DESCRIPTION OF MAP UNITS

[Bracketed numbers refer to locations shown on figure 6]

SURFICIAL DEPOSITS

Non-glacial deposits

Ql **Landslide deposits (Holocene)**—Diamictons composed of angular clasts of bedrock and surficial deposits derived from upslope. Commonly shown on map without unit label; arrows denote downslope direction of movement. Includes both transported material and unstable scarp area if present. Locally includes:

Qlo **Older landslide deposits (Holocene and Pleistocene)**—Similar to diamictons described above but with data to show age. Generally large and with somewhat subdued hilly topography. Church Mountain landslide in the North Fork of the Nooksack, the Bear Creek [45] landslide, and landslides in the Skagit River valley south of Damnation Creek [102]

Qmw **Mass-wastage deposits (Holocene and Pleistocene)**—Colluvium, soil, or landslide debris with indistinct morphology, mapped where sufficiently continuous and thick to obscure underlying material. Unit is gradational with units Qf and Ql

Qt **Talus deposits (Holocene)**—Non-sorted angular gravel to boulder diamicton. At lower elevations gradational with unit Qf. At higher elevations includes small rock-avalanche deposits as well as some Holocene moraines, rock glaciers, and protalus rampart deposits that lack characteristic morphology. Surfaces generally unvegetated. Mostly mapped from aerial photos in alpine valleys. Grades into unit Qf

Qf **Alluvial-fan deposits (Holocene)**—Poorly sorted cobble to boulder gravel, deposited either as a discrete lobe at the intersection of a steep stream with a valley floor of lower gradient or as a broad apron on steep sideslopes. Gradational with unit Qt, especially in granitic terrane where fans along major valleys commonly merge with talus. Mostly mapped from topography and aerial photos in alpine valleys

Qyal **Younger alluvium (Holocene)**—Moderately sorted deposits of cobble gravel to pebbly sand along rivers and streams. Generally unvegetated surfaces; gradational with both units Qf and Qb

Qb **Bog deposits (Holocene)**—Peat and alluvium. Poorly drained and intermittently wet. Grades into unit Qyal

Qoal **Older alluvium (Holocene and Pleistocene)**—Deposits similar to unit Qyal, but standing above modern-flood plain level and generally separated from it by a distinct topographic scarp. Age of deposits presumed younger than that of unit Qvr, but relations are ambiguous in some localities. In Middle Fork of the Nooksack River valley, may include lahar deposits from Mount Baker (Easterbrook and Kovanen, 1996)

Glacial deposits

Qam **Alpine glacial moraine (Holocene)**—Boulder till; sparsely vegetated to unvegetated. Commonly shown with symbolized moraine crest on bedrock unit

Qag **Alpine glacial deposits (Holocene and Pleistocene)**—Deposits ranging from boulder till in uplands and upvalley to gravel or sand outwash on broad valley floors. On valley sides and uplands, includes areas veneered with drift but also includes subordinate areas of bedrock, alluvial fans, colluvium, or talus deposits. On valley floors also includes small fans, bogs, and modern stream alluvium. Areas of thin, sparse drift not distinguished from bedrock

Qgu **Glacial deposits, undivided (Holocene and Pleistocene)**—Mostly morainal deposits or vegetated talus deposits similar to unit Qag or Qt, but includes outwash. May include considerable debris deposited from the Cordilleran ice sheet, especially in the North Fork of the Nooksack River and along Ross Lake. As mapped, includes deposits in part belonging to units Qyal, Qf, and Qmw

Deposits of the Vashon stade of the Fraser glaciation of Armstrong and others (1965) (Pleistocene)—Divided into:

Qvr **Recessional outwash deposits**—Stratified sand and gravel, moderately sorted to well-sorted, and well-bedded silty sand to silty clay. This deposit formed predominantly in outwash plain and valley train environments in the lowland areas

Qvt **Till**—Mainly compact diamicton with subangular to rounded clasts, glacially transported and deposited. In ice-marginal areas or where covered by a thin layer of recessional outwash, contact with unit Qvr is gradational. As mapped, also includes deposits of units Qf, Qmw, and Qyal too poorly exposed or too small to show at map scale

Qva **Advance outwash deposits**—Well-bedded gravelly sand, fine-grained sand, and bedded silt, generally firm and unoxidized; deposited by proglacial streams and in proglacial lakes

Non-glacial and glacial deposits

Qpf **Non-glacial and glacial sedimentary deposits older than Fraser Glaciation (Pleistocene)**—Moderately to deeply weathered, moderately sorted sand with volcanic clasts. Exposed only in the western part of the quadrangle along the south boundary

ROCKS OF THE CASCADE MAGMATIC ARC

Rocks of the Mount Baker volcanic center (Holocene and Pleistocene) — Broadly consists of (1) the active stratovolcano (Mount Baker itself); (2) Black Buttes [34] stratovolcano, a middle Pleistocene edifice now deeply eroded but once larger than modern Mount Baker; and (3) several volcanic units that erupted from vents peripheral to the stratovolcanoes. Divided into:

Qbsc **Basalt of Sulphur Creek (Holocene)** — Plagioclase-rich olivine-pyroxene basalt to andesite lava flows and scoria cone produced by a monogenetic eruption near the head of Sulphur Creek in the early Holocene. Lava complex dominantly basaltic but consists of basaltic andesite medially

and andesite proximally, zoned 51-59% SiO_2. Lavas flowed 12 km eastward to Baker River, where a remnant survives on the east shore of Baker Lake. Scoria cone indicated by pattern

Qbv **Andesite of present-day Mount Baker stratovolcano (Holocene and late Pleistocene)** — Plagioclase-rich pyroxene andesite (56-63% SiO_2; mostly olivine-bearing) lava flows and flow breccia with subordinate agglutinate, scoria, and pyroclastic-flow deposits — all erupted from the central vent of the modern stratovolcano. Consists dominantly of about 200 lava flows, nearly all emplaced radially and sector-confined. About 25 flows exposed between elevations of 2,500 m and 3,200 m make up the steep ridge west of the summit of Mount Baker. Debris flows derived from the cone have moved far down Park [38], Boulder [42], Sandy [43], Sulphur, Rocky, Bar [15], and Glacier [12] Creeks and the Middle Fork of the Nooksack River, but deposits have largely been reworked as alluvium or till. Unit includes andesite lava remnants along Kulshan [28], Heliotrope [27], and Glacier Creeks

Qbm **Miscellaneous lava-flow remnants** (**Pleistocene)** — Isolated andesite and dacite lava flows largely removed by erosion; source vents unknown but presumed to have erupted in the Kulshan caldera-Mount Baker area in postcaldera time. Includes: (1) reversely magnetized, olivine-pyroxene andesite lava-flow (55.5% SiO_2) remnant in upper Thompson Creek [9], K-Ar dated at 878 ± 18 ka; (2) reversely magnetized, undated, olivine-bearing pyroxene andesite lava-flow (60% SiO_2) remnant on southwest slope of Lookout Mountain [19] , K-Ar dated at 859 ± 14 ka; (3) undated, hornblende-pyroxene-plagioclase andesite (59% SiO_2) lava-flow remnant on lower north slope of Slate Mountain [8], 400 m east of Anderson Creek, about 370 m above the modern valley floor; and (4) undated plagioclase-rich hornblende-pyroxene andesite (57.5% SiO_2) dike cutting south slope of Mount Herman [11] (at 1,525 m elevation; but too small to show at map scale); and (5) rhyodacite lava-flow remnant on distal nose of Boulder Ridge, north of Boulder Creek, K-Ar dated at 199±5 ka; locally shown as:

Qbsw **Andesite of Swift Creek** (**late Pleistocene)**— Plagioclase-rich olivine-pyroxene basaltic andesite (54-56% SiO_2); isolated eroded remnants of lava flows along the floor of Swift Creek or banked against its east wall as high as 110 m above the floor. Vent unknown, probably farther north within Swift Creek drainage. Yields K-Ar determined age of 48±18 ka. Lava flows were emplaced after downcutting of Swift Creek gorge to approximately its present depth

Qbtp **Andesite of The Portals** (**late Pleistocene)** — Pyroxene andesite lava flows (57-62% SiO_2) distinguished by abundant small (<1 mm) plagioclase, erupted from a glacially eroded vent exposed on east face of Landes Cleaver (east of Mazama Glacier [30]). A few thick flows form a pyroximal stack still more than 350 m thick and an intracanyon tongue more than 200 m thick that caps the divide between Sholes [21] and Bar [15] Creeks. Most exposures are glassy and polygonally jointed, owing to ice-contact emplacement. Different flows yield K-Ar ages of 76±7 ka and 70±7 ka

Qbls **Basalt of Lake Shannon (late Pleistocene)** — Plagioclase-olivine basalt (51-52% SiO_2), hyaloclastite tuff and thin lava flows, making up two glaciated knobs and a roadcut remnant 1-2 km west of upper Lake Shannon. Poorly sorted and poorly stratified deposit, as thick as 150 m. Vesicular fragments 1-15 cm make up only 5-10% of glassy deposit dominated by sand-and silt-sized particles, which are locally palagonitized and indurated. Intercalated lava tongues, probably spatter-fed, are 1-3 m thick; one gave an age of 94±21 ka

Qbcd **Andesite of Cougar Divide** (**middle Pleistocene)** — Plagioclase-rich pyroxene andesite and olivine-pyroxene andesite lava flows (56-63% SiO_2) capping the northern part of Cougar Divide [14] and forming smaller remnants near upper Dobbs Creek

Qbpc **Andesite of Park Creek (late Pleistocene)** — Stack of five pyroxene andesite lava flows (57-61% SiO_2) on south wall of Park Creek. Source vent concealed beneath modern Mount Baker. Middle flow gives K-Ar age of 140±55 ka

Qbpl **Andesite of Pinus Lake** (**middle Pleistocene) —** Plagioclase-rich pyroxene andesite (59-62% SiO_2; sparse olivine) intracanyon lava flow, surviving only as a 1-km^2 remnant 100 m thick, 1-2 km east of the confluence of Wells Creek with the North Fork of the Nooksack River. Base of flow 120 m above present-day river. Not distinguished separately on map is a second intracanyon flow remnant of glassy hornblende dacite (65% SiO_2) that supports a 60-m cliff below the northwest face of the andesite. Another remnant of yet a third intracanyon flow is present 1.5 km farther west; consisting of olivine-pyroxene andesite (59% SiO_2), its base is 225 m above the river junction

Qbbb **Andesite of Black Buttes** (**middle Pleistocene)** — Olivine-pyroxene andesite (mostly 55-59% SiO_2) lava flows, flow breccia, and near-vent fragmental deposits (pattern) of Black Buttes stratovolcano. Plagioclase small and sparse in the dominant mafic lavas and ejecta but abundant in thicker flows of silicic andesite. Unit also includes sparse thin flows of olivine-plagioclase basalt (52% SiO_2). A fragmental vent complex interfingers radially with thick stacks of thin (1-15 m) proximal flows and flow-breccia. The fragmental core, extensively altered by fumarolic-hydrothermal fluids, has been glacially gutted to provide the west cirque of Deming Glacier. A few much thicker lava flows of pyroxene andesite (59-64% SiO_2) extend outward from the edifice, today supporting several high divides. Separate vents active during Black Buttes time include Forest Divide (Unit Qbfd), lava Divide (unit Qbid), and Lasiocarpa Ridge (unit Qbir)

Qbcp **Andesite of Coleman Pinnacle** (**middle Pleistocene)** — Hornblende-plagioclase andesite (59-63% SiO_2; pyroxene sparse to absent) lava flows and dikes, capping much of Ptarmigan Ridge [22]. Erupted from dike-fed fissure system that extends more than 2 km northeasterly along Ptarmigan Ridge. Glacially sculptured remnants are as thick as 200 m

Qbtm **Andesite of Table Mountain** (**middle Pleistocene)** — Plagioclase-rich pyroxene andesite lava flows (59-62.5% SiO_2) that form stacks as thick as 150 m at Table Mountain [17] and 250 m at nearby Kulshan Ridge [18]. Glacially scoured remnants, mostly glassy and polygonally jointed, make up much of the surface in the Heather Meadows ski area

Qbld **Andesite of Lava Divide** (**middle Pleistocene)** — Plagioclase-rich pyroxene andesite (58-63% SiO_2) lava flows, chaotic and stratified breccias, and vent-filling intrusion. Some flows olivine bearing. Vent plug is conical peak, fumarolically altered and laced with sulfides, forming western prow of cleaver between Park and Rainbow Glaciers. Most lavas bracketed between 460 and 296 ka, but a basal flow on Park Creek gives 743±72 ka

Qbbr **Andesite of Bastille Ridge** (**middle Pleistocene)** — Plagioclase-rich pyroxene andesite (59-63% SiO_2) lavas that form a 200-m stack of about10 west-dipping flows that cap Bastille Ridge [25]. Remnant of a single 60-m-thick flow about1 km northwest (on north side of Smith Creek [24]) is similar, probably related

Qbfd **Andesite of Forest Divide (middle Pleistocene)**—Olivene-bearing pyroxene andesite (58-61% SiO_2). Stack of about 10 lava flows capping Forest Divide. Vent buried by Mount Baker. Basal and top flows yield K-Ar ages of 455±9 ka and 366±10 ka

Qblr **Andesite of Lasiocarpa Ridge** [16] (**middle Pleistocene)** — Plagioclase-rich olivine-pyroxene andesite (58-62% SiO_2) lava flows and thick flow breccia. K-Ar dated at 515±8 ka

Qbpb **Basalt of Park Butte (and associated rocks)** (**middle Pleistocene)** —Plagioclase-olivine basalt (50% SiO_2) lava flow capping east ridge of Park Butte; yields K-Ar age of 716±45 ka. Nearby remnants of basaltic andesite lavas (52.5-56% SiO_2;mapped as Qbm), containing clinopyroxene as well as olivine and plagioclase, cap Cathedral Crag, the ridge north of Baker Pass, and the small plateau just east of Park Butte [41]. These yield K-Ar ages between 333 and 203 Ka and have no recognizable source vent

Rocks of Kulshan caldera (early Pleistocene)—Divided into:

Qkrl **Rhyodacite lava flows, domes, dikes and shallow intrusions** — At least seven separate eruptive units of biotite-hypersthene-hornblende-plagioclase rhyodacite (69-72% SiO_2) intrude and overlie intracaldera ignimbrite or sedimentary deposits. Five more intrude and overlie unit **KJna** on Cougar Divide (where three are shown on the geologic map), and at least one dike (30 m thick, but not shown on the map) of similar rhyodacite cuts unit **Pcmv** on the divide between Swift and Rainbow [36] Creeks just south of the caldera.

Compositionally, the lavas and dikes are similar to the dominant pumice in the ignimbrite or slightly less evolved. Phenocryst contents range widely, from 5 to 25%. Like the ignimbrite, the lavas and dikes contain plagioclase, hypersthene, hornblende, biotite, FeTi oxides, apatite, and zircon, although one or more of these

may be missing in some flows; sanidine is lacking, and clinopyroxene and quartz are absent or very rare. Lithologically, the lavas and dikes are massive or flow-banded felsite; glacial erosion has stripped all but sparse remnants of glassy external zones, which tend to be altered where they survive. The felsite is pale to medium grey where fresh but is largely tan to orange-brown owing to pervasive oxidation and ferruginous films on joints and vugs. In areas of hydrothermal alteration, especially where brecciated, the lavas are pale green, cream, or white, commonly stained and streaked ochre to rusty brown due to decomposition of disseminated pyrite

Qkls **Caldera-lake sedimentary deposits** — Laminated to thin-bedded ashy mudstone, ash-dominated debris-flow deposits, and intercalated sheets of rockfall breccia. Ashy sediments that originally consisted predominantly of vitric shards are mostly well-lithified and rich in calcite, clays, and pyrite. Colors range from pale grey or tan to black, or, where altered, ochre to rusty brown. Debris-flow deposits are diamictic massive or graded beds 0.1-7 m thick, containing pumice, caldera-wall lithics, and mudstone intraclasts in an ashy matrix. Sheets of lithic breccia, poor in ash, 0.1-5 m thick, largely made up of angular clasts of argillite, sandstone, and conglomerate, alternate with ash-rich laminated mudstone. Unit has been widely stripped by erosion. Surviving sections dip gently toward middle of caldera or are locally disrupted by intrusive rhyodacite and andesite

Qkig **Ignimbrite of Swift Creek** — Intracaldera rhyodacite ignimbrite (ash-flow tuff) filling Kulshan caldera. Mostly massive, but crudely stratified in top 100 m and near walls where myriad sheets of wall-collapse breccia are intercalated. Largely nonwelded but firmly indurated by groundwater and hydrothermal fluids. White to pale grey except where hydrothermally altered ochre to orange-brown. Pumice clasts are rarely larger than 10 cm and mostly smaller than 2 cm; nearly all are rhyodacite (72% SiO_2) containing 10-15 wt % phenocrysts (plagioclase >> hypersthene ≥ hornblende > biotite > FeTi oxides > rounded quartz > apatite ≈ zircon). Andesitic pumice is also present but very sparse. Ignimbrite matrix is crystal-enriched (relative to pumice) and is poor in lithic fragments except near walls, where they are abundant. In addition to feeders for the postcaldera rhyodacite lavas (unit **Qkrl**), the ignimbrite is cut by at least 60 andesitic dikes and irregular intrusions, none of which are known to extend out of the caldera into surrounding wall rocks

Qkmb **Caldera-collapse megablocks** — Partly shattered and sheared but quasi-coherent 0.1-to-1-km slide blocks of caldera-wall rock surrounded by intracaldera ignimbrite. Examples shown on map consist of Nooksack Formation (unit **KJna)** in upper Wells Creek and Lake Ann stock (unit **Tcla)** in upper Swift Creek

Hannegan Volcanics (Pliocene)—Divided into:

Thb **Volcanic breccia**—Mostly clinopyroxene-hornblende andesite clasts along with many clasts of older rocks in andesite tuff matrix. Many andesite dikes, sills and (or) flows

Thmb **Monolithologic breccia**—Angular debris of older rocks, probably talus, and (or) debris-flow deposits. Mapped on north side of Ruth Mountain [58] and above Sulphide Creek [63]. The latter occurrence includes volcanic breccia, is outside the caldera, and may be of different origin

Tht **Tuff**—White to light-brown dacite tuff and welded tuff, some rhyolite tuff, and rare andesite tuff and flow rocks, commonly highly altered. Bedding obscure

Other volcanic rocks

Tvr **Volcanic rocks of Mount Rahm (Oligocene)**—Dacitic to less commonly andesitic breccias, tuffs, and flows with some feldspathic sandstone and conglomerate interbeds. Welded dacite tuff common

Volcanic rocks of Big Bosom Buttes (Oligocene)—Divided into:

Tvbb **Breccia**—Predominantly dacite breccia; minor tuff beds. Forms massive cliffs. Scattered clasts of older rocks, including light-colored granitic rocks

Tvbd **Dacite tuff**—Biotite dacite tuff, commonly ash-flow tuff and bedded fine-grained tuff. Also includes dacite on Middle Peak [51]

Tvbm **Monolithologic granite breccia**—Angular blocks of biotite granite from a few cm to several meters across in a granitic sand matrix. Scattered volcanic fragments. Derived from granite of Pocket Peak phase (unit Tcp)

Volcanic rocks of Pioneer Ridge (Oligocene)—Divided into:

Tvpd **Dacite flows**—Plagioclase- and quartz-phyric dacite. Mafic minerals altered to smectites

Tvpb **Mudflow breccia**—Clasts of dacitic volcanic rocks and abundant clasts of underlying metamorphic rocks. Also includes volcanic-lithic sandstone. Locally strongly thermally metamorphosed

INTRUSIVE ROCKS OF THE CASCADE PASS FAMILY

Tdt **Tonalite of Cascade Pass dike (Miocene)**—Medium-grained hornblende-biotite tonalite, hypidiomorphic granular with small glomeroporphyrocrysts of mafic minerals. CI = 7-26 (Tabor, 1961, p. 175; Ford and others, 1988, p. 34), mostly CI=15-17. Massive and coarsely jointed, with local areas of disseminated sulfide minerals. The dike has finer-grained, porphyritic, chilled margins; contact lit-par-lit complexes are common, and alteration is locally pervasive. Exposed in southeast corner of map

Rocks of the Chilliwack composite batholith (Pliocene and Miocene). Divided into:—

Tcla **Lake Ann stock (Pliocene)**—Medium-grained hypersthene-clinopyroxene quartz monzodiorite and quartz monzonite, locally with biotite and very minor hornblende. Normatively some is granodiorite; CI=12_19 (James, 1980). Euhedral biotite common near roof above Lake Ann

Tcmi **Miscellaneous granodiorite intrusions (Pliocene and/or Miocene)**—Biotite granodiorite, micrographic, commonly altered, with much chlorite. As mapped comprises lithologically-similar stocks cropping out on the north side of Hagan Mountain [66], in Sulphide Creek [63], and upper Noisy Creek [68]. Also includes fine-grained biotite

pyroxene amphibole granodiorite stock on Bar Creek [15], which may be as young as middle Pleistocene (Hildreth and others, 2003)

Tcnm **Quartz monzonite and granite of Nooksack cirque (Pliocene)**—Quartz monzonite and granite with minor granodiorite and quarzt monzodiorite. Predominantly with uralitic hornblende and relict clinopyroxene. CI=7-15

Tcrg **Granite of Ruth Mountain (Pliocene)**—Biotite granite and granodiorite, commonly with large twinned perthite crystals. Minor hornblende. CI=4-17

Tcid **Quartz diorite and quartz monzodiorite of Icy Peak (Pliocene)**—Biotite-clinopyroxene quartz diorite to quartz monzodiorite with minor hypersthene and uralite. Some rock is plagioclase-porphyritic. CI=15-32

Tcgp **Granite porphyry of Egg Lake (Pliocene)**—Hornblende and biotite granite and granodiorite porphyry with phenocrysts of quartz, plagioclase, and hornblende in a xenomorphic matrix of K-feldspar, quartz, and plagioclase. Compositionally heterogeneous and commonly altered

Tcrgd **Ruth Creek pluton (Miocene)**—Biotite granodiorite, some granite and quartz monzodiorite, locally with quartz eyes as large as 1 cm in diameter; CI=3-7 (Tepper, 1991, p. 78), but mostly 4-5. Rare blocky hornblende with pyroxene cores

Tcm **Mineral Mountain pluton (Miocene)**—Biotite granite. CI=3-7. Characterized by conspicuous quartz eyes several centimeters across which are glomerocrysts of rounded quartz grains with K-feldspar in the curved triangular interstices. Micrographic integrowths of K-feldspar and quartz common. Conspicuous chloritic alteration

Tcwb **Granite of western Bear Mountain (Miocene?)**—Biotite granite and granodiorite, some with hornblende. Rock is heterogeneous; CI=2-12. Quartz eyes conspicuous. Rock is cut by numerous aplitic dikes (Tepper, 1991, p. 79)

Tcdcg **Granite of Depot Creek (Miocene)**—Biotite-hornblende granite with relict clinopyroxene cores in hornblende. Forms a small stock below the Redoubt Glacier [73]

Tcrq **Quartz monzodiorite of Redoubt Creek (Miocene)**—Biotite-pyroxene-hornblende quartz monzodiorite, quartz monzonite, granite, granodiorite, and diorite, commonly altered, with pinkish cast. CI=3-20, but most CI=11-17. Some rocks are porphyritic allotriomorphic and vermicular; micrographic quartz is common (Tepper, 1991, p. 68)

INTRUSIVE ROCKS OF THE SNOQUALMIE FAMILY

Rocks of the Chilliwack composite batholith (Miocene and Oligocene). Divided into:—

Tcbx **Intrusive breccia (Miocene and/or Oligocene)**—On north ridge of Mount Blum [64], unit consists of alaskite and other intermediate plutonic rocks mixed with hypabyssal rocks in altered porphyroclastic xenomorphic and cataclastic matrix of rhyolitic composition; rocks are thermally metamorphosed. Breccia is cut by or marginal to a variety of silicic dike rocks. Above Luna Lake [88], gneiss, hypabyssal dike rocks, mafic schist, and country rock gneiss clasts with vuggy quartz, pyrite, and radial

amphibole bursts. Near Tapto Lakes [83], mafic plutonic-rock clasts, such as diorite, are mixed with andesite clasts in an altered dacitic matrix (Moore, 1972, p. 49-50)

Tcsg **Mount Sefrit Gabbronorite of Tepper and others (1993) (Miocene)**—Mostly olivine-bearing gabbronorite with minor two-pyroxene diorite, hornblende diorite, and quartz diorite. Rocks are dark, partly because of swarms of minute dark inclusions in calcic plagioclase (Tepper, 1985)

Tcpc **Perry Creek phase (Miocene and Oligocene)**—Mostly biotite-hornblende tonalite and granodiorite, commonly with relict clinopyroxene. Minor quartz monzodiorite and quartz diorite. Hornblende or biotite may predominate. Quartz is typically mesostasic. CI=8-22, but most are CI=12-19. As mapped, probably includes several plutons. Locally includes:

Tcpct **Tectonized tonalite** —Shattered and locally cataclastic to mylonitic, highly altered tonalite and granodiorite; mafic minerals chloritized. Also includes hornfels and shattered and recrystallized plutonic and hypabyssal rocks, with biotite, amphibole, plagioclase and quartz mosaics.

Tcbg **Biotite granodiorite of Little Beaver Creek (Oligocene)**—Mostly hornblende-biotite granodiorite and minor granite, locally quartz and plagioclase phyric; CI=3-10

Tccv **Chilliwack valley phase (Oligocene)**—Biotite-hornblende tonalite, granodiorite, and minor quartz diorite, commonly with subhedral plagioclase prisms in quartz mesostasis. Minor clinopyroxene; locally. CI=7-30, but mostly CI=15-20. As mapped, probably includes several plutons. Locally includes:

Tccvt **Dark tonalite**—Pyroxene-hornblende tonalite with distinctive dark vitreous appearance in outcrop

Tcig **Indian Mountain phase (Oligocene)**—Biotite-hornblende granodiorite and granite, with minor quartz monzonite and quartz monzodiorite. CI=3-19, most CI=12-19. Texturally heterogeneous, some quartz or K-feldspar pheoncrystic but these minerals are generally mesostasic; locally granophyric. Rock is commonly pinkish and with chloritized hornblende and biotite. As mapped, probably includes several plutons

INTRUSIVE ROCKS OF THE INDEX FAMILY

Rocks of the Chilliwack composite batholith (Oligocene). Divided into:

Tcbr **Baker River phase (Oligocene)**—Mostly biotite hornblende granodiorite with some tonalite and quartz diorite, locally with clinopyroxene and hypersthene. Subhedral plagioclase in quartz mesostasis common. CI=7-25, but for most rocks in southern part CI=13-18 and, in Skagit Range [52], CI=17-20. Mostly tonalite, quartz diorite, and rare diorite in Skagit Range and in small pluton on American Border Peak [47]; some diorite is hornfelsic. As mapped, probably includes several plutons. Locally includes:

Tcbrp **Price Glacier pluton**—Biotite-hornblende quartz diorite with mesostasic quartz. CI=16-18. Tepper (1991) describes some of the rock

making up this unit as part of his granodiorite of Ruth Mountain [58]. Specific age uncertain

Tcml **Tonalite of Maiden Lake—**Biotite-hornblende metatonalite and metaquartz diorite with highly altered plagioclase and biotite. Hypidiomorphic granular. Metamorphic minerals are chlorite, epidote, prehnite, pumpellyite, sericite and carbonate

Tcsp **Silesia Creek pluton (Oligocene)**—Biotite-hornblende granodiorite, quartz monzodiorite and quartz diorite with inclusions and layers of biotite granodiorite and granite; some granitic xenoliths as long as 200 m. CI=5-20. Quartz diorite displays prominent magmatic alignment of feldspar and mafic minerals

Tcba **Biotite alaskite of Mount Blum (Oligocene)**—Medium-grained biotite alaskite (granite) with prominent perthite prisms, rare hornblende, locally quartz phyric. CI=1-4

Tcp **Pocket Peak phase (Oligocene)**—Biotite granite. Medium grained, hypidiomorphic granular. Commonly with quartz eyes, which are glomerocrysts of rounded quartz grains with K-feldspar in the curved triangular interstices. CI=1-5 mostly CI=3-5. As mapped, probably includes several plutons

Tcht **Heterogeneous tonalite and granodiorite of Middle Peak** [51] **(Oligocene?)**—Quartz diorite to biotite granite, mostly mafic-poor. Many rocks hornfelsic. Also includes amphibolite of unknown origin

Tcdg **Granodiorite of Mount Despair (Oligocene)**—Biotite-hornblende granodiorite with minor tonalite, quartz diorite, and quartz monzodiorite. Conspicuous quartz eyes which are glomerocrysts of rounded quartz grains with K-feldspar in the curved triangular interstices. CI=7-20, but mostly CI=10-12; hornblende usually predominates. Locally includes:

Tcdga **Agmatite**—Swarms of dark rounded inclusions from 0,25m to several meters across composed of mafic biotite-hornblende quartz diorite and fine-grained tonalite in a lighter colored granodiorite and tonalite matrix

Tcmg **Miscellaneous gabbros and diorites (Oligocene?)**—Pyroxene-hornblende gabbro, diorite, and quartz diorite. Rocks contain much uralite. Mafic hornblende gabbro near Mount Spickard is mixed with granitic rocks A small body of pyroxene gabbro at Chilliwack Pass [59] is not shown on the map. Locally includes:

Tcmge **Inclusion-rich diorite of Ensawkwatch Creek**—Layered hypersthene hornfels inclusions in diorite and quartz diorite. East of Pocket Peak [50]

Tcclg **Gabbro of Copper Lake (Oligocene)**—Oikocrystic hornblende gabbro surrounded by equigranular hornblende diorite. Some pyroxene in the diorite which is also zoned to quartz and biotite-bearing varieties. CI=25_ 40. Cumulous textures throughout. Description adopted from Tepper (1991, p. 20-27)

LATE OROGENIC AND POST OROGENIC DEPOSITS

Tc **Chuckanut Formation (Eocene)**—Mostly fluvial, plagioclase arkose, biotite-rich with minor muscovite, buff-weathering, medium- to thick-bedded, and minor interbeds of siltstone, mudstone, and very fine grained sandstone. Also includes minor pebble to cobble conglomerate. Conspicuous

crossbeds, convolute bedding, and plant fossils. Sandstone is locally thinner bedded and more lithic. Ochre-colored silty beds near base of unit may be paleosols. Basal beds, where exposed, commonly include bull-quartz pebble conglomerate which appears to have been derived from the underlying Easton Metamorphic Suite

Tys **Younger sandstone and conglomerate (middle Eocene or younger)**—West of lower Bacon Creek, mostly coarse cobble conglomerate with clasts derived from the Marblemount pluton

Tos **Older sandstone and conglomerate (age uncertain)**—Thick- to thin-bedded fluviatile arkosic sandstone and interbedded argillite, siltstone, and very fine grained sandstone. Locally has conspicuous crossbeds, fossil leaves, and fossil logs. Basal beds commonly rich in angular fragments derived from underlying rocks. Southeast of Berdeen Lake [65], unit includes conglomerate with clasts of granitic rock, geenstone, gneiss, schist, phyllite, abundant well-rounded cobbles of quartzite, and minor sandstone and limestone.

On Mount Despair, unit includes pebble to cobble conglomerate with clasts of gneiss, metachert, and minor pegmatite; intruded by granodiorite of Mount Despair, indicating unit age here is early Oligocene or older. Converted to biotite hornfels, commonly with cordierite and (or) andalusite, in proximity to younger plutons.

ROCKS WEST OF THE STRAIGHT CREEK FAULT

Northwest Cascades System

Welker Peak and Excelsior nappes

bc **Conglomerate of Bald Mountain (Age uncertain)**—Coarse polymictic conglomerate, chert-pebble conglomerate, grey lithic sandstone, and phyllitic black to silvery argillite. Polymictic conglomerate includes clasts of chert, argillite, green metatonalite, dacite, buff-weathering calcite-cemented quartzose sandstone, and rare bedded lithic sandstone. Clast-supported, pebbles and boulders well rounded. Clasts in conglomerates locally flattened and boudinaged. Rare siltstone and shale interbeds. East of Goat Mountain [46] unit contains abundant fossil plant material. Locally includes:

bcs **Sandstone and argillite**—Highly indurated, thin- to medium-bedded sandstone; beds generally disrupted. Sandstone poorly sorted, rich in chert clasts. Black argillite, flaky to slaty. Minor chert-pebble conglomerate beds

Rocks of the Bell Pass mélange (Cretaceous to Late Jurassic)

Kjb **Bell Pass mélange, undivided**—Disrupted argillite, slate, phyllite, sandstone, semischist, ribbon chert, and basalt of the Elbow Lake Formation of Brown and others (1987), with tectonic blocks of meta-igneous rocks, gneiss, schist, ultramafic rocks, and marble. Sandstone commonly lithic subquartzose, either volcanic rich and(or) chert rich; argillite is mostly scaly, and grades into slate and phyllite. Greenstones are recrystallized basalt, mafic tuff, diabase, and gabbro and commonly make the most

prominent outcrops. Metamorphic minerals in greenstones and metasedimentary rocks are chlorite, epidote, albite, pumpellyite, rare actinolite, carbonate minerals, and indistinct masses of pumpellyite and(or) lawsonite. Locally includes as tectonic blocks:

bb **Blueschist of Baker Lake (Cretaceous to Jurassic metamorphic age)**—Metabasaltic rocks, meta-ribbon chert, and marble, characterized by distinctive (for the Northwest Cascades System) high-pressure/low-temperature crossite, lawsonite, some aragonite metamorphism. Metabasaltic rocks range from very fine grained schistose metatuff to incipiently recrystallized basalt

Yellow Aster Complex of Misch (1966) (Paleozoic protolith age)—Medium- to coarse-grained feldspathic gneisses and associated weakly deformed plutonic rocks. Divided into:

byan **Non-gneissic rocks**—Predominantly massive metagabbro, metadiabase, metatonalite; locally includes minor gneissic igneous rocks. May include late Paleozoic or Mesozoic intrusive rocks similar to units MzPzg and MzPzt

byag **Gneissic rocks**—Layered siliceous gneiss, quartz-rich pyroxene gneiss, gneissic megacrystic granite, and minor marble, as well as associated metagabbro, metadiabase, and metatonalite. Gneissic granite with K-feldspar megacrysts known only from Kidney Creek [4]. Includes areas lacking siliceous gneiss, but with strongly mylonitic quartz-rich meta-igneous rocks. Talus blocks east of Park Butte [41] grade from graphitic marble to quartz-rich pyroxene gneiss. Most rocks are highly strained and recrystallized in amphibolite or upper-greenschist facies. Locally, intruded by associated metagabbro, metadiabase, and metatonalite

bu **Ultramafic rocks**—Serpentinite and partially serpentinized dunite and harzburgite. Outcrops too small to show at map scale shown with asterisk symbol. Locally includes:

but **Twin Sisters Dunite of Ragan (1961; 1963)**—Dunite and harzburgite, locally serpentinized.

bup **Pyroxenite**—Massive pyroxenite consisting of mostly enstatite and minor olivine and serpentine minerals

bv **Vedder Complex of Armstrong and others (1983) (Permian metamorphic age)**—Amphibolite, blueschist, micaceous quartzite, and mica-quartz schist. Some garnet. Amphiboles are hornblende, actinolite, and barroisite. Some amphibolites contain albite porphyroblasts

bm **Marble**—Coarsely crystalline marble. Outcrops near Anderson Creek [67] too small to show at map scale shown with star symbol

KJrs **Slate of Rinker Ridge (Cretaceous to Late Jurassic)**—Slate and semischist similar to the semischist of Mount Josephine, but less thoroughly recrystallized. Metamorphic minerals are chlorite and sericite. Exposed only in lower Skagit River valley

MzPzg **Gabbroic intrusions (Mesozoic and Paleozoic)**—Metagabbro, metadiabase, and minor mafic metatonalite. Generally highly cataclastically deformed and altered to chlorite, epidote, albite, pumpellyite, and carbonate minerals. Many rocks with very fine grained high-relief minerals replacing plagioclase, probably pumpellyite and (or) lawsonite

MzPzt **Tonalitic intrusions (Mesozoic and Paleozoic)**—Metatonalite, commonly strongly cataclastically deformed. Metatonalite in the Cultus Formation of Daly (1912) consists of albitic plagioclase and quartz, commonly in micrographic intergrowths, with less than10% chlorite, epidote, and opaque ore minerals, which have replaced hornblende and (or) biotite

MzPzcc **Chilliwack Group of Cairnes (1944) and Cultus Formation of Brown and others (1987) undivided (Mesozoic and Paleozoic)**

JTrc **Cultus Formation of Brown and others (1987) (Early Jurassic and Late Triassic)**—Tuffaceous siltstone, sandstone, and argillite, mostly thin bedded to finely laminated. Also includes much rhythmite. Medium-bedded sandstone on Loomis Mountain. Locally includes:

JTrcd **Dacite and associated tuffaceous sedimentary rocks**—Generally light green vitreous metadacite with microphyric plagioclase

PDc **Chilliwack Group of Cairnes (1944) (Permian, Carboniferous, and Devonian)**—Mostly well bedded gray to brown and black argillite and volcanic subquartzose sandstone with minor pebble conglomerate, marble, and rare chert. Also basalt, andesite, dacite, volcanic breccia, and tuff. In sedimentary rocks, graded beds, scour structures, and load casts locally prominent; also includes some rhythmite. Locally sandstone beds strongly disrupted in argillite matrix. Rocks grade rapidly from little-deformed to phyllitic with a pronounced foliation generally subparallel to bedding. Most rocks partially recrystallized in sub-greenschist facies. Locally divided into:

Pcmv **Volcanic rocks of Mount Herman (Permian)**—Breccia, pillows, pillow breccia, and associated volcanic sandstone of basalt or basaltic andesite composition. Most volcanic rocks are plagioclase-phyric, some are amygdaloidal. Unit weathers orange-brown; dark- to light-green on fresh surfaces

Pcms **Sedimentary rocks of Mount Herman (Permian)**—Volcanic sandstone, siliceous siltstone, argillite, and limestone. Generally well bedded and with little foliation.

PDcv **Volcanic rocks (Permian, Carboniferous, and Devonian)**—Mostly basaltic greenstone, with subordinate andesite and rare dacite or rhyolite. Breccia and tuff predominate. Mafic volcanic rocks commonly with relict plagioclase and clinopyroxene in a chlorite-epidote matrix, commonly with carbonate minerals. Plagioclase is mostly recrystallized as albite. Also includes some gabbro and diabase

PDcl **Limestone and marble (Permian, Carboniferous, and Devonian)**—Mostly coarsely crystalline, gray to black, and petroliferous limestone and marble; occurs in small isolated pods and blocks; locally fossiliferous. Outcrop too small to show at map scale shown with star symbol

Rocks of the Autochthon

Kg **Gabbroic intrusions (Early Cretaceous?)**—Metagabbro with relict clinopyroxene. Altered to chlorite, epidote, albite, carbonate minerals, and montmorillonoids after olivine(?). Intrudes the Nooksack Formation at the toe of the Roosevelt Glacier [29]. Lithologically similar dikes (unmapped) form swarm southeast of intrusion

Nooksack Formation (Early Cretaceous to Middle Jurassic)—Described here as sedimentary rocks, although much of the unit is incipiently recrystallized (Brown and others, 1981, 1987). Divided into:

KJna **Argillite and sandstone**—Predominantly massive to laminated black argillite. Locally with thin to medium beds of mostly lithic-volcanic sandstone. Also includes minor limy siltstone and limestone. Some beds heavily bioturbated. Local detrital muscovite. Cleavage weakly developed north of Mount Baker, but pronounced to south. Argillite near top of the Wells Creek Volcanic Member rich in pyrogenic plagioclase and quartz phenocrysts. Belemnite molds characteristic

KJnt **Thick-bedded sandstone and argillite**—Volcanic lithic sandstone with minor interbeds of argillite

KJng **Grit and thick-bedded sandstone**—Poorly rounded to angular small pebble conglomerate and volcanic-lithic sandstone. Minor interbeds of argillite

KJnv **Volcanic-rich conglomerate and sandstone**—Massive to locally well-bedded pebble to boulder conglomerate rich in dacite and tonalite clasts. Boulders as large as 1 m diameter. Also includes some well-bedded volcanic sandstone and tuff. Belemnite fragments common

Jnw **Wells Creek Volcanic Member —**Incipiently recrystallized dacite, dacite breccia and tuff, and andesite, with some argillite interbeds. Metamorphic pumpellyite, chlorite, epidote, and albite

Shuksan nappe

Kjs **Semischist and phyllite of Mount Josephine (Early Cretaceous?)**—Graphitic sericite-plagioclase-quartz phyllite and semischistose lithic-volcanic subquartzose sandstone. Protolith sediments thin to medium bedded. Locally highly contorted, but generally lacks prominent multiple crenulations characteristic of the Darrington Phyllite. Locally includes:

Kjsu **Ultramafic rocks**—Serpentinite and silica-carbonate rock

Easton Metamorphic Suite (Early Cretaceous)—Divided into:

Ked **Darrington Phyllite (Early Cretaceous)**—Silvery to black quartzose graphitic phyllite, with minor greenschist, metachert, and muscovite-quartz-albite schist. Commonly with multiple foliations and crenulation lineations; abundant quartz veins. Dominant foliation is commonly second-generation or later. Mineralogy is quartz-albite-white mica-chlorite, $\pm$ lawsonite, garnet, and margarite. Thin sections show well-crystallized white mica: fine grain size in hand sample reflects tendency of rock to break along post-peak metamorphic pressure-solution cleavage surfaces along which fine insoluble material has concentrated. Locally interlayered with unit Kes

Kes **Shuksan Greenschist (Early Cretaceous)**—Greenschist and lesser blueschist. Locally includes iron- and manganese-rich quartzite (metachert), greenstone, and graphitic phyllite. Rare relict clinopyroxene in some greenschist. Schist varieties include dark-green, fine-grained, muscovite-chlorite-epidote-actinolite schist with common knots and masses of epidote, quartz-albite-chlorite veins, and relict pillow or breccia structure, and well-layered light-green chlorite-rich schist that appears to be metamorphosed tuff. Well-layered, Fe^{3+}-poor metatuffs

with conspicuous patches of albite relict after plagioclase phenocrysts are locally abundant. Blueschist bears Na-amphibole (crossite-soda actinolite-riebeckite) +_hematite (Brown, 1986). Locally interlayered with unit Ked

Keu **Ultramafic rock (Early Cretaceous)**—Serpentinite, silica-carbonate rock, and forsterite-enstatite-tremolite-chlorite rock on Mount Sefrit (Tepper, 1985) and west of Grandy Creek. Shown with asterisk symbol only

ROCKS BETWEEN THE STRAIGHT CREEK FAULT AND ROSS LAKE FAULT ZONE

Terrane overlap units and stitching plutons

Skagit Gneiss Complex

Skagit Gneiss Complex (Middle Eocene to Late Cretaceous)—Heterogeneous complex of supracrustal schist, amphibolite, and rare marble and ultramafic rocks intruded in a lit-par-lit fashion by mostly hornblende-biotite and biotite-tonalite orthogneiss. Orthogneiss bodies range from a few centimeters thick in the banded gneisses to several kilometers thick in the mapped orthogneiss. Abundant deformed dikes and sills of light-colored pegmatitic tonalite and lineated granite. Divided into:

TKsgp **Granite pegmatite** —Granite pegmatite (associated with unit TKeb) in mostly layer-parallel sills and dikes; country rock sparse to absent between multiple intrusions. Quartz in pegmatite generally highly strained, mylonitic to blastomylonitic

TKsbg **Banded gneiss, mostly biotite gneiss**—Biotite schist, biotite-garnet schist, biotite paragneiss (some garnet, cummingtonite), hornblende-biotite paragneiss, gneissic hornblende-biotite tonalite, and tonalite gneiss. Strongly layered rocks with minor amphibolite gneiss, and hornblende schist. Commonly strongly migmatitic with concordant and crosscutting light-colored dikes of foliated, lineated, fine-grained to pegmatitic leucotonalite and lineated granite and granodiorite

TKsbga **Banded gneiss, mostly amphibole gneiss and amphibolite**—Hornblende and biotite-hornblende paragneiss, gneissic amphibolite, hornblende schist, biotite schist and paragneiss, and tonalite gneiss. Rare marble. In some mapped areas, hornblendic rocks are conspicuous but may not be dominant. Commonly strongly migmatitic with concordant and crosscutting light-colored dikes of foliated, lineated, fine-grained to pegmatitic leucotonalite and lineated granite and granodiorite

TKso **Orthogneiss**—Gneissic hornblende-biotite tonalite. Relatively uniform crystalloblastic granitoid gneiss with rare relict euhedral oscillatory-zoned plagioclase crystals. Hornblende or biotite may predominate. Garnet locally. Quartz and biotite commonly moderately to highly strained. Locally migmatitic with concordant and crosscutting light-colored dikes of foliated, lineated, fine-grained to pegmatitic leucotonalite. Locally includes:

TKsom **Mafic orthogneiss**—Garnet-hornblende diorite orthogneiss above Diablo Lake. Also includes amphibolite and hornblendite.

TKsoa **Mafic migmatite**—Heterogeneous hornblende tonalite migmatite and orthogneiss rich in slivers of hornblendite and amphibolite east of

Snowfield Peak. Cross-cutting dikes of light-colored, fine-grained to pegmatitic, foliated and lineated tonalite and lineated granite and granodiorite

TKsn **Orthogneiss of The Needle**—Hornblende tonalite to granodiorite orthogneiss with distinctive texture of approximately 1-mm equant crystals forming centimeter size patches rich in quartz, plagioclase, hornblende, or biotite. Dominant foliation locally axial-planar to small folds of an earlier foliation

TKsu **Ultramafic rocks**—Harzburgite tectonite, talc-tremolite schist, anthophyllite-talc-tremolite schist, chlorite-rich blackwall, and retrograde serpentinite. Common relict chromite attests to igneous origin. Small outcrops shown with asterisk symbol only

TKsm **Marble and calcsilicate rocks**—Shown with star symbol where outcrop too small to show at map scale

Plutons of the tonalitic group

TKho **Orthogneiss of Haystack Creek (Middle Eocene to Late Cretaceous)**—Hornblende biotite gneiss with blotchy patches of aggregate mafic minerals

TKmo **Orthogneiss of Marble Creek (Middle Eocene to Late Cretaceous)**—Biotite tonalite to granodiorite gneiss with minor hornblende, muscovite, and well-formed igneous(?) epidote. Ranges from granitoid gneiss with intergranular quartz and relict euhedral oscillatory zoned plagioclase to highly strained flaser gneiss with anastomosing mylonite with quartz and biotite. Pluton is rich in screens and rafts of supracrustal schists and pods of ultramafic rocks

TKto **Orthogneiss of Mount Triumph (Tertiary and Late Cretaceous)—**Gneissic medium-grained biotite-hornblende tonalite. Epidote locally intergrown with hornblende and biotite. Weak foliation and lineation and common cataclasis. Contact metamorphism by adjacent Chilliwack batholith has annealed some textures of earlier deformation

Plutons of the granodioritic group

TKeb **Eldorado Orthogneiss (Middle Eocene to Late Cretaceous)**—Biotite-hornblende monzodiorite to biotite granodiorite gneiss, rare tonalite and quartz diorite (Ford and others, 1988, p. 107-108). Medium-grained subhedral to euhedral sodic plagioclase commonly filled with epidote or clinozoisite and set in a crystalloblastic to mylonitic matrix of quartz, K-feldspar, hornblende, biotite, and epidote; accessory sphene, apatite, zircon, and opaque oxides; commonly well -aligned prismatic aggregates of hornblende and biotite, but in many rocks mafic minerals are aligned in a streaky planar fabric. Common mafic enclaves locally define strong flattening and weak strike-parallel elongation. Gradational over several 100 meters into unit TKef. Locally includes:

TKef **Flaser gneiss border zone**—Fine- to medium-grained biotite-hornblende metatonalite and metagranodiorite flaser gneiss, with augen of quartz and plagioclase or simple sodic plagioclase mosaic and rare filled plagioclase crystals set in mylonitic fabric of finer-grained quartz, plagioclase, and mafic minerals

TKhl **Hidden Lake stock (Middle Eocene to Late Cretaceous)**—Biotite metatonalite with relict hypidiomorphic granular texture. Rocks are

granodiorite based on CIPW normative minerals and d ^{18}O values greater than 10 (Ford and others, 1988, p. 26). Plagioclase mostly filled with well-crystallized metamorphic epidote and muscovite; some grain margins have recrystallized and quartz is sutured. Some K-feldspar is microcline. Rock is massive and sharply intrusive

TKao **Orthogneiss of Alma Creek (Middle Eocene to Late Cretaceous)**—Biotite leucogranodiorite and leucotonalite gneiss, with minor muscovite. Hypidiomorphic granular with highly strained quartz; biotite commonly decussate. CI<10. Local 2 to 4 -cm diameter orbicules are biotite which tangentially rims quartzofeldspathic cores. Some small irregular bodies northwest of Skagit River are not shown

Chelan Mountains terrane

TKns, Kns **Napeequa Schist (Middle Eocene to Late Cretaceous)**—Predominantly fine-grained hornblende-mica schist, mica-quartz schist, hornblende schist, amphibolite, garnet-biotite schist, and minor hornblende-zoisite schist, hornblende garbenschiefer, calc-silicate schist, marble, and ultramafic rocks. In the Cascade River area and in the Straight Creek Fault zone, phyllitic muscovite-chlorite-quartz schist predominates. Rocks are mostly white, tan, brown to black, locally greenish with conspicuous compositional banding. Fine lamellar foliation, locally blastomylonitic. On outcrop scale the schist is isoclinally folded, commonly crenulated; small crinkle folds of prominent foliation surfaces. Locally includes:

TKnm **Marble and minor amphibolite**—Small outcrops shown with star symbol or line symbol only

Tknu, Knu **Ultramafic rocks**—Serpentinite, talc-magnesite schist, talc schist, tremolite-talc schist, and olivine-talc rocks. Shown with asterisk symbol where too small to show at map scale

TKcs, Kcs **Cascade River Schist (Middle Eocene to Late Cretaceous)**—Mostly fine grained, highly fissile, green, brown, and black micaceous schist ranging from phyllitic sericite-quartz schist to granoblastic biotite- and muscovite-biotite-quartz-albite schist, hornblende-biotite-andesine schist, garbenschiefer, fine-grained amphibolite, and fine-grained paragneiss. Many rocks have garnet, less commonly staurolite and kyanite. Rare chloritoid. Calcareous mica schist locally. Hornblende is commonly blue green. Relict clastic textures common in metasandstone; unit also includes small-pebble metaconglomerate. Locally includes:

TKcc, Kcc **Metaconglomerate**—Gray to dark-green rocks ranging from boulder conglomerate with weak foliation to highly schistose rocks in which clasts are so highly attenuated that they are only visible on surfaces cut perpendicular to fabric lineation. Identifiable clast protoliths are quartzite, volcanic rocks, and granitoid rocks, including rocks derived from the protolith of the Marblemount pluton

Kcmv **Metavolcanic rocks**—Fine-grained leucogreenschist, commonly with relict highly flattened phenocrysts of plagioclase or mafic minerals

Kmd **Marblemount pluton (Middle Eocene to Late Cretaceous)**—Meta-quartz diorite and metatonalite and tonalitic gneiss; light-colored metatonalite dikes. Locally includes unmetamorphosed hornblende tonalite north of Skagit River. Rocks have CI =16-54 (Ford and others, 1988), are medium-grained, pale green, have numerous anastomosing zones rich in chlorite, epidote, and actinolitic hornblende, and vary from massive with

relict hypidiomorphic granular texture to highly foliate and mylonitic. Plagioclase commonly transformed to unzoned, complexly twinned albite filled with epidote and (or) white mica. Locally includes:

Kmf **Flaser gneiss border zone**—Dark-colored epidote-chlorite-muscovite-quartz-plagioclase flaser gneiss, locally with chlorite schist. Subhedral to subidioblastic sodic plagioclase in a foliate matrix, locally with biotite

ROCKS IN THE ROSS LAKE FAULT ZONE

TKhr **Ruby Creek Heterogeneous Plutonic Belt of Misch (1966) (Middle Eocene to Late Cretaceous)**—Heterogeneous gabbro to granodiorite in small masses and dikes. Grain size and composition varies considerably on an outcrop scale. Some rocks cataclastically foliated. Plutons of the belt intrude the phyllite and schist of Little Jack Mountain and are commonly rich in inclusions of the country rock. Also includes much medium-colored fine- to medium-grained, locally cataclastic, hornblende-biotite tonalite and abundant light-colored hornblende-biotite tonalite to granodiorite. Locally includes:

TKhri **Prominent inclusions of mafic metagabbro and ultramafic rocks**—Similar to TKhr, with prominent inclusions of mafic and ultramafic components of the Skymo Complex of Wallace (1976)

TKhrd **Diorite**—Pyroxene metadiorite, highly altered, locally cataclastic

TKs **Skymo Complex of Wallace (1976) (Middle Eocene to Late Cretaceous)**—Metamorphosed troctolite, gabbronorite, and anorthosite intruded by irregular patches and veins of lighter colored medium- to coarse-grained gabbro and rare tonalitic pegmatite. Gabbronorite locally grades to pyroxenite. Troctolite and gabbronorite weather orange-brown. Oikocrystic orthopyroxene in gabbronorite. Troctolite, gabbronorite, and anorthosite weakly layered; cumulate origin is probable. Unit is highly faulted and cut by mylonitic zones. Locally includes

Tksf **Fine-grained granulites**—Interlayered calc-silicate gneiss, garnet plagioclase schist, hypersthene-plagioclase gneiss, and orthogneiss (Hyatt and others, 1996)

TKsfm **Marble—**Small outcrops shown with star symbol only

Little Jack terrane

TKlp **Phyllite and schist of Little Jack Mountain (Middle Eocene to Late Cretaceous)**—Mostly quartz-mica phyllite and biotite schist with local staurolite, garnet, andalusite, and sillimanite. Rare ribbon chert, local marble, and ubiquitous pods of metapyroxenite, talc-bearing metaperidotite, and serpentinite. Local amphibolite and hornblende-biotite schist. Biotite commonly porphyroblastic. Intruded by dacite porphyry dikes ranging from undeformed to mylonitic with strong, mostly northwest-trending, stretching lineation. Locally includes:

TKlu **Ultramafic rocks**—Metaperidotite and metapyroxenite. Small outcrops shown by asterisk symbol only

Hozomeen terrane

Hozomeen Group (Mesozoic and Paleozoic)—Divided into:

JTRhgs **Greenstone, clastic sedimentary rock, limestone, and chert (Middle Jurassic to Late Triassic)**—Heterogeneous discontinuously bedded greenstone, graywacke, argillite, marble, and ribbon chert. Local chaotic mixing suggestive of deposition by submarine landslides. Greenstones commonly derived from Ti-rich basalt, locally with well-developed pillows. Partially recrystallized to prehnite-pumpellyite facies. Limestones mostly coarsely recrystallized, gray, and in 0.1- to 10-m pods. Deformational fabric ranges from none to (mostly) incipient slaty cleavage. Description modified from Haugerud (1985). Unit JTrhgs corresponds to the uppermost of four units described by McTaggart and Thompson (1967)

TRhc **Chert (Late and Middle Triassic)**—Mostly ribbon chert and slaty argillite with minor greenstone and marble. Probably equivalent to third highest of four units described by McTaggart and Thompson (1967)

Pzhg **Greenstone with minor argillite, chert, and limestone (Permian and Pennsylvanian)**—Mostly pillow basalt, pillow breccia, flows, and minor basaltic tuff, with minor argillite, volcanic lithic sandstone, ribbon chert, and limestone. Partially recrystallized to prehnite-pumpellyite facies. Probably corresponds to second highest of four units described by McTaggart and Thompson (1967). Locally includes:

Pzhgl **Limestone, chert, and minor greenstone and metatuff**—Mostly gray, well-recrystallized limestone.

ROCKS EAST OF THE ROSS LAKE FAULT ZONE

Methow Terrane

Js **Sandstone and argillite (Late Jurassic)**