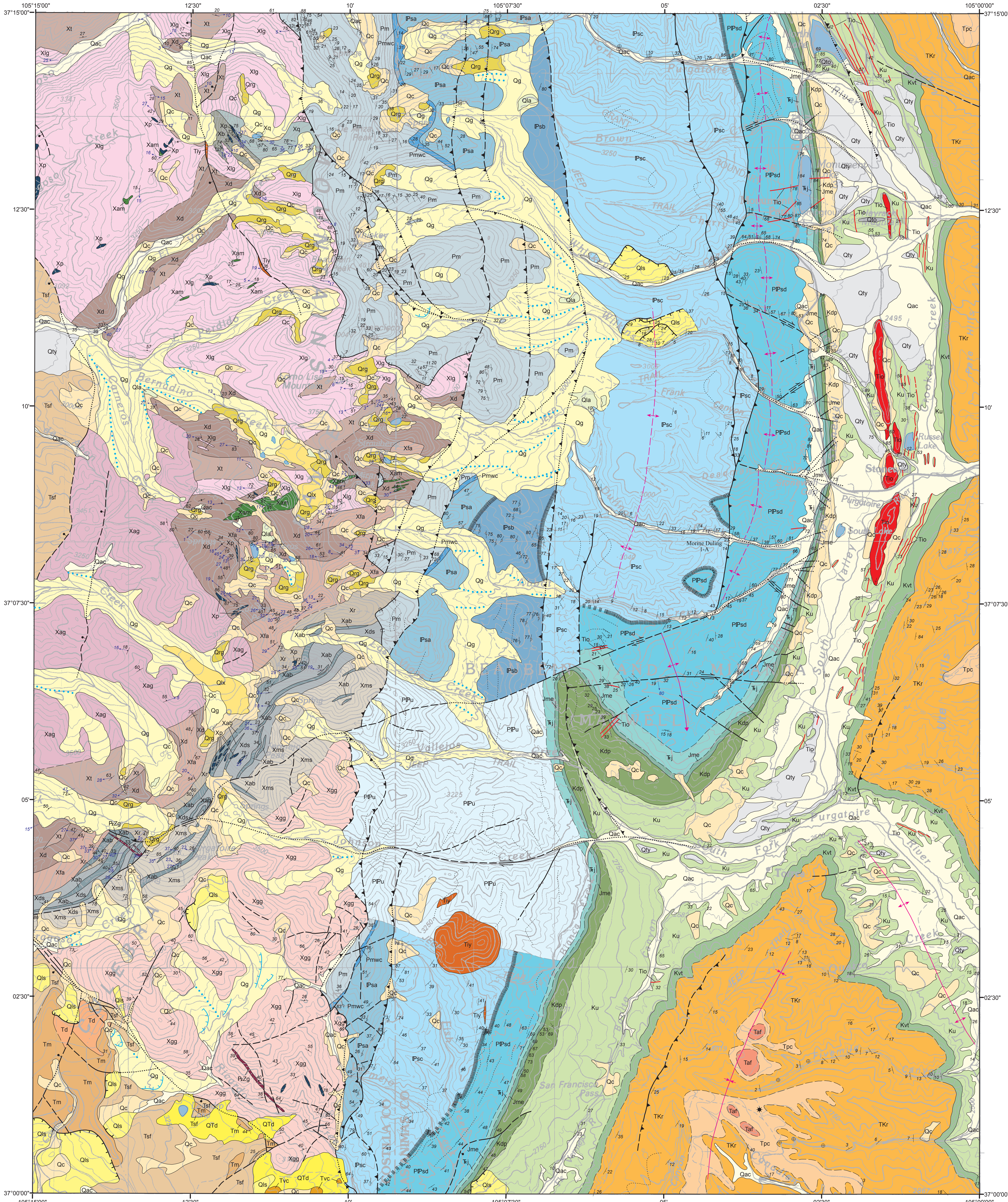
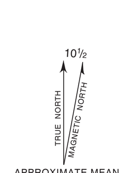
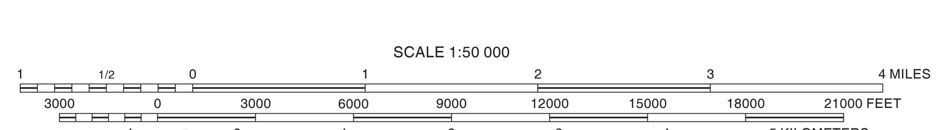
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

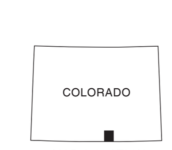
OPEN-FILE REPORT 2007-1428
Version 1.0



PROJECTION..................UNIVERSAL TRANSVERSE MERCATOR
UTM ZONE....................13
VERTICAL DATUM.......NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM................1927 NORTH AMERICAN DATUM
BASE FROM U.S. GEOLOGICAL SURVEY ALAMOSA 30' x 60' QUADRANGLE, 1983.
CONTOUR INTERVAL....................50 METERS
SUPPLEMENTARY CONTOUR INTERVAL..................25 METERS







Geology mapped by C. Fridrich and R. Kirkham, 2004-2006

Digital database and cartographic layout created by J. Workman, 2007

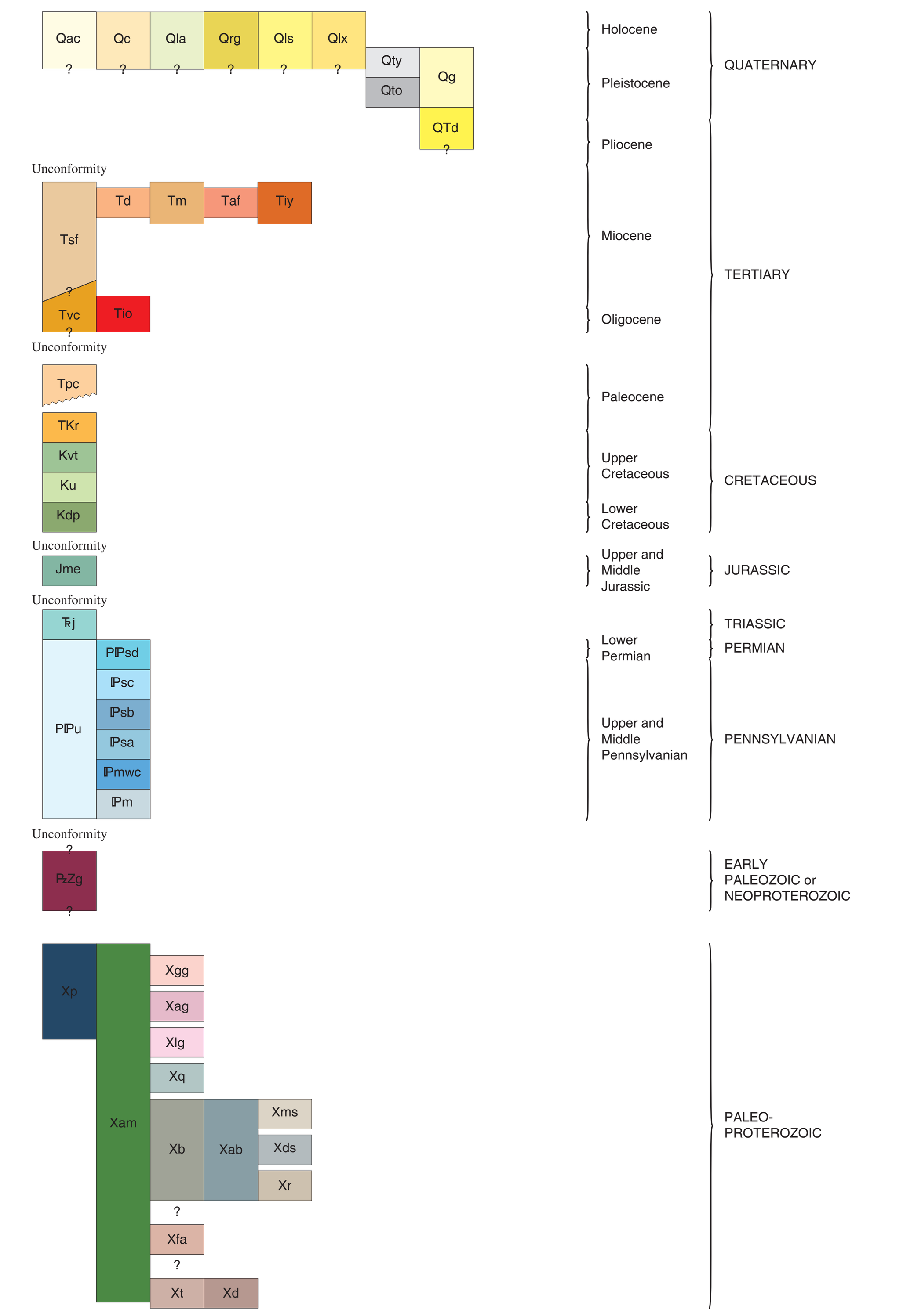
Manuscript approved for publication Dec. 12, 2007

PRELIMINARY GEOLOGIC MAP OF THE CULEBRA PEAK AREA, SANGRE DE CRISTO MOUNTAINS, LAS ANIMAS AND COSTILLA COUNTIES, COLORADO

By
Christopher J. Fridrich and Robert M. Kirkham

2007

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qac **Alluvium and lower-slope colluvial deposits (Holocene and late? Pleistocene)—**Gravel, sand, and clay

Qc **Talus and other hillside colluvial deposits (Holocene and late? Pleistocene)—**Angular clastic deposits, medium- to coarse-grained, typically with soil matrix

Qla **Lacustrine deposits (Holocene and late? Pleistocene)—**Silt and clay, flat-bedded

Qrg **Rock glacier deposits (Holocene and late? Pleistocene)—**Clastic deposits composed of angular to subangular, locally derived cobbles and boulders in steep-fronted, ropy-form mounds; some may be cored with ice

Qls **Landslide deposits (Holocene and late? Pleistocene)—**Angular clastic deposits with minor soil-matrix; coarse to extremely coarse-grained, formed by slow, small-transport-distance mass-wasting on oversteepened hillsides; locally includes abundant blocks of rock 30 m in diameter

Qlx **Rock-fall deposits (Holocene and late? Pleistocene)—**Rock-fall megabreccias with only crushed-rock matrix, formed by catastrophic collapse of cirque walls, probably triggered by seismic activity

Qty **Younger glacial-outwash terrace deposits (late Pleistocene)—**Fluvial cobbly gravels with well-rounded clasts in a sandy matrix, unconsolidated. Primary terrace morphology generally well preserved; presumed to be of Pinedale age

Qg **Glacial till (late to middle Pleistocene)—**Very poorly sorted deposits of rounded to subangular boulders, cobbles, pebbles, sand, and rock flour, in deposits with well-defined morainal landforms; presumed to be of Pinedale age, but older tills may locally be included

Qto **Older glacial-outwash terrace deposits (middle Pleistocene)—**Fluvial cobbly gravels with well-rounded clasts in a sandy matrix, unconsolidated. No primary geomorphology remains. Found at higher elevations and with greater weathering than Qty deposits in the same drainages; presumed to be Bull Lake age

QTd **Alluvial and colluvial deposits? (Pleistocene to upper Pliocene?)—**Very poorly sorted deposits of rounded to subangular boulders, cobbles, pebbles, sand, and clay; unconsolidated but mostly strongly weathered and dissected. Classified by Kirkham and others (2005) as diamicton. A small part of unit extends above 10,500 feet and locally includes a landform that dams a lake, and that may either be a moraine or have formed by large-scale slumping. Vast majority of deposit is too low in elevation to be of glacial origin and is presumed to be alluvial or colluvial

BEDROCK

Sedimentary and igneous rocks that postdate the ~70- to ~40-Ma Laramide orogeny

Santa Fe Group (Miocene to upper Oligocene)—Syntectonic sedimentary and volcanic rocks deposited as fill of basins of the Rio Grande rift. The Santa Fe Group may include strata as young as early Quaternary in other parts of the rift, but probably ranges to no younger than ~12 Ma within map area based on $^{40}Ar/^{39}Ar$ ages of locally capping volcanic rocks that are part of this sequence (Kirkham and others, 2005); overlies volcanic rocks dated at ~25 to ~30 Ma to south of map area

Tsf **Sediments (middle and lower Miocene) —**Alluvial conglomerates, with sandy matrices, and pebbly sandstones, typically bearing well-rounded clasts of Proterozoic and Pennsylvanian rocks exposed in the map area; locally cobbly to bouldery near the mountain front

Td **Felsic extrusive rocks (middle Miocene)—**Dacitic lava and related tephras and flow breccias; locally caps or is interbedded with Santa Fe Group sediments (Tsf) in southwest part of map area

Tm **Mafic extrusive rocks (middle Miocene)—**Basalt- to trachyandesite-composition lava flows and related scoria; unit locally caps or is interbedded with Santa Fe Group sediments (Tsf) in southwest part of map area

Taf **Felsic extrusive rocks (Miocene)—**Dacitic welded ash-flow tuff exposed in southeastern part of map area (in Raton Basin), bearing phenocrysts of plagioclase and very acicular hornblende, typically gray but locally black where glassy. Unit is probably equivalent to felsic extrusive rocks of Santa Fe Group (Td) but is classified separately because Taf is outside the rift

Tiy **Younger hypabyssal intrusive rocks (Miocene)—**Consists mainly of one 1.2-km-diameter stock of granodiorite porphyry and two nearby small intrusions of dacitic composition, all petrographically similar to unit Taf, above. All three intrusions are found in southeastern part of map area; the southernmost one alone consists of vertically compacted welded ash-flow tuff, is locally vitrophyric at the dike margins, and is the presumed feeder dike for the nearby dacitic ash-flow tuff (Taf). Unit also includes two small dikes emplaced along the Trinchera Peak fault in the northwest part of map

Tvc **Volcaniclastic sediments (early Miocene or late Oligocene)—**Alluvial cobble conglomerate with ashy or sandy matrices, bearing a heterolithic assemblage of volcanic clasts that resemble Oligocene rocks exposed to west, south, and north of map area. Unit may possibly be a laharic deposit that is part of an Oligocene (~25 to ~30 Ma) volcanic package that predates the Santa Fe Group; more likely, it may be a basal part of the Santa Fe Group, composed of material reworked from the underlying volcanic package

Tio **Older hypabyssal intrusive rocks (early Miocene or late Oligocene)—**Alkali basalt, lamprophyre, and granodiorite porphyry in sills, dikes, and elongate stocks. Distinguished from Tiy by coarser, typically sugary groundmasses even in small sills and dikes, and by more alkaline compositions. Similar to rocks of the Spanish Peaks intrusive complex in composition and age (~20 to ~25 Ma) with one exception—one strongly altered lamprophyre dike of this map unit (at ~0498-250E + 4103-280N) yielded replicate whole-rock and crystal-separate $^{40}Ar/^{39}Ar$ ages of ~9 Ma

Laramide-age syntectonic sedimentary rocks of Raton Basin

Tpc **Poison Canyon Formation (Paleocene)—**Thick beds of ledge-forming, coarse, commonly pebbly arkosic sandstones interbedded with slope-forming sandy micaceous siltstones; typically yellow-tan. Contains no coal and includes far more Proterozoic clasts than Raton Formation. Maximum exposed thickness ~60 m

TKr **Raton Formation (Paleocene and uppermost Cretaceous)—**Interbedded sandstone, siltstone, mudstone, coal, and black shale consisting of a deltaic sequence. Basal beige-colored sandy conglomerate bears abundant pebbles of Dakota Sandstone. Maximum thickness ~250 m

Cretaceous interior seaway sedimentary rocks

Kvt **Vermejo Formation and Trinidad Sandstone (Upper Cretaceous), undivided—**Vermejo Formation consists of interbedded sandstone, siltstone, carbonaceous shale and coal; slope-former; medium brown to black; ~40 m thick. Trinidad Sandstone consists of a cliff-forming fine- to very fine grained sandstone, calcite-cemented, light-yellowish-tan; maximum thickness ~30 m

Ku **Pierre Shale and related formations (Upper Cretaceous), undivided—**Silty shale, charcoal gray, with some sparse interbeds of dark-brown arkosic sandstones and medium-gray limestone. A slope-former; typically poorly exposed. Thicknesses are, from youngest to oldest: Pierre Shale (~550 m), Niobrara Formation (~200 m), Carlile Shale (~80 m), Greenhorn Formation (~40 m), and Graneros Shale (~35 m), for a total thickness of ~900 m

Kdp **Dakota Sandstone and Purgatoire Formation (Lower Cretaceous), undivided—**Dakota Sandstone consists of light-tan, cliff-forming, very well cemented, well-sorted, fine-grained, locally crossbedded but mostly massive quartz arenite sandstone; ~20 m thick. Underlying Purgatoire Formation is poorly exposed but existing outcrops are mainly dark-brown, fissile, silty shale and light-gray limestone with roughly cylindrical red chert nodules; ~70 m thick

Jurassic and Triassic post-tectonic sedimentary rocks

Jme **Morrison Formation (Upper Jurassic) and Entrada Sandstone (Middle Jurassic), undivided—**Morrison Formation consists of variegated, light-tan, light-gray, or light-purplish-pink bentonitic siltstone and claystone with interbedded thin sandstone and lesser marl beds, and with traces of gypsum in the lower part, ~20 m thick. Underlying Entrada Sandstone is an off-white quartz sandstone; also ~20 m thick

T̵Rj **Triassic sedimentary rocks, undifferentiated—**Variegated dark-red and lesser very pale green pebbly micaceous arkosic sandstones, siltstones, and shales with minor interbeds of bright-orange bentonitic claystones and siltstones. Bentonitic beds may correlate with ashes of Chinle Formation

Upper Paleozoic syntectonic sedimentary rocks of the Colorado trough related to the Ancestral Rocky Mountains

PIPu **Sangre de Cristo (Lower Permian and Pennsylvanian) and Madera (Pennsylvanian) Formations, undivided—**Combined unit used only in the area of the Culebra Mountain ranch, where access was denied

Sangre de Cristo Formation (Lower Permian and Pennsylvanian)—Red arkosic cross-bedded sandstone and conglomerate with interbedded ripple-marked siltstone and planar-bedded shale, mainly in fining-upward alluvial cycles up to 10 m thick. One minor oolitic limestone is exposed ~100 m above the base. Subdivided into four lithologic facies, which together are 3,000 m thick (Brill, 1952)

PIPsd **Upper conglomeratic facies (Lower Permian and Pennsylvanian)—**Strongly cross-bedded, dark-red sandstone and conglomerate, with minor interbeds of planar-bedded siltstone and shale; contains pebbles and cobbles as large as ~20 cm of numerous lithologies of Proterozoic units

IPsc **Medial shaly facies (Pennsylvanian)—**Dark-red, cross-bedded shaly sandstone, siltstone, and shale

IPsb **Lower conglomeratic facies (Pennsylvanian)—**Strongly cross-bedded, dark-red conglomerate and sandstone, with minor interbeds of planar-bedded siltstone and shale; contains pebbles, cobbles, and boulders as large as ~30 cm of many lithologies of Proterozoic units

IPsa **Basal siltstone facies (Pennsylvanian)—**Reddish- to greenish-brown siltstone, shale, and fine-grained thin sandstone beds, typically with low-amplitude wavy crossbeds. Includes one thin (10 m thick) oolitic limestone present near base of unit

Madera Formation (Middle Pennsylvanian)—Interbedded arkosic sandstone, limestone, siltstone, and shale, showing a cyclic alternation between marine and terrestrial sedimentation; Middle Pennsylvanian age at base, on basis of fossils (Brill, 1952); ~1,700 m thick

IPmwc **Whiskey Creek Pass Limestone Member—**Fossiliferous and oolitic limestone; ~70 m thick

IPm **Arkose and gray limestone members, undivided—**Arkose member consists of gray to greenish-gray and lesser reddish- to brownish-gray arkosic sandstone, gritstone, siltstone, and shale, with minor interbedded limestone. Gritstone beds locally include subangular to subrounded pebbles, and rare cobbles as much as 15 cm in diameter of Proterozoic quartzite. Underlying gray limestone member is a cyclic alternation of marine gray fossiliferous limestone and black shale with terrestrial reddish to greenish gray sandstone and siltstone. Unit has a thin basal conglomerate, with pebbles mainly of quartzite, deposited on deeply weathered Proterozoic rocks

Early Paleozoic or Neoproterozoic dikes

PzZg **Gabbro (early Paleozoic or Neoproterozoic)—**Dikes of nonfoliated quartz-bearing pyroxene gabbro, which cut foliated Paleoproterozoic rocks but do not cut overlying Middle Pennsylvanian sedimentary rocks

Paleoproterozoic crystalline basement rocks

Intrusive rocks

Xp **Pegmatite—**Granitic pegmatite and lesser aplite as dikes, sills, and irregular masses, found cutting all of the Paleoproterozoic units below. Mapped only where large bodies were encountered along traverses, and thus far more abundant than shown

Xam **Late intrusive amphibolite—**Strongly foliated, fine- to medium-grained, medium-gray to black; found as dikes intruding all of the units below except for Xq. Composition ranges from mafic diorite to hornblendite

Xgg **Gneissic granite of Hill Ranch—**Monzogranite with a weak to strong superimposed gneissic foliation

Xag **Augen gneiss of Carneros Creek—**Granodiorite or quartz monzonite, moderately to strongly foliated, typically with strong augen texture

Xlg **Leucocratic gneissic granite—**Leucocratic monzogranite, moderately to strongly foliated

Metasedimentary and bimodal metavolcanic sequence

Xq **Orthoquartzite—**Quartzite, massive and almost purely quartzose, very light gray and translucent or nearly white, with ubiquitous thin veinlets and bands of black, red, or metallic gray (specular) hematite, and rare muscovite-rich bands. Found only in northwest part of map, conformably overlying unit Xb

Xb **Bimodal and metasedimentary unit, undivided—**Combined unit consisting of interbedded dirty metasedimentary rocks (Xds), alkali granite gneiss (Xr), and amphibolites (Xab)

Xab **Amphibolites of bimodal sequence—**Amphibolite of basaltic composition, strongly foliated, fine- to medium-grained, dark gray; found as conformable layers within metasedimentary sequence

Xms **Clean metasedimentary rocks—**Quartzites with lesser interbeds of muscovite-quartz schist and amphibolites (Xab); medium-gray or pink; gradational to underlying unit Xds (dirty metasedimentary rocks)

Xds **Dirty metasedimentary rocks—**Sequence of bedded schists consisting mainly of biotite-muscovite-quartz-feldspar schist, with interbeds of muscovite-quartz schist, and thin amphibolites. Exceptionally thick interbedded amphibolites (Xab) in this sequence were split out as separate map units

Xr **Alkali granite gneiss—**Well-foliated, medium- to dark-pink, very massive and internally homogeneous

Calc-alkaline gneiss sequence

Xfa **Felsic gneiss and amphibolite, undivided—**Unit consists of interbedded felsic and mafic gneisses, in two end-member facies, which are highly gradational to one another. One facies typically overlies the other, but both facies, as well as intermediates between the two, are also found by themselves locally. Lower facies consists of ~55 percent granodioritic gneiss and ~45 percent amphibolite; upper facies consists of ~85 percent granitic composition gneiss, ~10 percent granodioritic gneiss, and ~5 percent amphibolite

Xt **Tonalite gneiss—**Interbedded gneisses of differing compositions: ~70 percent tonalitic, ~15 percent dioritic, and ~15 percent amphibolitic

Xd **Diorite gneiss—**Interbedded gneisses of differing compositions: ~80 percent dioritic layers, interbedded with ~10 percent tonalitic or granodioritic layers, and ~10 percent amphibolitic layers

Contact—Solid where location is certain; dashed where approximately located; "U" where unconformable

Key bed

Gradational contact—Solid where location is certain; dashed where approximately located

Fault—Solid where location is certain; dashed where approximately located; dotted where concealed; bar-and-ball on downthrown side; arrows indicate sense of offset for strike-slip motion

Thrust fault—Solid where location is certain; dashed where approximately located; dotted where concealed; teeth on upper plate

Landslide scarp—Solid where location is certain; dashed where approximately located; ticks on downthrown block

Terminal moraine—Limit of significant glacial advance

Lateral moraine—Crest line of moraine

Anticline

Syncline

40 **Inclined bedding—**Showing strike and dip

Horizontal bedding

Vertical bedding—Showing strike

65 **Overturned bedding—**Showing strike and dip

10 **Inclined foliation—**Showing strike and dip

Vertical foliation—Showing strike and dip

20 **Lineation—**Showing bearing and plunge

REFERENCES CITED

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