



Geologic Symbols

- Contact - Dashed where inferred
- - - Fault, unknown offset - Long dashed where approximately located, short dashed where inferred; dotted where concealed
- Normal fault - Bar and bell on downthrown side; dotted where concealed
- Right-lateral strike-slip fault - Half arrows indicate relative apparent strike-slip motion; dashed where approximately located
- Thrust fault - Sawtooth on upper plate; dotted where concealed
- Lateral Pleistocene to Holocene fluvial terrace - Hachures on scarp side
- Strike and dip of bedding (may be combined with other symbols)
 - inclined (glacial and volcanic deposits only)
 - inclined - indicates forest bedding (glacial and volcanic deposits only)
 - inclined
- Trend and plunge of fold axes (may be combined with other symbols)
 - Overturned minor fold axis (combined with F2 axial symbols below)
 - Minor F1 (first-generation) fold axis; arrow indicates the direction of plunge
 - Minor F2 (second-generation) fold axis and (or) crenulation lineation; arrow indicates direction of plunge
 - Minor F3 (third-generation) fold axis and (or) crenulation lineation; arrow indicates direction of plunge
 - Minor F2 S-shaped fold axis and (or) crenulation lineation; arrow indicates direction of plunge
 - Minor F2 Z-shaped fold axis and (or) crenulation lineation; arrow indicates direction of plunge
 - Minor F2 S-shaped fold axis and (or) crenulation lineation; arrow indicates direction of plunge
- Strike and dip of tectonic foliation and fold axial planes (may be combined with other symbols)
 - Penetrative tectonic foliation (undifferentiated); generally crystalliniferous S1 (first-generation) cleavage in the Shuksan Suite
 - inclined - may locally represent S2 or S3 foliation
 - vertical - may locally represent S2 or S3 foliation
- Strongly developed semi-penetrative to locally penetrative S2 (second-generation) axial plane foliation or F2 axial plane
 - inclined
 - vertical
- Strongly developed semi-penetrative to locally penetrative S3 (third-generation) axial plane foliation or F3 axial plane
 - inclined
 - vertical
- Strike and dip of fractures and joints (may be combined with other symbols)
 - Joint, undifferentiated
 - vertical
 - Subsidiary minor fault or slickensided fracture plane
 - inclined
- Trend and plunge of tectonic lineations
 - Lineation, undifferentiated (mostly stretching lineations and crenulation lineations; rarely pencil lineations, slickensides, or boudins); arrow indicates direction of plunge
 - inclined
 - Stretching lineation; arrow indicates direction of plunge
 - inclined
- Trend and plunge of current flow direction indicators (flutes, bubble imbrications, etc.)
 - inclined

Well and Borehole Symbols

- Water well
- Geotechnical borehole

Description of Map Units

Field mapping of the Darrington 7.5-minute quadrangle was completed during the summers of 2001 and 2002. Field observations were supplemented by whole-rock and clay geochemical analyses, pumice and ash (glass) microprobe analyses, radiocarbon dating, petrographic (thin section) analyses of bedrock, clasts, and mounted Quaternary sands, and subsurface analysis using water wells and geotechnical borings. A copy of the sample site map can be obtained by writing Joe Dragovich at the Washington Division of Geology and Earth Resources, Box 47007, Olympia, WA 98504-7007. joe.dragovich@dnr.wa.gov. Alphanumeric codes following color description refer to the Munsell rock color chart (Munsell Color, 1999) and are for dry samples.

QUATERNARY SEDIMENTARY AND VOLCANIC DEPOSITS

Holocene Nonglacial Deposits

Qa Alluvium, undivided (Holocene) - Gravel, gravely sand, sand, and cobbly gravel with rare boulders; gray, subrounded to rounded clasts; loose, well-sorted, and well-sorted; plane-bedded sands common; locally contains up to 40% reworked gray or reddish gray Glacier Peak dacite with boulder fraction locally greater than 50% dacite; locally rich in granitic and (or) phyllite clasts. Overbank deposits are mostly loose or soft to stiff, grayish brown to olive-gray stratified sand, fine sandy silt, silt, clay, and minor peat (unit Qp). Several radiocarbon ages from sticks in peat and organic sediments yield ages of less than 600 yr B.P. for surficial Saik River alluvium.

Qas Older alluvium (Holocene) (cross sections only) - Sand, gravel, cobbly gravel, silt, clay, and peat locally with abundant wood and organic matter (downed trees, shrubs, palisades, and swampy deposits) (cross sections A-A', B-B', C-C'). Unit Qas occurs below units Qa and Qm (unde Holocene). The upper portion of unit Qa commonly contains organic materials and is interpreted as a forest buried by Glacier Peak volcanic deposits (unit Qv).

Qaf Alluvial fans (Holocene) - Dominant, massive to weakly stratified with angular to rounded, locally developed, mostly poorly sorted debris-flow or debris-vent deposits, locally modified by fluvial processes. Alluvial fans mostly discontinuously overlie glacial or Glacier Peak volcanic deposits and locally interfinger with alluvium. Silt deposits locally divided into unit Qafg along the distal portions of some large alluvial fan complexes.

Qls Landslide complexes (Holocene) - Boulders, cobble, and gravel in a soft sand, silt, and (or) clay matrix; mostly poorly sorted and unstratified with locally derived angular to rounded clasts. Includes deep-seated landslides such as slump-sarrows and a few of the most prominent debris slide and talus or rockfall deposits. Scarps and deposits are mapped together as unit Qls.

Late Pleistocene and Holocene Glacier Peak Volcanic and Sedimentary Deposits

We correlate the volcanic assemblages in the study area with the Chocolate Creek, Kennedy Creek, and White Chuck assemblages of Beget (1981, 1982) that inundated valleys during late Holocene, mid-Holocene, and late Pleistocene eruptive episodes of Glacier Peak. These deposits are exposed as terraces with increasing elevation. For example, White Chuck assemblage terraces are typically up to 80 ft (24 m) above the modern flood plain and are higher than late volcanic assemblages. Glacier Peak dacite is homogeneous and contains plagioclase, hornblende, and hypersthene + augite and (or) olivine phenocrysts and rare biotite; each assemblage appears to have a generally similar but distinctive dacite-late trace-element geochemistry (Dragovich and others, 1999, 2000a,b,c; J. D. Dragovich, Wash. Div. of Geology and Earth Resources, unpub. data).

Chocolate Creek Assemblage

We mapped a labar deposit in the Darrington quadrangle that lithologically and temporally correlates with similar labar deposits and volcanic alluvium in the lower Skagit River valley. We informally assign the name Chocolate Creek assemblage to this deposit, which is similar to Labar of Beget (1981, 1982) along Chocolate Creek adjacent to Glacier Peak. This deposit probably resulted from the downstream transformation of one or more proclastic flows along the Skagit and Saik Rivers. In the study area, the labar forms a 1.5 m terrace-capping bed that overlies alluvium. This terrace is 12 to 15 ft above river level along the Saik and Saik River flood plains and channels. In the White Chuck and Saik River valleys east of the study area, the Chocolate Creek assemblage is composed of at least three distinct labars (Beget, 1981; J. D. Dragovich, Wash. Div. of Geology and Earth Resources, unpub. data). In the study area, radiocarbon dating yielded ages of 1,700 ± 70, 1,620 ± 70, and 1,830 ± 70 yr B.P. from charcoal obtained from silt and silt sand in alluvium directly below the labar at two sites (cross sections C-C' (Dragovich and others, 1999, 2000a,b,c, 2002); J. D. Dragovich, Wash. Div. of Geology and Earth Resources, unpub. data).

Non-cobble labar (Holocene) - Silty sandy gravel to gravely sand, few cobbles and rare boulders; compact and dacite-rich; clasts typically 1 to 2 cm but locally 20 cm in maximum dimension. Matrix is composed of very pale brown (10YR 7.5) fine to coarse ash containing crystals of plagioclase, hornblende, hypersthene, and quartz, plus or minus angular vitric and dacite lenticle fragments. Gray to dark gray (GLEY 4N-6N) and light gray (GLEY 1.7N to 10YR 7.1) dacite clasts are mostly angular to subangular and semi-vesicular to vesicular and compose 70% to 95% of the clasts; also contains scattered, altered, weak red (10R 5.3) dacite clasts; locally contains scattered very pale brown (10YR 8.4) pumice clasts; locally overlain by a very thin bed of reworked light gray (10YR 7.1) ash; minor exotic clasts include lacustrine clay rip-up clasts and granitic and orthogneiss clasts. Deposits commonly vertically symmetrical with a crudely normally graded top and a reversely graded base; faint basal horizontal laminations and water and (or) gas escape pipes observed locally.

Kennedy Creek Assemblage

The Kennedy Creek assemblage (KCA) originated from Glacier Peak and flowed down the Saik and Stillaguamish River valleys about 5,100 to 5,400 yr B.P. (Beget, 1981, 1982; Dragovich and others, 1999, 2000a,b,c; J. D. Dragovich, Wash. Div. of Geology and Earth Resources, unpub. data). The KCA forms a prominent 15 to 25 ft (4.6 to 7.6 m) high terrace. Stratigraphic relations as well as geochemical and petrographic data suggest that the assemblage resulted from inundation by labar(s) that transformed into hyperconcentrated flows (downstream through interaction with river water. This transformation is similar to the mechanism envisioned by Pierson and Scott (1985) for similar Mount St. Helens deposits. Hyperconcentrated flows in the quadrangle thickened to the north in the Saik River drainage as a result of this transformation. Subsequent fluvial incision and channel migration locally reworked the top of the KCA. The KCA forms a flat divide between the Saik and Stillaguamish Rivers. Beget (1981) suggested that the divide formed during deposition of the latest Pleistocene White Chuck assemblage, diverting the Saik River north to the Skagit River east of the study area. (White Chuck volcanic inundation occurred during the close of the last glaciation, when organic productivity was low and erosion was rate to nonexistent) However, unit Qm, which underlies the volcanic sediments of the divide (cross sections A-A', B-B', C-C'), contains organic material at various stratigraphic levels, implying equivalent post-glacial deposition representing much of the early Holocene. Therefore, we associate formation of this divide with deposition of the mid-Holocene KCA rather than the White Chuck assemblage.

Volcanic sediments, undivided (Holocene) - Hyperconcentrated flood deposits, labars, and volcanic alluvium, medium- to coarse-grained sand and thick beds of gravely sand and cobbly sandy gravel; loose, dacite-rich. Locally contains labar and thick beds of silty sandy gravel with few cobbles and boulders; these beds are similar to unit Qv, but are too thin (0.2 m to 1.5 m) to separate at map scale; some labars occur within granular hyperconcentrated flood deposits (this study; J. D. Dragovich, Wash. Div. of Geology and Earth Resources, unpub. data). Locally capped by reworked light brownish gray to light yellowish brown ash (10YR 6.2, 6.4, 7.1, 2.5YR 6.3) or gray (GLEY 1.5N-6N) dacite locally with scattered lapilli. Clasts include 70% to 90% light gray to gray (GLEY 1.5N-7N) dacite locally with scattered dark gray (GLEY 1.2.5N-4N) and altered pale red to dark reddish gray dacite (10YR 5.2, 10R 2.1, 7.2, 6.2-6.3); locally contains up to 50% pale yellow, very pale brown, light gray, white, or pinkish white pumice (GLEY 1.5N-8.5, 2.5YR 8.1-8.2, 10YR 5.1, 7.2, 8.1-8.3) as lenses or scattered clasts. Locally contains cobble to boulder-sized rip-up clasts of silt and (or) clay that were probably eroded from deposits mapped near Glacier Peak by Beget (1981) as sediments of volcanically dominated lakes. Nonlabar beds are typically nongraded to crudely graded and nonstratified; locally contain weak horizontal stratification, plane bedding, and cross bedding including rare antidunes. Stratigraphy and clast compositions indicate both fluvial and hyperconcentrated flood depositional mechanisms for the nonlabar sediments. Reworked terrace-capping topography represents one or more washing flood deposits. Locally divided into:

Qv1 Non-cobble labar (Holocene) - Silty sandy gravel to gravely sand with locally with cobbles and rare boulders up to 1 m (3 ft) compact, dacite-rich with clasts typically 1 to 2 cm (0.4-0.8 in.) but locally 10 to 30 cm (4-12 in.) in size. Very pale brown (10YR 7.1) labar matrix consists mostly of reworked pyroclasts of fine to coarse ash with crystals of hornblende, hypersthene, plagioclase, quartz, and rare augite, with vitric fragments and fragments of dacite. Clasts are angular to subangular, abundant 80-90% of clast composition, and vesicular to locally non-vesicular; some frothy flow banding mostly gray (GLEY 1.5N-6N) with some scattered altered reddish gray dacite (2.5Y 6.2) and pale yellow, pale brown, and pink pumice (10YR 8.2, 10R 8.3). Unit also contains rare boulder-sized rip-up clasts of lacustrine clay and minor exotic clasts of granitic, phyllite, and vein quartz. Nonstratified, deposits with weak normal grading occur to the top of the deposit. Commonly contains degrading and (or) gas-escape pipes; rarely contains crudely defined, meter-scale horizontal stratification defined by coarse-grained gravel and cobbles; grading; rarely contains flame structures, internal truncation surfaces, and very thin ash beds. Petrographic analysis of dacite clasts (J. Ladd, Western Wash. Univ., written commun., 2002) suggests deposition as a hot labar. Although base was not observed, deposit appears to be mostly laterally continuous and may be as thick as 15 m (49 ft) (cross sections A-A', B-B', C-C'); overlain by volcanic sediments of unit Qv2 (this study; J. D. Dragovich, Wash. Div. of Geology and Earth Resources, unpub. data).

Qv2 Non-cobble labar (Holocene) - Silty, clayey silt, silt, silty sand, and gravel in various proportions with disseminated cobbles and boulders, typically modified dark yellowish brown to brownish gray, grayish blue, or very dark gray; matrix consists of clay silt to coarse sand (s+cl). Includes rare Canadian and local provenance; up to 90% of clasts are locally derived and angular to subangular phyllite or gneiss and rare Glacier Peak dacite. Till unconformably overlies bedrock in elevated settings and locally occurs in the low valley-bottom glacial terraces, thus mantling topography.

Qv3 Advance outwash (Pleistocene) - Medium to coarse sand, pebbly sand, and sandy gravel with scattered lenses and layers of pebbly cobbly gravel; locally contains fine silty sand, silty clay, and clay interbeds; well-sorted; compact. Subhorizontal bedding or cross-stratification prominent; locally cut-and-fill structures and trough and ripple cross-beds. Mostly Canadian provenance, some locally derived clasts, and little or no Glacier Peak dacite. Interfingers with and conformably overlies unit Qv4, as a result of glacial lake impoundment during ice advance up the Stillaguamish and Saik River valleys; composite sections of advance outwash and glaciolacustrine deposits are up to 150 ft (46 m) thick. Primarily fluvial in origin, based on stratigraphic relations including subsurface stratigraphy, some advance outwash is inferred to be dacitic (cross sections A-A', B-B', C-C').

Qv4 Advance glaciolacustrine deposits (Pleistocene) - Clay, clayey silt, silt, silty sand, and silty fine sand with local deposits; locally contains fine to medium-grained sand lenses and beds; stiff, well-sorted; finely bedded or laminated. Silt and clay are dark gray, blue gray, and gray, weathering to pale yellowish brown; 1 to 4 cm (0.4-1.6 in.) thick rhythmic bedding (varves?) common, normally graded from sand to silty clay. Soft-sediment and (or) ice-sheet deformational features are common and include tilted and contorted bedding, overturned folds, and flame structures; overturned fold geometries are consistent with ice shear during ice advance up the major river valleys. Locally overlain by and interbedded with unit Qv5 (cross sections A-A', B-B', C-C').

Qv5 Till (Pleistocene) - Nonstratified, compact, matrix-supported mixture of clay, silt, sand, and gravel in various proportions with disseminated cobbles and boulders, typically modified dark yellowish brown to brownish gray, grayish blue, or very dark gray; matrix consists of silty silt to coarse sand (s+cl). Includes rare Canadian and local provenance; up to 90% of clasts are locally derived and angular to subangular phyllite or gneiss and rare Glacier Peak dacite. Till unconformably overlies bedrock in elevated settings and locally occurs in the low valley-bottom glacial terraces, thus mantling topography.

Qv6 Advance outwash (Pleistocene) - Medium to coarse sand, pebbly sand, and sandy gravel with scattered lenses and layers of pebbly cobbly gravel; locally contains fine silty sand, silty clay, and clay interbeds; well-sorted; compact. Subhorizontal bedding or cross-stratification prominent; locally cut-and-fill structures and trough and ripple cross-beds. Mostly Canadian provenance, some locally derived clasts, and little or no Glacier Peak dacite. Interfingers with and conformably overlies unit Qv7, as a result of glacial lake impoundment during ice advance up the Stillaguamish and Saik River valleys; composite sections of advance outwash and glaciolacustrine deposits are up to 150 ft (46 m) thick. Primarily fluvial in origin, based on stratigraphic relations including subsurface stratigraphy, some advance outwash is inferred to be dacitic (cross sections A-A', B-B', C-C').

Qv7 Advance glaciolacustrine deposits (Pleistocene) - Clay, clayey silt, silt, silty sand, and silty fine sand with local deposits; locally contains fine to medium-grained sand lenses and beds; stiff, well-sorted; finely bedded or laminated. Silt and clay are dark gray, blue gray, and gray, weathering to pale yellowish brown; 1 to 4 cm (0.4-1.6 in.) thick rhythmic bedding (varves?) common, normally graded from sand to silty clay. Soft-sediment and (or) ice-sheet deformational features are common and include tilted and contorted bedding, overturned folds, and flame structures; overturned fold geometries are consistent with ice shear during ice advance up the major river valleys. Locally overlain by and interbedded with unit Qv8 (cross sections A-A', B-B', C-C').

Qv8 Gabbro (Eocene) - Gabbro or diabase dikes, sills, and small irregular intrusions; nonfoliated; equigranular, medium-grained; greenish gray, some of the bodies appear to intrude faults; contains hornblende (commonly zoned), plagioclase (mostly labradorite), and minor clinopyroxene phenocrysts; common alteration minerals include disseminated calcite, quartz, sulfides, and sericite. Although not directly dated, gabbros are probably Eocene and possibly Oligocene in age and may represent feeder bodies for the volcanic rocks near the map area (Jones, 1959; Vance, 1957; this study; Dragovich and others, 2002).

MESOZOIC TO PALEOZOIC LOW-GRADE METAMORPHIC ROCKS (BLUESCHIST FACIES)

Thrust-faulting and nappage formation in the Northwest Cascades System occurred in the Cretaceous (~110-90 Ma) (see Brown, 1987). The Chilliwack Group of the Excelsior nappes of Tabor and others (1994) structurally underlies the Shuksan nappes in the northeast part of the Darrington quadrangle.

Easton Metamorphic Suite of the Shuksan Nappe

The Easton Metamorphic Suite of Tabor and others (1994) includes the Darrington Phyllite, semichist of Mount Josephine, and the Shuksan Greenschist. These units are interfolded on mountain to outcrop scales and are interpreted to be oceanic crust (Shuksan Greenschist and part of the Darrington Phyllite) and submarine fan deposits (part of the Darrington Phyllite and the semichist of Mount Josephine). Semichist and phyllite are locally interfingering on a scale of millimeters to meters; these are interpreted as distal turbidite and basin-plan deposits. Shuksan Greenschist is mostly mid- to upper greenschist facies. The Easton suite typically have a penetrative S1 (first-generation) foliation, with bedding truncation parallel to S1 and abundant quartz segregation along S1. The Easton Metamorphic Suite is probably Jurassic (Armstrong and Misch, 1987; Brown and others, 1982; Brown, 1986, 1987; Gallagher and others, 1988; Tabor and others, 1994; Dragovich and others, 1998, 1999, 2000a).

White Chuck Assemblage

The White Chuck assemblage resulted from Glacier Peak eruptions during Fraser deglaciation (~11,200-12,700 yr B.P.) (Beget, 1981, 1982; Porter, 1978; Folt and others, 1993). Deposits of the White Chuck assemblage commonly overlie dacite-poor recessional outwash of Qv6.

Qv6a Volcanic sediments, undivided (late Pleistocene) - Hyperconcentrated flood deposits, labars, and volcanic alluvium, medium- to coarse-grained sand, sandy gravel, and cobbly sandy gravel; loose; dacite-rich. Labars consist of poorly sorted, nonstratified gravely silty sand and silty sandy gravel with some cobbles and scattered boulders up to 44 cm (17 in.). Volcanic alluvium and hyperconcentrated flood deposits typically contain 50% to 95% white and light to dark gray (GLEY 4N-8N) or altered reddish gray or weak red (10R 6.1, 10R 4.5) dacite, commonly with white (10YR 8.1) to pinkish white or pale yellow to very pale brown pumice (2.5Y 6.2, 10YR 7.4, 8.2-8.3) up to 16 cm (6.3 in.) that locally constitutes up to 50% of the clasts; also contain pumice-rich lenses, cobble to boulder rip-up clasts of lacustrine or glaciolacustrine clay, and clasts of White Chuck volcanic tuff. Deposits vary from massive, crudely graded, or weakly horizontally stratified to rarely well-stratified with plane or cross bedding (this study; Beget, 1981; J. D. Dragovich, Wash. Div. of Geology and Earth Resources, unpub. data). Locally divided into:

Qv6a1 Pumice (late Pleistocene) - Terrace-capping pumiceous ash, ash-lapilli, and lapilli deposit forming a "pumice plain"; moderately to well-sorted; 0.3 to 2.7 m thick with pumice clasts up to 17 cm; pumice is white (GLEY 1.8N, 2.5Y 8.1), pink (2.5YR 8.2, 7.3), or very pale brown or yellow (2.5YR 8.3, 10YR 8.3-8.6) and ash is pale brown (10YR 8.4) to pale yellow (2.5Y 8.4); exotic clasts generally absent. Locally, pumice lapilli layers are interbedded with ash and ash-lapilli layers. Varies from nonstratified to locally plane- or cross-bedded; overlies dacitic sands and gravels of unit Qv6. Heterogeneous glass composition, phenocryst types, and stratigraphic position and distribution suggest that the pumice plain deposit is a washing flood deposit; drainage blocked by receding glacial ice in the Saik River valley may have promoted "ponding" of this deposit.

Qv6a2 Non-cobble labar (late Pleistocene) - Cobble to locally bouldery gravely sand commonly with a trace of ash; compact; light reddish brown, dacite-rich; clasts up to 55 cm (22 in.) in size; pumice clasts up to 4 cm (1.5 in.) and commonly flow-banded. Matrix composed of crystalline fine to coarse sand with hornblende, quartz, plagioclase, perminite, alk, and pumice. Dacite commonly 60% to 95% of the gravel and cobble component and is white and light to dark gray (GLEY 1.4N-8N, 2.5Y 8.1-8.2) and less commonly weak red (10R 4.3); dacite clasts are mostly angular and vesicular with fine banding in some clasts. Locally abundant brown to very pale brown and pink to white (10YR 8.2-8.4, 2.5YR 5.3, 8.4, 5YR 8.1) pumice concentrated near the top of the labar. Rare gravel to boulder-sized rip-up clasts of clay or clay with scattered gravel (possible dropstones) and rounded to subrounded clasts of granite, phyllite, and vein quartz. Mostly nonstratified with weak normal grading near the top; symmetrical coarse-tail grading. Commonly overlies recessional outwash. Thin rowlock(?) beds of ash-sized lepta at contact with outwash. Scarps and deposits are mapped together as unit Qv6.

Qv6b Recessional glaciolacustrine deposits (Pleistocene) - Silty clay, clay, silty sand, and sand with local dropstones; gray to light gray; well-sorted; loose, soft, or stiff; nonstratified to laminated with rhythmic beds typically 1 cm (0.4 in.) thick resembling varves; contains decimeter-wide sand dikes in the Stillaguamish valley, probably formed in glacial lakes impounded by retreating glacial ice; locally interfingers with and conformably overlies unit Qv6a (cross sections A-A' and B-B').

Qv6c Detritic outwash (Pleistocene) - Sand, sandy gravel, and cobbly sandy gravel; loose; moderately to well-sorted; beds are commonly 5 m (16 ft) thick with planar forest beds in sets 10 to 20 m apart; locally contains silty sand and silty clay. Includes rare Canadian and local provenance; up to 90% of clasts are locally derived and angular to subangular phyllite or gneiss and rare Glacier Peak dacite. Till unconformably overlies bedrock in elevated settings and locally occurs in the low valley-bottom glacial terraces, thus mantling topography.

Qv6d Recessional glaciolacustrine deposits (Pleistocene) - Silty clay, clay, silty sand, and sand with local dropstones; gray to light gray; well-sorted; loose, soft, or stiff; nonstratified to laminated with rhythmic beds typically 1 cm (0.4 in.) thick resembling varves; contains decimeter-wide sand dikes in the Stillaguamish valley, probably formed in glacial lakes impounded by retreating glacial ice; locally interfingers with and conformably overlies unit Qv6a (cross sections A-A' and B-B').

Qv6e In situ contact deposits (Pleistocene) - Sandy gravel, gravely sand, and bouldery cobbly gravel locally with interbedded beds of silty sand or silt; poorly to well-sorted; loose; boulders to 1.3 m (4.3 ft) typically clay-supported; rare flow and (or) alluvial tills with a sand or silt matrix; clasts are typically a decimeter to several meters thick. Contains massive structures, including overturned foreset bedding, ice-berf shales, and kettles, and subhorizontal beds of fluvial outwash typical of unit Qv6. Clasts are of mixed Canadian, granitic, and orthogneiss locally 50% to 90% of the clast (sample, greenish brown; contains clasts of Glacier Peak dacite up to 20%); typically 3-5% dacite clasts are light to dark gray or pale red or up to 0.9 m (3 ft) wide; also locally contains lenses rich in pumice. Ice-contact deposits are richer in dacite and pumice than most recessional outwash; it is likely that some White Chuck assemblage detritus followed marginal paths toward the Stillaguamish River basin during deglaciation (this study; Dragovich and others, 2002a; J. D. Dragovich, Wash. Div. of Geology and Earth Resources, unpub. data). Abundance of gravel- to boulder-sized rip-up clasts of glaciolacustrine clay suggest excavation of labar deposits by glacial-ice and (or) volcanic dam breakout mechanisms; ice-contact deposits are inferred to locally interfinger with glaciolacustrine deposits (unit Qv6) (cross section C-C').

Qv6f Till (Pleistocene) - Nonstratified, compact, matrix-supported mixture of clay, silt, sand, and gravel in various proportions with disseminated cobbles and boulders, typically modified dark yellowish brown to brownish gray, grayish blue, or very dark gray; matrix consists of silty silt to coarse sand (s+cl). Includes rare Canadian and local provenance; up to 90% of clasts are locally derived and angular to subangular phyllite or gneiss and rare Glacier Peak dacite. Till unconformably overlies bedrock in elevated settings and locally occurs in the low valley-bottom glacial terraces, thus mantling topography.

Qv6g Advance outwash (Pleistocene) - Medium to coarse sand, pebbly sand, and sandy gravel with scattered lenses and layers of pebbly cobbly gravel; locally contains fine silty sand, silty clay, and clay interbeds; well-sorted; compact. Subhorizontal bedding or cross-stratification prominent; locally cut-and-fill structures and trough and ripple cross-beds. Mostly Canadian provenance, some locally derived clasts, and little or no Glacier Peak dacite. Interfingers with and conformably overlies unit Qv6h, as a result of glacial lake impoundment during ice advance up the Stillaguamish and Saik River valleys; composite sections of advance outwash and glaciolacustrine deposits are up to 150 ft (46 m) thick. Primarily fluvial in origin, based on stratigraphic relations including subsurface stratigraphy, some advance outwash is inferred to be dacitic (cross sections A-A', B-B', C-C').

Qv6h Advance glaciolacustrine deposits (Pleistocene) - Clay, clayey silt, silt, silty sand, and silty fine sand with local deposits; locally contains fine to medium-grained sand lenses and beds; stiff, well-sorted; finely bedded or laminated. Silt and clay are dark gray, blue gray, and gray, weathering to pale yellowish brown; 1 to 4 cm (0.4-1.6 in.) thick rhythmic bedding (varves?) common, normally graded from sand to silty clay. Soft-sediment and (or) ice-sheet deformational features are common and include tilted and contorted bedding, overturned folds, and flame structures; overturned fold geometries are consistent with ice shear during ice advance up the major river valleys. Locally overlain by and interbedded with unit Qv6i (cross sections A-A', B-B', C-C').

Qv6i Gabbro (Eocene) - Gabbro or diabase dikes, sills, and small irregular intrusions; nonfoliated; equigranular, medium-grained; greenish gray, some of the bodies appear to intrude faults; contains hornblende (commonly zoned), plagioclase (mostly labradorite), and minor clinopyroxene phenocrysts; common alteration minerals include disseminated calcite, quartz, sulfides, and sericite. Although not directly dated, gabbros are probably Eocene and possibly Oligocene in age and may represent feeder bodies for the volcanic rocks near the map area (Jones, 1959; Vance, 1957; this study; Dragovich and others, 2002).

Qv6j Chilliwack Group of the Excelsior Nappe

The Chilliwack Group is largely volcanic in origin. U-Pb ages and fossils indicate that the Chilliwack Group is largely Permian to Devonian in age (see Tabor and others, 1994).

Qv6k Metasedimentary rocks (Permian to Devonian) - Volcanic subaqueous metasediments, and meta-argillite with minor marble and phyllite and rare chert and locally argillite. Metasediments are locally well-sorted. Locally contains basaltic to rhyolitic gneiss. Gneiss includes breccia, till, and flows and is locally angular and polished. Metamorphic minerals include albite, chlorite, epidote, and minor lawsonite, muscovite, and biotite. Metasediments are locally well-sorted and contain abundant rounded to slightly deformed pebbles of phyllite, siltstone, and argillite generally subparallel to bedding (Tabor and others, 1988; Vance, 1957; this study).

Qv6l Shuksan Greenschist (Pleistocene) - Mostly well-crystallized metabasite; strongly S1 foliated; locally includes iron- and manganese-rich quartzite (metachert) and granitic phyllite interlayers; greenschist locally contains epidote segregation or primary layers and is mostly shades of greenish gray and weathers to light olive gray; blueschist to bluish gray to bluish green. Greenschist commonly layered on a centimeter scale. S1 foliation and layering are commonly folded on an outcrop scale. Relict igneous minerals locally include saussuritized and albitized plagioclase, actinolite hornblende, and rare clinopyroxene. Metamorphic minerals include albite, actinolite, epidote, and chlorite with lesser lawsonite, Pumpellyite, muscovite, opacite, and calcite. In rocks of the appropriate iron composition and oxidation state, Na-amphibole (for example, crossite) replaces actinolite as the primary metamorphic amphibole to form blueschist instead of greenschist. Greenschist and blueschist are locally interbedded at outcrop scale (Hargrett and others, 1981; Brown, 1986; Tabor and others, 1988; in press; Morrison, 1977, this study).

Qv6m Shuksan Greenschist (Pleistocene) - Mostly well-crystallized metabasite; strongly S1 foliated; locally includes iron- and manganese-rich quartzite (metachert) and granitic phyllite interlayers; greenschist locally contains epidote segregation or primary layers and is mostly shades of greenish gray and weathers to light olive gray; blueschist to bluish gray to bluish green. Greenschist commonly layered on a centimeter scale. S1 foliation and layering are commonly folded on an outcrop scale. Relict igneous minerals locally include saussuritized and albitized plagioclase, actinolite hornblende, and rare clinopyroxene. Metamorphic minerals include albite, actinolite, epidote, and chlorite with lesser lawsonite, Pumpellyite, muscovite, opacite, and calcite. In rocks of the appropriate iron composition and oxidation state, Na-amphibole (for example, crossite) replaces actinolite as the primary metamorphic amphibole to form blueschist instead of greenschist. Greenschist and blueschist are locally interbedded at outcrop scale (Hargrett and others, 1981; Brown, 1986; Tabor and others, 1988; in press; Morrison, 1977, this study).

Qv6n Chilliwack Group of the Excelsior Nappe

The Chilliwack Group is largely volcanic in origin. U-Pb ages and fossils indicate that the Chilliwack Group is largely Permian to Devonian in age (see Tabor and others, 1994).

Qv6o Metasedimentary rocks (Permian to Devonian) - Volcanic subaqueous metasediments, and meta-argillite with minor marble and phyllite and rare chert and locally argillite. Metasediments are locally well-sorted. Locally contains basaltic to rhyolitic gneiss. Gneiss includes breccia, till, and flows and is locally angular and polished. Metamorphic minerals include albite, chlorite, epidote, and minor lawsonite, muscovite, and biotite. Metasediments are locally well-sorted and contain abundant rounded to slightly deformed pebbles of phyllite, siltstone, and argillite generally subparallel to bedding (Tabor and others, 1988; Vance, 1957; this study).

Qv6p Shuksan Greenschist (Pleistocene) - Mostly well-crystallized metabasite; strongly S1 foliated; locally includes iron- and manganese-rich quartzite (metachert) and granitic phyllite interlayers; greenschist locally contains epidote segregation or primary layers and is mostly shades of greenish gray and weathers to light olive gray; blueschist to bluish gray to bluish green. Greenschist commonly layered on a centimeter scale. S1 foliation and layering are commonly folded on an outcrop scale. Relict igneous minerals locally include saussuritized and albitized plagioclase, actinolite hornblende, and rare clinopyroxene. Metamorphic minerals include albite, actinolite, epidote, and chlorite with lesser lawsonite, Pumpellyite, muscovite, opacite, and calcite. In rocks of the appropriate iron composition and oxidation state, Na-amphibole (for example, crossite) replaces actinolite as the primary metamorphic amphibole to form blueschist instead of greenschist. Greenschist and blueschist are locally interbedded at outcrop scale (Hargrett and others, 1981; Brown, 1986; Tabor and others, 1988; in press; Morrison, 1977, this study).

Qv6q Chilliwack Group of the Excelsior Nappe

The Chilliwack Group is largely volcanic in origin. U-Pb ages and fossils indicate that the Chilliwack Group is largely Permian to Devonian in age (see Tabor and others, 1994).

Qv6r Metasedimentary rocks (Permian to Devonian) - Volcanic subaqueous metasediments, and meta-argillite with minor marble and phyllite and rare chert and locally argillite. Metasediments are locally well-sorted. Locally contains basaltic to rhyolitic gneiss. Gneiss includes breccia, till, and flows and is locally angular and polished. Metamorphic minerals include albite, chlorite, epidote, and minor lawsonite, muscovite, and biotite. Metasediments are locally well-sorted and contain abundant rounded to slightly deformed pebbles of phyllite, siltstone, and argillite generally subparallel to bedding (Tabor and others, 1988; Vance, 1957; this study).

Qv6s Shuksan Greenschist (Pleistocene) - Mostly well-crystallized metabasite; strongly S1 foliated; locally includes iron- and manganese-rich quartzite (metachert) and granitic phyllite interlayers; greenschist locally contains epidote segregation or primary layers and is mostly shades of greenish gray and weathers to light olive gray; blueschist to bluish gray to bluish green. Greenschist commonly layered on a centimeter scale. S1 foliation and layering are commonly folded on an outcrop scale. Relict igneous minerals locally include saussuritized and albitized plagioclase, actinolite hornblende, and rare clinopyroxene. Metamorphic minerals include albite, actinolite, epidote, and chlorite with lesser lawsonite, Pumpellyite, muscovite, opacite, and calcite. In rocks of the appropriate iron composition and oxidation state, Na-amphibole (for example, crossite) replaces actinolite as the primary