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

Preliminary Geologic Map of the Mount Baker 30- by 60-Minute Quadrangle, Washington

by

R.W. Tabor[1], R.A. Haugerud[2], D.B. Booth[3], and E.H. Brown[4]

Prepared in cooperation with the Washington State Department of Natural Resources, Division of Geology and Earth Resources, Olympia, Washington, 98504

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[1]U.S.G.S., Menlo Park, California 94025
[2]U.S.G.S., University of Washington, AJ-20, Seattle, Washington 98195
[3]SWMD, King County Department of Public Works, Seattle, Washington, 98104
[4]Department of Geology, Western Washington University, Bellingham, Washington 98225

INTRODUCTION

The Mount Baker 30- by 60-minute quadrangle encompasses rocks and structures that represent the essence of North Cascade geology. The quadrangle is mostly rugged and remote and includes much of the North Cascade National Park and several dedicated Wilderness areas managed by the U.S. Forest Service. Geologic exploration has been slow and difficult. In 1858 George Gibbs (1874) ascended the Skagit River part way to begin the geographic and geologic exploration of the North Cascades. In 1901, Reginald Daly (1912) surveyed the 49th parallel along the Canadian side of the border, and George Smith and Frank Calkins (1904) surveyed the United States' side. Daly's exhaustive report was the first attempt to synthesize what has become an extremely complicated geologic story.

Modern geologic work began almost a half a century later when, in 1948, Peter Misch began his intensive study of the range (1952, 1966, and see other references). His insights set the stage for all later work in the North Cascades. Considerable progress in understanding the North Cascades in light of modern plate tectonic theory has been made by E.H. Brown and his students. We have used much of their detailed geologic mapping (Fig. 2). Although our tectonic reference frame has changed much with the recognition of plate tectonics and exotic terranes, Misch's observations prove to be remarkably accurate.

Our work in this quadrangle began in 1983 as part of a project to map and compile the geology of the Concrete 1° by 2° quadrangle at 1:100,000 scale. We have mapped in cooperation with the Division of Geology and Earth Resources, Washington Department of Natural Resources. We have also benefited by the cooperation and helpfulness of the National Park Service and the U.S. Forest Service.

ACKNOWLEDGMENTS

Many people have helped with field work in the difficult terrane of the Mount Baker quadrangle: Michael Ort (1984–1985), Patrick Goldstrand (1985), Carolyn Ortenburger (1985–1986), Janet Slate and Robert Fillmore (1986), Kathleen Dungan (1987–1988), Scott Spees (1987), Eric Roth (1988), Kris Alvarez (1990–1991), Tom Grundy (1990), Carmello Ferlito, David Maher and Jim Montgomery (1991), Chad Nelson, Cathryn Dwyre, and Rob Osborn (1992). We thank Wes Hildreth for sharing unpublished data and mapping on Mount Baker volcano. Keith Howard constructively reviewed the manuscript. Many employees of North Cascades National Park and the Mount Baker Ranger District of the U.S. Forest Service have been helpful, in particular Craig Holmquist, Kevin Kennedy, Jerry Lee, and Bill Lester; Jon Reidel has been particularly helpful geologically. We are thankful that superb and ultimately cooperative helicopter pilots and their crews exist; thank you Tony and Sue Reese for our success and our safety.

R.W. Tabor produced this digital map with GIS technology using *Alacarte* (Wentworth and Fitzgibbon, 1991). Many computer and(or) GIS experts helped, especially Tracy Felger, Todd Fitzgibbon, Patricia Helton, Eric Lehmer, Bob Mark, Chad Nelson, Geoff Phelps, and Pahdy McCarthy. Many thanks to Carl Wentworth, who, no matter how busy, always answered questions about *Alacarte*.

GENERAL GEOLOGY

Rocks in the Mount Baker quadrangle represent almost all the geologic events recorded in the entire North Cascades: 1) pre-mid-Cretaceous assembly of Mesozoic and Paleozoic terranes that have different paleogeographic origins and structural and metamorphic histories (Tabor and others, 1989; Tabor 1994), 2) mid- to Late Cretaceous thickening by thrusting and (or) pluton accumulation (Misch, 1966; McGroder, 1991; Brown and Walker, 1993) accompanied and followed by regional metamorphism, 3) Eocene strike-slip faulting, extensional faulting, basin development, and continued metamorphism and plutonism (Johnson, 1985; Brown, 1987; Miller and Bowring, 1990; Haugerud and others, 1991; Miller and others, 1993), 4) growth of the Cascade magmatic arc in Oligocene to Holocene time (Vance and others, 1986; 1987; Smith, 1993; Tabor and others, 1989), and 5) Quaternary glacial erosion and deposition of glacial-derived sediments (Booth, 1987, 1990).

The Straight Creek Fault and the Ross Lake Fault Zone divide the rocks of the quadrangle into a core of deep-seated, thoroughly metamorphosed rocks, flanked by less metamorphosed rocks on either side (Fig. 1). These major faults are thought to be predominantly strike-slip (Misch, 1977a; Vance and Miller, 1981, 1992; Miller and others, 1993; Miller, 1994), though the rocks of the metamorphic core have been uplifted 15–25 kilometers relative to rocks on either side. The Straight Creek Fault, although now predominantly obliterated by Tertiary arc plutons, almost bisects the quadrangle. It separates core rocks from the Northwest Cascades System on the west. Estimates of right-lateral strike slip on the Straight Creek Fault range from about 90 to 190 km (Vance and Miller, 1981, 1992; Vance, 1985; Monger *in* Price and others, 1985; Kleinspehn, 1985; Coleman and Parrish, 1991; McGroder, 1991). Miller and Bowring (1990) described structural evidence of an early episode of strike slip on the Ross Lake fault, and Haugerud (1985) and Miller (1994) indicated a strong discontinuity in metamorphic grade and history across the zone. Kriens (1988) and Kriens and Wernicke (1990a, b) suggested that the Ross Lake fault zone is a minor dislocation in an essentially uninterrupted cross-section of a Mesozoic arc ranging from the deep roots in the North Cascade core to the unmetamorphosed marine and terrestrial deposits of the Methow region to the east.

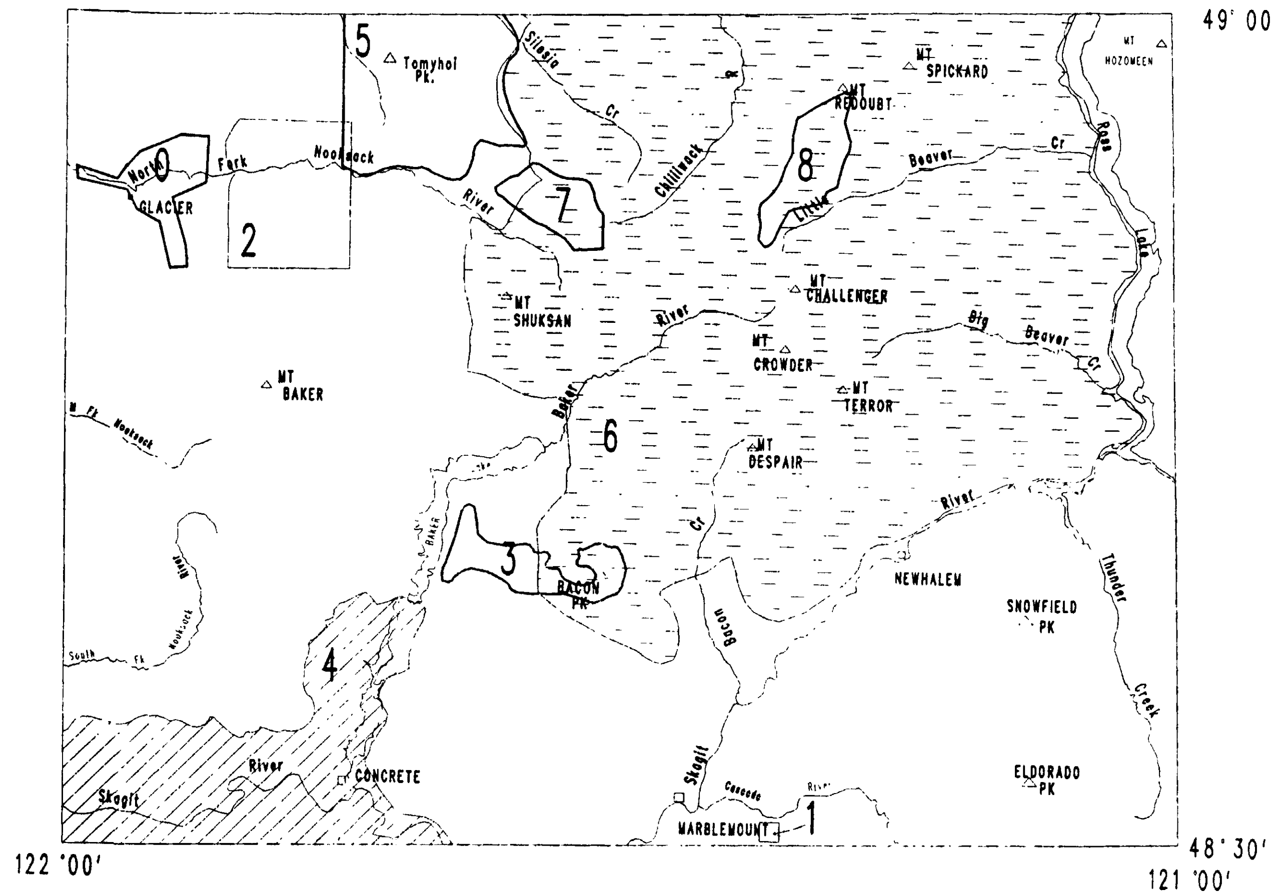
ROCKS WEST OF THE STRAIGHT CREEK FAULT

West of the Straight Creek fault, the North Cascades appear to be composed of two fundamental regional structural blocks separated by a complex tectonic belt and high-angle faults (Fig. 3; see also Tabor and others, 1989; Tabor 1994). The northeastern structural block, exposed primarily in the Mount Baker quadrangle, is mostly composed of Paleozoic and Mesozoic volcanic arc and associated clastic wedge deposits along with more

Map A.

0 Carpenter (1993, plate 1)
1 Dragovich, J. D. written comm. (1992)
2 Franklin (1985, plate 1)
3 Haugerud (1980, plate II)
4 Heller (1978, plate B)
5 Sevigny and Brown *in* Sevigney (1983, plate 1)
6 Staatz and others, (1972, plate 1) and unpublished U.S. Geological Survey data (1967-1968)
7 Tepper (1985, plate 1)
8 Tepper (1988)

Figure 2. - Sources of map compilation data.
A, Much data used with little to modest modification.



Map B.

9 Blackwell (plate 1, 1983)
10 Brown and others (1987)
11 Cary (1990, plate I)
12 Dragovich (1989, plate 1)
12a Dragovich, J.D. written comm. (1993)
13 Frasse (1981, plate 1)
14 Fugro (1979, enclosure 1)
14a Hildreth, Wes written commun.,(1994)
15 James (1980, plate 1)
16 Jewett, 1984 (plate 1)
17 Johnson (1982, plate 1)
18 Jones (1984, plate 1)
19 Jones and others (unpublished map for U.S.Forest Service, 1984)
20 Leiggi (1986, plate 1)
21 Misch (1979)
22 Moore (1972, plate 1)
23 Rady (1980, plate 1)
23a Riedel (1990, Figs. 1,2)
24 Tepper (1991, Fig. II.2)
25 Shideler (1965, plate 1)
26 Smith (1986, plate 1)
27 Sondergaard (1979, plate 1)
28 Staatz and others (1971, Plate 1)
29 Wallace (1976, plate I)
30 Zieglar (unpublished map for U.S. Forest Service, 1985)
31 Zieglar (1986, plate 1)

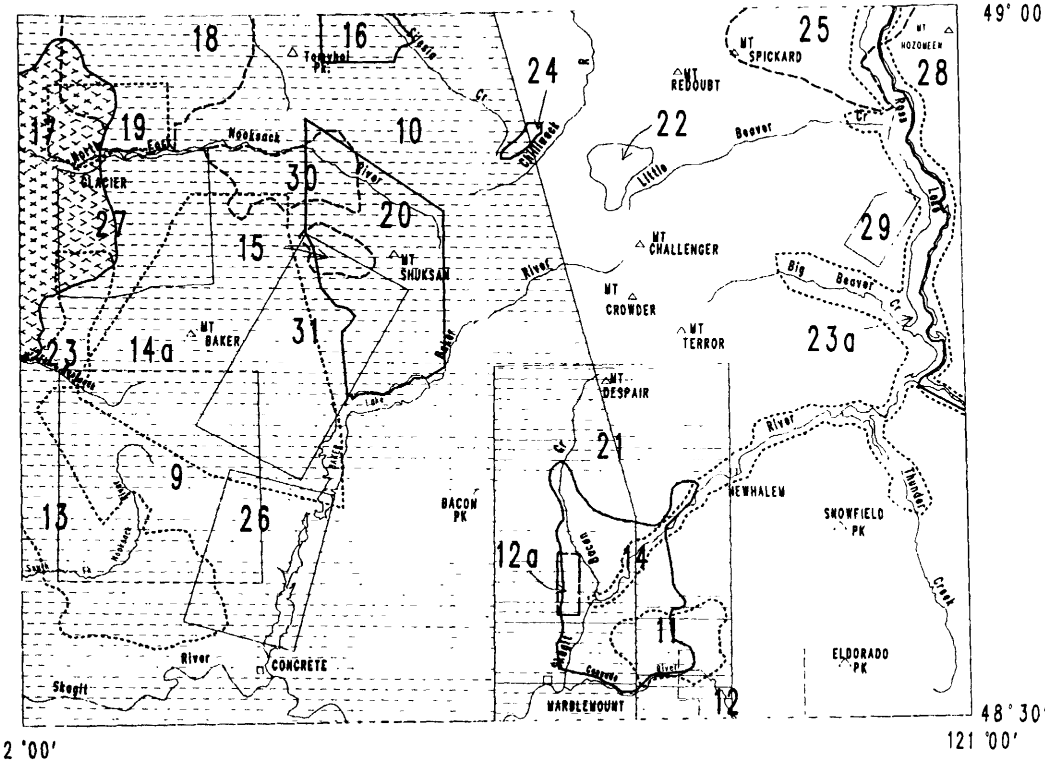


Figure 2 cont. Sources of map compilation data.
B, Some data used.

Map C.

32	Bechtel (1979, appendix H, sheet 1)
33	Bryant (1955, plate 48)
34	Christensen (1981, plate 1A)
35	Cook (1947, plate 20)
35a	Coombs (1939, fig. 2)
35b	Crickmay (1930)
36	Daly (1912, sheets 15 and 16)
37	Danner (1966, figs. 117,126, 127,129,137,138,139,143,145)
38	Grant (1969, fig. 21)
38a	Heller and Dethier (1981, fig. 2)
39	Kriens (1988, plates 1-5)
40	McCleary, and others (1978, figs. 4 ,5, 15)
41	McKeever (1977, Plate)
42	Misch (1966, plate 7-1)
43	Misch (1977, figs. 4, 2, 3)
44	Ragan (1961, plate 1)
44a	Riedel (1988, fig. 13)
45	Robertson (1981, plate 1)
46	Russell (1900, plate 9)
47	Tepper (1991, map 1)
47a	Smith and Calkins (1904)
48	Smith, C. L. (1961, plate XII)
49	Vonheeder (1975, plate 2)

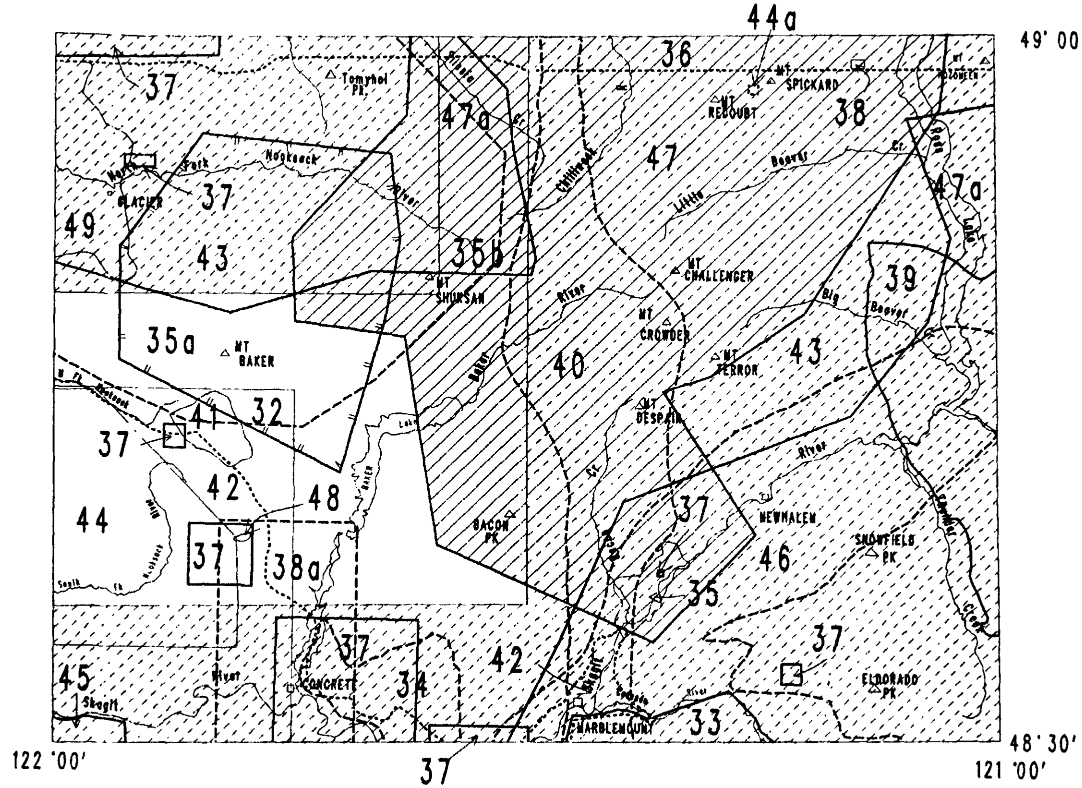


Figure 2 cont.
Sources of map compilation data.
C, Consulted extensively but data not used on map.

thoroughly metamorphosed oceanic rocks, thrust in the mid-Cretaceous into a series of nappes. The overall structure has been likened to a regional mélange by Brown (1987) who, broadening the earlier terminology of Misch (1966, p. 128), called this structural block the Northwest Cascade System. The southwestern block, exposed just south of the Mount Baker quadrangle, is mostly Mesozoic clastic rocks of submarine fan origin and relatively unmetamorphosed oceanic rocks. Tabor and others (1982, 1989, 1993), Frizzell and others (1987), and Tabor (1994) described this block as the western and eastern mélange belts.

Rocks of the Northwest Cascade System

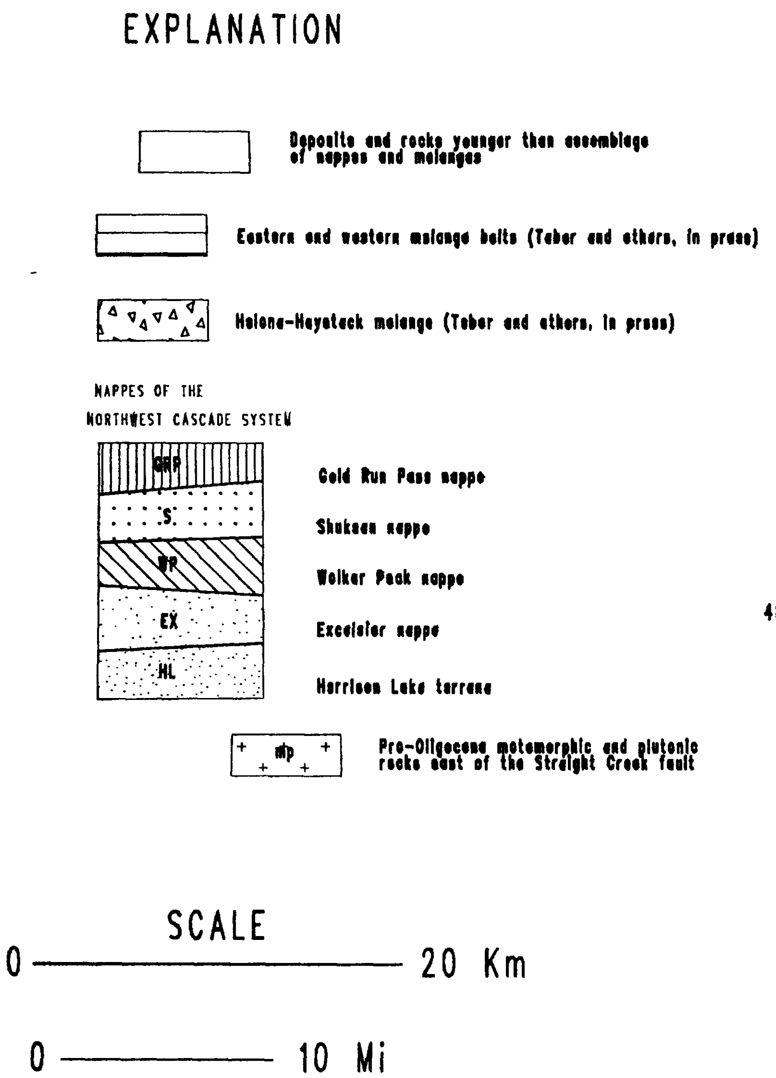
Four major nappes, stacked along folded thrusts, and their probably autochthonous footwall comprise the Northwest Cascades System (Figs. 3 and 4). The structural stratigraphy of the Northwest Cascades System (NWCS) appears to be consistent over a wide area of northwest Washington. The rocks in the three lowermost nappes and the autocthon differ enough in lithology, structure, and metamorphic history to warrant consideration as separate terranes, but the highest and youngest Gold Run Pass Nappe consists of slices of the lower nappes and autochthon.

Harrison Lake terrane

Wells Creek Volcanics and Nooksack Group. At the bottom of the exposed stack of nappes are the Middle Jurassic Wells Creek Volcanics of Misch (1966) (see also Franklin, 1985) overlain by and interfingering stratigraphically with the Nooksack Group of Danner (1958). These units appear correlative with similar rocks exposed west of Harrison Lake, British Columbia, and thus we consider them to belong to the Harrison Lake terrane of Monger (1986, 1993). Misch (1966) noted that, although the Wells Creek Volcanics and Nooksack Group look autochthonous, the bottom of the Wells Creek is not exposed, and they too might be part of an allochthonous nappe. Sondergaard (1979) considered the Nooksack to be a submarine fan deposit associated with a volcanic arc. Locally abundant megafossils in the Nooksack indicate a Late Jurassic and Early Cretaceous age (Misch, 1966). The Nooksack is generally not strongly penetratively deformed, although commonly it has slaty cleavage. Sevigny (1983), Jones (1984), and Ziegler (1986) reported minor metamorphic lawsonite, pumpellyite, and aragonite.

Excelsior and Welker Peak nappes

Chilliwack Group and Cultus Formation. Structurally overlying the Nooksack Group along the Excelsior thrust fault (the Church Mountain fault of Misch (1966) is the Chilliwack Group of Cairnes (1944) composed of partly metamorphosed basaltic and andesitic volcanic rocks, sandstone, siltstone, shale and minor limestone. Marble in the Chilliwack yields fossils ranging in age from Silurian (?) and Devonian to Permian but most are Mississippian. Rocks are slaty to phyllitic, and planar structures are low-angle. Christenson (1981) and Blackwell (1983) described lawsonite and aragonite as common metamorphic minerals; Smith (1988) reported rare glaucophane. Monger (1970), Christenson (1981), Blackwell (1983), and Sevigny and Brown (1989) considered the Chilliwack to have been developed in an arc setting. The Chilliwack is depositionally overlain by the little



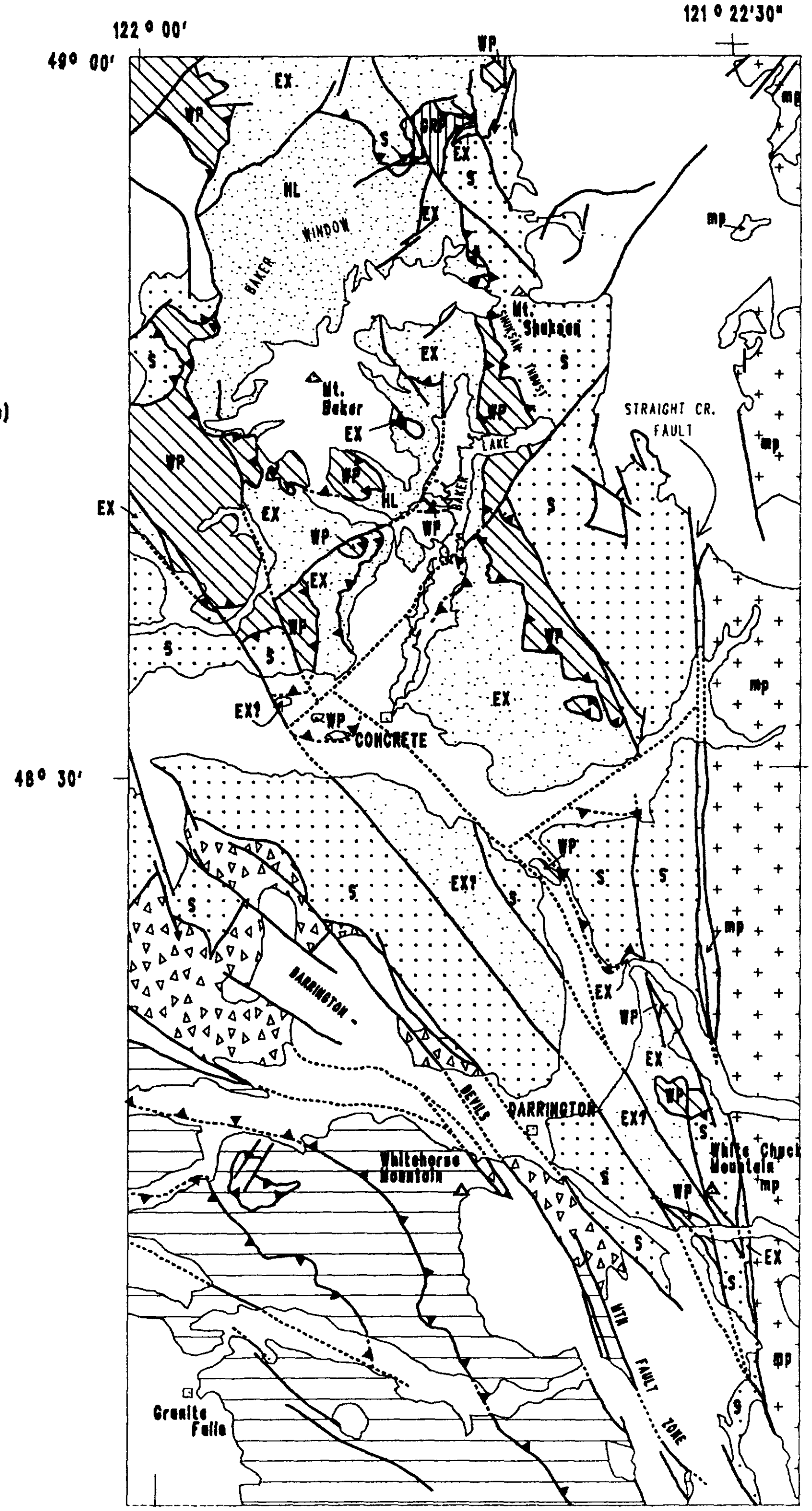


Figure 3. Generalized map of nappes of the Northwest Cascade System and melange belts to the southwest

deformed and little metamorphosed Cultus Formation of Daly (1912), a Triassic to Early Jurassic marine and dacitic volcanic unit (Monger, 1970). The Chilliwack Group and Cultus Formation occur mainly in the Excelsior nappe (Fig. 3). The Excelsior nappe contains significant internal thrusts, rocks of the Chilliwack Group and Cultus Formation are regionally overturned, and they have penetrative fabrics in most locales, suggesting a pre-mid Cretaceous, possible pre-Late Jurassic tectonic event not seen in the underlying Nooksack Group (Haugerud and others, 1992).

A unit with similarities to the clastic facies of the Chilliwack Group, the Mount Josephine unit, the Darrington Phyllite, and the clastic parts of the Elbow Lake unit is the slate of Rinker Ridge. It is poorly exposed in the lower Skagit River valley of the Mount Baker quadrangle. Good exposures in the Sauk River quadrangle (Tabor and others, in press) to the south indicate that the slate of Rinker Ridge is consistently less deformed and recrystallized than the Darrington Phyllite, has a protolith that was generally sandier than that of the Darrington and less sandy than that of the Mount Josephine unit, and appears to be a fault bounded block within extensive outcrops of Easton Metamorphic Suite. Tabor and others (op.cit.) discuss the possible protoliths for the slate of Rinker Ridge and tentatively assign it to the Chilliwack Group. We show it to be part of the Excelsior nappe in Figure 3.

Bell Pass mélange. The Chilliwack Group and Cultus Formation are overlain along the Welker Peak thrust by the Bell Pass mélange, much of which is comprised of the Elbow Lake Formation of Brown and others (1987), a mélange-like assemblage of foliated sandstone, argillite (phyllite), ribbon chert, basalt, and very rare marble. Commonly in or associated with the Elbow Lake assemblage are ultramafic rocks, various blocks of gneiss and schist, and granitoid rocks ranging from granite to gabbro in composition. These are locally mapped as the Twin Sisters dunite, the Baker Lake blueschist unit of Brown and others (1987), the Vedder Complex of Armstrong and others (1983), and the Yellow Aster Complex of Misch (1966). Ages of radiolarians from chert blocks in the Elbow Lake Formation are Pennsylvanian, Triassic, and Jurassic (Brown and others, 1987; C.D. Blome, written commun., 1988, 1991). Gneiss and schist of the Vedder Complex yield K-Ar ages indicating Permian metamorphism (Armstrong and others, 1983). Zircons from Yellow Aster paragneiss have discordant U-Pb ages interpreted to be Precambrian and probably representing detritus derived from Proterozoic basement (Mattinson, 1972; Rasbury and Walker, 1992). We consider these rocks to make up the Welker Peak nappe (Fig. 3). In part, the Bell Pass mélange is coincident physically and in concept with the thick tectonic zone at the base of the mid-Cretaceous Shuksan thrust fault as described by Misch (1966, 1980), which separates more thoroughly metamorphosed rocks of the Easton Metamorphic Suite—equivalent to Misch's (1966) Shuksan Metamorphic Suite—from the structurally underlying Nooksack and Chilliwack Groups. However, we suspect that some of the mixing and deformation within the Bell Pass mélange predates mid-Cretaceous tectonism and is unrelated to the Shuksan thrust.

Shuksan nappe

Easton Metamorphic Suite. The Easton Metamorphic Suite, also referred to the Easton terrane (Tabor and others, 1989), is composed of the Shuksan Greenschist and the Darrington Phyllite. It generally overlies lower nappes along the Shuksan thrust fault. The Easton records a more thorough episode of high P/T metamorphism than the other units in the NWCS. The well-recrystallized Shuksan Greenschist commonly bears blue amphibole, and the Darrington Phyllite locally contains lawsonite. Most workers interpret the protolithic shale and local sandstone of the Darrington Phyllite to have been deposited on the ocean floor basalt protolith of the Shuksan Greenschist (Brown, 1986; Dungan and others, 1983; Haugerud and others, 1981), but in some areas phyllite and greenschist are clearly interlayered, suggesting depositional interfingering. Based on isotopic analysis, Brown and others (1982) and Armstrong and others (1983) considered the Easton to have a Middle to Late Jurassic depositional age (about 150–160 Ma) and an Early Cretaceous metamorphic age (about 120–130 Ma), with evidence for local earlier metamorphism (Brown and others, 1982).

The semischist and phyllite of Mount Josephine crops out in extensive tracts along the west side of the Mount Baker quadrangle and farther west. These rocks overlie the Bell Pass mélange along a thrust here correlated with the Shuksan thrust. Rocks of this unit are similar lithologically to the Darrington Phyllite and were so correlated by many workers (Misch, 1966; Miller, 1979; Brown and others, 1987; Gallagher and others, 1988), but differ in that their protolith was sandier and that they appear less thoroughly recrystallized than the Darrington. Greenschist and blueschist intercalations are lacking and rare metavolcanic rocks are greenstones. Based on metamorphic and structural history, Gallagher and others (1988) considered metatonalite with a Middle Jurassic protolith age and associated metavolcanic rocks surrounded by the semischist and phyllite of Mount Josephine, and cropping out about 14 km west of the Mount Baker quadrangle, to be magmatic arc rocks depositionally tied to the semischist and phyllite which they considered to be Darrington Phyllite. Although this correlation may indeed be correct and the differences in lithology and grade of the Mount Josephine rocks and the Darrington Phyllite due to sedimentary facies changes and decrease in metamorphism from east to west, this transitional relation has yet to be documented and we here consider the Mount Josephine rocks a separate unit.

ROCKS BETWEEN THE STRAIGHT CREEK FAULT AND THE ROSS LAKE FAULT ZONE

In the Mount Baker quadrangle, the high-grade metamorphic core of the North Cascades is made up of the Chelan Mountains terrane and plutons that intrude it, as well as the Skagit Gneiss Complex, derived from the supracrustal rocks of the Chelan Mountains terrane by more-intense metamorphism and pervasive deep-seated intrusion. K-Ar ages of schists and gneisses in much of the region west of the Ross Lake Fault Zone are almost all middle and late Eocene, reflecting early Tertiary unroofing and cooling of these deep-crustal rocks. Much of the core has been intruded by arc-root magma of the Tertiary Chilliwack composite batholith.

Rocks derived from the Chelan Mountains terrane

Rocks derived from the Chelan Mountains terrane include the Napeequa unit, the metaplutonic rocks of the Marblemount–Dumbell–Entiat belt, and the Cascade River unit. Rocks of the Napeequa unit are mostly micaceous quartzite, fine-grained hornblende schist, and amphibolites derived from a protolith of oceanic chert and basalt. Minor marble and small bodies of metamorphosed ultramafic rock are also characteristic. Mica schist and hornblende mica schist probably derived from shale and sandstone are common.

The Marblemount Meta Quartz Diorite of Misch (1966) comprises the northern end of the Marblemount–Dumbell–Entiat plutonic belt which stretches about 128 km southeast from the Mount Baker quadrangle. Protolith of the Marblemount Meta Quartz Diorite is Late Triassic in age based on U-Pb analyses of zircons (Mattinson, 1972). Tabor and others (1989) suggested deposition of the Cascade River unit protolith in a forearc or intra-arc basin wherein intrusion of arc-root plutons, such as the Marblemount pluton, was followed by rapid unroofing and further deposition of arc volcanic rocks.

Protolith of the Cascade River unit was a thick sequence of arc-derived clastic rocks with minor volcanic rocks (Misch, 1966; Tabor and others, 1989), now metamorphosed to plagioclase-rich mica schist, metaconglomerate, and amphibolitic schist. Prominent in the metaconglomerate are clasts of the Marblemount Meta Quartz Diorite of Misch (1966). Minor constituents of the unit are silicic schists (metatuff), marble, and amphibolite. Zircons from a dacitic metatuff yielded Late Triassic U-Pb ages.

The original contact between the oceanic rocks of the Napeequa unit and locally-coarse arc-derived metaclastic rocks of the Cascade River unit is now obscured by faulting, folding, and metamorphism. Tabor and others (1989), Haugerud (1989) and Dragovich and Derkey (1994) proposed that the protolith arc of the Cascade River unit was deposited on the oceanic crust of the Napeequa unit protolith. Without direct information on the protolith age of the Napeequa unit this relation remains uncertain and original juxtaposition by faulting is possible.

Based on perceived stratigraphy in the Cascade River unit, Dragovich and others (1989), Dragovich (1989), Dougan and Brown (1991) and Dougan (1992) considered the Napeequa unit to have been thrust over the Cascade River unit and then downfolded along a north-plunging synform in its primary area of exposure along the southern border of the Mount Baker quadrangle. Tabor and others (in press) suggest that the Napeequa is exposed in the core of a south-plunging antiform (Fig. 1), an interpretation adopted here without consensus.

Large amounts of tonalitic to granodioritic magma intruded the supracrustal rocks of the Chelan Mountains terrane in Late Cretaceous and earliest Tertiary time. The plutons were deformed and partially recrystallized to orthogneiss, a process that continued into the early Tertiary as shown by Eocene K-Ar ages and fabrics similar to demonstrably Eocene fabrics in the nearby Skagit Gneiss Complex (Haugerud, 1985; Haugerud and others, 1991). The Eldorado Orthogneiss was intruded at 90 Ma and is strongly deformed and extensively recrystallized; according to McShane and Brown (1991), Brown and Walker (1993) and McShane (1992), it intruded rocks of the Chelan Mountains terrane at relatively shallow depths, at pressures of 3–4 kb. Subsequent loading, at least in part by superjacent magmas, increased metamorphic pressures in the vicinity of the Eldorado Orthogneiss to 7–8 kb (Brown and Walker, 1993). The orthogneiss of Marble Creek was intruded at about 75 Ma and is extensively deformed and recrystallized. The orthogneisses of Haystack Creek and Mount Triumph are lithologically similar to orthogneiss bodies within the Skagit Gneiss Complex which have 60–70 Ma U-Pb zircon ages. Orthogneiss of Alma Creek is less deformed and perhaps slightly younger. The Hidden Lake stock, apparently on the edge of the deep orogen, was intruded at 75 Ma and is less deformed than the above-mentioned bodies, but nonetheless is extensively recrystallized.

The Skagit Gneiss Complex (Skagit Gneiss of Misch, 1966) is banded biotite gneiss, banded amphibolite gneiss and large bodies of tonalitic orthogneiss, all mostly migmatitic. The banded gneisses contain abundant orthogneiss layers on all scales. Small bodies of mafic gneiss, mafic migmatite, ultramafic rock and marble crop out also. All of the complex is pervaded by concordant to discordant deformed bodies of light-colored tonalitic pegmatite. Based on composition and observed transition to the protoliths, the banded gneisses appear to be highly metamorphosed Cascade River and Napeequa units. The orthogneiss of The Needle yields discordant U-Pb zircon ages and reveals textural evidence of multiple deformation suggesting it is a highly metamorphosed pluton of the Late Triassic Marblemount intrusive episode (Haugerud and others, 1991). Much of the Skagit is permeated by dikes and irregular bodies of granite and, locally, granitic pegmatite which are characterized by a prominent lineation and weak, or absent, foliation; isotopic ages of the granites indicate middle Eocene intrusion (Haugerud and others, 1991).

Miller and others (1993), Brown and Walker (1993), and Brown and others (1994) discuss evidence that rocks in the vicinity of the Skagit Gneiss Complex were not buried deeply until after 90 Ma. U-Pb zircon ages of several bodies of migmatitic orthogneiss, which probably correspond to the age of intrusion, are Late Cretaceous and earliest Tertiary (Miller and others, 1989; Haugerud and others, 1991). Deformed granite bodies with middle Eocene protolith ages demonstrate that ductile deformation and recrystallization of at least parts of the complex continued into the middle Eocene.

ROCKS IN THE ROSS LAKE FAULT ZONE

Regionally the northwest-trending Ross Lake Fault Zone juxtaposes the higher-grade North Cascade core rocks with a little-metamorphosed sequence of Mesozoic marine and terrestrial deposits of the Methow terrane to the east. In the Mount Baker quadrangle several faults in the zone separate higher-grade metamorphic core rocks from a sliver of lower-grade schist and phyllite—the Little Jack terrane—and a sliver of essentially unmetamorphosed Late Paleozoic and Mesozoic oceanic rocks—the Hozomeen terrane. For much of their contact, the Hozomeen terrane overlies the Little Jack terrane along a low-angle thrust which probably predates the high-angle faults of the Ross Lake Fault Zone.

Hozomeen terrane

The Hozomeen Group of Cairnes (1944) is the sole component of the Hozomeen terrane. Following the example of McTaggart and Thompson (1967) we have, in reconnaissance, roughly subdivided the unit into: a lowermost exposed unit of probable upper Paleozoic greenstone with minor chert and limestone; a middle unit of predominantly Middle and Late Triassic ribbon chert and argillite, and an upper unit of predominantly Late Triassic greenstone, clastic sedimentary rocks, ribbon chert, and limestone, with minor Jurassic chert and clastic sedimentary rocks. These three units appear to correlate with the upper 3 of McTaggart and Thompson's 4 units. Preliminary examination of poorly preserved fossils raised the possibility that some rocks of the southwesternmost part of the Hozomeen, adjacent to or within the Ross Lake fault zone, are as young as mid-Cretaceous (C.D. Blome, written commun., 1988), but further collecting has failed to substantiate this age, which we now believe to be spurious. Hozomeen rocks are deformed, but have not developed much slaty cleavage. The Late Triassic alkali-basalt protolith of the uppermost unit originated as a within-plate seamount(s) (Haugerud, 1985). Ray (1986) considered the Hozomeen to be a dismembered ophiolite, with volcanic rocks including both arc tholeiites and oceanic island–seamount subalkaline basalts.

Within the Ross Lake fault zone, the Ruby Creek Heterogeneous Plutonic Belt of Misch (1966) comprises a group of plutons ranging from diorite to granodiorite in composition and intruding rocks of the Little Jack terrane and of the Skymo Complex of Wallace (1976). Gneissic and massive plutons suggest a long history of intrusion during and after deformation in the Ross Lake Fault Zone (Misch 1966). The only age available from the Ruby Creek belt is middle Eocene (Miller and others, 1989), from a body that on structural grounds must be among the youngest components of the belt. Other components are lithologically similar to tonalite of the Black Peak batholith and may be early Late Cretaceous like the Black Peak (Miller and others, 1993).

The Skymo Complex of Wallace (1976), of unknown age, consists of locally orthopyroxene-bearing mafic to ultramafic cumulate igneous rocks intruded by clinopyroxene gabbro. Wallace (1976) reports that many of the earlier mafic–ultramafic rocks are extensively recrystallized to granulite-facies mineral assemblages. The unit is faulted against the phyllite and schist of Little Jack Mountain, in part along low-angle faults. Skymo rocks are also faulted against orthogneiss of the Skagit Gneiss Complex on the west, but are partially engulfed in tonalitic material associated with the metamorphism affecting the Skagit (Staatz and others, 1972) indicating little displacment of the Skymo Complex relative to the Skagit since Late Cretaceous–early Tertiary metamorphism.

Rocks derived from the Little Jack terrane

Phyllite and schist of Little Jack Mountain are derived from the Little Jack terrane. Most of the unit is biotite±amphibole-bearing metapelite and lesser meta-arenite, with minor fine-grained amphibolite and rare recrystallized ribbon chert and marble. Scattered pods of meta-ultramafic rocks are characteristic of the unit. Metadacite porphyry dikes are abundant, some with little deformation and others strongly lineated and (or) foliated. The protolith age is pre-Late Cretaceous but otherwise unknown; we tentatively consider it to be Mesozoic, the age of most dominantly clastic terranes in the Pacific Northwest.

Metamorphism ranges from amphibolite facies on the southwest side of outcrop belt, adjacent to the Skymo Complex, to sub-greenschist facies on the northeast, off the quadrangle to the east. Mica schist locally contains garnet, staurolite, andalusite, and sillimanite. The age of dynamothermal metamorphism is not well constrained but we suspect it is Late Cretaceous to middle Eocene, the same as metamorphism of the adjoining Skagit Gneiss Complex. The Little Jack unit appears to be thermally metamorphosed as well by plutons of the middle Eocene and older Ruby Creek Heterogeneous Plutonic Belt.

SYN- AND POST-METAMORPHISM FAULTING AND DEPOSITION

At the same time as Eocene metamorphism continued in the Skagit Gneiss Complex, extension at shallower levels, associated with strike-slip faulting, opened depressions where fluviatile feldspathic sandstone and conglomerate accumulated (Tabor and others, 1984; Johnson, 1985; Heller and others, 1987). Most of such deposits are preserved outside of the Mount Baker quadrangle, but a few remnants crop out in the quadrangle. Sandstone and conglomerate of the Eocene Chuckanut Formation crop out along the western side of the quadrangle, in part separated from underlying older rocks by low-angle extensional faults. Smaller patches of probably partly correlative rocks (mapped as unnamed sandstone and conglomerate, other), are preserved on Mount Despair, near Bacon Peak, under and near the volcanic rocks of Big Bosom Buttes, and along the Straight Creek Fault. Young unnamed sandstone and conglomerate crops out along the Straight Creek Fault north of Marblemount where a clast of Marblemount Meta Quartz Diorite with a zircon fission track age of 45 Ma (J.A. Vance, written commun., 1993) shows the deposit to be late middle Eocene or younger.

ROCKS OF THE CENOZOIC CASCADE MAGMATIC ARC

Although the Cascade magmatic arc came to life at about 36 Ma (Vance and others, 1987; Smith, 1993), the oldest Cascade arc rock in the Mount Baker quadrangle is the 32-Ma granodiorite of Mt. Despair, an early phase of the Chilliwack composite batholith. Arc-root plutons of the batholith range from gabbro to alaskite in composition and from 32 to 2.5 Ma in age. In the quadrangle, plutons of the batholith with ages >30 Ma appear to belong to the Index family of arc-root plutons as defined by Tabor and others (1989). Those in the range of about 30 to 20 Ma are in the Snoqualmie family, and those <20 Ma are in the Cascade Pass family.

Volcanic rocks of the Cascade magmatic arc are sparse, preserved in down-faulted blocks in a scattered areas. They commonly were erupted on eroded early phases of the Chilliwack composite batholith and then intruded by younger phases. The volcanic rocks of Big Bosom Buttes, of Mount Rahm, and of Pioneer Ridge range from dacite to less common andesite and basalt in composition and are probably Oligocene in age. The volcanic rocks of Hannegan Pass are mostly rhyolitic to dacitic and erupted in the Pliocene. The volcanic deposits of Swift Creek are mostly rhyolitic and are Pliocene and (or) Pleistocene. The Swift Creek deposits underlie andesitic breccia and lava of Mount Baker volcano, an active calc-alkaline stratovolcano.

QUATERNARY GLACIAL AND NON-GLACIAL DEPOSITS

Glaciations in the Mount Baker Quadrangle are represented by deposits of both alpine and ice-sheet glaciers. Valley-bottom and valley-wall deposits in the upland trunk drainages (such as Big and Little Beaver Creek, Goodell Creek, Thunder Creek, and the Cascade River) include till and outwash from alpine glaciers that originated at the drainage headwalls. Most of these deposits probably date from the Evans Creek stade of the Fraser glaciation (Armstrong and others, 1965), about 20,000 yr. B.P., but were probably augmented during the Vashon stade, about 15,000 yr. B.P., when the high peaks in the eastern two-thirds of the Mount Baker quadrangle appear to have once again been a significant ice source. Additional deposits have been derived from lesser expansions of these same glaciers in Holocene time.

In the western part of the quadrangle, deposits derived from the Puget lobe of the Cordilleran ice sheet fill many of the lower valleys and mantle the upland surfaces. Virtually all deposits date from the Vashon stade of the Fraser glaciation culminating about 15,000 yr. B.P. (Booth, 1987). In general the surface altitude of the ice sheet increased to the north, reflecting the major source area in British Columbia (Booth, 1986). The projected high altitude of the Puget lobe ice-sheet surface at this latitude indicates that it would have submerged most of the western part of the quadrangle and much of the mountainous eastern part.

Unvegetated moraines and outwash are common in many alpine cirques in the quadrangle, especially below still-active alpine glaciers.

Beds of fine volcanic ash are exposed in roadcuts along the Skagit River west of Damnation Creek. The deposits are too small to show at map scale. The ash must have been deposited in a short-lived lake dammed by the landslides between Damnation Creek and Bacon Creek. F.F. Foit (Washington State University, written commun. to Jon Riedel, 1989) identified the ash as Mazama ash which is about 6850 years old.

A landslide of more than usual extent clogs the valley floor of the North Fork of the Nooksack River and lower Glacier Creek (Cary and others, 1992a; Carpenter, 1993; Carpenter and Easterbrook, 1993). Radiocarbon ages from logs buried beneath the deposit led Carpenter (1993) to infer deposition at about 2.7 ka.

DESCRIPTION OF MAP UNITS

QUATERNARY UNITS

Non-Glacial Deposits

Ql **Landslide deposits (Holocene)**—Diamictons composed of angular clasts of bedrock and surficial deposits derived from upslope. Commonly shown without letter symbol; arrows denote downslope direction of movement. Includes both transported material and unstable scarp area if present. Heller and Dethier (1981) describe landslides in the lower Skagit River valley. Locally mapped as:

Qlc Church Mountain landslide—Thick diamicton forming hilly deposit mostly of volcanic rocks of the Chilliwack Group exposed on Church Mountain. Carpenter (1993) and Carpenter and Easterbrook (1993) refer to this deposit as the Church Mountain sturtzstrom

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 altitudes gradational with Qf. At higher altitudes 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 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. Gradation with Qt, especially in granitic terrane where fans along major valleys commonly merge with talus. Many fans mapped from aerial photo interpretation of cone-shaped topography. Includes many post-glacial mudflow deposits in eastern and southern drainages from Mount Baker Volcano (Hyde and Crandall, 1978)

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. Includes lahar deposits derived from Mount Baker volcano in the North Fork of the Nooksack River (Cary and others, 1992b)

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

Qoal **Older alluvium (Holocene and Pleistocene)**—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

Glacial Deposits

Qam **Alpine glacial moraine (Holocene)**—Boulder till; sparsely vegetated to unvegetated

Qag **Alpine glacial deposits (Holocene and Pleistocene)**—Ranges 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.

Qvg Glacial deposits undivided—Mostly morainal deposits (Qvt) but includes outwash. Includes Qyal, Qf, and Qa. In area of North Fork of the Nooksack may include some deposits of Sumas Stade. East-derived glacial erratics littering the ground surface on Grandy Ridge and the ridges north and south of Jackman Creek indicate that during Vashon time there was a significant contribution of North Cascade ice to the Puget lobe of the Cordilleran ice sheet

Deposits of the Fraser Glaciation of Armstrong and others (1965) (Pleistocene)

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 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 units Qvi or Qvr is gradational. Mapped areas also include deposits of units Qf, Qmw, and Qyal too small or too poorly exposed to show at map scale

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

Non-Glacial and Glacial Deposits

Qa **Alluvium and mass-wastage deposits, undivided (Holocene and Pleistocene)**—Includes deposits of units Qf, Qyal, Qmw, Qvt, and Qvr, intermixed on the sides and floors of upland stream valleys. Similar to unit Qag in heterogeneity but occurring where deposits of alpine glaciers have been later obscured or are absent

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 southern boundary

ROCKS OF THE CASCADE MAGMATIC ARC

Deposits of Mount Baker volcano (Holocene and Pleistocene)

Qbsc Sulphur Creek cinder cone—Composed principally of loose blocks of scoreaceous olivine basalt

Qbs Sulphur Creek flow—Aa flow of olivine basalt

Qbv Volcanic rocks of present-day cone—Mostly plagioclase-phyric pyroxene andesite flow rock, breccia, and tuff. Some pyroxene- and hornblende-phyric andesite (Swan, 1980). Commonly very fresh

Qbm Miscellaneous flows—Commonly two-pyroxene andesite in isolated and highly eroded flows. Includes ridge-capping flows as well as isolated valley-bottom flows. Includes some ridge-capping flows and the isolated remnant near Wells Creek considered by Easterbrook (1975) to be remnants of the Black Buttes volcano and yielding K-Ar whole rock ages of 400 ka (Table 2, nos. 1 and 2).

Qbbx Breccia and tuffs of Black Buttes volcanic center—Includes some two-pyroxene andesite flow rock

Qbbf Ridge-capping andesite flows associated with Black Buttes volcanic center

Qlv **Lake Shannon volcanic neck (Pleistocene or older)**—Andesite

Volcanic deposits of Swift Creek (Pleistocene and Pliocene?)—Hildreth (1994) has described some of these deposits as fill of his Kulshan caldera. Mapped as:

QPsl Lake deposits—Thinly bedded rhyolite tuff and lapilli tuff. Mostly white, weathering brown and yellow. Locally contorted by intruding rhyolite or andesite flows. Scattered clasts of older rocks locally

QPsr Rhyolite tuff and breccia—Biotite-hornblende rhyolite tuff and breccia with quartz and K-feldspar phenocrysts. White to brown, poorly bedded, commonly vitrophyric but widely altered to carbonates

QPsm Mudflow breccia—Diamictite of rhyolite clasts and abundant older rocks in white tuffaceous matrix

QPsb Basalt and (or) andesite flow rock—Brown to black olivine basalt and pyroxene andesite; some hornblende andesite. Rocks generally more altered than similar-looking Mount Baker andesites

QPsrd Rhyolite dome or plug—Biotite rhyolite vitrophyre. Zircons have a fission-track age of 1.5 Ma (Table 2, no. 3)

QPsrf Rhyolite and dacite flow rock—Similar to clasts in breccia of unit QPsr. Some with brown hornblende and hypersthene

QPss Slide block—Block of Nooksack Group rock engulfed in tuff

Rocks of the Chilliwack composite batholith (Pliocene, Miocene, and Oligocene)—Rocks of the Chilliwack batholith range in composition from gabbro to granite. Most of the calc-alkaline plutons are of intermediate composition and are medium-grained hypidiomorphic granular. Tepper (1985, 1991) has made the most complete study of the batholith to date, and our descriptions below draw heavily on his work. For detailed chemical, isotopic, and petrologic data as well as petrogenesis and source of magma see Tepper (1991) and Tepper and others (1993). Mapped as:

Cascade Pass family

Tcla Granodiorite of Lake Ann stock (Pliocene)—Medium-grained biotite—hypersthene-clinopyroxene granodiorite and granite, locally with minor hornblende. CI (color index)=12–18 (James, 1980).

Biotite from the pluton and from hornfels within a few meters of the pluton yielded K-Ar ages of 2.7 and 2.5 Ma respectively (Table 2, nos. 7, 8). Detailed petrographic and chemical data are in James (op.cit.)

Tcnm Quartz monzonite and granite of Nooksack Cirque (Pliocene)—Ranges from quartz monzodiorite to granite, predominantly with uralitic hornblende and relict clinopyroxene. CI=7–15. Intrudes Tcid which intrudes 3.6-Ma volcanic rocks of Hannegan Pass

Tcrg Granite of Ruth Mountain (Pliocene)—Biotite granite and granodiorite, commonly with large twinned perthite crystals. Some minor hornblende. CI=4–17. Intrusive contacts not observed, but pluton is faulted against Tcid. As mapped includes part of Tepper's (1991) granodiorite of Ruth Mountain

Tcid Quartz diorite and quartz monzodiorite of Icy Peak (Pliocene)—Biotite-clinopyroxene quartz diorite to quartz monzodiorite with some hypersthene and uralite. Some rock is plagioclase-porphyritic. CI=15–32. Intrudes 3.6-Ma volcanic rocks of Hannegan Pass

Tcgp Granite porphyry of Egg Lake (Pliocene)—Hornblende granite and granodiorite porphyry with phenocrysts of quartz, plagioclase, and hornblende in a xenomorphic matrix of K-feldspar, quartz and plagioclase. Commonly altered. Intrudes Mineral Mountain phase. At Egg Lake the granite porphyry underlies the volcanic rocks of Hannegan Pass, but a dike of this rock intrudes the northern arcuate fault bounding the volcanic rocks of Hannegan Pass, suggesting that the granite porphyry is about the same age as the volcanic rocks overall. Similar rocks crop out on Easy Ridge. Tepper (1991) includes this rock in his granodiorite porphyry of Copper Ridge.

Tcrgd Granodiorite of Ruth Creek (Miocene)—Biotite granodiorite, locally with quartz eyes up to 1 cm; CI=3–7 (Tepper, 1991). Biotite and whole-rock Rb-Sr analyses define an age of 8.7 Ma (Table 2, no. 10). As mapped includes Tepper's porphyritic tonalite of Hannegan trail, a dike-like body which intruded Tcrgd and, nevertheless, yielded a zircon fission track age of 8.7 Ma (Table 2, no. 9)

Tcdcg Granite of Depot Creek (Miocene)—Biotite hornblende granite with relict clinopyroxene cores in hornblende. A small stock in Depot Creek cirque which intrudes Tcrcg

Tcrcg Granite of Redoubt Creek (Miocene)—Biotite-pyroxene-hornblende granite, granodiorite, quartz monzonite, and quartz monzodiorite, commonly altered, with pinkish cast. CI ranges from 2 to 20 but most CI=15–17. Some rocks are porphyritic allotriomorphic and vermicular; micrographic quartz is common (Tepper, 1991). Hornblende yields a K-Ar age of 10.8 Ma (Table 2, no. 11). Mathews and others (1981) report a ca. 12 Ma K-Ar age for a stock at the head of McNaught Creek in Canada, which lies along trend just north of the quadrangle, and which we interpret to be part of the Redoubt Creek pluton (Table 2, no. 12)

Tcgh Granodiorite of Hagan Glacier (Age uncertain)—Biotite granodiorite, micrographic, highly altered. We observed no contacts but plug-like shape suggests this rock intrudes Tcbrg. As mapped includes lithologically-similar stocks cropping out in Sulphide Creek and upper Noisy Creek

Tcbx Intrusive breccia (Age uncertain)—On north ridge of Mount Blum consists of alaskite and other intermediate plutonic rocks mixed with hypabyssal volcanic rocks in altered porphyroclastic xenomorphic and cataclastic matrix of rhyolitic composition; rock is thermally metamorphosed. Breccia is cut by or marginal to a variety of silicic dike rocks. Near Tapto Lakes mafic plutonic-rock clasts such as diorite are mixed with andesite clasts in an altered dacitic matrix (Moore, 1972)

Tcsg Gabbronorite of Mount Sefrit (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). An Rb-Sr isochron age is 23 Ma (Table 2, no. 13)

Tcpt Perry Creek phase (Miocene and Oligocene)—Mostly hornblende-biotite tonalite and granodiorite, commonly with relict clinopyroxene. Quartz is typically mesostasic. CI=15–25. As mapped may include several plutons. K-Ar ages on hornblende and biotite range from about 22 to 25 Ma (Table 2, nos. 15, 16, 18); a single biotite age of 32 Ma (Table 2, no. 17) seems too old. Locally mapped as:

Tcptt Tectonized tonalite (Miocene and Oligocene)—Shattered and locally cataclastic to mylonitic, highly altered tonalite and granodiorite; mafic minerals chloritized. Includes hornfels and shattered and recrystallized plutonic and hypabyssal rocks

Snoqualmie family

Tcbg Biotite granodiorite of Little Beaver Creek (Oligocene)—Mostly hornblende-biotite granodiorite and minor granite, locally quartz and plagioclase porphyritic; CI=3–10. Intrudes Tcpt, although appears to be about the same age, with hornblende and biotite K-Ar ages of about 25 and 23 Ma respectively (Table 2, no. 14)

Tcvt 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 15–20. Two K-Ar hornblende ages are about 24 and 27 Ma and a biotite age is 26 Ma (Table 2, nos. 19, 20). The errors suggest that an age of about 26 Ma is about right, which is appropriate for evidence that the tonalite of this phase intrudes the 34-Ma gabbro of Copper Lake (Tcclg). Tepper (1991) describes a small part of this unit as the tonalite of Copper Mountain. Unit probably includes several plutons. Locally mapped as:

Tcvtd Dark tonalite (Oligocene)—Pyroxene-hornblende tonalite with distinctive dark vitreous appearance in outcrop

Index family

Tcbrg Baker River phase (Oligocene)—Mostly biotite hornblende granodiorite, with minor tonalite and quartz diorite, locally with clinopyroxene. Subhedral plagioclase in quartz mesostasis common. CI=7–25 but for most rocks in southern part CI=13–18 and, in Skagit Range, CI=17–20. Mostly tonalite and quartz diorite in Skagit Range. Engels and others (1976) interpreted a K-Ar age of an impure hornblende sample to place an older limit of 27 Ma on the southern part of this unit, but these same rocks appear to be intruded by 30-Ma alaskite of the Mount Blum pluton and hence may be older. Tonalite included in this phase in the Skagit Range may be younger because it intrudes the volcanic rocks of Big Bosom Buttes which in turn depositionally overlie 31-Ma granite and granodiorite of Mineral Mountain. Tepper (1991) describes this unit in part as the granodiorite of Hannegan Peak. Locally mapped as:

Tcbrp Price Glacier pluton (Oligocene)—Biotite-hornblende quartz diorite with mesostasic quartz. CI=16–18. Tepper (1991) describes some of this unit as part of his granodiorite of Ruth Mountain. Age uncertain

Tcst Tonalite of Silesia Creek (Oligocene)—Hornblende-biotite tonalite with inclusions and layers of biotite granodiorite and granite; some granitic xenoliths to 200 m long. Tonalite displays prominent flow alignment of feldspar and mafic minerals. Except for flow structure this pluton is petrologically similar to the 22–25-Ma Perry Creek and the 31(?)-Ma Baker River phases of the batholith. Concordant K-Ar ages of hornblende and biotite are about 30 Ma (Table 2, no. 21)

Tcba Biotite alaskite of Mount Blum (Oligocene)—Medium-grained biotite granite with prominent perthite prisms, rare hornblende, locally quartz phyric. CI=1–4. Two K-Ar biotite ages are 29.4 and 30.8 Ma. Biotite and whole-rock Rb-Sr analyses give an age of about 30 Ma. Zircon fission track ages from adjacent hornfels are about 20 Ma (Table 2, nos. 22, 23). These ages suggest that the alaskite is older than the tonalite of the Baker River phase of the Chilliwack batholith, but above Blum Lakes, where the contacts are mostly gradational, the alaskite contains inclusions of the tonalite suggesting it is at least slightly younger

Tcmbg Mineral Mountain phase (Oligocene)—Biotite granite and granodiorite with some tonalite, quartz monzodiorite and quartz monzonite. Characterized by conspicuous quartz eyes up to several cm across which are glomerocrysts of rounded quartz grains with K-feldspar in the curved triangular interstices. Biotite dominates and is usually the only mafic phase, but hornblende is more abundant than biotite in a few rocks. CI=1–19 but mostly <10. Rock is commonly pinkish and with chloritized biotite. Intruded by tonalite of Chilliwack valley phase, partly faulted against Baker River phase, and grades downward into granodiorite of Mount Despair by gradual increase in hornblende.

A chloritized granodiorite from east of the Chilliwack River above the younger Chilliwack valley phase of the batholith contains hornblende and biotite which yield K-Ar ages of about 26 and 23 Ma respectively (Table 2, no. 25). These minerals may have lost argon as K-Ar ages of muscovite and biotite from near Canada, well removed from younger plutons, are concordant at 29.5 and 30.9 Ma respectively (Table 2, no. 26). Hornblende from a dike cutting Tcmbg on Mineral Mountain yielded a K-Ar age of about 32 Ma (Table 2, no. 27). The K-Ar ages and field relations indicate that in general the Mineral Mountain phase is older than most of the tonalite such as the Perry Creek phase (at about 22-25 Ma). However, U-Pb analyses of zircon from the Mineral Mountain phase suggested an age of about 7 Ma (Table 2, no. 24), more in agreement with Tepper (1991) who shows the rock to be chemically and lithologically similar to the granodiorite of Ruth Creek which he dated at 8.7 Ma. We here tentatively adopt the older age of about 31 Ma for the Mineral Mountain phase

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 about 10–12; hornblende usually predominates. An array of isotope ages by different methods ranges from about 30 to 35 Ma (Table 2, nos. 28–36). The pluton is probably about 32 Ma. It is sharply intruded by 30-Ma alaskite of the Mount Blum pluton and appears to grade into the 31-Ma Mineral Mountain phase. Locally mapped as:

Tcda Agmatite—Swarms of dark rounded inclusions from 1/4 to several meters across composed of mafic biotite hornblende quartz diorite and fine-grained tonalite in a lighter-colored granodiorite and tonalite matrix

Tcht Heterogeneous tonalite and granodiorite of Middle Peak (Age uncertain)—Ranges from quartz diorite to biotite granite. Many rocks hornfelsic. Includes amphibolite of unknown origin

Tcmg Miscellaneous gabbros and diorites (Age uncertain)—Pyroxene hornblende gabbro, diorite and quartz diorite. Much uralite. Tepper (1991) describes several occurrences together with the gabbronorite of Mount Sefrit. Age uncertain. See also Moore (1972) and Tepper (1988) for mafic plutons north of Whatcom Pass. Locally mapped as:

Tcmge Inclusion-rich diorite of Ensawkwatch Creek—Layered hypersthene hornfels inclusions in diorite and quartz diorite.

Tcclg Gabbro of Copper Lake (Oligocene)—Hornblende gabbro and diorite with CI=25–40. Tepper (1991) describes a small core of hornblende gabbro bearing poikilitic hornblende surrounded by hornblende diorite. A 3-point Rb-Sr isochron for the gabbro gives an age of 34 Ma (Table 2, no. 38), an age supported by evidence of intrusion by tonalite of the 26-Ma Chilliwack valley phase of the batholith

Volcanic rocks of Hannegan Pass (Pliocene)

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. Hornblendes from two separate clasts of andesite yield K-Ar ages of 3.6 and 3.3 Ma (Table 2, nos. 4, 5)

Thmb Monolithologic breccia—Angular debris of older rocks, probably talus, and/or debris flow deposits

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. Zircon from a vitrophyric flow yields a FT age of 4.4 Ma (Table 2, no. 6). Further descriptions of volcanic rocks of Hannegan Pass are in Staatz and others (1972)

Tdt **Tonalite of Cascade Pass dike (Miocene)**—Medium-grained hornblende-biotite tonalite, hypidiomorphic granular with small glomeroporphyrocrysts of mafic minerals. 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 (Tabor, 1963). A number of samples from south of the Mount Baker quadrangle yielded K-Ar hornblende and biotite ages ranging from 16–19 Ma (Tabor and others, in press). Concordant pairs suggest that the age of this pluton is about 18 Ma

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. Originally called the Skagit Volcanic Formation by Daly (1912), included in the Hannegan Volcanics by Misch (1966), and renamed the Skagit Volcanics by Staatz and others (1972). The names Skagit Volcanic Formation and Skagit Volcanics were abandoned by Haugerud and others (1991). Rocks are older than the 22 to 25 Ma phase of the batholith (Tcpt) that intrudes them. K-Ar ages of about 13 Ma reported by Mathews and others (1981) have been reset by the young Redoubt Creek pluton that intrudes the volcanics of Mount Rahm

Volcanic rocks of Big Bosom Buttes (Oligocene) Unconformably overlie the 30-Ma granite of Mineral Mountain but appear to be intruded by tonalite of the Baker River phase, an anomalous relationship (see Tcbrg). Mapped as:

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. Includes dacite on Middle Peak

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 Mineral Mountain (Tcmbg)

Volcanic rocks of Pioneer Ridge (Oligocene)

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

Tvpb Mudflow breccia—Clasts of dacitic volcanic rock and abundant clasts of underlying metamorphic rock. Some volcanic-lithic wacke. Locally strongly thermally metamophosed

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Tusy **Unnamed sandstone and conglomerate, young (middle Eocene and (or) younger)**—West of lower Bacon Creek, mostly coarse cobble conglomerate with clasts derived from the Marblemount Meta Quartz Diorite (TKm) one of which yielded a zircon fission track age of 45 Ma (Table 2, no. 41). Assuming that age was not reset after deposition, unit is middle Eocene or younger

Tcs **Chuckanut Formation (Eocene)**—Mostly plagioclase arkose, biotite-rich with minor muscovite, buff-weathering, medium to thick-bedded, fluvial, and minor interbeds of siltstone, mudstone and very fine-grained sandstone. Minor pebble to cobble conglomerate. Conspicuous cross beds, 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 underlying Easton Metamorphic Suite. Small amounts of anthracite have been mined from deformed, pyritic beds near basal contact north of Coal Pass (Moen, 1969).

Chuckanut beds within the map area have been referred to the Bellingham Bay, Slide, and Warnick Members by Johnson (1982, 1984) which he felt ranged from early to middle Eocene in age. J.A. Vance (oral commun., 1993) reports that detrital zircon populations separated from numerous samples of Chuckanut Formation each show an age peak of ca. 56 Ma, implying that most of the unit is younger than this

Tuso **Unnamed sandstone and conglomerate, other (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 of underlying rocks. Southeast of Berdeen Lake includes conglomerate with clasts of granitic rock, geenstone, gneiss, schist, phyllite, minor sandstone and limestone, and abundant well-rounded cobbles of quartzite. On Mount Despair, pebble to cobble conglomerate with clasts of gneiss, metachert, and minor pegmatite; intruded by granodiorite of Mount Despair, indicating unit here is early Oligocene or older. Converted to biotite hornfels, commonly with cordierite and (or) andalusite, in proximity to younger plutons. These rocks may correlate in part with the Chuckanut Formation (Tcs) or other early Tertiary fluviatile deposits (see Tabor and others, in press)

ROCKS BETWEEN THE STRAIGHT CREEK FAULT AND THE ROSS LAKE FAULT ZONE

Skagit Gneiss Complex (Tertiary and Late Cretaceous)—Heterogeneous complex of supracrustal schist, amphibolite, rare marble and ultramafic rock 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. Misch (1966, 1968), Misch and Onyeagocha (1976), Yardley (1978), Babcock and Misch (1988, 1989), Haugerud and others (1991), and Whitney (1992a, b) describe the rocks and discuss their petrogenesis. Mapped as:

TKsgp Granite pegmatite (associated with TKeb)—Granite pegmatite 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. 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. Concordant to moderately discordant U-Pb ages of zircons from several bodies of orthogneiss suggest original igneous crystallization between 75 and 60

Ma (Table 2, nos. 55, 56, 59, 60, 62). A biotite K-Ar age of 30 Ma from Newhalem (Table 2, no. 55) must reflect subsequent heating by the nearby Chilliwack batholith. Locally mapped as:

TKsom Mafic orthogneiss—Hornblende diorite orthogneiss. Some amphibolite and hornblendite

TKsmm Mafic migmatite—Heterogeneous hornblende tonalite migmatite and orthogneiss rich in slivers of hornblendite and amphibolite. Cross-cutting light-colored dikes of light-colored, fine-grained to pegmatitic, foliated and lineated tonalite and lineated granite and granodiorite

TKson Orthogneiss of The Needle—Hornblende tonalite to granodiorite orthogneiss with distinctive texture of ca. 1 mm equant crystals forming cm-sized patches rich in quartz, feldspar, hornblende, or biotite. Dominant foliation locally axial-planar to small folds of an earlier foliation. U-Pb ages of zircons are discordant, ranging from 113 to 122 Ma (Table 2, no. 61), considerably older than other orthogneiss in the Skagit. Haugerud and others (1991) suggest the gneiss is a recrystallized Triassic pluton, coeval with Marblemount Meta Quartz Diorite

TKsu Ultramafic rock—Includes hartzburgite gneiss, talc-tremolite schist, anthophyllite-talc-tremolite schist, chlorite-rich blackwall, and retrograde serpentinite. Common relict chromite attests to igneous origin. For discussion see Whitney and Evans (1988), Misch and Rice (1975), Haugerud and others (1991), Tabor and others (1989). Shown in small outcrop with burst symbol only

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

TKmo **Orthogneiss of Marble Creek (Tertiary and Late Cretaceous)**—Biotite tonalite to granodioriote gneiss with minor hornblende, muscovite, and well-formed igneous(?) epidote. Ranges from granitoid gneiss with integranular quartz and relict euhedral oscillatory zoned plagioclase crystal to highly strained flaser gneiss with anastomosing mylonitic quartz and biotite. Pluton is rich in screens and rafts of supracrustal schists and pods of ultramafic rock. U-Pb ages of zircon are slightly discordant at about 75 Ma (Table 2, nos. 46). Haugerud and others (1991) interpret this to be the age of intrusion. K-Ar ages of muscovite and biotite—about 50 and 44 Ma respectively (Table 2, no. 47)—reflect Eocene unroofing

TKho **Orthogneiss of Haystack Creek (Tertiary and Late Cretaceous)**—Hornblende biotite gneiss, with blotchy patches of aggregate mafic minerals. K-Ar ages of muscovite and biotite, about 48 and 44 Ma respectively (Table 2, no. 45) reflect Eocene unroofing

TKao **Orthogneiss of Alma Creek (Tertiary and Late Cretaceous)**—Biotite leucogranodiorite and leucotonalite gneiss, with minor muscovite. Alma Creek Leucotronhjemite of Misch (1966). Hypidiomorphic granular with highly strained quartz; biotite commonly decussate. CI<10. Local 2-4 cm diameter orbicules are biotite which tangentially rims quartzofeldspathic cores.

Muscovite and biotite K-Ar ages of about 49 and 39 Ma respectively (Table 2, no. 44) reflect Eocene unroofing. Smaller irregular bodies northwest of Skagit River not shown

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

TKhl **Hidden Lake stock (Tertiary and Late Cretaceous)**—Biotite metatonalite with good relict hypidiomorphic granular texture. Plagioclase mostly filled with well-crystallized epidote and muscovite; some grain margins have recrystallized and quartz is sutured. Some K-feldspar is microcline. Rock is massive and sharply intrusive. Haugerud and others (1991) interpret 75 Ma zircon U-Pb (Table 2, no. 49) to represent primary crystallization. A 38 Ma K-Ar biotite age probably reflects Tertiary unroofing, perhaps with additional argon loss due to reheating by a subjacent intrusion of the Cascade magmatic arc

TKeb **Eldorado Orthogneiss (Tertiary and Late Cretaceous)**—Biotite-hornblende tonalite to biotite granodiorite gneiss; Ford and others (1988) report quartz monzodiorite southeast of quad. Medium-grained subhedral to euhedral sodic plagioclase commonly filled with epidote or clinozoisite and set in matrix of crystalloblastic to mylonitic 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 Keof. For further descriptions of lithology and mineral parageneses see McShane (1992). Concordant U-Pb isotope ages of zircon of about 88 to 92 Ma from hornblende gneiss (Table 2, no. 63; Mattinson, 1972) indicate that the protolith of the Eldorado is Late Cretaceous. Hornblende K-Ar age of 43 Ma (southeast of quad; see Engels and others, 1976) reflects Eocene unroofing. Locally mapped as:

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

Rocks derived from the Chelan Mountains terrane

TKm **Marblemount Meta Quartz Diorite of Misch (1966) (Tertiary and Late Cretaceous)**—Meta-quartz diorite and tonalite and gneiss; light-colored metatonalite dikes. Locally unmetamorphosed hornblende tonalite north of Skagit River; greenschist facies meta-quartz diorite at and south of Skagit River; locally gneissic in Cascade River area. Most common rock has CI =16–54 (Ford and others, 1988), is medium-grained, pale green, has numerous anastomosing shears rich in chlorite, epidote, and actinolitic hornblende, and varies 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. Concordant U-Pb ages of zircons are about 220 Ma (Late Triassic; Table 2, no. 69) reflecting protolith crystallization (Mattinson, 1972). A 94 -Ma K-Ar age from metamorphic muscovite from a schistose light-colored dike in the pluton (Table 2, nos. 68) could reflect early Late Cretaceous metamorphism of part of the unit, early Late Cretaceous cooling following earlier metamorphism, or (and) a combination of excess argon and latest Cretaceous to early Tertiary heating and argon loss. Locally mapped as:

TKmf 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

TKns **Napeequa unit (Tertiary and 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 rock. 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 or contorted; small crinkle folds on prominent foliation surfaces.

K-Ar ages of hornblende, muscovite, and biotite are about 55, 46 and 49 Ma respectively, reflecting Eocene unroofing (Table 2, nos. 66, 67). Locally mapped as:

TKnm Marble and minor amphibolite. Shown with star symbol or line symbol where outcrops too small to show at map scale

TKnu Ultramafic rock—Serpentinite, talc-magnesite schist, talc schist, tremolite-talc schist, and olivine-talc rocks. Shown with burst where too small to show at map scale

TKc **Cascade River unit (Tertiary and 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 (or oligoclase) schist and fine-grained paragneiss. Many rocks have garnet, less commonly staurolite and kyanite. Rare chloritoid. Hornblende-biotite-andesine schist, garbenschiefer, and fine-grained amphibolite common. Calcareous mica schist locally. Hornblende is commonly blue-green. Relict clastic textures common in metasandstone; unit includes small-pebble metaconglomerate. Most descriptions abstracted from Tabor (1961) Locally mapped as:

TKcc 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, and granitoid rocks, including rocks derived from the protolith of the Marblemount unit. A K-Ar age of muscovite from a meta-quartz diorite clast in metaconglomerate is about 46 Ma, reflecting Eocene unroofing, and is a younger age limit for metamorphism (Table 2, no. 64)

TKcmv Metavolcanic rocks—Fine grained leucogreenschist, commonly with relict highly flattened phenocrysts of plagioclase or mafic minerals. Silicic mica schist (metarhyolite) about 500 m stratigraphically above the Marblemount contact (Cary, 1990) and structurally overlain by metaconglomerate yields concordant zircon ages of about 220 Ma (Table 2, no. 65). For further descriptions see Dragovich (1989) and Cary (op.cit.)

ROCKS IN THE ROSS LAKE FAULT ZONE

TKhr **Ruby Creek Heterogenous Plutonic Belt of Misch (1966) (Tertiary and Late Cretaceous)**—Heterogneous gabbro to granodiorite in small masses and dikes. Plutons of the belt intrude phyllite and schist of Little Jack Mountain and, east of quad along State Route 20, intrude Skagit Gneiss Complex. Much medium-colored hornblende biotite tonalite, fine to medium grained, locally cataclastic. Abundant light-colored hornblende biotite tonalite to granodiorite. Just east of the quadrangle on SR 20, U-Pb analyses of zircons from an undeformed light-colored tonalite yield an age of 48 Ma (Miller and others, 1989). Locally shown containing:

TKhrs Prominent remnants of Skymo Complex of Wallace (1976)—Similar to TKhr but with many small masses of metagabbro and meta-ultramafic rock

TKsmc **Skymo Complex of Wallace (1976) (Tertiary and Late Cretaceous)**— Troctolite, gabbronorite, and anorthosite intruded by irregular patches and veins of lighter-colored medium- to coarse-grained gabbro and rare tonalitic pegmatite. Gabbro-norite 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. Wallace (op. cit.) describes gneissic granulites and considered the rocks to have been metamorphosed in the granulite facies. For additional description see Wallace (op. cit) and Kriens (1988)

Rocks derived from the Little Jack terrane

TKlp **Phyllite and schist of Little Jack Mountain (Mesozoic)**—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 NW-trending, stretching lineation. Some description in Staatz and others (1972) and Wallace (1976). Locally mapped as:

TKlu Ultramafic rocks (Mesozoic)—Metaperidotite and metapyroxenite. Shown by burst symbol for outcrop too small to show at map scale

Hozameen terrane

Hozomeen Group of Cairnes (1944) (Mesozoic and Paleozoic)

JTRhgs Greenstone, clastic sedimentary rocks, limestone, chert (Jurassic and Triassic)—Heterogeneous, discontinuously bedded greenstone, greywacke, argillite, marble and ribbon chert. Local chaotic mixing suggestive of deposition by submarine landslides. Greenstones commonly derived from Ti-rich basalt, locally with good pillows. Partially recrystallized to prehnite-pumpellyite facies. Limestones mostly coarsely-recrystallized, gray, and in discrete 0.1–10 m pods. Deformational fabric ranges from none to (mostly) incipient slatey cleavage. Description modified from Haugerud (1985). Unit Mzhgs corresponds to the uppermost of 4 units described by McTaggart and Thompson (1967). Radiolarians in correlative rocks north of quad yield Late Triassic (Table 1, nos. 83f–86f) and Jurassic (Table 1, nos. 81f, 82f) ages

TRhc Chert (Triassic)—Mostly ribbon chert and slatey argillite with minor greenstone and marble. Radiolarians yield Middle and Late Triassic ages (Table 1, nos. 77f, 78f, 80f). Probably corresponds to 3rd highest of 4 units described by McTaggart and Thompson (1967)

Pzhg Greenstone with minor argillite, chert, and limestone (late Paleozoic)—Mostly pillow basalt, pillow breccia, flows, and minor basaltic tuff, with minor argillite, ribbon chert, limestone. Partially recrystallized to prehnite-pumpellyite facies. Radiolarians from off quad to east are Permian (Table 1, no. 87f). Probably corresponds to 2nd highest of 4 units described by McTaggart and Thompson (1967). Ray (1986) reports some chemical data from Hozomeen greenstones. Locally mapped as:

Pzhgl Limestone, chert and minor greenstone and metatuff—Mostly gray well-recrystallized limestone. Conodonts from a limestone north of Mount Hozomeen are Early to Middle Pennsylvanian in age (Table 1, no. 76f)

ROCKS WEST OF THE STRAIGHT CREEK FAULT

Rocks of the Northwest Cascade System

Welker Peak and Excelsior nappes

bg **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 contains abundant fossil plant material. See Johnson (1982, 1984) for further description.

Two chert clasts yield possible Triassic and Late Triassic radiolarians. Poorly preserved pollen from a shale interbed suggests a Late Cretaceous to early Tertiary age (Table 1, nos. 1f–3f), which led Johnson (1982, 1984) to consider unit a member of the Chuckanut Formation. Deformation of unit makes a pre-Tertiary age more likely. Locally mapped as:

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

Rocks of the Bell Pass mélange

KJbu Bell Pass mélange undivided (Cretaceous and Late to Middle (?) Jurassic)—Disrupted argillite, slate, phyllite, sandstone, semischist, ribbon chert, and basalt of the Elbow Lake Formation of Brown and others (1987), with tectonic clasts of meta-igneous rocks, gneiss, schist, ultramafic rocks, and marble. Sandstone commonly lithic subquartzose, either volcanic rich and(or) chert rich; argillite is mostly scaley, and grades into slate and phyllite. Greenstones are recrystallized mafic basalt, mafic tuff, diabase, and gabbro and commonly make the most prominent outcrop. Metamorphic minerals in greenstones and metasedimentary rocks are chlorite, epidote, albite, pumpellyite, rare actinolite, carbonate and indistinct masses of pumpellyite and(or) lawsonite.

Ribbon chert of the Elbow Lake unit, commonly highly deformed and locally occurring as resistant knockers, yields mostly Jurassic and Triassic radiolarians; a few late Paleozoic forms have been identified (Table 1, nos. 29f–47f). Sevigny and Brown (1989) report chemical characteristics of the high-Ti greenstones of the unit.

Tectonic clasts within the Bell Pass mélange are locally mapped as:

bb Blueschist of Baker Lake (Jurassic to Cretaceous)—Metabasaltic rocks, meta-ribbon chert, and marble, characterized by distinctive (for the NWCS) high pressure/low temperature crossite + lawsonite $\pm$ aragonite metamorphism. Metabasaltic rocks range from very fine-grained schistose metatuff to incipiently recrystallized basalt. Protolith assemblage—especially basalt with high-Ti clinopyroxene—appears correlative with the Elbow Lake unit, indicating metamorphism is younger. Brown and others (1987) report a 127 Ma whole rock K-Ar age of uncertain significance (Table 2, no. 74). Leiggi (1986) and Brown and others (1981, 1987) describe petrographic and chemical aspects of the unit

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

byan Non-gneissic rocks—Metagabbro, metadiabase, metatonalite, and minor gneissic igneous rocks. May include Mesozoic or late Paleozoic intrusive rocks similar to 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. Includes areas lacking siliceous gneiss but with strongly mylonitic quartz-rich meta-igneous rocks. Talus blocks east of Park Butte show lithologic gradation from graphitic marble to quartz-rich pyroxene gneiss, establishing that at least some of gneiss is metasedimentary. Gneissic granite with K-feldspar megacrysts known only from Kidney Creek, northwest of Church Mountain. Most rocks are highly strained and recrystallized in amphibolite or upper greenschist facies. Locally, intruded by associated metagabbro, metadiabase, and metatonalite. Descriptions and chemical data in Blackwell (1983), Sevigny (1983), and Sevigny and Brown (1989).

Discordant U-Pb ages of zircon and sphene from pyroxene gneisses range from 64 to 912 Ma (Table 2, nos. 84–88). Mattinson (1972) interpreted a 1.4 Ga (Proterozoic) Pb-Pb age for pyroxene gneiss, thought to be orthogneiss, to represent a minimum protolith age for rock metamorphosed at about 400 Ma (Devonian) and perhaps at about 270 Ma (Permian) as well. Rasbury and Walker (1992) report similar analyses of single zircon grains, but interpret the zircons to be detrital relics of 1.85 Ga crust

byu Ultramafic rocks—Serpentinite and serpentinized hartzburgite. For descriptions see Sevigny (1983)

bu Ultramafic rocks—Serpentinite and partially serpentinized dunite and hartzburgite. Detailed descriptions of petrography, chemistry, and metamorphism are in Leiggi (1986). Outcrops too small to show at map scale shown with burst symbol. Locally mapped as:

but Twin Sisters Dunite of Ragan (1961)—Dunite and minor harzburgite, locally serpentinized. Enstatite-bearing dunite with accessory chromite and chromium diopside; olivine has a high-temperature tectonite fabric indicative of a mantle origin (Christensen, 1971; Hersch, 1974; Levine, 1981). High-temperature metamorphic layering of chromite and pyroxenes generally steep and parallel to the long axis of the body as are zones of finely-recrystallized olivine (Ragan, 1963). On the basis of gravity and magnetic measurements, Thompson and Robinson

(1975) show the mass to be a plate-like body, mostly less than 2 km thick, but with a serpentinite keel on the west (see cross-section CC')

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

bv Vedder Complex of Armstrong and others (1983) (Permian)—Amphibolite, blueschist, micaceous quartzite, and mica quartz schist. Some garnet. Amphiboles are hornblende, actinolite, and barroisite. Some amphibolites are albite-porphyroblastic. In the quadrangle, K-Ar ages range from 196 to 283 Ma (Table 2, nos. 75–80), and in the type area on Vedder Mountain, 13 km northwest of the quadrangle, Rb-Sr ages of minerals and rocks are in the 229–285 Ma range (Armstrong and others, 1983). Petrographic, chemical, and isotopic data are in Armstrong and others (1983)

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

KJrs **Slate of Rinker Ridge (Cretaceous and Late to Middle Jurassic)**—Slate and semischist. Similar to semischist and phyllite of Mount Josephine, but less thoroughly recrystallized. Exposed only in lower Skagit River valley. Structural position suggests this protolith of this unit was sedimentary rock of the Chilliwack Group. Metamorphism presumably is coeval with deformation in the Excelsior and Welker Peak nappes, of probable Middle to Late Jurassic and (or) Cretaceous age. For more thorough description of unit see Tabor and others (in press)

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. 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 Cultus Formation consists of albitic plagioclase and quartz, commonly in micrographic intergrowths, with <10% chlorite, epidote, and opaque ore minerals which have replaced hornblende and (or) biotite. Some of these rocks are described by Blackwell (1983).

Stock near Lake Ann has largely undeformed hypidiomorphic granular texture with relict green hornblende in quartz-rich mesostasis. It intrudes the probable Late Permian rocks of Mount Herman (Chilliwack Group)

MzPzcc **Chilliwack Group and Cultus Formation undivided (Mesozoic and Paleozoic)**

JTRc **Cultus Formation (Early Jurassic and Late Triassic)**—Tuffaceous siltstone, sandstone, and argillite, mostly thin-bedded to finely laminated. Much rhythmite. Medium-bedded sandstone on Loomis Mountain. For further description, see Blackwell (1983). Radiolarians from several localities are Triassic (Table 1, nos. 5f, 6f, 8f), but in the area of Frost Creek on the northern border of the map, a chert layer yields probable Middle to Late Jurassic radiolarians (Table 1, no. 7f). Locally mapped as:

JTRcd Dacite and associated tuffaceous sedimentary rocks—Generally light green vitreous metadacite with microphenocrystic plagioclase. Interbedded limestone on Loomis Mountain contains Triassic corals (Table 1, no. 4f)

PDcs **Chilliwack Group (Permian, Carboniferous, and Devonian)**—Mostly basalt, andesite, dacite, volcanic breccia and tuff, marble, well-bedded gray to brown and black argillite and volcanic subquartzose sandstone with minor pebble conglomerate, and rare chert. Graded beds, scour structures, and load casts locally prominent; 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. Chilliwack Group rocks are described by Misch (1966), Monger (1970), Blackwell (1983), Christianson, (1981) and Smith (1985, 1988).

Fusulinids and macrofossils in limestone range from Devonian to Permian (Table 1, nos. 9f–27f). Distinctive 1- to 3-cm diameter crinoid columnals led Danner (1966) to correlate many marble outcrops with his Red Mountain limestone unit, which he considered to be Pennsylvanian. Liszak (1982) restudied the Red Mountain fauna and determined a Mississippian (late Visean) age, which we adopt for all the large-crinoid limestones of the NWCS (Table 1, nos. 12f, 15f, 17f, 19f, 23f, 24f). Single crystal U-Pb ages of detrital zircons from Chilliwack clastic rocks in the Jackman Creek area (Table 2, nos. 81–82) suggest Late Devonian deposition of the original sediments (McClelland and Mattinson, 1993). Locally mapped as:

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

Pcms Sedimentary rocks of Mount Herman (Permian)—Volcanic sandstone, argillite, and limestone. Generally well-bedded and with little foliation. Radiolarians from siliceous siltstone interbedded with limestone southeast of Coleman Pinnacle are ?Late Permian in age (Table 1, no. 28f)

PDcv Volcanic rocks—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. Plagioclase is mostly recrystallized as albite. Includes some gabbro and diabase

PDcl Limestone and marble—Mostly coarsely crystalline, gray to black, and petroliferous; in small isolated pods and blocks; locally fossiliferous

Harrison Lake terrane

Kg **Gabbroic intrusions (Early Cretaceous?)**—Metagabbro with relict clinopyroxene. Altered to chlorite, epidote, albite, carbonate, and montmorillonoids after olivine(?). Intrudes Nooksack Group northwest of Mount Baker. Lithologically similar dikes form swarm to southeast of intrusion

Nooksack Group (Early Cretaceous and Late and Middle(?) Jurassic)—Described here as sedimentary rocks, though much of the unit is incipiently recrystallized (Brown and others, 1981; 1987). Mapped as:

KJna Argillite and sandstone—Predominantly massive to laminated black argillite. Locally with thin to medium beds of mostly lithic-volcanic sandstone. Minor limey 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 Wells Creek Volcanics of Misch (1966) rich in pyrogenic plagioclase and quartz phenocrysts. Belemnite molds characteristic. Locally abundant macrofossils indicate most of the unit is Late Jurassic to Early Cretaceous in age (Table 1, nos. 48f–75f). Misch (1966) and Sondergaard (1979) describe unit in more detail

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

KJng Grit and thick bedded sandstone—Poorly rounded to angular 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 to 1 meter diameter. Some well-bedded volcanic sandstone and tuff. Belemnite fragments common

Jw **Wells Creek Volcanics of Misch (1966) (Middle Jurassic)**—Incipiently recrystallized andesite, dacite, dacite breccia and tuff with some argillite interbeds. Metamorphic pumpellyite, chlorite, epidote, albite. See Misch (1966, 1977b) and Franklin (1985) for further description. U-Pb ages of zircon from a tuff are 173–175 Ma (Table 2, no. 70) and are interpreted by J.M. Mattinson (cited in Franklin, 1985) to indicate crystallization at about 175–180 Ma

Shuksan nappe

Easton Metamorphic Suite (Early Cretaceous)

Ked Darrington Phyllite—Silvery to black quartzose graphitic phyllite, with minor greenschist, metachert, and muscovite-quartz-albite schist. Commonly with multiple crenulation lineations and abundant quartz veins. Dominant foliation is commonly second-generation or later. Mineralogy is quartz–albite–white mica–chlorite, ± lawsonite, garnet, 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 Kes

Kes Shuksan Greenschist—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. Blueschist bears Na-amphibole (crossite–soda actinolite–riebeckite) ± hematite (Brown, 1986). Locally interlayered with Ked.

Bulk compositions indicate a basaltic, largely MORB, protolith (Street-Martin, 1981; Dungan and others, 1983). Armstrong (1980) and Brown and others (1982) proposed that the protolith age of the Easton Metamorphic Suite is Jurassic, possibly Late Jurassic. More recently a Middle Jurassic protolith age has been interpreted from a 163 Ma $^{206}Pb/^{238}U$ zircon age of a metadiorite within rocks west of the quad thought to be correlative with the Darrington Phyllite (Brown, 1986; Gallagher and others, 1988).

Epidote balls, knots and masses formed during early static hydrothermal metasomatism; the balls are vesicle fillings (Haugerud, 1980; Haugerud and others, 1981; compare, Misch, 1965). Co-occurrence of abundant white mica, Na-amphibole and hematite suggest oxidation and incorporation of potassium during submarine weathering.

Subsequent blueschist-facies metamorphism involved large strains, as schists are commonly conspicuously layered on the centimeter scale, and foliation and layering are tightly folded on the outcrop scale. Metamorphism at P~8 kb, T~400°C (Brown, 1986) is dated by K-Ar and Rb-Sr at 120–130 Ma (Table 2, nos. 79, 80). Latest Jurassic metamorphism at higher temperatures is evident at Gee Point, south of the Mount Baker quadrangle (Brown and others, 1982; Armstrong and Misch, 1987; Tabor and others, in press)

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

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

Kju Ultramafic rock—Serpentinite and silica-carbonate rock

LIST OF ILLUSTRATIONS

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TABLE 1—Fossils and fossil locations in the Mount Baker 30- by 60-minute quadrangle, Washington

Map no.	Sample number	Latitude	Longitude	Description	Age	Reference
				Conglomerate of Bald Mountain		
1f	SJ88-BM1	48°58.13'	121°57.18'	Pollen from mudstone	Late Cretaceous-Early Tertiary	E. Leopold, written comm. to S.Y. Johnson, 1980
2f	RH88-139a	48° 57.61'	121°56.50'	Radiolarians in chert clasts in younger conglomerate	?Triassic	C.D. Blome, written comm., 1990
3f	RH88-106a	48°36.08'	121°49.23'	Radiolarians in sandstone and chert granules in younger rock	Late Triassic	Do.
				Cultus Formation		
4f	91-115	48°40.79'	121°50.26'	Coral and spongiomorph in limestone	Triassic	W.R. Danner *in* Blackwell, 1983, p. 70l
5f	RWT 309-87	48°40.83'	121°50.26'	Radiolarians in limey argillite	?Triassic	C.D. Blome, written comm., 1988
6f	1502-517	48°59.8'	121°56.7'	Ammonites and belemnites in argillite	Jurassic (originally reported as Triassic, but fossil since reclassified as Jurassic)	T.W. Stanton *in* Daly, 1912, p. 517; Hillhouse, 1956
7f	RWT 133-88	48°59.98'	121°56.14'	Radiolarians in chert	Probably Middle or Late Jurassic	C.D. Blome, written comm., 1990
8f	RWT 65-90	48°34.91'	121°39.79'	Radiolarians in thinly laminated chert	Probably Late Triassic, Karnian or Norian	C.D. Blome, written comm., 1991
				Chilliwack Group		
9f	101-234	48°59.65'	121°54.97'	Fusulinids in limestone	Permian	Jones, 1984, p. 25 and 27
10f	D248	49°00.0'	121°55.7'	Fusulinid in limestone	Permian	Danner, 1966, p. 248
(11f)	M58	49°00.19'	121°59.16'	Fusulinids in limestone; off quad to north	Early Permian	Monger, 1966, p. 173
12f	101-109	48°59.59'	121°51.35'	Crinoids in limestone	Mississippian (?)*	Jones, 1984, p. 25
13f	101-311	48°59.64'	121°50.82'	Carbonized plant debris in clastic rocks	Probably Pennsylvanian	Rouse, *in* Jones, 1984, p. 32
14f	D255	48°54.75'	121°55.08'	Coral in limestone	Devonian	Danner, 1966, p. 255-256
15f	D257	48°43.24'	121°53.15'	Crinoids in limestone	Mississippian*	Danner, 1966, p. 257

16f	101-188	48°58.17'	121°54.22'	Corals in limestone	Probably Devonian	W.R. Danner, *in* Jones, 1984, p. 22
17f	D263	48°39.3'	121°46.1'	Large crinoid stem fragments	Mississippian*	Danner, 1966, p. 263
18f	RH90-43	48°38.2'	121°48.8'	Fine plant hash and stem impression	Paleozoic	S. H. Mamay, written comm., 1991
19f	D264	48°37.81'	121°49.69'	Crinoids, bryozoans and brachiopods in limestone	probably Mississippian*	Danner, 1966, p. 264-268
20f	RH 90-46	48°37.66'	121°48.66'	Stem casts in fine grained sandstone	Pennsylvanian-Early Permian	S.H. Mamay, written comm., 1991
21f	RH 90-47	48°37.43'	121°48.95'	Conodont from limestone	Middle Pennsylvanian	A.G. Harris, written comm., 1991
22f	CO 121-85	48°35.55'	121°39.95'	Conodonts in crinoidal limestone	Late Mississippian, Chesterian	R.T. Lierman and K.S. Schindler, written comm., 1986
23f	D271	48°33.10'	121°44.05'	Crinoids in limestone	Mississippian*	Danner, 1966 p. 271-275
24f	D271	48°33.15'	121°43.12'	Crinoids in limestone	Mississippian*	Do.
25f	D276	48°33.22'	121°39.16'	Coral in limestone	Devonian	Danner, 1966, p. 277
26f	D281	48°32.87'	121°38.49'	Corals and stromatoporoids in limestone	Devonian(?)	Danner, 1966, p. 281-282
27f	D289	48°30.01'	121°35.63'	Brachiopods in limestone	Silurian-Devonian	Danner, 1966, p.289-292
				Volcanic rocks of Mount Herman		
28f	RH90-138	48°48.78'	121°42.94'	Radiolarians in siliceous siltstone	?Late Permian (Guadalupian)	C.D. Blome, written comm., 1991
				Bell Pass melange		
29f	RWT 120-88	48°59.68'	121°59.87'	Radiolarians in cherty argillite	?Jurassic	C.D. Blome, written comm., 1990
30f	RH88-141a	48°58.90'	121°57.13'	Radiolarians in chert	Late Jurassic (undifferentiated)	Do.
31f	RH88-142a	48°58.86'	121°56.30'	Radiolarians in black chert	Permian (undifferentiated)	Do.
	RH88-142b			Radiolarians in grey chert	Early Permian	Do.
32f	RH88-138a	48°57.19'	121°56.29'	Radiolarians in chert	Mesozoic	Do.

33f	RH88-136	48°56.93'	121°56.04'	Radiolarians in chert	?Late Triassic	Do.
(34f)	RH88-150	48°56.81'	122°00.89'	Radiolarians in chert; off quad to west	?Permian	Do.
35f	RH88-153	48°57.98'	122°01.69'	Radiolarians in red chert	Permian	Do.
36f	RWT 100-88	48°49.32'	121°58.91'	Radiolarians in black chert	Mesozoic	C.D. Blome, written comm., 1989
(37f)	B871	48°46.70'	122°03.40'	Radiolarians in chert; off quad to west	Mesozoic, probably Jurassic	B. Murchey, written comm., 1986
38f	RH88-116	48°46.03'	121°58.13'	Radiolarians in chert	Late Triassic	C.D. Blome, written comm., 1990
39f	RH88-114b	48°45.91'	121°58.52'	Radiolarians in chert	Late Triassic	C.D. Blome, written comm., 1989
40f	KD 43-87	48°39.82'	121°47.43'	Radiolarians in interbedded chert and argillite	?Late Triassic	C.D. Blome, written comm., 1988
41f	RWT 84-90	48°56.47'	121°41.63'	Highly deformed chert	?Triassic or ?Early Jurassic	C.D. Blome, written comm., 1991
42f	RWT 82-90	48°56.11'	121°41.61'	Highly deformed chert	Questionable Middle or Late Jurassic	Do.
43f	RH90-66	48°50.49'	121°39.12'	Highly deformed chert	Mesozoic	Do.
44f	MR0922	Probably same locality as # 47		Radiolarians in chert	Late Penn. to Early and middle Permian	D. L. Jones and B. Murchey, written comm. to W.R. Danner, 1980
45f	RH88-35	48°43.52'	121°36.26	Radiolarians in chert	Mesozoic Jurassic?	C.D. Blome, written comm., 1990
46f	RH86-153	48°45.1'	121°37.3'	Radiolarians in chert	Triassic (? Late Triassic)	C.D. Blome, written comm., 1993
47f	RH86B-141a	48°41.7'	121°37.8'	Radiolarians in chert	Probably early to mid Permian	Do.
				Nooksack Group		
48f	101-108	48°56.74'	121°49.84'	Belemnite in siltstone	Late Jurassic to Early Cretaceous	Jones, 1984 p. 40,43
49f	101-98	48°55.88'	121°51'	Pelecypod in volcanic arenite	Late Jurassic to Early Cretaceous	Jones, 1984 p. 40-41
50f	RWT 163-88	48°56.05'	121°47.35'	Radiolarians in cherty argillite and siltstone	Mesozoic (?Jurassic)	C.D. Blome, written comm., 1990
51f	9.22.52.2	48°55.77'	121°49.04'	Belemnites	Jurassic-Lower Cretaceous	J.A. Jeletzky, GSC Report no. K-9-1954/1955 and PMA**
52f	9.22.52.15	48°55.67'	121°50.33'	Pelecypods and belemnites	Mid Late Jurassic	Do.
53f	9.22.52.14	48°55.51'	121°49.70'	Belemnites	Jurassic-Lower Cretaceous	Do.

54f	8.29.54.27	48°55.10'	121°51.35'	?	Mid Late Jurassic, Lower Kimmeridgian	authority unknown, PMA**
55f	10.4.54.1	48°54.69'	121°47.54'	?	Middle Jurassic (Early Cretac?)	Do.
56f	101-256	48°55.04'	121°53.11'	Pelecypod in siltstone	Late Jurassic to Early Cretaceous	Jones, 1984 p. 40-41
57f	9.23.52.5	48°54.34'	121°52.61'	Pelecypods	Mid Late Jurassic, Oxfordian to Lower Kimmeridgian	J.A. Jeletzky, GSC Report no. K-9-1954/1955 and PMA**
58f	9.23.52.4	48°54.30'	121°53.38'	Belemnite in float	Jurassic-Lower Cretaceous	Do.
59f	9.23.52.7	48°54.30'	121°51.43'	Pelecypods and belemnites in float	Mid Late Jurassic, Oxfordian to Lower Kimmeridgian	Do.
60f	9.15.77.3	48°54.19'	121°52.99'	?	Early Cretaceous, Upper Valanginian	authority unknown, PMA**
61f	9.17.77.4	48°54.19'	121°52.41'	?	Late Jurassic, Oxfordian-Kimmeridgian	Do.
62f	Misch 77	48°53.83'	121°53.74'	?	Early Cretaceous, Upper Valanginian	Do.
63f	9.23.52.1	48°53.76'	121°54.92'	Belemnite	Jurassic-Lower Cretaceous	J.A. Jeletzky, GSC Report no. K-9-1954/1955 and PMA**
64f		48°53.37'	121°51.85'	?	Early Cretaceous, Middle or Upper Valanginian	authority unknown, PMA**
65f		48°53.36'	121°51.92'	? in float	Early Cretaceous, Middle or Upper Valanginian	Do.
66f	RH88-180c	48°52.87'	121°56.22'	Radiolarians in argillite concretions	?Middle Jurassic	C.D. Blome, written comm., 1990
67f	9.21.52.8	48°52.44'	121°45.91'	Pelecypods	Mid Late Jurassic, Oxfordian to Lower Kimmeridgian	J.A. Jeletzky, GSC Report no. K-9-1954/1955 and PMA**
68f	9.2.54.10	48°50.71'	121°51.22'	?	Latest Jurassic, Purbeckian (Upper Tithonian)	authority unknown, PMA**
68f	9.2.54.11	48°50.71'	121°51.22'	? in float	Late Jurassic, Portlandian to Purbeckian	Do.
69f	9.2.54.1	48°49.60'	121°50.72'	?	Mid Late Jurassic, Upper Oxfordian or Lower Kimmeridgian	Do.
70f	7.10.49.1	48°48.66'	121°49.32'	Pelecypods in thin limestone	Earliest Cretaceous, Middle or (?)Upper Valanginian	J.A. Jeletzky, GSC Report no. K-9-1954/1955 and PMA**
71f	KA90-205A	48°47.09"	121°53.09'	Radiolarians in concret. in argillite	?Cretaceous (middle to late)	C.D. Blome, written comm., 1991
72f	RH88-96b	48°45.65'	121°42.85'	Radiolarians in slaty, phyllitic argillite	Early Jurassic to Cretaceous	C.D. Blome, written comm., 1990

73f	RWT 303-85	48°41.76'	121°43.56'	Radiolarians in oncret. in slatey arg.	Mesozoic or younger	C.D. Blome, written comm., 1986
74f	RWT 305-85	48°41.64"	121°43.32'	Radiolarians in concret. in slatey arg.	Possibly Late Jurassic	Do.
75f	RWT 297-92	48°57.42"	121°39.06'	Belemnite in argillite	Lower Jurassic to Early Cretaceous	W. Elder, oral comm., 1993
				Hozameen Group		
76f	RWT310-91	48°59.71'	121°00.39'	Conodonts m(CAI=chiefly 6, one at 3 or 4; contact met. at >200°C but prob. <400°C)	Early to Middle Pennsylvanian	Bruce R. Wardlaw, written comm., 1991
77f	RH81-D28a	48°55.77'	121°04.09'	Radiolarians in chert	Late Triassic, Karnian-Norian	E.A. Pessagno, written comm., *in* Haugerud, 1985
78f	RH 81-D14a	48°55.15'	121°05.85'	Radiolarians in chert	Late Triassic, Upper Karnian? lower to upper middle Norian	Do.
79f	KD 94-87	48°51.47'	121°05.06'	Radiolarians in chert	?Early Cretaceous	C.D. Blome, written comm., 1988
(80f)	RH81-D59b	49°04.72'	121°06.62'	Radiolarians in chert; off quad to north	Middle Triassic, Ladinian	E.A. Pessagno, written comm., *in* Haugerud, 1985
(81f)	RH81-D72b	49°04.54'	121°14.02'	Radiolarians in chert; off quad to north	Jurassic, Sinemurian or younger	Do.
(82f)	RH81-D73b	49°04.54'	121°14.10'	Radiolarians in chert; off quad to north	Middle Jurassic, Aalenian to upper lower Bajocian	Do.
(83f)	RH81-D75g	49°04.18'	121°13.21'	Radiolarians in chert; off quad to north	Late Triassic, Upper Karnian(?); lower to upper middle Norian	Do.
(84f)	RH82-E19b	49°04.73'	121°14.02'	Radiolarians in chert; off quad to north	Late Triassic, Upper Karnian(?); lower to upper middle Norian	Do.
(85f)	RH82-E20b	49°02.31'	121°11.56'	Radiolarians in chert; off quad to north	Late Triassic, upper middle Norian	Do.
(86f)	RH82-E36b	49°03.85'	121°13.22'	Radiolarians in chert; off quad to north	Late Triassic, Upper Kamian(?); lower to upper middle Norian	Do.
(87f)	-----	48°45'	120°51'	Radiolarians in chert; off quad to east	Permian	Tennyson and others, 1981

* These samples of coarse crinoidal limestone were identified by the cited authors as Pennsylvanian by lithologic correlation with the Red Mountain limestone unit of Danner (1966), which is now known to be late Visean (Mississippian) in age (Liszak, 1982). See text for discussion

** PMA = unpublished map of Mount Baker 15' quadrangle by Peter Misch, in archives, Suzallo Library, University of Washington, Seattle

Table 2—Summary of fission track (FT) and isotope age analyses of rocks in and near the Mount Baker 30- x 60-minute quadrangle, Washington

[nn=no sample number available. Map numbers in parentheses are not on this map. All fission-track ages calculated with F=7.03x10^{-17}/yr. All USGS K-Ar ages calculated on basis of 1976 IUGS decay and abundance constants. K-Ar ages from Engels and others (1976) and earlier reports are corrected by use of table in Dalrymple (1979). Errors on single new K-Ar ages of this report based on an empirical function relating the coefficient of variation in the age to percent radiogenic argon (Tabor and others, 1985). U-Th-Pb isotope ages reported in following order $^{206}Pb/^{238}U$; $^{207}Pb/^{235}U$; $^{207}Pb/^{206}Pb$; $^{208}Pb/^{232}Th$. Constants: $^{238}U=1.55125x10^{-10}$/yr; $^{235}U=9.8485x10^{-10}$/yr; $^{232}Th=4.9475x10^{-11}$/yr; $^{238}U/^{235}U=137.88$]

Map no.	Sample number	location Lat N	Long W	Method	Material*	Age (m.y.)	Map unit, comment	References
				Deposits of Mount Baker volcano				
1	nn	48°54'	121°47'	K-Ar	whole rock	0.4 ± 0.1	hypersthene basalt; loc. uncertain	Easterbrook (1975)
2	nn	48°51'	121°42'	K-Ar	whole rock	0.4 ± 0.2	hornblende andesite; loc. uncertain	Do.
				Volcanic deposits of Swift Creek				
3	RH90-122	48°48.7'	121°43.9'	FT	zircon	1.46±0.15	Biotite dacite dome	J.A.. Vance (written commun., 1992)
				Volcanic rocks of Hannegan Pass				
4	RWT469A-67	48°51.8'	121°31.2'	K-Ar	hornblende	3.6 ± 1.0	Andesite clast	Engels and others (1976)
5	RWT469B-67	48°51.8'	121°31.2'	K-Ar	hornblende	3.3 ± 1.0	do.	Do.
6	TG90-64	48°53.2'	121°31.7'	FT	zircon	4.4±0.5	Biotite vitrophyre	J.A. Vance (written commun., 1992)
				Chilliwack composite batholith				
7	RWT 480-67**	48°49.6'	121°37.8'	K-Ar	biotite	2.7 ± 0.3	Lake Ann stock	Engels and others (1976)
8	DFC 1-69	48°50'	121°38'	K-Ar	biotite	2.5 ± 0.1	Hornfels adjacent to Lake Ann stock	Do.
9	CB87(JT)-120	48°53.8'	121°33.6	FT	zircon	8.7	Granodiorite of Ruth Creek	J.A. Vance cited in Tepper (1991)
10	CB82-074	48°53.8'	121°34.7'	Rb-Sr	biotite-wr	8.7	do.	Tepper (1991; written commun., 1993)
11	RWT 500-66	48°56.4	121°18.2'	K-Ar	hornblende	10.8 ± 0.9	Granite of Redoubt Creek	Engels and others (1976)
(12)	---	49°00.7'	121°12.3	K-Ar	biotite	12.1± 0.4	Just north of quadrangle	Mathews and others (1981)
13	CB88-038	48°53.0'	121°34.6'	Rb-Sr	biot–cpx–plg–wr isochron	22.85 ± 0.05	Gabbronorite of Mount Sefrit	Tepper (1991; written commun., 1993)

14	PM 27***	48°54.6'	121°11.8'	K-Ar	hornblende	25.2 ± 0.7	Biotite granodiorite of Little Beaver Creek.	Engels and others (1976)
				K-Ar	biotite	22.6 ± 0.7		
15	RWT 474-67	48°51.6'	121°18.4	K-Ar K-Ar	hornblende biotite	21.6 ± 0.7 21.9 ± 0.7	Perry Creek phase	Do.
16	RWT 501-66	48°57.2'	121°10.4'	K-Ar	hornblende	23.0 ± 0.7	do.	Do.
				K-Ar	biotite	25.3 ± 0.7		
17	PM 7	48°57'	121°10'	K-Ar	biotite	31.8	Perry Creek phase, location uncertain	Engels and others (1976)
18	75R-66	48°58.5'	121°0.1'	K-Ar	biotite	23.8 ± 0.7	Hozameen plug	Do.
19	RH90-194	48°55.25'	121°27.3'	K-Ar	hornblende	23.8 ± 1.7	Chilliwack valley phase	This report
20	RWT 475-67	48°59.4'	121°28.7'	K-Ar K-Ar	biotite amphibole	25.7 ± 0.8 27.1 ± 3.0	do.	Engels and others (1976)
21	RWT 206-91	48°59.2'	121°36.2'	K-Ar	hornblende	30.3 ± 1.2	Tonalite of Silesia Creek	This report
				K-Ar	biotite	30.7 ± 0.9		
22	R-212	Location uncertain		K-Ar	biotite	29.4, 30.8 (average 30.1 ± 0.7)	Mount Blum pluton	J.A. Vance (written commun., 1986)
				Rb-Sr	biotite–wr	30.3 ±0.6		
23	JV	Location uncertain		FT	zircon	20	Hornfels adjacent to Mount Blum pluton	Do.
24	RWT 269-87	48°50.2'	121°27.2'	U-Pb	zircon		Mineral Mountain phase; age suspect, see text	J.S. Stacey (written commun., 1988)
					nm [+102]	7.5; 7.4; 14.3; --		
					nm [-63]	7.4; 8.1;225.6; --		
					m [-63]	7.3; 7.5; 44.3;--		
25	RWT 298-90	48°54.5'	121°23.7'	K-Ar K-Ar	hornblende biotite	26.5 ± 1.3 23.4 ± 0.6	Mineral Mountain phase	This report
26	RWT 476-67	48°59.6'	121°32.9'	K-Ar K-Ar	biotite muscovite	30.9 ± 0.9 29.5 ± 1.2	do.	Engels and others (1976)
27	RWT 482-67	48°51.7'	121°28.8'	K-Ar	hornblende	32.5 ± 2.1	Dike cutting Mineral Mountain phase	Do.
28	JV 290	48°40.4'	121°19.5'	K-Ar	biotite	29.5 ± 0.6	Granodiorite of Mount Despair	J.A. Vance (written commun., 1986)
				K-Ar FT U-Pb	hornblende zircon zircon	32.9 ± 3.1 33.1		Vance and others (1986)
					fine	--; --; 31.9; --		
					coarse	--; --; 31.8; --		
				U-Pb	zircon	--; --; 34.8; --		W. Hoppe, *in* Vance and others, (1986)
29	JV			FT	zircon	20	Location uncertain (ridge of Mount Despair)	J.A. Vance (written commun., 1986)

30	827-7I	48°38.3'	121°19.1'	K-Ar	hornblende	29.4 ± 0.6	Granodiorite of Mount Despair	R. Fleck (written commun., 1993)
					biotite	30.1 ± 0.2		
31	PM 14	48°39.6'	121°17.7'	K-Ar	biotite	30 ± 1	do.	Engels and others (1976)
32	RWT 471-67	48°44.7'	121°25.0'	K-Ar	hornblende	31.1 ± 1.4	do.	Do.
33	PM 13	48°39'	121°18.4'	K-Ar	biotite	32 ± 1	do.	Misch (1963, 1964)
34	PM 12	48°38'	121°19'	K-Ar	biotite	33 ± 1	do.	Do.
35	PM 4	48°38'	121°20'	K-Ar	biotite	34.9	do.	Do.
				K-Ar	biotite	32.6		
36	---	Location uncertain		Rb-Sr	unknown	33.5 ± 2		J. Gabites, *in* Tepper (1991)
37	PM 6	48°38'	121°19'	K-Ar	biotite	50 ± 1	Ages for this sample suspect	Misch (1963, 1964)
				K-Ar	biotite	40 ± 1	Rerun of above	
				K-Ar	hornblende	51 ± 1	Contamination?	
38	CB88-23	48°54.8'	121°27.3'	Rb-Sr	biot-hbl-plag-wr isochron	34 ± 0.9	Gabbro of Copper Lake	Tepper (1991; written commun., 1993)
					Volcanic rocks of Mount Rahm			
39	---	48°59.8'	121°11.2'	K-Ar	wr	12.6 ± 0.4	Tuff; age probably reset by granite of Redoubt Creek	Mathews and others (1981)
(40)	---	49°00.7'	121°13.3'	K-Ar	plagioclase	13.1 ± 0.5	Volcanic dike; age probably reset by granite of Redoubt Creek	Do.
					Unnamed sandstone and conglomerate, young, on Diobsud Ridge			
41	JV-x	48°36'	121°25'	FT	zircon	~45	Clast of Marblemount pluton in conglomerate (location uncertain)	J.A. Vance (written commun., 1989)
					Unnamed sandstone in fault zone along west side of Twin Sisters Mountains			
(42)	KD 17-87	48°41.5'	121°00.8'	FT	zircon	>60, <73	Off quadrangle to west; probable stratigraphic age	J.A. Vance (written commun., 1992)
					Foliated dioritic dike in Welker Peak thrust zone			
43	2-268c	48°57.0'	121°37.8'	K-Ar	hornblende	58.2 ± 2.3		Brown and others (1986), R.L. Armstrong (written commun., 1983)
					Alma Creek pluton			
44	MO 272-85	48°36.0'	121°21.4'	K-Ar	biotite	38.8 ± 1.8		This report
				K-Ar	muscovite	49.3 ± 0.7		

					Haystack pluton			
45	RWT 421-85	48°34.1'	121°15.6'	K-Ar	biotite	44.4 ± 0.6		This report
				K-Ar	muscovite	48.0 ± 0.6		
					Marble Creek pluton			
46	RWT 434-85	48°34.0'	121°16.7'	K-Ar	biotite	45.0 ± 1.9		This report
				U-Pb	zircon			Haugerud and others (1991)
					nm [63-102]	75.6; 75.9; 83±7; --		
					m [63-102]	75.7; 76.3; 94±7; --		
					nm [-63]	75.1; 76.4;116±11;--		
					m [-63]	74.7; 73.4; 33±16; --		
47	MO 107-85	48°31.9'	121°16.1'	K-Ar	biotite	43.8 ± 1.1		This report
				K-Ar	muscovite	49.6 ± 1.7		
					Hidden Lake Peak stock			
48	827-6D	48°30.0'	121°12.0'	K-Ar	biotite	37.6±0.3		R.J. Fleck and A.B. Ford (written commun., 1992)
49	RH86-B127A	48°30.6'	121°12.3'	U-Pb	zircon			Haugerud and others (1991)
					(-60+140)	75.4;75.5;80±12;--		
					(-140)	72.9;73.1;79±12;--		
					Skagit Gneiss Complex			
50	PM 1	48°42'	121°12'	K-Ar	biotite	44 ± 2	Biotite schist septum in orthogneiss	Misch (1963, 1964)
51	PM 2	48°42'	121°12'	K-Ar	biotite	45 ± 2	do.	Do.
52	PM 20	48°34'	121°02'	K-Ar	hornblende	57 ± 2	Amphibolite	Do.
53	RWT 428-85	48°36.3'	121°17.9'	K-Ar	biotite	44.2 ± 0.8	Orthogneiss	Do.
54	RWT 338-85	48°34.1'	121°13.9'	K-Ar	hornblende	53.3 ± 1.7		Do.
55	RWT 179-86	48°40.5'	121°14.8'	U-Pb	zircon		Orthogneiss	Haugerud and others (1991)
					nm [63-102]	64.8; 65.0; 74±11; --		
					nm [-63]	63.3; 63.9; 84±13; --		
	827-8C	do.	do.	K-Ar	biotite	30.2 ± 0.1	do.	R.J. Fleck and A.B. Ford (written commun., 1992)
				K-Ar	hornblende	42.9 ± 0.2		
56	68-16	48°42.5'	121°05.6'	U-Pb	zircon	66; 67; 79±10; --	Mafic orthogneiss	Mattinson (1972)
	827-8J	do.	do.	K-Ar	biotite	42.5 ± 0.2	do.	R.J. Fleck and A.B. Ford (written commun., 1993)
				K-Ar	hornblende	42.5 ± 3.3		
	827-8H	do.	do.	K-Ar	biotite	41.2 ± 0.3	Biotite granodiorite dike intruding mafic orthogneiss	

59	RWT 97-86	48°39.71'	121°15.05'	U-Pb	zircon		Orthogneiss	Haugerud and others (1991)
					nm [+102]	74.1; 74.7; 92±4; --		
					nm [-63]	72.5; 72.1; 61±11; --		
60	69-12	48°42.4'	121°10.2'	U-Pb	zircon		Pegmatite gneiss	Mattinson (1972)
					coarse	90; --; --; --		
					fine	57; --; --; --		
61	RWT 211-86	48°37.73'	121°08.14'	U-Pb	zircon		Orthogneiss of the Needle	Haugerud and others (1991)
					nm[63-103]	116.9;122.0;221±13;--		
					nm [-63]	112.9;117.7;242±6;--		
62	69-10	48°41.4'	121°13.7'	U-Pb	zircon	98; 112 ;428±10; --	Biotite gneiss	Mattinson (1972)
					apatite	46; --; --; --		
					Eldorado Orthogneiss			
63	RWT-204-86	48°31.1'	121°08.5'	U-Pb	zircon			Haugerud and others (1991)
					(-60+140)	87.7; 88.2;102±6; --		
					(-140+200)	88.3; 88.7; 99±4; --		
					Cascade River Schist			
64	RWT-42-85	48°32.1'	121°18.2'	K-Ar	muscovite	45.8 ± 0.8	Marblemount Meta Quartz Diorite clast in metaconglomerate	This report
65	118-15G	48°32.6'	121°19.7'	U-Pb	zircon		Metatuff	J.S. Stacey (written commun., 1987)
					(-150)	219;221; 240; --		
					Napeequa Schist			
66	RWT 426-85	48°35.4'	121°15.5'	K-Ar	hornblende	54.8±1.7	Amphibolite	This report
67	PM 3	48°37'	121°22'	K-Ar	biotite	49±2	Biotite schist	Misch (1963, 1964)
					Marblemount Meta Quartz Diorite			
68	RWT-39-85	48°31.1'	121°21.8'	K-Ar	muscovite	94.0 ±1.5		
69	68-18	48°34.8'	121°24.4'	U-Pb	zircon	222;221; 214±30; --		Mattinson (1972)
					Wells Creek Volcanics of Misch (1966)			
70	F64F	48°52.6'	121°49.8'	U-Pb	zircon		Dacite tuff	J.M. Mattinson, *in* Franklin (1985)
					coarse	174.5; 175.3; 187±5; --		
					fine	173.2; 173.7; 181±5; --		
					Semischist and phyllite of Mount Josephine			
71	PM 16	48°49'	121°56'	K-Ar	whole rock	113±3	Sericite phyllite	Misch (1963, 1964)

				Easton Metamorphic Suite				
72	RH78-E69	48°39.4'	121°33.7'	K-Ar	whole rock	122 ± 4	Micaceous blueschist	Haugerud (1980); Armstrong and Misch (1987)
73	27Q	48°30.9'	121°58.4'	K-Ar	muscovite	130 ± 5	Muscovite schist	Brown and others (1982)
				Blueschist of Baker Lake				
74	887E	48°44.0'	121°37.1'	K-Ar	whole rock	127 ± 5	meta-ribbon chert	Brown and others (1987)
				Bell Pass melange, Vedder Complex of Armstrong and others (1983)				
75	RH78-D61	48°41.7'	121°38.2'	K-Ar	muscovite	196 ± 7	Quartz-mica semischist	Haugerud (1980)
76	PM 24	48°47'	121°58'	K-Ar	whole rock	259 ± 8	Crossite schist	Armstrong (1980), Armstrong and others (1983)
77	Baker 10B Baker 10D	48°47.2' 48°47.2'	121°57.0' 121°57.0'	K-Ar K-Ar	whole rock whole rock	219 ± 9 221 ± 8		Do. Do.
78	PL90-8	48°45.0'	121°36.7'	K-Ar	muscovite	274 ± 9	Albite-muscovite schist	Armstrong and Misch (1987)
				Rb-Sr	musc-wr	273		
79	NR-311	48°44.8'	121°57.2'	K-Ar	muscovite	277 ± 9		R.L. Armstrong, *in* Rady (1980), Armstrong and Misch (1987)
				K-Ar	barrosite	279 ± 9		
80	PM 101	48°45.1	121°36.9'	K-Ar	muscovite	283 ± 9	Albite-muscovite-amphibole schist	Armstrong and Misch (1987)
				K-Ar Rb-Sr	amphibole musc-amph-wr isochron	259 ± 9 280 ± 39		
				Chilliwack Group of Cairnes (1944)				
81	WMc	Jackman Creek		U-Pb	detrital zircons			W.C. McClelland (1993, written commun., 1993)
						--;--;370±20;--	Single crystal; concordant	
						--;--;376±10;-- --;--;390±19;-- --;--;378±5;--	Do. Do. Single crystal; discordant	
						--;--;378±5;-- --;--;353±9;-- --;--;367±4;--	Do. Multigrain; discordant Do.	
82	WMc	Jackman Creek		U-Pb	detrital zircons			McClelland and Mattinson (1993), W.C. McClelland, written commun., 1993)
						--; --; 373±2; --	Tonalite clast, multigrain concordant	
						--; --; 370±4; -- --; --; 379±2; --	Multigrain; discordant Do.	
						--; --; 381±2; --	Do.	

83	WMc	Jackman Creek		U-Pb	detrital zircons			Do.
						--; --; 708±1; --	Orthogneiss clast; discordant	
						--; --; 971±1; --	Do.	
						--; --; 999±1; --	Do.	
Bell Pass Melange, Yellow Aster Complex of Misch (1966)								
84	69-8	48°57.3'	121°40.2'	U-Pb-Th	zircon	64; 75; 427±75;248	Pegmatite gneiss	Mattinson (1972)
85	80-100	48°41.85'	121°38.3'	U-Pb-Th	zircon	320;329; 393; 305	Phacoid in Bell Pass melange	R.E. Zartman (written commun. to Peter Misch, 1983)
86	69-7	48°57.3'	121°40.2'	U-Pb	zircon			Mattinson (1972)
					coarse	370;376; 411±15; --		
					fine	368;374; 412±15; --		
87	69-9	48°56.3	121°40.4'	U-Pb	zircon	711;912;1452±20; --		
				U-Pb	sphene	415;415; 410±85; --		

* Abbreviations: biot–biotite, cpx–clinopyroxene, hbl–hornblende, plag–plagioclase, wr–whole rock, c–coarse, f–fine, m–magnetic, nm–nonmagnetic.
Mesh sizes in parentheses, size range in microns in brackets

**Sample erroneously reported by Engels and others (1976) to be from hornfels

***Chilliwack batholith sample PM28 not included; see #26, Engels and others (1976)

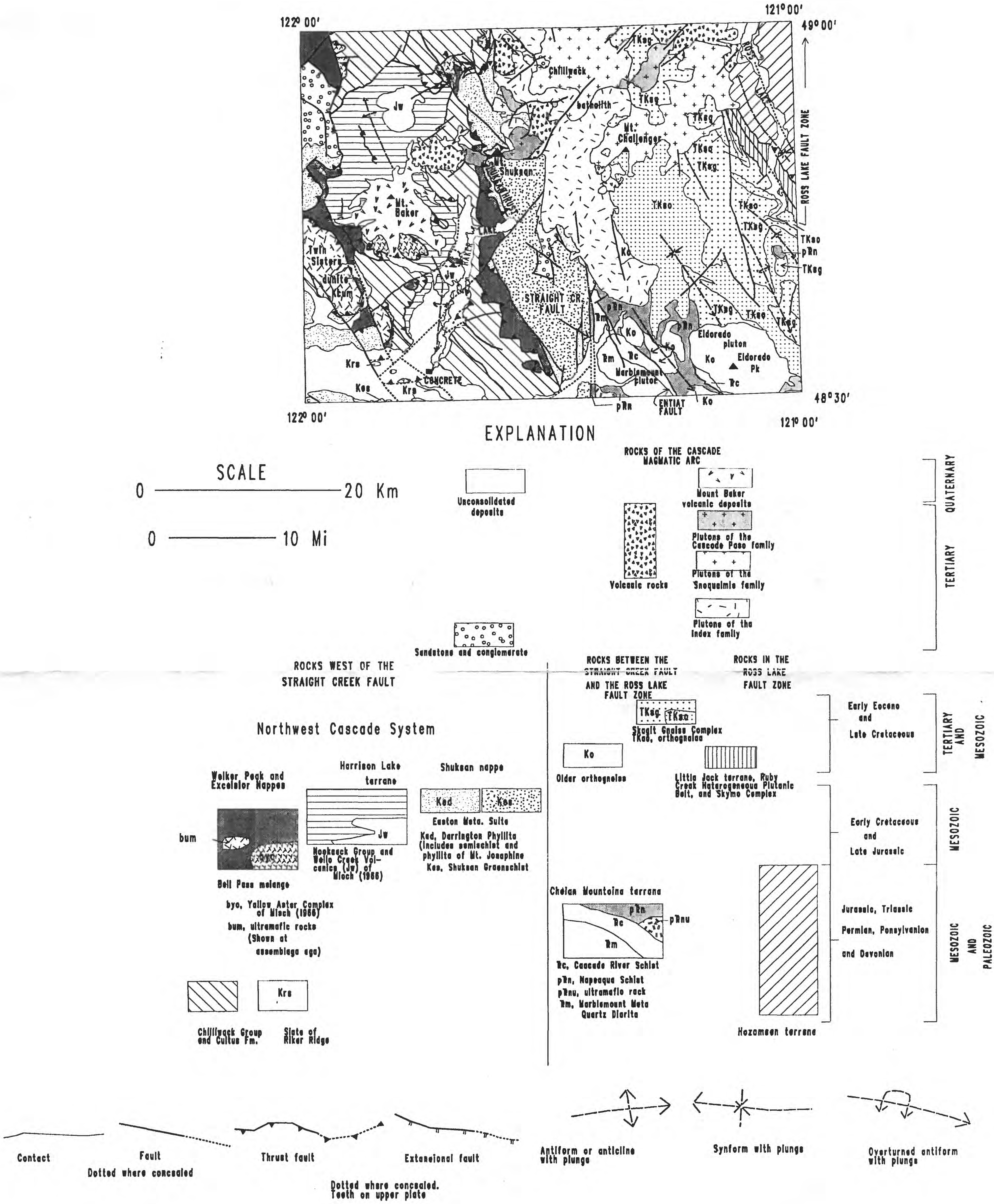

FIGURE 1. GENERALIZED GEOLOGIC MAP

OF THE MOUNT BAKER QUADRANGLE

(Metamorphosed supracrustal rocks and older orthogneiss shown with protolith age)