirish, 1996) occurs in folded Early Cretaceous sandstone and siltstone that is intruded by a Late Cretaceous granite porphyry stock and lamprophyre dikes. The deposit occurs in a linear zone of fractured sedimentary rock that is about 1.5 km wide and 0.8 to 30.0 m thick. The zone contains several quartz-sulfide veins that range from 1.5 to 3.0 m thick and linear stockworks. Veins and veinlets consist of fine-grained quartz and sulfides including pyrite, pyrrhotite, and arsenopyrite. The deposit is small with an average grade of 7.0-12.2 g/t Au, 30-70 g/t Ag, 0.5-1.0% Pb, 0.03-0.5% Sn.

Origin and Tectonic Controls for Pilda-Limuri Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along along the Khingan transform continental-margin arc consisting of the the Khingan-Okhotsk volcanic-plutonic belt that is related to oblique subduction of ancestral Pacific Ocean plate.

REFERENCES: Moiseenko and Eirish, 1996.

Malo-Khingan Metallogenic Belt of Porphyry Sn and Rhyolite-Hosted Sn Deposits (Belt MKh) (Russia, Far East)

This Late Cretaceous metallogenic belt is related to granitoids in the Khingan-Okhotsk volcanic-plutonic belt. The intrusive rocks of the Khingan-Okhotsk belt in this area are dominantly granite and are comagmatic with the volcanic rock. The granitoids are interpreted as subduction-related, calc-alkalic igneous rocks and include both S- and I-type granite. The major deposit is at Khinganskoe.

Khingan Porphyry Sn Mine

This deposit (Ognyanov, 1986) occurs in a pipe-shaped, hydrothermal explosion breccia that intrudes felsic volcanic rock. The deposit occurs in15 areas in a zone that ranges from 10 to 50 m across, varies from 100 to 400 to 500 m long, and at depth occurs in a symmetrical breccia zone that is about 250 to 300 m wide across. The zone extends to depths of over 1,200 m. At the upper levels, the breccia is replaced by chlorite, and at the depths of 700 to 800 m, the breccia is replaced by quartz-muscovite (sericite)-topaz greisen. Most of the district consists of quartz, fluorite, and cassiterite with subordinate arsenopyrite, marcasite, loellingite, chalcopyrite, and Bi-minerals. The deposit is interpreted as probably genetically related to a subalkaline potassium granite with a K-Ar isotopic age of

80 to 90 Ma, a Rb-Sr whole-rock isochron age of 78 Ma, and an initial Sr isotopic ratio of 0.7123. The deposit has been mined since the 1960's. The deposit is medium size and averages 0.6 to 0.7% Sn.

Origin and Tectonic Controls for Malo-Khingan Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along along the Khingan transform continental-margin arc consisting of the Khingan-Okhotsk volcanic-plutonic belt that is tectonically to oblique subduction of the ancestral Pacific Ocean plate. The southwest part of Khingan-Okhotsk volcanic-plutonic belt occurs in a post-accretionary Cretaceous volcanic-tectonic basin in the eastern Bureya continental-margin arc superterrane. The basin is filled with mid-Cretaceous, intermediate volcanic rock and overlying Late Cretaceous tuff and rhyolite lava that range from 1.5 to 3.0 km thick. The basin overlies a Proterozoic metamorphic rock of the Bureya superterrane.

The Khingan-Okhotsk belt is part of the Khingan continental-margin arc that is interpreted as forming from oblique subduction of the ancestral Pacific Ocean plate. Fragments of this plate are interpreted as occurring in tectonically interwoven units of the Amur River, Khabarovsk (younger Early Cretaceous part), and Kiselevka-Manoma accretionary-wedge terranes. This tectonic linkage of the arc to the subduction units is based on: (1) occurrence of accretionary-wedge terranes outboard (oceanward) of, and parallel to the various parts of the Khinghan arc; (2) formation of melange structures during the Early and mid-Cretaceous; and (3) where not disrupted by extensive Cretaceous movement, dipping of melange structures and bounding faults toward and beneath the igneous units of the arc. Formation of the Khingan arc and related subduction is generally interpreted as ending in the late mid-Cretaceous when oblique subduction changed into sinistral-slip faulting along the outboard margin of the arc.

REFERENCES: Ognyanov, 1986; Vrublevsky and others, 1988; Natal'in, 1991, 1993; Nokleberg and others, 1994, 1997, 1998, 2000, 2003; Nechaev and others, 1996; Sengor and Natal'in, 1996; Gonevchuk and others, 1998.

Badzhal-Komsomolsk Metallogenic Belt of Sn-W Greisen, Stockwork, and Quartz Vein, Cassiterite-Sulfide-Silicate Vein and Stockwork, Cu (±Fe, Au, Ag, Mo) Skarn, and Porphyry Mo (±W, Sn, Bi) Deposits (Belt BKS) (Russia, Far East)

This Late Cretaceous metallogenic belt is related to veins and replacements in the Khingan-Okhotsk volcanic-plutonic belt. The major deposits are at Pravourmiyskoe, Solnechnoe, Festivalnoe, and Sobolinoye.

Solnechnoe Sn-W Greisen, Stockwork, and Quartz Vein Mine

This mine (Ognyanov, 1986) consists of highly altered quartz-tourmaline zone numerous apophyses and occurs along, and is related to a long north-south-striking, left-lateral, strike-slip fault. The zone ranges varies from 0.5 to 15 m thick, is 800 m long, and extends deep more than 500 m deep. Five vertically-zoned mineral assemblages occur, from bottom to top: (1) quartz-tourmaline; (2) quartz-arsenopyrite-cassiterite with wolframite, bismuthinite, and scheelite; (3) quartz-sulfide (pyrrhotite, chalcopyrite, and marcasite); (4) quartz-galena-sphalerite; and (5) quartz-carbonate. The deposit is closely related to a K-rich granite phase of a gabbro, diorite, granodiorite complex with a K-Ar isotopic age of 75 to 86 Ma. The deposit is medium size with an average grade of 0.56% Sn, 0.05% W, and 0.1% Cu. The deposit has been mined since 1960's and is mostly exhausted.

Sobolinoye Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (G.E. Usanov, written commun., 1987; Onikhimovskiy and Belomestnykh, 1996) occurs in the northern part of Amutsk volcanic basin in a fault-bounded district that covers an anrea of 5.4 km^2. The deposit is bounded by the Leningradskiy thrust that dips west at a low angle (48^o) and contains mylonite tectonic breccias. Along the thrust, folded Jurassic flysh is overthrust by Late Cretaceous andesite, dacite, and rhyolite. Units along the thrust are intruded by Late Cretaceous a diorite and quartz-diorite stock and dikes. Sedimentary and volcanic, and intrusive rocks are cut by generally steeply-dipping (60 to 80^o) fracture zones that occur in or near the thrust in feathering, strike-slip faults. The deposit contains about ten fracture zones quartz-tourmaline, quartz-sericite, and quartz-chlorite. Zones range up to 1.1 km long and about 3 to 7 m thick, with some ranging up to 60 m thick. The deposit contains Sn, W, Cu, Bi, Ag, and economic In. Quartz-tourmaline forms an older mineral assemblage that grades upward into: (1) quartz-cassiterite with arsenopyrite; (2) quartz-pyrrhotite-chalcopyrite with stannite, fluorite, and magnetite; (3) quartz-galena-sphalerite; and (4) quartz-fluorite-calcite. Host rocks are generally altered to quartz-sericite and quartz-chlorite alteration in the upper parts of the deposit. The deposit is large with an average grade of 0.3-0.7% Sn, 0.53% Cu, 0.06% WO_3, 0.014% Bi.

Pravourmiskoe Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Ognyanov, 1986) consists of disseminations and veins that occur in a linear area over 1,500 m long, 5 to 25 m thick, and extends several hundred m down dip. An earlier ore assemblage consists of quartz-topaz-cassiterite with fluorite, and a later assemblage consists of quartz-arsenopyrite-chalcopyrite, and quartz-tourmaline with cassiterite and stibnite. The deposit contains Sn, W, and Cu; Bi, Pb, and Sb. Gangue mineral assemblages are quartz-siderophyllite (zwitters) with quartz-topaz greisen. The deposit occurs along an east-west-trending thrust fault with small offset, and is hosted in, and is genetically related to Late Cretaceous felsic volcanic rock that overlie the large, shallow, granite and leucogranite complex of the Verkhneurmiisky batholith with K-Ar isotopic ages of 75 to 85 Ma. The granite has a Rb-Sr isochron age of 95 to 83 Ma and an initial Sr ratio of 0.703 to 0.708. The deposit is medium size with an average grade of 0.1 to 5% Sn, 0.05% W03, and 0.5% Cu.

Origin and Tectonic Controls for Badzhal-Komsomolsk Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along the Khingan transform continental-margin arc that is related to oblique subduction of ancestral Pacific Ocean plate. The Khingan-Okhotsk volcanic-plutonic belt that hosts the metallogenic belt, is divided into two main sequences: (1) Berriasian to Cenomanian calc-alkalic andesite and minor tholeiitic basalt, with coeval gabbro, diorite. and granodiorite; and (2) Late Cretaceous (mainly pre-Senonian) K-rich felsic volcanic rock, tuff, and ignimbrite, and coeval subvolcanic intrusive and granitoids plutons. The Cretaceous granitoids include granite, leucogranite, and composite gabbro, diorite, granodiorite that are coeval and comagmatic with volcanic rock. Both suites exhibit high K contents. The Khingan-Okhotsk belt overlies the Turan and Malokhingask terranes of the Bureya continental-margin arc superterrane, and Badzhal and Ulban accretionary-wedge terranes.

REFERENCES: Ognyanov, 1986; Nokleberg and others, 1994, 1997, 1998, 2000, 2003; Lebedev and others, 1994; Rodionov, 2000.

Durmin Metallogenic Belt of Au-Ag Epithermal Vein Deposits (Belt Dur) (Russia, Far East)

This Late Cretaceous metallogenic belt is related to veins related to East Sikhote-Alin volcanic-plutonic belt (too small to show at 10 M scale) that overlies and intrudes the Kiselyovka-Manoma Accretionary wedge terrane (too small to show at 5 M scale) along the southern side of the Amur River terrane, north of the Amur fault. The stratigraphy and structure are poorly known. The major deposit is at Durminskoye.

Durmin Au-Ag Epithermal Vein Deposit

This deposit (Moiseenko and Eirish, 1996) consists of five zones of hydrothermally altered, quartz-adularia-sericite, quartz-adularia, and quartz veins and breccia that range up to 220 m long and up to 7 m thick. The ore minerals are pyrite and pyrrhotite with rare arsenopyrite, galena, sphalerite, and chalcopyrite. Au/Ag ratio is 1: 20 to 30. The deposit is hosted in Late Cretaceous andesite, dacite, and rhyolite that overlie Early Cretaceous sandstone and siltstone sequence. Stocks and dikes of Late Cretaceous granite, granite porphyry, and granodiorite intrude the volcanic and sedimentary rock. The deposit is small.

Origin and Tectonic Controls for Durmin Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along the East-Sikhote-Aline continental-margin arc that is tectonically related to oblique subduction of ancestral Pacific Ocean plate.

REFERENCES: Filippov, 1988; Natal'in, 1991; Moiseenko and Eirish, 1996.

Tumnin-Anyuy Metallogenic Belt of Porphyry Sn, Cassiterite-Sulfide-Silicate Vein and Stockwork, and Au-Ag Epithermal Vein Deposits (Belt TuA) (Russia, Far East)

This Late Cretaceous to Paleocene metallogenic belt is related to veins and granitoids in the perivolcanic zone of the East Sikhote-Alin volcanic-plutonic belt that overlies and intrudes the Kema, Luzhkinsky, and Samarka terranes. The major deposits are at Mopau and Tumninskoye.

Mopau Porphyry Sn Deposit

This deposit (Finashin, 1959; Usenko and Chebotarev, 1973) is the most important deposit of the belt and consists of lenticular zones in quartz-sericite rock. The zones contain abundant quartz-cassiterite, cassiterite-quartz-feldspar, quartz-cassiterite-chlorite, and quartz-cassiterite-arsenopyrite-chlorite veinlets. The veinlets range from paper-thin to 0.5 cm thick, and locally up to 10 cm thick. Where closely-spaced, the veinlets form an intricate stockwork up to 100 m across with high Sn content. The zones are over 400 m long and several tens of m thick. Some zones occur at contacts with diabase porphyry dikes. The deposit extends to depths of more than 200 m, is sulfide poor, and is easily concentrated. The deposit is hosted in a group of closely-spaced volcanic vents composed of rhyodacite breccia that is intruded by felsite porphyry intrusions and quartz porphyry dikes. The deposit is related to a major felsic pluton. The age of the deposit interpreted as Late Cretaceous to Paleogene. The deposit is small with an average grade of 0.3% Sn.

Tumninskoye Au-Ag Epithermal Vein Mine

This mine (Moiseenko and Eirish, 1996) occurs in the northern part of Samarka terrane. The deposit consists of low sulfide Au quartz veins that parallel, or rarely crossut strike in wall rocks. Isolated granite porphyry dikes also contain Au. The Au quartz veins range from about 200 to 500 m long and from 0.2 to 6.0 wide (locally up to 19) m. veins are predominantly (90 to 95%) composed by quartz. Ore are arsenopyrite, galena, sphalerite, chalcopyrite, pyrrhotite, gold, and wolframite Gangue minerals are presented, except quartz, by calcite, albite, adularia, sericite, and chlorite as well. Gangue quartz contains locally contains numerous host rock fragments. The deposit is hosted in Early Cretaceous sandstone and siltstone in the Oyemku anticline that trends north-northeast. The core of anticline consists of siltstone the flanks are composed by sandstone with interlayered siltstone. The main Au veins and rare dikes of granite porphyry, diorite porphyry, spessartite, and malchite occur along steeply-dipping (50 to 60^{o}) bedding faults. Bedding faults are widespread. The deposit is small with production of 576 kg of Au from 1962 to 1966.

Origin and Tectonic Controls for Tumnin-Anyuy Metallogenic Belt

The belt interpreted as forming during generation of granitoids along the East-Sikhote-Aline continental-margin arc related to subduction of ancestral Pacific Ocean plate.

REFERENCES: Moiseenko and Eirish, 1996; Nokleberg abd others, 1998, 2000, 2003; S.M. Rodionov, this study.

Luzhkinsky Metallogenic Belt of Sn-W Greisen, Stockwork, and Quartz Vein, Cassiterite-Sulfide-Silicate Vein and Stockwork, W-Mo-Be Greisen, Stockwork, and Quartz Vein, Porphyry Sn, Porphyry Cu (±Au), Porphyry Cu-Mo (±Au, Ag), and Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposits (Belt LZH) (Far East Rusia)

This mid-Cretaceous to early Tertiary metallogenic belt is related to veins, replacements, and granitoids in the East Sikhote-Alin volcanic-plutonic belt that overlies and intrudes Zhuravlevsk-Amur River terrane. The significant deposits in the belt are cassiterite-silicate-sulfide vein and porphyry Sn deposits (Yantarnoe), and Sn-W greisen, stockwork, and quartz vein deposits (Tigrinoe and Zabytoe). The Sn deposits are interpreted as forming in the mid-Cretaceous to early Tertiary between 100 and 50 Ma. Also in the same area are younger, generally uneconomic Sn-W greisen, stockwork, and quartz vein occurrences with K-Ar isotopic ages of 60 to 50 Ma age. In addition to Sn deposits, the northern Luzhkinsky metallogenic belt contains sparse small porphyry Cu (±Au) deposits (Verkhnezolotoe) that are hosted in Senomanian and Turonian monzodiorite in the northwestern part of the metallogenic belt near the Samarka accretionary-wedge terrane that contains abundant oceanic rocks. The porphyry Cu (±Au) deposits are coeval with the Sn deposits of the Luzhkinsky metallogenic belt, but presumably reflect the anomalous Cu-rich composition of the Samarka terrane.

Tigrinoe Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Korostelev and others, 1990; Gonevchuk and Gonevchuk, 1991) is complex and consists of: (1) a greisen along the contact of a Li-F granite pluton; (2) a linear stockwork consisting of a thick network (5 to 10 to 70 veinlets per meter) of parallel, north-south-trending quartz-topaz veins that range from 3 to 100 cm thick and are hosted in metasedimentary rock adjacent to the granite intrusion; and (3) a sulfide-cassiterite breccia pipe that contains rock fragments of the stockwork and greisen cemented by quartz and lesser carbonate, fluorite, and sulfides. Three stages occur: (1) early stage with quartz-molybdenite-bismuthinite; (2) middle stage of REE greisen with wolframite-cassiterite with high contents of Sc, Ni, and Ta; and (3) late stage with hydrothermal quartz-fluorite-carbonate-sulfide veins. In, Cd, Ag, and Se are enriched in sulfides in the two last stages. K-Ar isotopic age of the lithium-fluorine granite is 90 Ma ± 5%. A Rb-Sr isochron age for the Li-F granite is 86 ± 6 Ma with an initial Sr ratio of 0.7093. A Rb-Sr age for the greisen is 73 ± 18 Ma with an initial Sr ratio of 0.7105. The deposit is medium size with an average grade of 0.14% Sn and 0.045% WO_3.

Vysokogorskoe Cassiterite-Sulfide-Silicate Vein and Stockwork Deposit

This deposit (Litavrina and Kosenko, 1978; Ryabchenko, 1983) consists of quartz-chlorite-cassiterite, quartz-sulfide-cassiterite and sulfide-cassiterite veins and fracture zones in Early Cretaceous olistostrome partially overlain by Late Cretaceous felsic volcanic rock. Sn minerals are related to the areas of quartz-tourmaline alteration about 5-6 m thick. Average thickness of veins and zones is 1.2 to 1.4 m, with lengths of 400 to 500 m. Deposit extends to a depth of 700 m. In addition to cassiterite, deposit contains chalcopyrite, arsenopyrite, pyrrhotite; and rare galena and sphalerite. Sulfosalts of Bi and Ag are common. The deposit is medium size with a grade of 1.0% Sn. The deposit has been mined from 1960's to present, and is the largest mine in Kavalerova area.

Zimnee Sn-W Greisen, Stockwork, and Quartz Vein Deposit

This deposit (P.G. Korostelev and others, written commun., 1980; Nazarova, 1983) consists of breccia, breccia- and fracture-filling veins, zones of closely spaced veinlets, and pockets that occur in fracture zones. These structures range up to 1200 m long, are extensive down dip, and vary from several tenths of a meter to several tens of meters wide. The deposit occurs near a granodiorite body and consists mainly of pyrrhotite, pyrite, arsenopyrite, sphalerite, stannite, and cassiterite. Far from the granodiorite and in the upper part of veins, the deposit is mostly galena with finegrained cassiterite. Near the granodiorite, the deposit consists of breccia-bearing fragments of Sn-sulfide minerals that are cemented by a quartz-mica (greisen) aggregate with arsenopyrite and cassiterite. The K-Ar age of altered rocks related to the Sn-polymetallic deposits is 75 Ma. The K-Ar isotopic age of the greisen and granodiorite is approximately 50 Ma. The deposit is regionally metamorphosed and deformed. The deposit is small with an average grade of 0.1-3.0% Cu, 3.18% Pb, 0.59% Sn, and 4.09% Zn.

Arsenyevsky Sn-W Greisen, Stockwork, and Quartz Vein Mine

This mine (Rub and others, 1974; Radkevich and others, 1980) consists of a series of parallel, steeply-dipping quartz veins that extend up to 1000 m along strike and 600 to 700 m downdip. The deposit is closely controlled by moderate-to steeply-dipping rhyolite dikes with a K-Ar isotopic age of 60 Ma. The ore mineral assemblage is vertically zoned. From the top downwards, the assemblages are: quartz-cassiterite; quartz-arsenopyrite-pyrrhotite; polymetallic; and arsenopyrite-pyrrhotite. The rhyolite exhibits quartz-sericite alteration. Local miarolithic cavities are filled with cassiterite. The deposit is medium-size with an average grade of 2-3% Sn, and locally up to 20-25% Sn. The deposit also contains from 0.1-0.5% WO_3 , 1-2% Pb and Zn , and a few hundred ppm Ag. The deposit has been mined since 1970's.

Yantarnoe Porphyry Sn Deposit

This deposit (Rodionov, 1988) consists of veinlets and disseminations of cassiterite and sulfide minerals in a pipe-like body of volcanic breccia composed of trachyandesite and rhyolite. These units intrude Early Cretaceous clastic sedimentary rock. The older part of the deposit is in rhyolite in the pipe-like body that contains pyrite and chalcopyrite. The younger and major part of the deposit formed after intrusion of the explosive breccia and consists of metasomatic quartz-chlorite, quartz-sericite, and quartz-chlorite-sericite alterations that contain a sulfide-free cassiterite-chlorite-quartz assemblage, and a Sn-polymetallic assemblage rich in galena, sphalerite, and chalcopyrite. The host igneous rocks are spatially related to Paleocene volcanic vents with K-Ar isotopic ages of about 65 Ma. The deposit is small with an average grade of 0.1-2.17% Cu, 0.03-1.02% Pb, 7.3% Sn, and 0.7-2.22% Zn.

Origin and Tectonic Controls for Luzhkinsky Metallogenic Belt

The belt is interpreted as forming during generation of granitoids in back-arc part of the the East-Sikhote-Aline continental-margin arc that is tectonically linked to oblique subduction of ancestral Pacific Ocean Plate. Like the Sergeevka-Taukha and Kema metallogenic belts, the coeval Luzhkinsky metallogenic belt is hosted in East Sikhote-Alin volcanic-plutonic belt. The differences between the coeval metallogenic belts are interpreted as the result of the igneous rocks that host these metallogenic belts intruding different bedrock. The Sergeevka-Taukha metallogenic belt contains mainly B skarn, Zn-Pb (±Ag, Cu) skarn, and Pb-Zn polymetallic vein deposits, and is hosted in, or near igneous rocks that intrude the Taukha accretionary-wedge terrane that contains a complex assemblage of abundant Paleozoic and early Mesozoic oceanic rocks, and lesser Jurassic and Early Cretaceous turbidite deposits. In contrast, the Kema metallogenic belt contains mainly Ag-Au epithermal deposits, and is hosted in or near granitoids that intrude the Cretaceous island arc rocks of the Kema terrane. And in contrast, the Luzhkinsky belt is related to granitoid that intrudes the southern Zuravlevksk-Tumnin turbidite basin terrane. Additional controls for the Luzhkinsky metallogenic belt are: (1) the turbidite deposits in the Zuravlevksk-Tumnin terrane are enriched in Sn; and (2) the Luzhinsky belt occurs in the back-arc part of the East Sikhote-Alin igneous belt in which magnetite-series granitoids are predominate.

REFERENCES: Rub and others, 1974; Radkevich and others, 1980; Rodionov and Rodionova, 1980; Nazarova, 1983; Rodionov and others, 1984, 1987; Rodionov, 1988; Ruchkin and others, 1986; 1987; Gerasimov and others, 1990; Korostelev and others, 1990; Gonevchuk and Gonevchuk, 1991; Nokleberg and others, 1994, 1997, 2003; Gonevchuk and Korkorin, 1998; Gonevchuk and others, 1998.

Sergeevka-Taukha Metallogenic Belt of Granitoid-related Au Vein, Boron (datolite) Skarn, Zn-Pb (±Ag, Cu) Skarn, Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork, Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite, Au-Ag Epithermal Vein, and Porphyry Cu (±Au) Deposits (Belt Ser) (Russia, Far East)

This Late Cretaceous and early Tertiary metallogenic belt is related to veins and granitoids related to East Sikhote-Alin volcanic-plutonic belt that overlies and intrudes Sergeevka, Samarka, and Taukha terranes. The belt includes several deposit types.

Progress Granitoid-Related Au Vein Deposit

This deposit (A.N. Rodionov, written commun., 1991) consists of sulfide-poor veins and small veinlets that contain pyrite, arsenopyrite, quartz, and Au. In addition the deposit contains poorly mineralized fracture zones, mylonite zones, and zones of metasomatically-altered carbonate and chlorite-sericite rock. The deposit occurs in, or near a Late Cretaceous granitoid pluton and dikes that intrude Cambrian granitic and gabbro rocks of Sergeevka complex. The deposit is also the source for local placer Au mines. The deposit is medium size with an average grade 5.89 g/t Au.

Askold Granitoid-Related Au Vein Deposit

This deposit (M.I. Efimova and others, written commun., 1971; Efimova and others, 1978) consists of a Au-quartz vein stockwork in a Mesozoic granite that is altered to greisen and that intrudes Paleozoic volcanic and sedimentary rock. A K-Ar muscovite age for alteration associated with the vein is 83.2 Ma. The deposit is prospected to depths of more than 100 m. The deposit is medium size with an average grade of 5.9 to 7.6 g/t Au.

Dalnegorsk Boron (datolite) Skarn Mine

This major, world-class boron mine (Ratkin, 1991; Ratkin and Watson, 1993; P. Layer, V. Ivanov, and T. Bundtzen, written commun., 1994) occurs in a thick skarn formed in a large, upturned olistolith of bedded Triassic limestone that is enclosed in Early Cretaceous clastic sedimentary rock. The skarn extends to a depth of approximately 1 km, where it is intrude off by a granitic intrusion. The skarn formed in two stages, with a second-stage skarn over-printing an earlier skarn. The two stages of skarn formation are separated in time by intrusion of intermediate-composition magmatic bodies (with an approximate K-Ar isotopic age of 70 Ma). The first stage skarn consists of grossular-wollastonite skarn, is concentrically zoned, and consists of finely-banded aggregates with numerous finely crystalline datolite and druse-like accumulations of danburite crystals in paleohydrothermal cavities. The second stage skarn consists predominantly of long, radiated hedenbergite and andradite with coarsely-crystalline datolite, danburite, quartz, axinite, and calcite. An Ar-Ar isotopic age for orthoclase in the second stage skarn assemblage is 57 Ma. The silicate mineralogy of the first-stage skarn is similar to Zn-Pb (±Ag, Cu) skarn deposits in the belt. B isotopic studies indicate a magmatic source for boron. The Dalnegorsk open-pit mine at the deposit is explored to a depth of 1 km. The deposit is very large and had been mined from 1970's to present. The deposit produces over 90% all borate in Russia.

Nikolaevskoe Zn-Pb (±Ag, Cu) Skarn Mine

This mine (Garbuzov and others, 1987; V.V. Ratkin in Nokleberg and others, 1997) is hosted in a giant olistolith of Triassic limestone that is part of an Early Cretaceous accretionary complex. The skarn occurs along the contacts of limestone with hosting siltstone and sandstone, and with overlying felsic volcanic rock of a Late Cretaceous to Paleogene post-accretionary sequence. Small skarn bodies also occur in limestone blocks in the volcanic rock that were faulted from the underlying basement. The ore minerals are dominantly galena and sphalerite that replace an older hedenbergite skarn near the surface, and, at depth, replace a garnet-hedenbergite skarn. Subordinate ore minerals are chalcopyrite, arsenopyrite, pyrite, pyrrhotite, fluorite, and Ag-sulfosalts. The K-Ar age of deposits ranges between 60 and 80 Ma. Average grades are 62 g/t Ag, 1.5 to 8.7% Pb, and, 1.36 to 10.5% Zn. The deposit has been mined from 1970's to present.

Partizanskoe Zn-Pb (±Ag, Cu) Skarn Mine

This mine (Ratkin and others, 1991) consists of numerous, small, steeply-dipping skarn bodies that occur at the contact of a Triassic limestone olistolith surrounded by Early Cretaceous clastic rock. The deposits merge and form a single skarn body about 400 m below the surface, and pinch out at a depth of approximately 600 m. The skarn assemblages are vertically zoned and higher temperature assemblages occur deeper. Massive, densely disseminated Ag-Pb-Zn sulfides (with a Pb/Zn ratio of about 1.0) occur above a quartz-calcite aggregate in the upper part of the deposit. Massive, densely-disseminated Pb-Zn sulfides (with a Pb/Zn ratio of about 0.8) are associated with Mn hedenbergite skarn and occur in the middle part of the deposit. Disseminated Zn sulfides (with a Pb/Zn ratio of about 0.5) occur in ilvaite-garnet-hedenbergite skarn in the lower part of the deposit. Galena and sphalerite are the dominant ore minerals; chalcopyrite and arsenopyrite are common; and minor magnetite, pyrrhotite, and marcasite also occur. Silver-bearing minerals are Ag-and Sb-sulfosalts in the upper part of the deposit and galena in the lower part. Galena contains Ag as a solid solution of matildite. The age of deposits is bracketed between 60 and 80 Ma by basalt dikes that intrude the deposit at the contact of olistolith, and by the lower part of the overlying volcanic strata that are intruded by deposit. The deposit consists of four or more related ore bodies that occur along an about 5 km strike length, including the Soviet 2, Partizansk East, Partizansk West, and Svetliyotvod bodies. The underground workings have a total length of about 11 km. The deposit is medium size and average grades are 67.6 g/t Ag, 1.5 to 3% Pb, and 0.6 to 4 Zn%. The deposit has been mined from the 1950's to present.

Krasnogorskoye Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Deposit

This deposit (Ratkin and others, 1990) consists of steeply-dipping quartz-sulfide veins that range up to several hundred m long along strike and from 0.2 to 1.5 m thick. The veins intrude Late Cretaceous tuff. Sphalerite, cassiterite, and galena are the dominant ore minerals and the margins of veins contain pyrite-marcasite-pyrrhotite with lesser Sb-Ag-sulfosalts. In the deeper level of the deposit, galena contains up to several percent Ag and Bi in matildite. The volcanic rock adjacent to the polymetallic veins is altered to quartz and chlorite. In the core of the veins, chlorite, Mn calcite, rhodochrosite, rhodonite, and spessartine occur with quartz gangue. The veins occur near a Late Cretaceous and Paleocene volcanic vent. The vent breccia also contains disseminated sphalerite, galena, and cassiterite. The veins formed immediately after deposits of the vent breccia that has an approximate K-Ar isotopic age of 65 Ma. The deposit is medium size and average grades are 62 g/t Ag, 5% Pb, 0.26% Sn, and 6.77% Zn.

Origin and Tectonic Controls for Sergeevka-Taukha Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along the East-Sikhote-Aline continental-margin arc related to subduction of ancestral Pacific Ocean Plate. This belt is hosted in, or near igneous rocks that intrude the Taukha accretionary-wedge terrane that contains a complex assemblage of abundant Paleozoic and early Mesozoic oceanic rocks and lesser Jurassic and Early Cretaceous turbidite deposits.

REFERENCES: M.I. Efimova and others, written commun., 1971; Efimova and others, 1978; Garbuzov and others, 1987; Ratkin and others, 1990, 1991; Ratkin, 1991; Ratkin and Watson, 1993; Ishihara and others, 1997; Vasilenko and Valuy, 1998; S.M. Rodionov, written commun., 1991; Nokleberg and others, 2003.

Hidaka Metallogenic Belt of Cyprus Cu-Zn Massive Sulfide and Besshi Cu-Zn-Ag Massive Sulfide Deposits (Belt HD) (Japan, Hokkaido)

This Middle Cretaceous to Eocene metallogenic belt is related to stratiform units in in the Hidaka belt of the Shimanto accretionary wedge terrane. The belt occurs in the central part of the Hokkaido island, trends north-south for more than 350 km, and ranges from 20 to 70 km wide. The belt is hosted in a Cretaceous and Paleogene accretionary complex. The northern Hidaka belt contains mainly clastic rocks, and the southern Hidaka belt contains the Hidaka metamorphic rock. Saito (1958) defined this belt as the Main Central Hokkaido belt, and Tsuboya and others (1956) used the name Hidaka metallogenic province that also contained the Kamuikotan metallogenic belt of present study. Saito and others (1967) used the name Central Hokkaido metallogenic province with similar definition as for the Hidaka metallogenic province. The Hidaka metallogenic belt contains at least ten Cyprus type massive sulfide deposits (Saito, 1958), but most are small and not included in the database. The major deposit is the Shimokawa Besshi Cu-Zn-Ag massive sulfide deposit.

Besshi Cu-Zn-Ag Massive Sulfide Deposit

This deposit (Suyari and others, 1991; Watanabe and others, 1998) consists of four srtratiform ore bodies. The Main Motoyama body extends 1,600 m along strike and 2,000 m down dip, and has dimensions of 3,000 by 11,000 m. Average thickness is 2.4 m with a maximum thickness of 15 m. The ain ore minerals are pyrite, chalcopyrite, bornite, and magnetite. Gangue minerals are chlorite, hornblende, glaucophane, and quartz. Deposit hosted in pelitic schist of Cretaceous Sambagawa Metamorphic Rocks. Mafic schist and piedmontite schist occur the ore zone. Geochemistry indicates mafic schist derived from basalt that formed in an oceanic intra-plate or constructive plate margins. Age of peak of metamorphism is 110 Ma according to Rb-Sr and K-Ar isotopic studies. Possible age for submarine basaltic volcanism and deposit formation is 200 Ma (Late Triassic) to 140 Ma (Jurassic). Deposit was discovered in 1690. The deposit is large with a grade of 1.0-1.8% Cu, 0.1-1.4% Zn, 11.9-40% S, 0.3-0.7g/t Au, 7-20g/t Ag. The deposit has produced 706,000 tonnes Cu, and has reserves of 8,000,000 tonnes.

Shimokawa Besshi Cu-Zn-Ag Massive Sulfide Deposit

This deposit (Mining and Metallurgical Institute of Japan, 1965; Kato and others, 1990; Mariko and Kato, 1994) consists of of seven sulfide bodies that occur along the same stratigraphic horizon. The horizon strikes north-south, and dips 50 to 60^{o}east. The sulfide bodies occur along a 1,800 m long zone. Average thickness of the bodies is 5.2 m with a maximum of 30 m. The main ore minerals are pyrite, chalcopyrite, pyrrhotite, sphalerite, and magnetite. Minor ore minerals are cubanite, valleriite, cobalt-bearing pentlandite, and cobaltite. Gangue minerals are quartz, chlorite, sericite, and cabonate minerals. The deposit occurs between tholeiitic pillow basalt and slate of the Cretaceous Hidaka Group. Tholeiitic rocks show geochemical similarity to mid-ocean ridge basalt or marginal basin basalt. Host rocks are altered from zeolite to amphibolite facies. The deposit is medium-size with average grade of 2.3% Cu, 0.8% Zn, 0.22%Co, and 20.3% S. 6,800,000 tonnes ore was produced from 1941-1982. The main mining occurred from 1941 to 1982.

Origin and Tectonic Controls for Hidaka Metallogenic Belt

The belt is interpreted as forming in basalt generated along the Kula-Pacific ridge. Subsequently, the host rocks and deposits were structurally incorporated into the Shimanto accretionary wedge terrane. The basalt associated with the deposits has geochemical characteristics of N-type MORB (Miyashita and others, 1997). The ages of basalt are interpreted as mid-Cretaceous to Eocene. The basalt occurs in clastic sedimentary rock, suggesting occurrence of a spreading ridge near a subduction zone (Miyashita and others, 1997). The deposits in the belt are interpreted as forming during this magmatism along the Kula-Pacific ridge that was being subducted under the East Asia continental margin

REFERENCES: Tsuboya and others, 1956; Saito, 1958; Saito and others, 1967; Miyashita and others, 1997.

Inner Zone Southwest Japan Metallogenic Belt of Zn-Pb (Ag, Cu, W) Skarn, W-Mo-Be Greisen, Stockwork, and Quartz Vein, W±Mo±Be skarn, Cu (±Fe, Au, Ag, Mo) Skarn, Porphyry Mo (±W, Sn, Bi), Polymetallic Pb-Zn ±Cu (± Ag, Au) Vein and Stockwork, Fluorspar Vein, and Metamorphic Graphite Deposits (Belt ISJ) (Japan)

This Cretaceous to Paleogene metallogenic belt is related to veins and replacements in Nohi rhyolitic volcanic belt and Hiroshima granitic belt that overlie and intrude the Hida, Sangun-Hidagaien-Kurosegawa, Akiyoshi-

Maizuru, Mino-Tamba-Chichibu terranes (some too small to show at 15 M scale). The metallogenic belt occurs in the western part of Honshu Island and northern Kyushu Island, trends east-northeast to west-southwest for more than 1,000 km, and ranges up to 150 km wide. The eastern margin is bounded by the Tanakura tectonic line, and the Kitakami metallogenic belt is interpreted as eastern extension of the Inner Zone Southwest Japan metallogenic belt. The belts contains a large number of skarn deposits (Kamioka Tochibara deposit), and polymetallic veins (Ikuno deposit). Tsuboya and others (1956) used the name Inner Zone Southwest Japan metallogenic province in a similar as in this study. However, Ikuno and Akenobe deposits were excluded because being interpreted as Neogene at that time. The Ikuno and Akenobe deposits are included in the Inner Zone Southwest Japan metallogenic belt.

Kamioka Mozumi Zn-Pb (Ag, Cu, W) Skarn Mine

This mine (Akiyama, 1980; Akiyama, 1981; Nagasawa and Shibata, 1985; Sato and Uchiumi, 1990; Kato, 1999) consists of more than 18 skarn bodies that occur in masses, stratiform layers, and veins. The Main ore body is 300 m long, 400 m wide, and 10 m thick. The ain ore minerals are sphalerite, galena, chalcopyrite, magnetite, pyrite, and pyrrhotite with miner molybdenite and scheelite. The skarn minerals are hedenbergite,actinolite, diopside, garnet, wollastonite, and epidote. The skarn is clinopyroxene skarn that is replaced by garnet or by magnetite, calcite, and quartz. Replacements are likely related to deposition of Zn-Pb sulfides. Host rocks are crystalline limestone, diopside gneiss, amphibole gneiss, and amphibolite of the Hida Metamorphic Rock. K-Ar age for sericite from the Kamioka Tchibora and Kamioka Mozumi deposits are 63.8-67.5 $\pm$ 0 Ma and a K-Ar age isotopic for hastingsite from skarn near the Kamioka Tchibora deposit is 63.3 $\pm$ 1.6 Ma. Those ages suggest mineralization during the Late Cretaceous to Paleogene. Mineralization is related to the quartz porphyry or granite intrusion. The deposit was discovered in 1589. The deposit is medium size with production of 815,000 tonnes Zn, 52,000 tonnes Pb, 190 tonnes Ag. Average grade is 7.9% Zn, 2.68% Pb, 31 g/t Ag.

Bandojima Cu (±Fe, Au, Ag, Mo) Skarn Mine

This mine (Geological Survey of Japan, 1956; Mining and Metallurgical Institute of Japan, 1965) consists of nine skarn bodies that occur in masses and sheets. The Main ore body is 150 m long, 85 m wide, and 4 m thick. The main ore minerals are sphalerite, galena, chalcopyrite, and pyrrhotite. Skarn minerals are garnet and epidote. Host rocks are crystaline limestone, calcareous shale, and chert of the Hida Metamorphic Rock. Mineralization is related to intrusion of Mesozoic quartz diorite that occurs under the deposit. The deposit found before 1900. The deposit is small with production of 1,723 tonnes Zn, 1,464 tonnes Pb, and 105 tonnes Cu from 1952 to 1961 grading 10-15% Pb, 5-7% Zn, 1-2% Cu. The mine contains reserves of 600,000 tonnes ore.

Kamioka Tochibora Zn-Pb (Ag, Cu, W) Skarn Mine

This mine (Akiyama, 1980; Akiyama, 1981; Nagasawa and Shibata, 1985; Sato and Uchiumi, 1990; Kato, 1999) consists of more than 34 skarn bodies with local massive ore. The main ore body is 250 m long, 500 m wide, and 60 m thick. The main ore minerals are sphalerite, galena, chalcopyrite, matildite, magnetite, pyrite, and hematite. The minor minerals are molybdenite native silver, argentite, and scheerlite. Skarn minerals are hedenbergite,actinolite, diopside, garnet, wollastonite, and epidote. Host rocks are crystaline limestone, diopside gneiss, amphibole gneiss, and amphibolite of the Hida metamorphic rock. K-Ar ages of sericites from Kamioka Tchibora and Kamioka Mozumi deposits are 63.8-67.5 Ma and a K-Ar age of hastingsite from skarn near the Kamioka Tchibora deposit is 63.3 +/- 1.6 Ma. Those ages suggest mineralization took place at late Cretaceous-Paleogene. The mineralization may be related to the quartz porphyry. The deposit was discovered in 1580.

Ikuno Polymetallic Pb-Zn ±Cu (± Ag, Au) Vein and Stockwork Mine

This mine (MITI 1988; Shimizu and others, 1998) consists of more than 50 northwest and north-south striking polymetalic veins. The Main vein is 1,900 m long and with average width of 1.4 m. Veins occur in a area 8 km (east-west) by 6 km (north-south). The host rocks are rhyolite, andesite, and associated pyroclastic rock, and minor sedimentary rocks of Cretaceous-Paleogene Ikuno Group. A zonal distribution of metals occurs. From the center of the deposit to marginal are Cu, Cu-Zn, Zn, Pb-Zn, and Au-Ag assemblages. Sn and Sn-W zones also occur. Ore minerals are pyrargyrite, stephanite, native silver, native gold, and scheelite. Rare Se-bering benjaminite and matildite occur. Gangue minerals are quartz, calcite, fluorite, chlorite, siderite, and feldspar. Wall rocks are altered to quartz, chlorite, and sericite. A K-Ar isotopic age for adularia from the vein is 65.6 $\pm$ 2.0 Ma and 63.0 $\pm$ 1.9 Ma. The deposit was discovered in 807 and the mine closed in 1972. The mine is medium size with production of 47,000 tonnes Cu, 92,000 tonnes Zn, 19,000 tonnes Pb, 1,500 tonnes Sn grading 0.3 g/t Au, 60 g/t Ag, 1.4% Cu, 5% Zn, 0.8% Sn, 1.5% Pb.

Otani W-Mo-Be Greisen, Stockwork, and Quartz Vein Mine

This mine (Mining and Metallurgical Institute of Japan, 1968; Shibata and Ishihara, 1974; Imoto and others 1989) consists of northeast striking veins. The Main vein is 700 m long with average thickness of 1.5 m. The host rocks are Cretaceous granodiorite. The main ore minerals are scheelite, cassiterite, chalcopyrite, arsenopyrite, pyrite, pyrrhotite, sphalerite, and stannite. Gangue minerals are mainly quartz, calcite, muscovite, and fluorite. Greisen alteration occurs in the wall rocks. Deposit formed during intrusion of Cretaceous granite. K-Ar isotopic age of muscovite from the vein is 91 Ma. Deposit was found in 1912 and mine closed in 1983. The mine is medium size production of 776,000 tonnes ore (from 1951-1971) with an average grade of 0.46% WO_3, 0.26% Cu, 0.11% Sn.

Origin and Tectonic Controls for Inner Zone Southwest Japan Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along the East Asia magmatic arc related to subduction of of Kula and Pacific plates. The deposits in the belt are interpreted as forming during siliceous granitoid magmatism. Granitoids in the Inner Zone of Southwest Japan are classified into three belts, from south to north, the Ryoke, Sanyo, and Sanin belts. Granitoids in the Ryoke and Sanyo belts are typically ilmenite-series, and those in the Sanin are magnetite-series (Ishihara and others, 1992). Ages of granitoids from the Ryoke and Sanyo belts are Cretaceous, however, those of the Sanin belt are mostly Paleogene. Deposits are not related to granitoids of Ryoke belt. Granitoids in the Sanyo belt host W-Sn-Cu skarn or veins deposits. Ishihara (1978) defined a W-Sn-Cu metallogenic province for this belt. Mo-Pb-Zn deposits characterize the Sanin belt, and were defined as a Mo-Pb-Zn metallogenic province by Ishihara (1978). The Inner Zone Southwest Japan metallogenic belt is thereby be divided into two units, the southern W-Sn-Cu Sanyo belt, and the Mo-Pb-Zn Sanin belt.

REFERENCES: Tsuboya and others, 1956; Ishihara, 1978; Ishihara, Sasaki, and Sato, 1992.

Wolak Metallogenic Belt of Polymetallic Pb-Zn Vein, W±Mo±Be Skarn, W-Mo-Be Greisen, Stockwork, and Quartz Vein, Cu (±Fe, Au, Ag, Mo) Skarn, Fe Skarn, and Weathering Crust Fe Deposits (Belt WO) (South Korea)

This metallogenic belt is hosted in the Cambrian and Ordovician Great Limestone Group, Ogcheon Group and terrane, and Proterozoic Gyenggi terrane of the South China (Yangzi) Craton, and in the Jurassic Daebo Granite. These units are intruded by the Cretaceous Bulgugsa granite. The age the belt is interpreted as Cenomanian through Campanian with K-Ar isotopic ages of 96 to 75 Ma. The Gyeonggi Gyenggi terrane consists mostly of metasedimentary rock iincluding chlorite-sericite-quartz schist and hornblende-biotite-gneiss. The Ogcheon Group consists of slate, calc-silicate and granitic gneiss. The Cretaceous Bulgugsa granite consists of biotite granite, leucogranite, and hornblendite. The major deposits are at Wolak, Susan, Jesamuk, and Youngdeog.

Wolak W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

The deposit (Kim and Koh, 1963) consists of fissure filling pegmatitc quartz veins that strike N20^{o}E and dip 85 to 90^{o} southeastern in the calc-silicate rock, cordierite-biotite hornfels, and biotite granite. The ore minerals consist of wolframite, scheelite, bismuthinite, chalcopyrite, pyrite, galena, and sphalerite. The host rocks are mainly calc-silicate rock and slate that are intruded by leucogranite and hornblendite. In underground tunnels, the veins occur in sygmoid curves, and in shingle and horsetail patterns. The deposit is small with an average grade of 2% WO_3, 0.6% MoS2.

Susan Fe Skarn Mine

This mine (Kim and Kim, 1962) consists of Cambrian and Ordovician limestone that is intruded by Cretaceous biotite granite. Both limonite and Mn deposit occur. The limonite part of the deposit occurs sporadically in limestone in masses or layers between *terraossa* and limestone, or in limestone. The Mn part of the deposit occurs in veins in limestone. The veins pinch out at depth. The limonite is interpreted as a residual deposits, and the Mn deposit is interpreted as a hydrothermal deposit. The deposit is small resources of 338,450 tonnes Fe, and 3,171 tonnes Mn grading 50.95% Fe, 34.84% Mn.

Jesamuk Cu (±Fe, Au, Ag, Mo) Skarn Mine

This mine (Moon and Cho, 1965.) consists of sulfide skarn in limestone of the Cambrian and Ordovician Great Limestone Series that is intruded by biotite granite of the Cretaceous Bulgugsa Series. The limestone bedding generally strikes N20 to 30°E and dips 20 to 30° northwest. The deposit is interpreted as a pocket type, hydrothermal sulfide replacement in limestone. The sulfides are mainly galena, sphalerite, chalcopyrite, arsenopyrite, pyrrhotite, and pyrite. Gangue minerals are calcite, fluorite, and quartz. The mine is small with reserves of 135,000 tonnes ore; indicated reserves of 35,000 tonnes; and resources 100,000 tonnes. Grades range from 0.18-2.05% Cu, 1.44-6.54% Pb, 2-3.01% Zn, 30.7-843.4 g/t Ag.

Youngdeog Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (Oh and Kim, 1980) is hosted in the Proterozoic Ogcheon Group granitic gneiss that is intruded by Cretaceous granite, leucocratic granite, and intermediate composition dikes. A conjugate joint pattern is common in the leucocratic granite with joints striking N30°W, dipping 75° southwest and N 48°E dipping 83°SE. The deposit consists of hydrothermal sulfides in disseminations that occur in an altered zone in leucocratic granite. The sulphide minerals are galena and sphalerite with Au and Ag, and other sulphide minerals such as pyrite and chalcopyrite. The most common hydrothemal alteration, especially at shallow depth, is softening and bleaching of the leucocratic granite. The deposit is small with reserves of 100,000 tonnes ore. Average grade is 0 .4-4.0 g/t Au, 149-488 g/t Ag, 1.26-5.31% Pb, 3.99-13.9% Zn.

Origin and Tectonic Controls for Wolak Metallogenic Belt

The belt is interpreted as forming during generation of granitoids during the Late Cretaceous to Early Tertiary Bulgugsa orogeny. The deposits formed during intrusion of Cretaceous Bulgugsa granite (biotite granite, leucogranite, and hornblende granite). The belt is hosted hosted in the Proterozoic Gyenggi terrane of the South China (Yangzi) Craton, that contains the Ogcheon Group, and in the Cambrian and Ordovician Great Limestone Group, and Jurassic Daebo Granite that are intruded by the Cretaceous Bulgugsa granite.

REFERENCES: Kim and Kim, 1962; Kim and Koh, 1963; Moon and Cho, 1965; Oh and Kim, 1980; Duk Hwan Hwang, this study

Gyeongpuk Metallogenic Belt of Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork, W-Mo-Be Greisen, Stockwork, and Quartz Vein, Sn-W Greisen, Stockwork, and Quartz Vein, Fe Skarn, and Polymetaliic Ni Vein Deposits (Belt GP) (South Korea)

This metallogenic belt is hosted in the Yeongnam Metamorphic Complex, Gyeongsang Supergroup, Yeongnam granulite-paragneiss terrane, that is part of the Sino-Korean Craton, and in the Late Cretaceous Bulgugsa Granite. The age range of the belt is interpreted as Cenomanian through Campanian (96 to 75 Ma). The Yeongnam Metamorphic Complex consists of leucogranite gneiss, hornblende plagioclase gneiss, and biotite gneiss and schist of the Wonnam Formation. The Gyeongsang Supergroup consists of shale and sandstone of Hadong and Sindong Group and volcanic rock of Yucheon Group. The Bulgugsa Granite consists of biotite granite, granodiorite, anorthosite, porphyry, and felsic and quartz porphyry dikes. The major deposits are at Darak, Kyeongju, Chilgok, and Wangpiri.

Darak Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (Cho and Lee, 1966) is hosted in Precambrian granite gneiss and Cretaceous biotite granite and granodiorite that are intruded by Late Cretaceous porphyry, felsite and quartz porphyry dikes. The deposit consists of sulfide veins in hydrothermal fissure fillings in granite gneiss, granodiorite, and biotite granite. The main vein strikes N50-60° W, dips 70-90° southwest, and averages 70 cm wide. Average grade is 3.57% Pb, 3.72% Zn. The ore minerals are galena, sphalerite, pyrite, pyrrhotite, and chalcopyrite. Gangue minerals are quartz, feldspar, calcite, chlorite, sericite, and fluorite. The deposit is small with resources of 85,720 tonnes ore. Average grade is 3.01% Pb,4.41% Zn. 1.63 g/t Au, 41.23 g/t Ag.

Kyeongju W-Mo-Be Greisen, Stockwork, and Quartz Vein Deposit

This deposit (Park amd others, 1969) is hosted in Cretaceous shale and sandstone of the Hadong group and volcanic rock of Yucheon group that are intruded by the Late Cretaceous Bulgugsa biotite granite. The deposit consists mainly of disseminated molybdenite in leucogranite that forms the margin part of agranite stock, and partly in extrusive breccia, and in quartz veins in granite. The deposit is medium size with resources of 260,000 tonnes ore grading 0.2-0.3% Mo.

Chilgok Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Deposit

This deposit (**Koo and Kim, 1965**) is hosted mainly in hornblende granite of the Cretaceous Bulgugsa granite series that south of the intrudes older sedimentary rock of the Sindong Group. The deposit is controlled by joints and faults that mainly strike N40^{o}W and dip 75 to 85^{o} northeast. The fissures are filled by quartz with ore minerals of mainly galena, sphalerite, and pyrite, lesser chalcopyrite and arsenopyrite, and rare pyrrhotite. The deposit is small with resources of 3,000 to possiblly 5,900 tonnes, and reserves of 5,300 tonnes ore.Grades are 0.9-5.5 g/t Au, 154.4-280.8 g/t Ag, 3.9-8.83% Pb and 4.1-7.08% Zn.

Wangpiri Sn-W Greisen, Stockwork, and Quartz Vein Mine

The deposit (Kim and Shin, 1966) is hosted in Precambrian metasedimentary rock in the Wonnam and Yulri Series and in the Cretaceous Bunchon granite gneiss, granite, and granitic. The deposit is hosted in granitic pegmatite that intrudes the contact between granite and the Yulri Series. The veins are mostly concordant with schistosity in phyllite, mica schist, and micaceous metasandstone, and strike NS to N60^{o}E and dip 30 to 80^{o} northwest. The deposit consists of cassiterite pegmatite veins that are banded structure with alternating quartz and feldspar zones that range from 2 to 22 mm wide. Local homogeneous and coarse granular textures occur. The main ore mineral is cassiterite along with quartz, microcline, perthite, plagioclase, sericite, and muscovite and sparse tourmaline. The deposits consists of small lenses, pipes, or large veins that range from 0.3 to 15 m wide and 5 to 150 m long. Fine cassiterite grains occur occasionally. Cassiterite is generally concentrated in quartz-rich zones in the homogeneous pegmatite vein, and also is disseminated in muscovite-rich zones on the hanging wall in fine grains, and rarely occurs in feldspar-rich zones. Average width of the veins is 1.24 m. The deposit is small with an average grade of 0.45% Sn.

Samkwang Polymetaliic Ni Vein Deposit

This unusual, multi-stage deposit (Kim, 1982) consists of Ni sulfide minerals in amphibolite bodies that are part of a Precambrian assemblage of granitic gneiss, banded gneiss, and siliceous dikes that are intruded by Cretaceous biotite granite, lamprophyre dikes, quartz veins, and pegmatitic quartz veins. The amphibolite consists of coarse-grained Ni sulfide minerals in fine- to medium-grained ultramafic rock. The deposit occurs in the top parts of amphibolite near the surface and grades downwards into barren or very low-grade parts. The major ore minerals are pyrrhotite with subordinate pentlandite, chalcopyrite, and pyrite that occurs in disseminations, predominantly in the upper ,subsurface part of the amphibolite. Three stages of mineralization occurred: (1) magmatic segregation with formation of disseminated Ni sulfide minerals; (2) deuteric or hydrothermal alteration associated with Cretaceous plutonism with alteration of rock forming minerals; and (3) remobilization of sulfides, mainly pyrrhotite with pentlandite. The ore minerals are pyrrhotite, pentlandite, chalcopyrite, and pyrite, and gangue minerals are plagioclase, sericite, tremolite-actinolite, talc, chlorite, calcite, and quartz. Areas with sulfides are vary from 5 to 8 m thick and 45 to 50 m long. The deposit is small with reserves of 17,820 tonnes ore grading 0.57% Ni.

Origin and Tectonic Controls for Gyeongpuk Metallogenic Belt

The belt is interpreted as forming during generation of the Bulgugsa Granite during the Late Cretaceous to Early Tertiary Bulgugsa orogeny. The Bulgugsa Granite consists of biotite granite, granodiorite, porphyry, and felsic and quartz porphyry. The belt is hosted in the Yeongnam Metamorphic Complex, Gyeongsang Supergroup, Yeongnam granulite-paragneiss terrane, that is part of the Sino-Korean Craton, and in the Late Cretaceous Bulgugsa Granite.

REFERENCES: Cho and Lee, 1966; Park and others, 1969; Kim and Shin, 1966; Duk Hwan Hwang, this study.

Gyeongnam Metallogenic Belt of Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork, Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite, Fe Skarn, W-Mo-Be Greisen, Stockwork, and Quartz Vein, Porphyry Mo (±W, Sn, Bi), Cu-Ag Vein, Au in Shear Zone, and Quartz Vein Deposits (Belt GN) (South Korea)

This metallogenic belt is hosted in Yeongnam Metamorphic Complex (part of Sino-Korean Craton, Yeongnam granulite-paragneiss terrane), Gyeongsang Supergroup, and the Late Cretaceous Bulgugsa Granite. The age range of the belt is interpreted as Cenomanian through Campanian (96 to 75 Ma). Yeongnam metamorphic complex consists of leucogranite gneiss, hornblende plagioclase gneiss, biotite gneiss and schist of Wonnam Formation. The Gyeongsang Supergroup consists of shale and sandstone of the Hadong and Sindong Groups and volcanic rock of Yucheon Group that are intruded by Late Cretaceous Bulgugsa biotite granite, granodiorite, anorthosite, porphyry, and felsic and quartz porphyry dikes. The major deposits are at Cheolma, Gwymyeong, Mulkum, Kuryong, Ulsan, Goseong, Tongyoung, and Haman-Gunbuk.

Cheolma Au in Shear Zone and Quartz Vein Deposit

This deposit (Hwang and others, 1987) consists of gold bearing quartz veins following fault shear zone, joint and fractures. Host rocks are Cretaceous andesitic rocks, lapilli tuffs, rhyolitic tuffs and felsophyre intruded by Cretaceous granodiorite, hornblende granite, biotite granite and aplite. Veins trend N20-40°W, dip 70-85°NE, and range in length and width 65-130 m and 1.0-1.5 m, respectively. Ore minerals are chalcopyrite, galena, sphalerite, pyrite, pyrrhotite and magnetite. The deposit is small with resources of 98,700 tonnes grading 0.5-1.3 g/tAu, 2-30 g/t Ag, and 0.5-3.01% Cu.

Gwymyeong Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Deposit

This deposit (Hwang and others, 1989) is hosted by Cretaceous tuffaceous rock and Late Cretaceous andesite and diorite. Deposit occurs along fissures and shear zones in andesite and diorite. The width, length, and depth of veins are 0.3-1 m, 60-120 m, and 90-200 m, respectively. Ore minerals are chalcopyrite, galena, and sphalerite. The deposit is small with reserves of 6,080 tonnes ore grading 6.8% Pb, 9.2%Zn, 1.3% Cu, 1.1 g/t Au and 94.83g /t Ag.

Kuryong Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Mine

This mine (Park, 1963; Kim and Oh, 1966) is hosted in a Cretaceous granite porphyry that intrudes widespread limestone of unknown age. Associated with the granite porphyry is a succession of intrusive andesite, agglomerate, pyroxene andesite, masanite, quartz-feldspar porphyry, and altered andesite. The intrusive andesite is partly covered by the agglomerate that forms an extrusive phase. The pyroxene andesite forms a bedded flow. The deposit is mainly sulfide veins and propylitic, hydrothermal alteration zones. Quartz monzonite intrudes both the andesite and the altered andesitic. Quartz-feldspar porphyry occurs only in drill cores. The altered zone occurs in both andesite and agglomerate. The alteration is contemporaneous with, or post-dates quartz monzonite intrusion. Propylitically-altered rocks are green-grey, weather to light grey, and contain a fine-grained pyrite in disseminations. Chlorite, epidote, sericite, kaoline, calcite, quartz, and pyrite are extensively developed in the propylitic zone. Degree of alteration and pyrite content increase with proximity to veins. The deposit is small with resources of 413,280 tonnes grading 41.6% Fe,0.11% S, 0.04% P.

Mulkum Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Mine

This mine is (Hwang and Kim, 1962) hosted in a Cretaceous feldspar porphyry that was intruded by an extensive Late Cretaceous biotite granite. The deposit consists of a magnetite metasomatite that occurs in fissure fillings. The ore minerals are magnetite, pyrite, chalcopyrite, galena, and sphalerite. The average width of veins ranges from 1 to 6 m, and the average length ranges from 44 to 250 m. In The average depth ranges from 70 to 150 m. The deposit is small with reserves of 1,741,875 tonnes ore. Average grade is 60% Fe,13.61% SiO_2, 0.12% S, 0.26% P, and 0.006% TiO_2.

Ulsan Fe Skarn Mine

This mine (Hwang, 1963) is hosted in limestone and serpentine of unknown age, Cretaceous slate and hornfels, and Cretaceous biotite granite. The Fe skarn occurs along the bedding limestone, or on the contact zone between limestone and serpentinite. The ore minerals are magnetite, chalcopyrite, sphalerite, galena, pyrrhotite, and arsenopyrite. Drilling reveals several deposits occur that have a lenticular shape that vary from170 to 180 m long, 140 m wide, and 80 m deep. The deposit is medium size with reserves of 1,708,400 tonnes grading 43% Fe and 0.02% Pb.

Goseong Cu-Ag Vein Mine

This mine (Park and others 1988) is hosted in Cretaceous greenish grey shale and sandstone of Jindong Formation, rhyolite tuff of Yucheon group, and that are intruded by late Cretaceous granodiorite. Deposit occurs along fissures and a fault-shear zone. The ore minerals consist of arsenopyrite, pyrite, sphalerite, chalcopyrite and galena. The mine is small with production of 6,900 tonnes from 1929 to 1964 grading 2.6-10.0% Cu, 1.2-10 g/t Au and 65-300 g/t Ag.

Tongyoung Cu-Ag Vein Mine

This mine (Park and others 1988) is hosted in Cretaceous andesite and andesitic tuff breccia of Yucheon group that are intruded by a Late Cretaceous quartz porphyry and diabase. The veins occur along fissures and shear zones in andesite, andesite tuff breccia, and quartz porphyry. The ore minerals are chalcopyrite, pyrite, galena, sphalerite, electrum, and argentite. The deposit is small with production of 5,000 tonnes grading 0.3-5.5 g/t Au,15-366 g/t Ag, 0.2-1.2% Cu.

Haman-Gunpuk Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite Deposit

This deposit (Kim and Kim, 1977) is hosted in light-gray chert of the Cretaceous Jindong Formation. The deposit consists of fissure-filling hydrothermal veins composed of Cu sulfide, specularite, and tourmaline. Sixteen veins crop out at the surface. Drilling reveals that the C and M veins are economic. The C vein is0.1 to 1.2 m wide, 130 m long, and 120 m deep, and has reserves of 34,920 tonnes grading 0.89% Cu. The M vein is 0.5 to 3.3 m wide, 160 m long, and 75 m deep, and has reserves of 77,992 tonnes grading 0.83% Cu. The deposit is medium size with reserves of 112,912 tonnes grading 0.86% Cu.

Origin and Tectonic Controls for Gyeongnam Metallogenic Belt

The belt is interpreted as forming during generation of granitoids during the Late Cretaceous to Early Tertiary Bulgugsa orogeny. The deposits occur along the fissures and shear zones and formed during intrusion of Bulgugsa granite (biotite granite, granodiorite and quartz-porphyry).

REFERENCES: Hwang and Kim, 1962; Park, 1963; Hwang, 1963; Kim and Kim, 1977; Park and others, 1988; Duk Hwan Hwang, this study.

MAASTRICHTIAN THROUGH OLIOGOCENE METALLOGENIC BELTS (72 to 24 Ma)

Popigay Metallogenic Belt of Impact Diamond Occurrences (Belt PP) (Russia, northern North Asian Craton)

This Eocene metallogenic belt is related to an astrobleme or impact ring structure developed on Early Precambrian crystalline basement and Phanerozoic sedimentary rock of the North Asian Craton. The age of the belt is interpreted as Eocene. The belt occurs in the Popigay ring structure.

Popigay Impact Diamond Deposit

This deposit (Masaitis and others, 1975, 1998) occurs in an impact structures that is about 80 km in diameter on the northeastern margin of the Anabar shield. The ring structure forms a round basin with a floor that is 200 to 300 m lower relative to the surrounding plateau. The basin contains a specific rock complex, including volcanic-like rock. Masaitis and others (1975, 1998) identified an impactite with varying amounts of glass that chemically corresponds to andesite and dacite, rock and mineral fragments; explosive allogenic breccia that fell after the explosion in, or beyond the limits of the crater; and authigenic breccis formed from brecciated material at the bottom of the crater and that underwent high-grade shock metamorphism with melting and formation of pseudotachylite. The impactite is classified as a massive lava-like tagamite and glassy-clastic suevite. The tagamite and impact glasses have an $^{40}Ar/^{39}Ar$ isotopic age of 35.7 ± 0.2 Ma. Diamond occurs in graphite gneiss and tagamite that undersent shock metamorphism (Masaitis and others, 1998). Diamond crystals range from 0.05 to 2.0 mm diameter. Adjacent placer deposits contain diamonds up to 8 to 10 mm. Most abundant are yellow; colourless, transparent, grey, and black crystals are rare. Diamonds from the gneiss retain morphological and structural features inherited from crystalline graphite. Common are tabular crystals with a characteristic striation of basal planes due to repeated twinning, parallel intergrowths, irregular intergrowths, and aggregates.

Origin and Tectonic Controls for Popigay Metallogenic Belt

The belt is hosted in the Popigay ring structure for which two origins are proposed, either meteoritic impact, or cryptovolcanic eruption. Most popular is a meteoritic origin idea (Masaitis and others, 1975, 1998) who interpret the structure as resulting from the impact of a giant meteorite. They note numerous indications of shock metamorphism and partial melting of Early Precambrian crystalline rock. The other cryptovolcanic hypothesis consists of explosion during a volcanic eruption with the ring structure being the stage of kimberlite formation, both alnoite kimberlite and carbonatite, and cryptoexplosion.

REFERENCES: Masaitis and others, 1975, 1998.

Lower Amur Metallogenic Belt of Au-Ag Epithermal Vein, Epithermal Quartz-Alunite, Porphyry Au, Porphyry Cu (±Au), Sn-W Greisen, Stockwork, and Quartz Vein Deposits (Belt LAM) (Russia, Far East)

This Late Cretaceous and Paleocene metallogenic belt is related to veins in the East Sikhote-Alin volcanic-plutonic belt that intrudes or overlies the Amur River and Kiselyovka-Manoma accretionary-wedge terranes. The Au-Ag epithermal vein deposits, as at Mnogovershinnoe, range from medium to large and are generally hosted in Paleocene alkaline granitoids that are closely related to coeval andesite to dacite volcanic rock. A few Au-Ag epithermal vein deposits are related to Eocene and Oligocene volcanism. The Au-Ag epithermal vein deposits, as at Belaya Gora and Bukhtyanskoe, are closely associated with rhyolite and trachyrhyolite flows and vent rocks that are commonly hydrothermally-altered to siliceous and adularia phases. Au is either disseminated throughout the hydrothermally-altered rock or is concentrated in small quartz veins. The adularia phases also locally contain Au. Placer Au deposits, as at Kolchanskoe, Ulskoe, and Oemku, are derived from Au-Ag epithermal vein deposits. In addition to the Au-Ag epithermal vein deposits, the Lower Amur metallogenic belt contains a few, small porphyry Cu (±Au) deposits that are all hosted in, or near Paleogene alkaline granitoids. The major Au-Ag epithermal vein deposits are at Belaya Gora, Bukhtyanskoe, and Mnogovershinnoe; a porphyry Cu (±Au) deposit is at Tyrskoe; and a major and large quartz-alunite deposit is at Iskinskoe.

Mnogovershinnoe Au-Ag Epithermal Vein Deposit

This large deposit (Zalishchak and others, 1978; Ivanov and others, 1989) consists of hydrothermally altered, adularia-sericite-quartz vein zones that range up to 800 m long and contain a series of adularia-quartz veins and veinlets. Some deposits consist of rhodonite-carbonate veins, and lenses of skarn and sulfides. The ore minerals are pyrite, marcasite, gold, argentite, Au-and Ag-tellurides, galena, sphalerite, chalcopyrite, and freibergite. The ore minerals comprise up to 1% veins and the Au:Ag ratio is 1:1. The deposit is hosted in Paleocene andesite and dacite that are genetically related to a multiphase intrusion of highly alkaline granitoids. K-Ar isotopic studies indicate an age of deposits of 49 to 69 Ma. During formation of local Au-bearing skarn, that presumably formed during intrusion of Paleogene subalkaline granite, Au was remobilized. The deposit is medium size.

Belaya Gora Au-Ag Epithermal Vein Deposit

The deposit (Mel'nikov, 1978) consists of disseminations and stockworks that occur in extrusive bodies of subalkalic rhyolite and dacite, and in explosive breccia of an Eocene-Oligocene igneous complex. Alteration minerals are quartz (50 to 90%), kaolinite, dickite, sericite, hydromica, and adularia. The ore minerals are gold, silver, argentite, pyrite, marcasite, chalcopyrite, sphalerite, galena, hematite, and cinnabar. The ore assemblages are gold-quartz and Au-sulfosalts-sulfide-quartz. Gold distribution is highly irregular and the deposits have gradational boundaries. The deposit is medium-size.

NOTE: Need latitude and longitude.

Iskinskoe Epithermal Quartz-Alunite Deposit

The deposit (Onikhimovsky and Belomestnykh, 1996) is hosted in intensively altered Tertiary dacite and rhyolite. The deposit consists of a etasomatic body of quartz-alunite surrounded by a concentric zone of quartz-sericite alteration, and an outer zone of propylitic alteration. The deposit is 2.3 km long, 1.2 km wide, and up to 360 m deep. The ore minerals are: 29.4-32.0% alunite; 60.0-66.0% quartz; 2.0% halloysite; 1.5-5.0% Fe oxides; 1.5-1.6% kaolinite; and up to 2.0% beudantite. Rare minerals are pyrite, diaspore, andalusite, dickite, montmorillonite, and kaolinite. Pure alunite occurs in descrete masses ranging up to 8 to 10 cm in diameter. The deposit is large with reserves of 336,581,000 tonnes alunite ore with an average of grade of 26.1% alunite.

Origin and Tectonic Controls for Lower Amur Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along a continental-margin arc related to subduction of the ancestral Pacific Ocean Plate. The granitoids hosting the belt are part of the Late Cretaceous and early Tertiary East Sikhote-Alin volcanic-plutonic belt. This belt consists chiefly of five major units: (1) Early Cenomanian rhyolite and dacite; (2) Cenomanian basalt and andesite; (3) thick Turonian to Santonian ignimbrite sequences; (4) Maastrichtian basalt and andesitc; and (5) Maastrichtian to Danian (early Paleocene) rhyolite. The East Sikhote-Alin belt also contains coeval, mainly intermediate-composition granitoid plutons that in the frontal (eastern) part of the belt are predominantly Early Cretaceous magnetite-series granitoids. The East-Sikhote-Alin belt is correlative with the Okhotsk-Chukotka volcanic-plutonic belt on strike to the north in the Russian Northeast, and is tectonically linked to the Aniva, Hidaka, and Nabilsky accretionary wedge and subduction-zone terranes.

REFERENCES: Mel'nikov, 1978; Zaiishchak and others, 1978; Ivanov and others, 1989; Khomich and others, 1989; Nokleberg and others 1994, 1997, 1998, 2000, 2003.

Kema Metallogenic Belt of Ag-Au Epithermal Vein, Porphyry Cu-Mo (±Au, Ag), Porphyry Cu (±Au), and Porphyry Mo (±W, Sn, Bi) Deposits (Belt Kem) (Russia, Far East)

This early Tertiary metallogenic belt is related to veins in the East Sikhote-Alin volcanic-plutonic belt that intrudes and overlies the Kema island arc terrane. The Ag epithermal vein deposits, as at Tayoznoe, occur in Early Cretaceous clastic and volcaniclastic rocks and in overlying Late Cretaceous and Paleogene, subalkalic, postaccretionary volcanic rock. Rare Pb-Zn polymetallic vein deposits occur, but are not economic. The epithermal vein deposits generally occur mostly in, or neai Danian (early Paleocene) and Paleocene volcanic rock; however, a few occur in granodiorite plutons. Porphyry Cu-Mo (±Au, Ag) deposits in the metallogenic belt occur mainly in the northern part of the belt. These deposits generally consist of disseminations and veinlets in, and near intrusive rocks and coeval volcanic rock that often contain anomalous Pb, Zn, W, Au, and Ag in addition to Cu and Mo. The porphyry Cu-Mo deposits occur in Late Cretaceous to Paleogene granitic and diorite intrusions. A porphyry Cu (±Au) deposit also occurs in the southern part of the belt. The major Au-Ag epithermal vein deposits are at Burmatovskoe, Glinyanoe, Salyut, Sukhoe, Tayozhnoe, Verkhnezolotoe, and Yagodnoe. Porphyry Cu (±Au) deposits are at Nesterovskoe and Nochnoe, a porphyry Cu-Mo (±Au, Ag) deposits is at Sukhoi Creek, and a porphyry Mo (±W, Bi) deposit is at Moinskoe.

Glinyanoe Ag-Au Epithermal Vein Deposit

This deposit (A.N. Rodionov, written commun., 1986) consists of adularia-quartz, sericite-chlorite-quartz, and carbonate and chlorite-quartz veins and zones that contain pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, argentite, acanthite, Ag-tellurides, and native gold and silver. The veins and zones occur in altered, silicified volcanic rock that overlie Late Cretaceous (Santonian) felsic volcanic rock. The deposit as occurring in four stages: (1) gold-pyrite-quartz; (2) quartz-hydromica and quartz-carbonate; (3) gold-silver; and (4) quartz-chlorite-adularia with Ag-sulfosalts. The age of the deposit is interpreted as Late Cretaceous to Paleogene. The deposit is small with an average grades of 8.3 g/t Au, and 122 g/t Ag.

Sukhoi Creek Porphyry Cu-Mo (±Au, Ag) Deposit

This deposit (Petrachenko and others, 1988) consists of stockworks that are several hundred m across, and in altered zones. Polymetallic ore is dominant. The ore minerals are chalcopyrite, molybdenite, sphalerite, galena, cassiterite, scheelite, and pyrite; with significant Au and Ag. The deposit occurs in Early Cretaceous sedimentary rock that is overlain by Late Cretaceous volcanic rock and crosscut by deposit-hosting granitic intrusions with a K-Ar isotopic age of 73 Ma. The deposit is related to several granodiorite and granite stocks that are intensely hydrothermally altered. Quartz-sericite alteration, and medium-temperature epidote-prehnite-chlorite propylitic alteration occur at the core and grade into micaceous-chlorite-carbonate propylite at the periphery. Granite is locally altered to quartz-muscovite greisen with tourmaline and sphene, and in a few places into a peculiar garnet-phlogopite rock with apatite. Host siltstone and sandstone are altered to orthoclase-actinolite-chlorite hornfels and the felsic extrusive rocks are altered to quartz and phyllite. The deposit is small and grades up to 0.2% Cu and 0.01% Mo.

Tayozhnoe 1 Ag-Au Epithermal Vein Mine

This mine (A.N. Rodionov and others, written commun., 1976; Ratkin and others, 1991) consists of steeply-dipping quartz veins that occur along northwest to north-south fractures that intrude Early Cretaceous sandstone. The veins vary from 100 to 500 m long and 0.5 to 2 m thick, and also occur laterally beneath a contact between sandstone and an overlying 50 to m-thick section of Late Cretaceous felsic volcanic rock. The ore minerals occur in veins, and in metasomatic zones along the sub-horizontal contact, and between veins and overlying volcanic rock. The major Ag minerals are Ag sulfosalts and sulfides. Pyrite and arsenopyrite are rare and formed before Ag minerals. In the upper part of veins, Ag occurs in tetrahedrite, freibergite, stephanite, pyrargyrite, and polybasite. At middle depths, Ag occurs mainly in acanthite and stephanite, along with arsenopyrite and allargentum. Acanthite is dominant at depth. The deposit is medium size with an average grade of 50-2000 g/t Ag and 1 g/t Au. Mined since 1980's.

Verkhnezolotoe Porphyry Cu (±Au) Deposit

This deposit (Orlovsky and others, 1988) occurs at the northwest margin of a caldera that contains dikes of calc-alkaline andesite porphyry that is interpreted as tongues of a dome-like subvolcanic intrusion. A stockwork occurs in a circular aureole of hydrothermally altered rock with a surface exten of 200 m^2 over the intrusive dome. Successive alterations are: (1) quartz-biotite-actinolite with pyroxene and epidote; (2) quartz-biotite-actinolite; (3) quartz-biotite-sericite and local chlorite; and (4) quartz-hydromica with carbonate. The stockwork contains the first three alterations and consists of a thick network of quartz-epidote-actinolite veinlets and lenses up to 2 to 3 cm thick with chalcopyrite, bornite, and pyrite. The stockwork is related to a diorite stock. The stockwork boundary coincides with the aureole of the biotite alteration. An intensely-fractured breccia of mineralized siliceous siltstone was encountered by drill holes that extend to 100 m depth. The ore minerals in the breccia zones are chalcopyrite and bornite. Molybdenite and pyrite, and rare pyrrhotite, cubanite, arsenopyrite, galena, and sphalerite also occur. Carbonate and chalcopyrite veinlets also occur. The richest ore is associated with Sn, Cu, and local W tungsten minerals. A zone of oxidized ore up to 20-30 m thick caps the deposit. The deposit is small with an average grade of 3 g/t Au, 86 g/t Ag, 0.35-2.27% Cu, 0.69% Pb, 0.26% Sn.

Origin and Tectonic Controls for Kema Metallogenic Belt

The belt is interpreted as forming during generation of granitoids along a continental-margin arc related to subduction of ancestral Pacific Ocean Plate. The granitoids hosting the belt are part of the Late Cretaceous and early Tertiary East Sikhote-Alin volcanic-plutonic belt. This belt consists chiefly of five major units: (1) Early Cenomanian rhyolite and dacite; (2) Cenomanian basalt and andesite; (3) thick Turonian to Santonian ignimbrite sequences; (4) Maastrichtian basalt and andesitc; and (5) Maastrichtian to Danian (early Paleocene) rhyolite. The East Sikhote-Alin belt also contains coeval, mainly intermediate-composition granitoid plutons that in the frontal (eastern) part of the belt are predominantly Early Cretaceous magnetite-series granitoids. The East-Sikhote-Alin belt is correlative with the Okhotsk-Chukotka volcanic-plutonic belt on strike to the north in the Russian Northeast, and is tectonically linked to the Aniva, Hidaka, and Nabilsky accretionary wedge and subduction-zone terranes.

REFERENCES: S.M. Rodionov and others, written commun., 1976, 1986; Orlovsky and others, 1988; Petrachenko and others, 1988; Khomich and others, 1989; Nokleberg and others, 1994, 1997, 1998, 2000, 2003; Pakhomova and others, 1997.

MIOCENE THROUGH QUATERNARY METALLOGENIC BELTS (24 to 0 Ma)

Northeast Hokkaido Metallogenic Belt of Au-Ag Epithermal Vein, Volcanic-Hosted Hg, Hg-Sb-W Vein and Stockwork, and Clastic Sediment-Hosted Hg±Sb Deposits (Belt NEH) (Japan, Hokkaido)

This Miocene to Quaternary metallogenic belt is related to veins and replacements in the Quaternary Japan volcanic belt and in the Japan Cenozoic sedimentary basin that overlies and intrudes the Hidaka zone of the Shimanto accretionarry wedge terrane. The metallogenic belt occurs in northeastern Hokkaido island in an area that is 250 km by 130 km and extends to the east of the study area Saito (1958) defined five districts in the Northeast Hokkaido belt. The Kitami metallogenic province of Urashima (1961) is similar to this study but excludes Quaternary deposits. Saito and others (1967) defined a Northeast Hokkaido metallogenic province for Neogene deposits in the area, and Yahata and others (1999) named the Northeast Hokkaido metallogenic province of Quaternary epithermal vein deposits. Most of deposits of the metallogenic belt occur in the Monbetsu-Kamishihoro Graben that ranges from 10 to 60 km wide and trends for 120 km north-south in the middle of the belt. The Kitami district of Saito (1958) covers the graben. The Utoro and Ohmu districts of Saito (1958) occur in the northwestern

Northeast Hokkaido metallogenic belt and include the Motokura Pb-Zn-Cu deposit and some gold deposits. The districts also occur in the basins as indicated by gravity data (MITI, 1994). Au epithermal deposits also occur near the Quaternary volcanic front. Limonite and sulfur deposits are associated with the volcano but are not described in the mineral deposit database. Ages of epithermal deposits vary from 14.4 Ma to 0.3 Ma, and tend to young southward (Yahata and others, 1999). The ages of deposits indicate two stages of deposits in the belt, an early stage (14.4 to 11.2 Ma) and a late stage (8.1 to 0.3 Ma). The belt contains Au-Ag epithermal vein deposits (Konomai), volcanic-hosted Hg deposits (Itomuka), and Pb+Zn+Cu veins (Saito).

Konomai Au-Ag Epithermal Vein Mine

This mine (Kato and others, 1990; Mining and Materials Processing Institute of Japan, 1990; Maeda, 1990) consists of of east-west and northeast striking quartz veins. More than 18 veins occur in an area 15 by 5 km. One typical vein is 10 thick m and 2,100 m long. The veins mainly consists of quartz, chalcedony, calcite, and adularia. The main ore minerals are native gold, native silver, argentite, and miargyrite. Minor ore minerals are chalcopyrite, galena, and sphalerite. Theveins are hosted in Miocene rhyolitic tuff, mudstone and altered andesite. A K-Ar age isotope age for adularia from the vein is 12.9 $\pm$ 0.4Ma. Deposit was discovered in 1915 and the mine closed in 1973. The deposit is medium size with production of 11,486,000 tonnes ore, 73.2 tonnes Au, 1,240 tonnes Ag from 1917-1973 with an average grade of 6.4 g/t Au and 108 g/t Ag.

Itomuka Volcanic-Hosted Hg Mine

This mine (Saito and others, 1967; Kishimoto, 1975) consists of disseminated and vein ore bodies that occur along faults. The ore bodies occur in a area 3 km east-west by 1.5 km north-south. A typical ore body has an average thickness of 6 m and length of 140 m. The main ore minerals are native mercury and cinnabar. Quartz, calcite, pyrite, and marcasite also occur. The deposit is hosted in altered Miocene andesite. Miocene rhyolite occurs near the deposit and is part of host rock sequence. The deposit was discovered in 1936, and was largest Hg mine in Japan. The mine is medium size with production of 3,300 tonnes Hg grading 0.35% Hg.

Ryushoden Hg-Sb-W Vein and Stockwork Mine

This mine (Mining and Metallurgical Institute of Japan, 1968; Kato and others, 1990) consists of dissemination that occur along faults. Pyrite, cinnabar, and calcite veins occur in the disseminated zone. The main ore mineral is cinnabar and minor ore minerals are native mercury and pyrite. Gangue mineals are quartz, chlorite, and calcite. The deposit is hosted in Miocene sandstone. Rhyolite is present southwest of the deposit and may be related to the deposit. The deposit is medium size with production of 880 tonnes Hg (from 1947-1974). Average grade is 0.27% Hg.

Origin and Tectonic Controls for Northeast Hokkaido metallogenic belt

This belt is interpreted as forming along an island arc related to subduction of the Pacific Plate beneath eastern Hokkaido Island. Deposits in formed during Miocene and Quaternary island arc volcanism and related hydrothermal activity.

REFERENCES: Saito, 1958; Urashima, 1961; Saito and others, 1967; Yahata and others, 1999.

Northeast Japan Metallogenic Belt of Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types), Au-Ag Epithermal Vein, Sulfur-Sulfide (S, FeS2), Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) Volcanic-Hosted Metasomatite, Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork, Mn vein, Volcanogenic-Sedimentary Mn, Chemical-Sedimentary Fe-Mn, and Limonite from Spring Water Deposits (Belt NEJ) (Japan)

This Miocene to Quaternary metallogenic belt is related to layers and veins in the Quaternary Japan volcanic belt and Japan Cenozoic sedimentary basin that overlie and intrude the Hiroshima granitic plutonic belt, and the Mino-Tamba-Chichibu and South Kitakami terranes. The belt occurs in the western part of northeastern Honshu and southwestern Hokkaido Islands, trends north-south for more than 1,300 km, and varies from 100 to 150 km wide. The belt extends into the Izu-Bonin island arc. Most of the associated deposits occur in Miocene volcanic rock in the Neogene sedimentary basin. The volcanic rock is mostly altered and is generally described as the Green Tuff. The southwestern margin of the belt in Honshu Island is bounded by the Itoigawa-Shizuoka tectonic line.

The belt contains a large number of Kuroko deposits (Kosaka, Shakanai), Au-Ag epithermal vein deposits (Sado), polymetallic vein deposits (Hosokura), and sulfur-sulfide (S, FeS2) deposits. Iwasaki (1912) used the name Kosaka metallogenic province that covers most of the Northeast Japan metallogenic belt of this study. Watanabe (1923) also used the name Kosaka metallogenic province and slightly modified definition as the Ikuno-Kosaka metallogenic province. Tsuboya and others (1956) used the name Hokkaido-Northeast Japan Green Tuff metallogenic province with four provinces: Nemuro-Shiretoko province (in eastern Hokkaido Island); Kitami province (in northeastern Hokkaido Island); Inner Zone of Northeast Japan province; and Fossa Magna province (major graben in central Honshu Island). The Northeast Japan metallogenic belt of this study contains the Inner Zone of Northeast Japan province and the Fossa Magna province. Ishihara (1978) classified three metallogenic provinces in an area that is similar to this belt on the basis of metals in the deposits: Mn Au-Ag-Cu-Pb-Zn province in southwestern Hokkaido Island; Au-Ag-Cu-Pb-Zn province in northern Honshu Island; and Ag-Pb-Zn province for central Japan. Many Kuroko-type deposits occur in Hokuroku area in Akita Prefecture, northern Honshu. These deposits formed in the middle Miocene at around 13 Ma. Available K-Ar ages of vein deposits suggest two stages of ore formation: an early stage (15 to 10 Ma); and a late stage (8 to 2 Ma). Sulfur-sulfide (S, FeS2) and limonite deposits formed along with Quaternary volcanoes. Tsuboya and others (1956) defined sa eparate Pleistocene-Holocene metallogenic province around the volcanoes that is herein included in the Northeast Japan metallogenic belt.

Ashio Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork Mine

This mine (Shibata and Ishihara, 1974; Omori and others, 1986) consists of northeast, east-northeast, and east-west striking veins. Eight main vein systems occur. Each vein system consists of 100-300 veins. About 1,400 veins were minned. The Main vein is 2,100 m long and 0.2 m thick. The host rocks are Miocene rhyolite (Ashio Rhyolite) that occurs as a slightly elongated circular shape (4.4 by 3.3 km) on the surface and isfunnel-shaped. Most of veins occur in the rhyolite. At depth the deposit extends into a Mesozoic accretionary complex. The main ore minerals are chalcopyrite, arsenopyrie, and pyrite. Minor ore minerals are bornite, chalcocite, covellite, pyrrhotite, sphalerite, galena, wolframite, cassiterite, stannite, bismuthinite, and native gold. Gangue minerals are mainly quartz, calcite, fluorite, and apatite. A zonal distribution of ore minerals occurs: a central zonewith Sn-W-Bi-Cu, an intermediate zone withCu-As-Zn, and a marginal zone with Zn-Pb-Cu-As minerals. Massive replacement ore bodies also occur Messozoic chert, and the ore minerals are similar to the veins. Wallrocks are altered to quartz, sericite, chlorite, and calcite. Quartz-sericite-calcite alteration is the most common. A K-Ar isotopic age for altered tuff is 14.8 $\pm$ 1.1 Ma. The deposit was discovered in 1550, mining started around 1600 for Au, and the mine closed in 1973. The deposit is medium size with production of about 800,000 tonnes Cu, 4.5 tonnes Au, 600 tonnes Ag, and 22,000 tonnes Zn. Average grade is 20-30% Cu.

Gumma Limonite Mine

This mine (Geological Survey of Japan, 1954; Ota, 1957) occurs in the eastern foothill of Ksatsu-Shirane volcano above tuff breccia and andesite. The deposit is more than 10 m thick, and occurs along an old valley for 2,200 m long and is several tens to 200 m wide. The deposit formed by precipitation in the valley from a mineral spring from the Ksatsu-Shirane volcano. The ore mineral is limonite that is generally porous and reddish brown or dark brown. Jarosite occurs mainlyin the upstream part of the deposit. At the upper part of the deposit, mineral spring is still active. The deposit is small with production of 850,000 tonnes from 1950 to1955 , and resources of about 2,000,000 tonnes. Average grade is 49% Fe.

Horobetsu Sulfur-Sulfide (S, FeS2) Mine

This mine (Ota, 1954; Saito and others, 1967) consists of three ore connected bodies. The ore bodies are about 300 m long, 150 m wide, and 10-20 m thick. The host rock is Pliocene andesite lava. The ore minerals are native sulfur and pyrite. One ore body is consists of pyrite that occurs above the sulfur ore body. The deposit is surrounded by alteration zones, including opal, allunite, and kalonite. The deposit was discovered in 1902. The deposit is small production of 1,571,000 tonnes ore grading 39.7% S.

Hosokura Au-Ag Epithermal Vein Mine

This mine (Shikazono and Tsunakawa, 1982; Kawakami and others, 1986; Takahashi, 1988) consists of 13 main vein systems that strike east-west, north-south, and northwest. The veins occur in an area 4 km by 5 km. The Main Vein is 2,200 m long and 1.3 m thick. The main ore minerals are sphalerite, galena, chalcopyrite, tetrahedrite, pyrargyrite, stibnite, pyrite, marcasite, pyrrhotite, magnetite, hematite, chalcocite, covellite, native copper, and native silver. Gangue minerals are mainly quartz, chlorite, sericite, kaolin, calcite, montmorillonite, and fluorite. Wall rocks are latered to quartz, K-feldspar, albitized plagioclase, chlorite, sericite, kaolin, montmorillonite, and calcite. The host rocks are Miocene altered andesite and tuff. A K-Ar adularia age for the vein is 5.8 $\pm$ 0.2Ma and for adularia from the host dacite is 9.7 U 0.5 Ma. The deposit was discovered in the early Ninth Century and the mine closed in 1987. The deposit is medium size with production of 26,000,000 tonnes ore, 775,000 tonnes Zn, 280,000 tonnes Pb, 400 tonnes Ag, 1 tonnes Au, and 9,500 tonnes Cu. Average grade is 4.12% Zn, 1.59%Pb, 0.05% Cu, 0.2 g/t Au, 40 g/t Ag.

Kinjo Volcanogenic-Sedimentary Mn Mine

This mine (Saito and others, 1967; Suzuki and others, 1969) consists of a horizontal stratiform ore body. Maximum thickness is 3 m. The deposit extends 120 m north-south and 100 m east-west. The ore body occurs between a lower greenish Miocene tuff breccia and an upper hornblende dacite and mudstone. Mn minerals were deposited in the Miocene. The ore minerals are psilomelane and pyrolusite. Gangue minerals are quartz and calcite. Deposit was discovered in 1952. The mine closed in 1961. The deposit is small with production of 2,289 tonnes MnO_2 (from 1953-1955), and 4,699 tonnes Mn (from 1955-1958). Average grade is 53.79% MnO_2.

Kosaka Volcanogenic Zn-Pb-Cu Massive Sulfide (Kuroko, Altai types) Mine

This mine (Oshima and others, 1974; Hashiguchi, 1983; Nakajima, 1989) consists of three main ore bodies, Motoyama, Uchinotai, and Uwamuki. The Motoyama body is 600 m long, 250 m wide, and 30 m thick. The Uchinotai ore body is 700 m long, 400 m wide, and 20 m thick. The kuroko deposit is divided into three type of ore, kuroko (narrow definition), yellow, and siliceous ores. The main ore minerals of the kuroko are chalcopyrite, pyrite, galena, sphalerite, and tennantite. The main ore minerals of the yellow and siliceous ores are pyrite, chalcopyrite, sphalerite , bornite, chalcocite, and covellite. Minor minerals are quartz and barite. Barite is enriched at the top of kuroko deposit. Host rocks are Miocene rhyolite and rhyolitic tuff. The Motoyama ore body was discovered in 1861. The Uchinotai ore body was discovered 1959. The deposit is medium size with production of 510,000 tonnes Cu, 520,000 tonnes Zn, 150,000 tonnes Pb, and reserves of 30 million tonnes. Average grade is 8.48% Zn, 2.84% Pb, 2.59% Cu, 1.15 g/t Au, 184.7 g/t Ag.

Shakanai Volcanogenic Zn-Pb-Cu massive sulfide (Kuroko, Altai type) Deposit

This deposit (Ohtagaki and others, 1974; Tanimura and others 1983; Nakajima, 1989) consists of eleven main bodies. The bodies are located in area of 4 km long, 2 km wide, with typical depth of 200 m. Main deposit minerals of the kuroko (black ore) are chalcopyrite, pyrite, galena, sphalerite, tetrahedrite and tennantite. Main deposit minerals of the yellow and siliceous ores are pyrite, chalcopyrite and small amont of sphalerite and galena. Siliceous and gypsum ore occurs below the unite of black ore and yellow ore. Minor minerals are quartz and barite. Host rock is Miocene rhyolite, rhyolite tuff and mudstone. Matsuki, Takadate, Takadate South deposits occur several hundred m W of the Shakanai deposit. Deposit was discovered in 1961. Mine closed in 1987. The deposit is medium size with an average grade of 3.3% Zn, 2.15% Cu, 0.9% Pb, 0.35 g/t Au, 77 g/t Ag. The deposit has produced 320,000 tonnes Zn, 130,000 tonnes Cu, 670,000 tonnes Pb, and has reserves of 30 million tonnes.

Sado Au-Ag Epithermal Vein Mine

This mine (Shikazono and Tsunakawa, 1982; Mining and Materials Processing Institute of Japan, 1994a) consists of seven main east-west striking veins. The main vein is 2,100 m long and 6 m wide. Host rocks are Miocene dacite tuff, andesitic tuff, and mudstone. The main ore minerals are native gold, argentite, pyrargyrite, pyroustite, miargyrite, chalcopyrite, tetrahedrite, pyrite, galena, and sphalerite. Gangue minerals are mainly quartz, chalcedony, calcite, barite, adularia, rhodochrosite, gypsum, and sericite. Wall rocks are altered to chlorite, albite, sericite, quartz, and pyrite. K-Ar adularia ages for the vein are 134 $\pm$ 0.5 and 14.5 $\pm$ 0.5 Ma. The deposit was discovered in 1601 and the mine closed in 1989. The deposit is medium size with production of 78 tonnes Au, 2,330 tonnes Ag, 5,400 tonnes Cu, and 15,300,000 tonnes ore. Average grade is 1-5 g/t Au, 30-100 g/t Ag, 0.1-0.3% Cu.

Toyoha Au-Ag Epithermal Vein Mine

This mine (Mining and Metallurgical Institute of Japan, 1968; Kuwahara and others, 1983; Kato and others, 1990) consists of east-west and northwest striking veins. About 50 veins are present in the area 2km east-west by 3km north-south. Veins have maximum thickness of 4m and about 1300m long. Main ore minerals are sphalerite, galena, pyrite, and rhodochrosite. Minor ore minerals are chalcopyrite, hematite, pyrrhotite, stibnite, and marcasite. Indium minerals are found in the ore. The gangue minerals are quartz and small amounts of chlorite and calcite. Wall rocks altered to quartz, chlorite, and sericite. The deposit was one of the largest mines in Japan. Deposit is hosted in Miocene pyroclastic rocks. K-Ar age of sericite in the vein is 2.2 Ma. The deposit is medium size with an an average grade of 9.6% Zn, 3.4% Pb, 179g/t Ag. The mine produces 12,000,000 tonnes ore with 1,400 tonnes Ag, 300,000 tonnes Pb, 780,000 tonnes Zn. Reserves of 13,000,000 tonnes ore grading 7.0% Zn, 2.1% Pb, 124g/t Ag.

Origin and Tectonic Controls for Northeast Japan Metallogenic Belt

The volcanogenic massive sulfide deposits interpreted as forming in back-arc region of an island arc related to subduction of the Pacific Plate beneath eastern Hokkaido Island. Pliocene Au-Ag epithermal vein deposits on Izu Peninsula formed in the Izu-Bonin island arc that accreted to Honshu Island before the formation of the deposits. Sulfur-sulfide and limonite deposits formed in the active island arc. Island arc magmatism is related to subduction of Pacific Plate.

REFERENCES: Iwasaki, 1912; Watanabe, 1923; Tsuboya and others, 1956; Ishihara, 1978.

Hokuriku-Sanin Metallogenic Belt of Au-Ag Epithermal Vein, Polymetallic Pb-Zn ± Cu (± Ag, Au) Vein and Stockwork, Ag-Sb vein, and Clastic-Sediment-Hosted U Deposits (Belt Hok) (Japan)

This Miocene to Pleistocene metallogenic belt is related to veins and replacements in the Japan Cenozoic sedimentary basin that overlies and intrudes the Hiroshima granitic plutonic belt, and the Akiyoshi-Maizuru and Mino-Tamba-Chichibu terranes. The belt occurs in the western part of Honshu and northern Kyushu Islands, trends east-northeast to west-southwest for more than 900 km, and ranges up to 50 km or more wide. The belt occurs in northern most part of the Inner Zone of southwestern Japan and contains Au-Ag epithermal vein deposits (Omori), and polymetallic vein deposits (Taishu). The deposits are associated with siliceous and intermediate magmatism. Tsuboya and others (1956) used the names Toyama, Noto, and Shimane provinces for the Hokuriku-Sanin metallogenic belts. A small number of the Kuroko-type deposits occur in the belt but not described in the mineral deposit database. Ishihara (1978) defined this belt as a Ag-Cu-Pb-Zn province. The belt was originally interpreted as Miocene; however, new K-Ar isotopic ages for the Omori Au-Ag deposit suggest the deposits into the Pleistocene (Sakoda and others, 2000).

Omori Au-Ag Epithermal Vein Mine

This mine (Mining and Materials Processing Institute of Japan, 1994b; Sakoda and others, 2000) consists of seven main northeast striking veins. The Main vein is 400 m long and 0.5 m wide. The veins occur in a area 0.5 km (east-west) by 0.7 km (north-south). The host rocks are Miocene dacite. The ore minerals are argentite, chalcopyrite, pyrite, galena, sphalerite, siderite, and hematite. Gangue minerals are quartz, barite, and chalcedony. Wall rocks are altered to quartz and chlorite. K-Ar sericite age for the alteration zone are 1.07 $\pm$ 0.04 Ma. A stockwork with disseminated silver ocurs 1 km east of the Main vein. Mining started from 1309 and stopped in 1923. Deposit was also known as the Iwami silver deposit, and was one of the biggest silver mines in Japan. The mine is small with production of 1.4 tonnes Au, 65.7 tonnes Ag, and 6,300 tonnes Cu (from 1891-1919). Average grade is 1,000-2,000 g/t Ag.

Taishu Polymetallic Pb-Zn ± Cu (± Ag, Au) Vein and Stockwork Mine

This mine (Karakida, 1987; Karakida and others, 1992; Ishihara and Imai, 2000) consists of three main north-south and northeast striking vein systems. The Main vein is 2,200 m long and 2 m thick. The host rocks are Paleogene sandstone and shale. The deposit formed during intrusion of a Miocene granitoid that occurs 5 km south. The granitoid consists of fine- to medium-grained monzogranite, granodiorite, and local quartz diorite. The average K-Ar biotite age for the granite is 16.1 $\pm$ 0.8 Ma. The main ore minerals are sphalerite, galena, pyrrhotite, arsenopyrite, and chalcopyrite. Gangue minerals are calcite and quartz. Wall rocks are altered to chlorite, calcite, sericite, and lesser quartz. The deposit was discovered in 674 and the mine closed in 1973. The mine is medium size with production of 230,000 tonnes Zn, and 139,000 tonnes Pb from 5,000,000 tonnes ore. The average grade is 6.4% Zn, 2.9% Pb.

Origin and Tectonic Controls for Hokuriku-Sanin Metallogenic Belt

The belt is interpreted as forming along an island arc during back-arc rifting or axial part of an island arc that was related to subduction of Philippine Sea Plate. The deposits are associated with siliceous to intermediate magmatism in a back-arc rift or in an island arc.

REFERENCES: Tsuboya and others, 1956; Ishihara, 1978; Sakoda and others, 2000.

Outer Zone Southwest Japan Metallogenic Belt of Sn Skarn, Sn-W Greisen, Stockwork, and Quartz Vein, Polymetallic Pb-Zn ± Cu (±Ag, Au) Vein and Stockwork, Au-Ag Epithermal Vein, Volcanic-Hosted Hg, Ag-Sb Vein, Zn-Pb (±Ag, Cu, W) Skarn, W-Mo-Be Greisen, Stockwork, and Quartz Vein, Hg-Sb-W Vein and Stockwork, Cassiterite-Sulfide-Silicate Vein and Stockwork, and Clastic-Sediment-Hosted Sb-Au Deposits (Belt OSJ) (Japan)

This middle Miocene metallogenic belt is related to veins and replacements in the Japan Cenozoic sedimentary basin that overlies and intrudes the Hiroshima granitic plutonic belt, Sambagawa, Shimanto, and Mino-Tamba-Chichibu terranes. The belt occurs in the outer zone of the Southwestern Japan, trends roughly northeast-southwest for more than 1,000 km, and varies from 50 to 150 km wide. The belt extends further south along the Ryukyu island arc. Most of deposits occur south of Median tectonic line (MTL), but some Hg and Sb deposits occur north of the MTL. The metallogenic belt extend to the east of Itoigawa-Shizuoka tectonic line to the Chichibu deposit.

The deposits are formed during mainly siliceous Miocene magmatism around the igneous bodies. The siliceous igneous rocks are scattered in mainly four areas, the Kii Peninsula (Kumano siliceous igneous rocks) on Honshu Island, the Okueyama-Osuzuyama area on central Kyushu Island, the Osumi Peninsula on southern Kyushu and Yakushima Islands. The siliceous igneous rocks range form 15.5 Ma to 13 Ma. The associated granitoids are mainly ilmenite-series. S-type granitoids occur in the southern part of the belt and I-type granitoids occur in the northern part of the belt. The granitoids are interpreted as occurring along a forearc. The occurrence of siliceous igneous activity in the forearc is unusual. The igneous rock related to the Hg deposit is interpreted as member of Miocene Setouchi volcanic rock that consists of high-Mg andesite. Tsuboya and others (1956) used the name Outer Zone Southwest Japan siliceous igneous rock metallogenic province. Ishihara (1978) used the name Sn-W-Cu-As-Sb province for this metallogenic belt.

Chichibu Zn-Pb (±Ag, Cu, W) Skarn Mine

This mine (Ueno and Shibata, 1986; Ishihara and others, 1987; Mining and Materials Processing Institute of Japan, 1994a) consists of four ore bodies. The ain ore body is 350 m long, 600 m wide, and 40 m thick. The skarn occurs along the margin of a quartz-diorite and averages 30-50 m wide. The ore bodies occur between limestone and skarn. The skarn was formed during intrusion of Miocene quartz-diorite and quartz-diorite porphyry. The granitoids have I-type characteristics. The main ore minerals are native gold, native silver, sphalerite, galena, magnetite, chalcopyrite, pyrite, pyrrhotite, arsenopyrite, and limonite. The gangue minerals are hedenbergite, garnet, epidote, and diopside, quartz, and calcite. Host rocks are Paleozoic limestone and mudstone. K-Ar biotite ages from the quartz-diorite are 5.87 ± 0.37 and 6.59 ± 0.27 Ma. The aage of ore deposit formation is interpreted as 6.6. The deposit was discovered in 1205 and the mine closed in 1978. The mine is medium size with production of 16.3 tonnes Au, 72 tonnes Ag, 100,000 tonnes Zn, 7,000 tonnes Pb, 440,000 tonnes Fe. Resources of 8,000,000 tonnes.Average grades of 5 g/t Au, 60 g/t Ag, 5.5% Zn, 0.45% Pb, 27.2% Fe.

Kishu Au-Ag Epithermal Vein Mine

This mine (Mining and Metallurgical Institute of Japan, 1968; Mining and Materials Processing Institute of Japan, 1994b) consists of 24 east-west striking vein systems. The veins occur in an area 3 km (east-west) by 5 km (north-south). The Main vein is 1,800 m long and 0.5 m thick. The host rocks are Shimanto Supergroup and Miocene sandstone. The main ore minerals are native gold, argentite, chalcopyrite, pyrite, sphalerite, galena, pyrrhotite, cassiterite, and wolframite. Gangue minerals are mainly quartz, calcite, chlorite, fluorite, sericite, and adularia. Wall rocks are altered mainly to chlorite. The deposit is associated with Miocene Kumano siliceous igneous rocks. The mine is medium size with production of 0.6 tonnes Au, 153 tonnes Ag, and 93,000 tonnes Cu from 9,400,000 tonnes ore. Average grade is 0.2 g/t Au, 26 g/t Ag, 1.4% Cu.

Obira Cassiterite-Sulfide-Silicate Vein and Stockwork Mine

This mine (Mining and Metallurgical Institute of Japan, 1965; Karakida and others, 1992) consists of four main northeast striking veins. The Main vein is 1,400 long and 1.5 m thick. The host rocks are slate of Chichibu Group and Miocene granite porphyry and granite. The deposit formed during intrusion of Miocene granite. The ore minerals are cassiterite, arsenopyrite, pyrite, pyrhotite, and wolframite, molybdenite, chalcopyrite, and sphalerite. Gangue minerals are quartz, tourmaline, and fluorite. The deposit was discovered in 1574. The mine is medium size with production of 800,000 tonnes Sn ore, and 5,000 tonnes Sn. Average grade is 1.2% Sn, 1.56% Cu, and 11.2% As.

Yamatosuigin Hg-Sb-W Vein and Stockwork Mine

This mine (Geological Survey of Japan, 1955; Mining and Metallurgical Institute of Japan, 1968) consists of six northwest striking veins. The Main vein is 400 m long, 0. 5 m wide, and extends 440 m downdip. The host rocks are Cretaceous biotite granite of the Ryoke belt. The ore minerals are cinnabar, native marcury, realgar, and pyrite. Gangue minerals are quartz, chalcedony, sericite, calcite, and adularia. Wall rocks are altered to kaolinite, montmorillonite, and sericite. Deposit formed during Miocene igneous activity. The mine is medium size with production of 645 tonnes Hg grading 0.5% Hg.

Origin and Tectonic Controls for Outer Zone Southwest Japan Metallogenic Belt

The belt is interpreted as forming along an island arc during back-arc rifting or axial part of an island arc that was related to subduction of Philippine Sea Plate.

REFERENCES: Tsuboya and others, 1956; Ishihara, 1978.

Kyushu Metallogenic Belt of Au-Ag Epithermal Vein Deposits (Belt Kus) (Japan)

This Pliocene to Quaternary metallogenic belt is related to veins and replacements in the Quaternary Japan volcanic belt and Japan Cenozoic sedimentary basin that overlies and intrudes the Akiyoshi-Maizuru, Shimanto, and Mino-Tamba-Chichibu terranes. The belt occurs in central and southern Kyushu island, trends northeast to southwest for more than 400 km, and ranges from 50 to 100 km wdie. The belt extends further south along the Ryukyu Island arc. The belt contains a large number of Au-Ag epithermal vein deposits (Taio and Hishikari). The Satsuma metallogenic province was defined by Iwasaki (1912) and Watanabe (1923) and is similar to the Kyushu belt. However, the Satsuma province contains Sado and other Au-Ag deposit in other areas of Japan. Tsuboya and others (1956) used the name Kyushu Au-Ag epithermal vein metallogenic province that is similar to the Kyushu metallogenic belt, but excluded sulfur and limonite deposits related to recent volcanoes.

The deposits in the Kyushu metallogenic belt occur mainly in two districts, the Central and Southern Kyushu districts. The Central Kyushu district contains the Taio metallogenic district, and the southern Kyushu district contains the Kushikino metallogenic district of Kinoshita (1961). The Central Kyushu district is closely related to the Beppu-Shimabara graben that trends northeast-southwest, extends for 100 km long, and ranges up to 40 km wide. The Beppu-Shimabara graben is an early Pliocene volcano-tectonic basin. Au-Ag deposits in the area range from 2.7 to 3.5 Ma (MITI, 1999). Although, some Au-Ag epithermal vein deposits are Quaternary, most deposits formed in the Pliocene. Pliocene Au-Ag deposits occur along the northern side of the graben whereas Quaternary deposits occur in the graben (Izawa and Urashima, 1989).

The Southern Kyushu district is subdivided into two areas, the northern Hokusatsu and southern Nansatsu areas., Typical low sulfidation Au-Ag epithermal vein deposits (Hishikari and Kushikino) occur in the Hokusatu area. High sulfidation type epithermal Au deposits occur in the Nansatsu area. The Kushikino deposit in the Hokusatsu area, and high sulfidation type epithermal Au deposits in the Nansatsu area formed in the Pliocene (MITI, 2000a, b). These deposits occur along the western side of the district. The Hishikari, Fuke and other low sulfidation Au-Ag epithermal vein deposits in the Hokusatsu area formed in the Quaternary along the eastern side of the district. Migration of location of deposits from the western backarc side to the eastern volcanic front side occurring with younging (Izawa and Urashima, 1989). Most Au-Ag deposits range from Pliocene to Quaternary in the Southern

Kyushu district. Host rock are generally andesitic. However, veins in the deep portion of the Hishikari deposit are occur in the underlying Shimanto Group. The Kyushu metallogenic belt also contains minor sulfur and limonite deposits in Quaternary volcanoes (Kinoshita, 1961). The Kuju sulfur deposit occurs in the Kuju volcano, and the Iojima deposit occurs on the small Iojima Island south of Kyushu Island. Limonite deposits occur in the Aso volcano. However, these deposits are small and not significant and are not listed in the mineral deposit database. The Kagoshima graben, that formed during Quaternary volcanism, occurs in the eastern Southern Kyushu district.

Hishikari Au-Ag Epithermal Vein Deposit

This deposit (Ibaraki and Suzuki, 1993; Naito, 1993; Izawa and others, 1993; Sekine and others, 1998) consists of NE striking veins. Three main vein systems are Honko, Yamada, and Sanjin. Veins occur in an area 2.5 km (EW) by 0.8 km (NS). Veins in Honko range from 1-3 m wide with a maximum strike length of 400 m. Maximum width of the vein is 13 m. Host rock is pre-Miocene Shimanto Supergroup and Quaternary andesite. Ore minerals are electrum, pyrite, chalcopyrite, marcasite, spahlerite, galena, and stibnite. Au/Ag ratio is high, typically about 2. Average grade of Ag is about 100 g/t. Gangue minerals are quartz, adularia, smectite, kaolinite, sericite, chlorite, and calcite. About 20% of gangue is adulaia. Grain size of electrum is about 10 microns. Wallrock show zonal alteration from center to outwards, chlorite-sericite zone, interstratified clay mineral zone, quartz smectite zone, and cristobalite smectite zone. K-Ar isotopic ages of adularia range from 0.78+/-0.07 Ma to 1.05+/-0.07 Ma. Deposit was discovered in 1981. The deposit is medium size with an average grade of 46 g/t Au, and resources of 250 tonnes Au.

Kushikino Au-Ag Epithermal Vein Mine

This mine (Shiga and Urashima, 1988; Karakida and others, 1992) consists of northeast striking veins. The Main vein is 2,600 m long and ranges from 3 to 50 m wide. The veins occur in a area 3 km (east-west) by 2.5 km (north-south). The host rocks are Miocene andesite and andesite tuff. The ore minerals are electrum, native silver, argentite, pyrargyrite, stibnite, naumannite, hessite, and stephanite. Gangue minerals are quartz, adularia, sericite, and calcite. Wall rocks are altered to quartz, pyrite, chlorite, calcite, sericite, and kaolinite. A K-Ar isotopic age is 4.0 ± 0.3 Ma. Mining started in the Seventeenth century. The mine is medium size with production of 54.7 tonnes Au and 497 tonnes Ag from 8,270,000 tonnes ore. Average grade is 6.6 g/t Au, 60 g/t Ag.

Taio Au-Ag Epithermal Vein Mine

This mine (Mining and Materials Processing Institute of Japan, 1989; Karakida and others, 1992) consists of two main vein systems that strike east-northeast and northwest and dip north. The veins occur in an area 3 km (east-west) by 2 km (north-south). The Main vein is 1,750 m long and 2.5 m thick Host rocks are altered Miocene andesite. The main ore minerals are native gold, argentite, miargyrite, chalcopyrite, pyrite, galena, and sphalerite. Gangue minerals are mainly quartz, calcite, adularia, and rhodonite. Wall rocks are altered to quartz, chlorite, sericite, montmorillonite, and kaolinite. A K-Ar adularia age for the vein is 3.6 Ma. The deposit was discovered in 1894. The mine closed in 1970. The mine is medium size with production of 37 tonnes Au and 160 tonnes Ag from 5,870,000 tonnes ore. Average grade is 6.3 g/t Au, 27 g/t Ag.

Origin and Tectonic Controls for Kyushu Metallogenic Belt

This belt is interpreted as forming during hydrothermal activitiy along a Pliocene and Quaternary island arc during back-arc rifting or the axial part of an island arc that was related to subduction of Philippine Sea Plate.

REFERENCES: Iwasaki, 1912; Nishiwaki and Watanabe, 1956; Watanabe, 1923; Kinoshita, 1961; Tsuboya and others, 1989; MITI, 2000a, b.