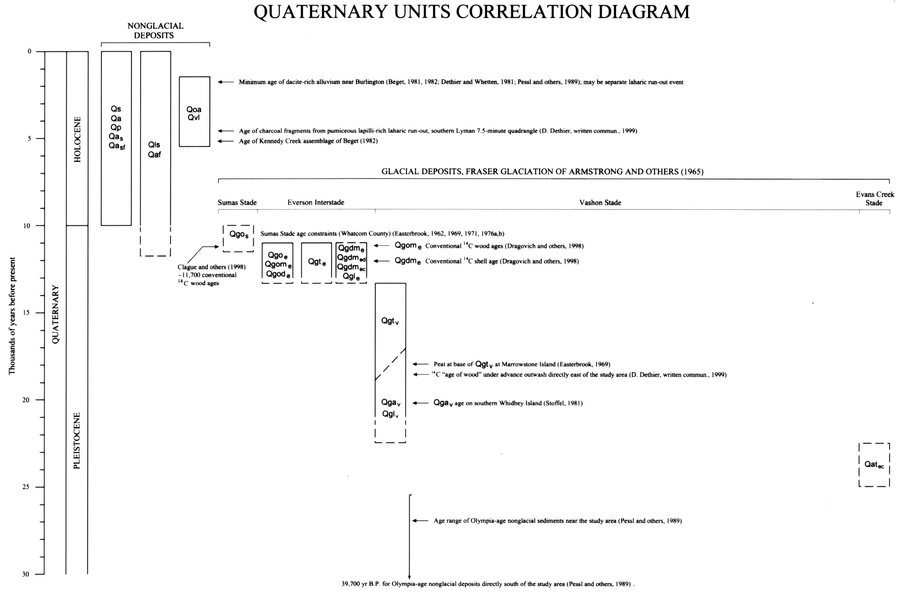
WASHINGTON STATE DEPARTMENT OF
Natural Resources
Jennifer M. Belcher - Commissioner of Public Lands

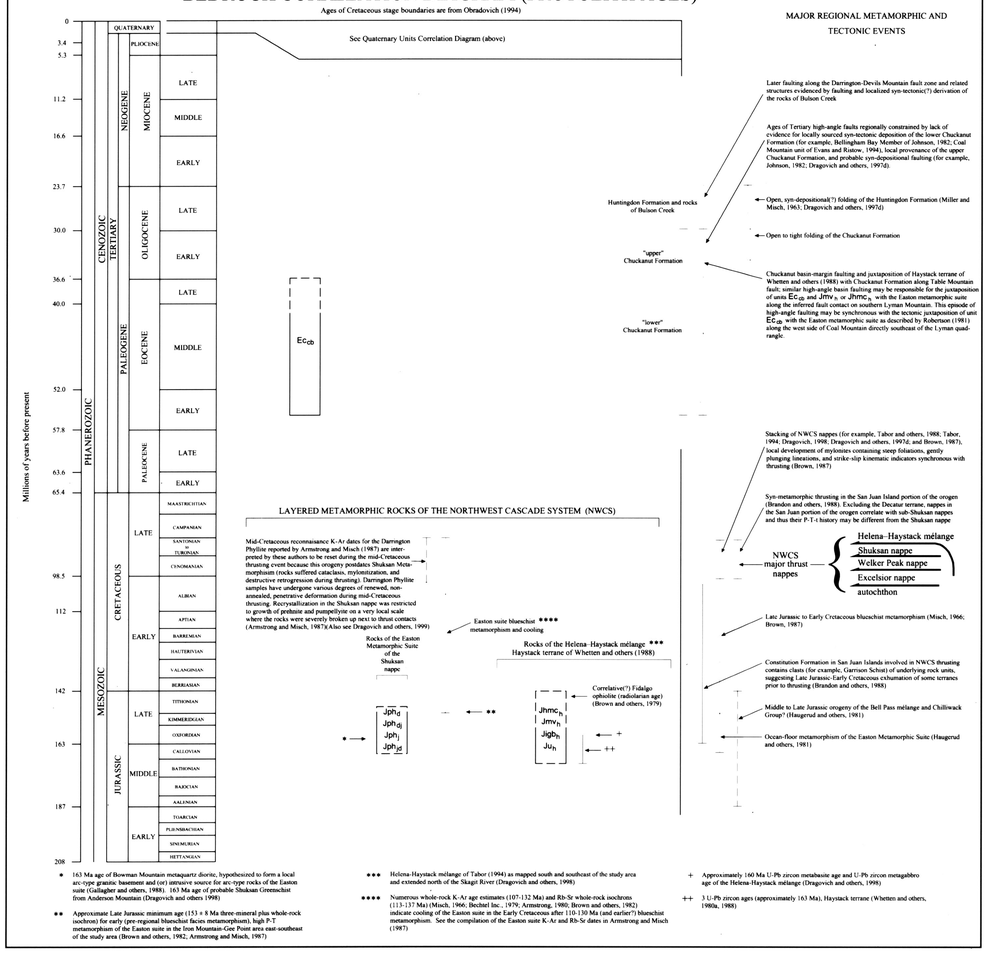
Produced in cooperation with the U.S. Geological Survey
National Cooperative Geologic Mapping Program
Agreement Number 98HQAG2062

WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
Raymond Lasmanis, State Geologist
PLATE 2
OPEN FILE REPORT 99-3
GEOLOGIC MAP OF THE SEDRO-WOOLLEY NORTH AND LYMAN 7.5-MINUTE QUADRANGLES, WESTERN SKAGIT COUNTY, WASHINGTON

QUATERNARY UNITS CORRELATION DIAGRAM



BEDROCK CORRELATION DIAGRAM (PROTOLITH AGES)



* 163 Ma age of Bowman Mountain metaquartz diorite, hypothesized to form a local arc-type granitic basement and (or) intrusive source for arc-type rocks of the Easton suite (Gallagher and others, 1988). 163 Ma age of probable Shuksan Greenschist from Anderson Mountain (Dragovich and others 1998)

** Approximate Late Jurassic minimum age (153 + 8 Ma three-mineral plus whole-rock isochron) for early (pre-regional blueschist facies metamorphism), high P-T metamorphism of the Easton suite in the Iron Mountain-Gee Point area east-southeast of the study area (Brown and others, 1982; Armstrong and Misch, 1987)

*** Helena-Haystack mélange of Talbot (1994) as mapped south and southeast of the study area and extended north of the Skagit River (Dragovich and others, 1998)

**** Numerous whole-rock K-Ar age estimates (107-132 Ma) and Rb-Sr whole-rock isochrons (113-137 Ma) (Misch, 1966; Bechtel Inc., 1979; Armstrong, 1980; Brown and others, 1982) indicate cooling of the Easton suite in the Early Cretaceous after 110-130 Ma (and earlier?) blueschist metamorphism. See the compilation of the Easton suite K-Ar and Rb-Sr dates in Armstrong and Misch (1987)

\+ Approximately 160 Ma U-Pb zircon metabasite age and U-Pb zircon metagabbro age of the Helena-Haystack mélange (Dragovich and others, 1998)

++ 3 U-Pb zircon ages (approximately 163 Ma), Haystack terrane (Whetten and others, 1980a, 1988)

GEOLOGIC UNITS

SEDIMENTARY AND VOLCANIC DEPOSITS AND ROCKS

Quaternary Sedimentary Deposits

Nonglacial Deposits

Qs Surficial deposits, undivided (Holocene to Pleistocene)(cross sections only)

Qa Alluvium of the Skagit River valley, undivided (Holocene)--Clay, silt, and fine sand with minor sand and cobble gravel; rare peat; organic matter common; local volcaniclastic materials derived from Cascade volcanoes, particularly Glacier Peak; finer-grained fluvial facies associated with deltaic-estuarine settings (Samish Bay) where fluvial facies are interbedded with fossil-bearing shallow marine (locally deltaic) and tidal flat or estuarine facies

Qoa Older alluvium and lahar run-out deposits of the Skagit River valley (Holocene)--Iron-stained sand, silt, and clay; minor volcaniclastic sands and gravels of probable Glacier Peak origin; forms terraces generally 5 to 15 m above modern flood plain

Qvl Laharic diamicton (Holocene)--gravelly sandy silty clay deposits containing significant dacite clasts; outcrops near Lyman

Qa_{sf} Alluvium of the South Fork Nooksack River valley, undivided (Holocene)--Cobbly gravel, gravel, with lesser sand, silt, and clay

Qa_s Alluvium of the Samish River valley, undivided (Holocene)--Cobbly gravel, sand, silt, and clay

Qp Peat (Holocene)

Qaf Alluvial fan deposits (Holocene to latest Pleistocene?)--Cobble, sand, and boulder diamicton; local lenses of gravel, sand, silt, and clay; locally sourced

Qls Landslide deposits undivided (Holocene and Pleistocene?)--Diamicton, locally sourced

Glacial Deposits, Fraser Glaciation of Armstrong and Others (1965) (Pleistocene)

Sumas Stade

Generally low-density proglacial outwash deposited during the Sumas re-advance north of the study area

Qgo_s Glaciofluvial outwash--Sandy cobbly gravel, gravel, and minor gravelly sand, rare silt and clay; minor clasts of probable Twin Sisters Dunite and Mount Baker andesite origin; occurs mostly as cut-fill terraces 1 to 30 m above the Samish River valley floor

Everson Interstade

Generally low-density glaciomarine and rare glaciolacustrine deposits

$Qgdm_e$ Glaciomarine drift--Clayey silt, silty clay, clay, and clay-rich diamicton; locally contains lenses and layers of sandy or gravelly outwash

Locally divided into:

$Qgdm_{ac}$ Fine glaciomarine sediment--Mostly clayey silt, silty clay, and clay; massive to locally rhythmically bedded or varved with lesser sand and silt interbeds; rare or no gravel (dropstones); unit gmd_c on cross sections (Plate 4)

$Qgdm_{ad}$ Diamicton--Mostly silty sandy clay with scattered gravel (dropstones) or clayey silty sandy gravel; unit gmd_d on cross sections (Plate 4)

Qgo_e Terrestrial recessional outwash--sand, sandy gravel, gravelly sand, and sandy cobble gravel with rare interlayered silt; massive to crudely bedded on a scale of centimeters to a meter; commonly has low-amplitude foreset beds (1 m high), pebble imbrication, truncation surfaces (scoured bedding), and moderate sorting indicative of high-energy braided river deposition; rare planar foreset beds and phyllite- and vein-quartz-rich clast composition on Lyman Mountain suggest alluvial fan deposition on the terrestrial outwash braid plain occupying Lyman Pass; mapped above the glaciomarine limit of 360-400 ft elevation

$Qgom_e$ Fluvial-deltaic-turbiditic glaciomarine outwash--Sand, gravel with minor interlayered silts and silty sands; rare diamicton; occurs below the glaciomarine limit of 360-400 ft elevation

Locally divided into:

$Qgod_e$ Deltaic glaciomarine outwash--Sandy gravel, gravelly sand, and silty sand with lesser sandy cobbly gravel and rare interlayered silt; typically thinly to thickly bedded and distinctly stratified on a scale of centimeters to a few meters; very commonly displays planar high-amplitude foreset beds (tens of meters vertical extent; dipping 15-40°) and suggestive of deltaic foreset deposition (into the Skagit River marine embayment) forests locally overlain along a distinct truncation surface by 1-2 m of sandy cobbly gravel suggestive of topset beds; deposits typically a mixture of phyllite, vein-quartz, and other local rock types, as well as clasts of Canadian provenance; mapped at and directly below the glaciomarine limit of 360-400 ft elevation; locally interlayered with or underlain by Everson Glaciomarine Drift (for example, unit $Qgdm_{ad}$) near the transition from foreset to bottomset beds, suggestive of deltaic progradation into the open marine Skagit River embayment

Qgl_e Glaciolacustrine deposits; recessional glacial lake rhythmites of the South Fork Nooksack River and Lyman Hill--Silty clay, clayey silt, silty sand, and sand with random local dropstones; moderately to well-sorted rhythmically bedded and (or) varved; gravel and sand clast compositions indicate a mixed local northern and Canadian provenance; rhythmite bedding typically 1 cm thick and coarsening upward from clay to silty sand and sand; included in this unit are elevated occurrences of glacial lake sediments on Lyman Hill that consist of varved to laminated sandy silt or clayey silty sand rhythmites with soft-sediment deformational features including folded or contorted bedding; probable glaciolacustrine deposits of recessional origin; Everson glacial lakes interpreted to be impounded by the retreating glacial ice and topographic barriers such as Lyman Hill

Qgt_e Till--typically clayey, silty, sandy gravel diamicton to silty, sandy, gravel with boulder diamicton; clast types indicate mixed local northern and Canadian provenance (for example, predominately granite, Chuckanut, phyllite, and vein-quartz clast types); massive; occurs north of Sedro-Woolley as a moderately dense to loose diamicton of probable flow-till origin; interpreted to demark positions of stranded retreating ice near the glaciomarine limit of 360-400 ft elevation

Vashon Stade

Moderate- to high-density glacial deposits

Qgt_v Till--Clayey, silty, sandy gravel diamicton; Locally includes layers and lenses of gravel and sand

Qga_v Advance outwash--Sandy gravel, sand, and scattered lenses of cobbly gravel with lesser silt and clay interbeds; Canadian or local northern provenance; mostly composed of moderately to well-sorted, distinctly stratified, medium to coarse sand and pebbly sand with minor amounts of fine sand, silty sand, or sandy silt and scattered lenses and layers of pebble-cobble gravel; deltaic foresets (10-20 m in vertical extent) pronounced in the South Fork Nooksack River valley where Qga_v is interlayered with Qgl_v; elsewhere Qga_v in Qgl_v displays trough cross-bedding, and bedding truncates surfaces suggestive of a braided river deposit

Qgl_v Glaciolacustrine deposits: advance glacial lake rhythmites and associated glacial outwash of the South Fork Nooksack River--Silty clay, clayey silt, silty sand, and sand with random local dropstones; sand lenses common in silt and gravel layers; also includes lesser sand, sandy cobble gravel, and rare, typically clast-supported, boulder gravel deposits in a sandy silt matrix (both flow till and valley-margin alluvial fan origin); gravel and silt layers commonly contain silty rip-up clasts of glacial lake rhythmites; rhythmite bedding is typically 1 cm thick and coarsens upward from silty clay to silty sand or sand; in outcroppings elsewhere, rhythmic bedding is less pronounced and the interlayered clays, silts, sands, and lesser gravels are well-stratified and thinly to thickly bedded and commonly define an overall coarsening-upward sequence (grades to Qga_v, above); mixed local northern to Canadian provenance; soft-sediment deformational features in silts and clays include contorted bedding, overturned folds, and rare flame structures (see geologic structure symbols); sands commonly plane bedded (grades to Qga_v); areas with greater than 50 % interlayered outwash sand and gravel are mapped as Qga_v in the South Fork Nooksack River valley; units Qgl_v and Qga_v are interlayered on a scale of centimeters to tens of meters and display an overall coarsening-upward sequence

Evans Creek (alpine) Stade

Qat_{ec} Till--Typically clayey, silty, sandy gravel diamicton; clast types indicate local eastern or headwaters of the South Fork Nooksack River provenance (mostly dunite, slate, phyllite, and andesite clast types); massive; occurs at several localities as a very dense "till pavement" observed near the river level of the South Fork Nooksack River; This "till pavement" at river level is tentatively correlated with similar till on Miners Mountain

Glacial Deposits, Pre-Fraser Glaciation of Armstrong and Others (1965)(Pleistocene)

ot Older till (Pleistocene)--silty, sandy, clayey gravel (diamicton); massive; small outcroppings of till below advance outwash in the Skagit and Samish River valleys. See Heller (1978) for further description of the older till in the Skagit River valley near Lyman; tentatively correlated with the Possession till (for example, Easterbrook, 1994); unit ot not further described in the text

Tertiary Sedimentary Rocks

Chuckanut Formation

Ec_{cb} Bellingham Bay Member (Eocene)--Conglomerate, arkose, siltstone, shale, and coal

LOW-GRADE LAYERED METAMORPHIC ROCKS OF THE NORTHWEST CASCADE SYSTEM

Mesozoic Metamorphic Rocks of the Shuksan Nappe of Tabor and Others (1994)

Easton Metamorphic Suite of Misch (1966)(Jurassic)--Metasedimentary clastic and lesser metavolcanic rocks. Metapelite (shale) to siliceous meta-argillite of the Darrington Phyllite grades to the semischist of Mount Josephine with increasing sand and (rarely) gravel content of the protolithic sediments; Darrington Phyllite predominantly graphitic quartzose phyllite with lesser calcareous graphitic quartzose phyllite (metamarl?) to micaceous quartzite; phyllonitic or mylonitized near the thrust contact with the overlying Helena-Haystack mélange. Divided into:

Jph_d Darrington Phyllite (<10% semischist);

Jph_{dj} Darrington Phyllite (10-50% interlayered semischist)

Jph_{jd} Semischist of Mount Josephine (10-50% interlayered phyllite)

Jph_j Semischist of Mount Josephine (<10% phyllite)

Jsh_s Shuksan Greenschist (Jurassic)--Mostly epidote ± actinolite-bearing metabasalt, metabasaltic andesite, and rarely andesitic greenschist; common relict igneous minerals include sausseritized (locally) and albitized, euhedral to subhedral plagioclase laths (0.2-2 mm long), occasionally with corroded, anhedral, and replaced (by actinolite) hornblende. Texturally, greenschists are moderately well to very well recrystallized, strongly S1 foliate, and thinly banded as a result of metamorphic differentiation of quartzo-feldspathic components, typically giving the rock a slight segregated appearance (~1-2 mm bands). Syn-D1 tectonic recrystallization of the primary metamorphic minerals is evident. The greenschists differ from the Helena-Haystack mélange greenstone, which very commonly have relict augite, vesicules (amygdaloidal metabasalt), and pillows

* Serpentinite or talc-bearing ultramafite pods and outcroppings too small to show at map scale

Mesozoic Metamorphic Rocks of the Haystack Thrust Nappe of Whetten and Others (1988) and the Helena-Haystack Mélange of Tabor (1994)(Jurassic)

Generally, blocks in a serpentinite-matrix mélange overlying the Easton Metamorphic Suite. Divided into:

$Jhmc_h$ Heterogeneous metamorphic rocks north of Sedro-Woolley--Metabasaltic greenstone, phyllitic to slaty, graphite-bearing meta-argillite, serpentinite, and metasandstone

Outcrops dominated by augite-bearing metabasalt, metabasaltic andesite, and meta-andesitic greenstone (locally pillowed)

Jmv_h Metabasaltic greenstone--Commonly augite-bearing; pillows and pillow breccia usually preserved

Metavolcanic greenstone, undivided

Outcrops dominated by pillowed metabasalts and metabasaltic andesite

$Jigb_h$ Augite-bearing metagabbroic greenstone

Ju_h Serpentinite with lesser talc schist, talc-tremolite schist, and tremolite schist with rare diopside-bearing pyroxenites; alpine ultramafic bodies occurring as tectonic slices within the mélange, serpentinite common along the thrust contact between the Easton Metamorphic Suite and the Helena-Haystack mélange

* Serpentine or talc-bearing ultramafite pods and outcroppings too small to show at map scale

EXPLANATION

Contact--Dashed where inferred; dotted where concealed

D / U High-angle fault--Dashed where inferred; dotted where concealed; U, upthrown block; D, downthrown block; arrows indicate relative apparent strike-slip motion

Thrust fault--Dashed where inferred; dotted where concealed; sawteeth on upper plate

Antiform--Dashed where inferred; dotted where concealed; arrow indicates direction of plunge

Synform--Dashed where inferred; dotted where concealed; arrow indicates direction of plunge

Direction of landslide movement

Fining: Fining trend in Everson Interstade outwash (see text)

Latest Pleistocene to Holocene fluvial terrace--Dashed where inferred; hachures on scarp side

Bar and swale topography in unit Qa (lateral accretion surfaces of meandering river point bars) visible on the NW-1996 aerial photographs (age unknown)

Abandoned channels visible on 1:12,000-scale NW-1996 aerial photographs (ages of these channels are unknown)(see Plate 3 for former Skagit River channels mapped from aerial photograph and historical map analyses)

Strike and dip of bedding (may be combined with other symbols)

inclined (glacial deposits only; includes foreset bedding)

inclined

vertical

inclined bedding parallel to tectonic foliation

Trend and plunge of fold axes (glacial deposits only)

Overturned to upright fold axes in advance glacial lake rhythmites of South Fork Nooksack River (soft-sediment folding)

horizontal fold axes

plunging fold axes; arrow indicates direction of plunge

Trend and plunge of minor fold axes (may be combined with other symbols)

Overturned fold axis (combined with F2 and F3 fold axis symbols below)

F1 fold axis; arrow indicates the direction of plunge

F2 fold axis and (or) crenulation lineation; arrow indicates direction of plunge

F3 fold axis and (or) crenulation lineation; arrow indicates direction of plunge

F2 M-shaped fold axis and (or) crenulation lineation; arrow indicates direction of plunge

F3 M-shaped fold axis and (or) crenulation lineation; arrow indicates direction of plunge

F2 Z-shaped fold axis and (or) crenulation lineation; arrow indicates direction of plunge

F3 Z-shaped fold axis and (or) crenulation lineation; arrow indicates direction of plunge

F2 S-shaped fold axis and (or) crenulation lineation; arrow indicates direction of plunge

F3 S-shaped fold axis and (or) crenulation lineation; arrow indicates direction of plunge

F4 fold axis and (or) crenulation lineation; arrow indicates direction of plunge

Kink fold

Strike and dip of tectonic foliation (may be combined with other symbols)

Penetrative tectonic foliation (undifferentiated) compiled from Bechtel Inc. (1979) geologic map of the study area; arrowed ends have no kinematic significance; Bechtel structural site revisitations indicate that the foliation measurements represent an undifferentiated composite of S1, S2, S3, and rarely S4 foliations

inclined

vertical

Penetrative tectonic foliation (undifferentiated); generally crystalloblastic cleavage in the Easton metamorphic suite and Helena-Haystack mélange metasedimentary rocks; generally syn- to late-metamorphic protomylonitic to mylonitic in Helena-Haystack mélange meta-igneous rocks (greenstones)

inclined (parallel to subparallel to locally preserved bedding; rarely oblique to bedding in unit $Jhmc_h$)

vertical (parallel to subparallel to locally preserved bedding; rarely oblique to bedding in unit $Jhmc_h$)

Penetrative S2 axial plane foliation forming a "slaty cleavage" (F2 folds or crenulations apparent only upon close macroscopic examination or microscopic examination)

inclined

vertical

Strongly developed semi-penetrative to locally penetrative S2 axial plane foliation

horizontal

inclined

vertical

Weakly developed semi-penetrative to non-penetrative S2 axial plane foliation or F2 axial plane

inclined

vertical

Penetrative to semi-penetrative cataclastic foliation or fracture cleavage associated with high-angle fault zones (commonly slickensided fracture planes)

inclined

vertical

Areas of pervasive brittle to semi-ductile shear deformation adjacent to fault zones

Thin (meter-scale to tens of meters) mylonitic inhomogeneous shear zone (typically near D3 thrust zones), inclined

Strike and dip of fractures and joints (may be combined with other symbols)

Joint, undifferentiated

inclined

vertical

Subsidiary minor fault or slickensided fracture plane

inclined

vertical

Minor fault (commonly with gouge zone)

inclined

vertical

Veins (includes asbestos-fiber extensional veins in serpentinite)

inclined

vertical

Trend and plunge of tectonic lineations

Lineation, undifferentiated (mostly stretching lineations and crenulation lineations; rare pencil lineations, slickenlines, and boudins are included); arrow indicates direction of plunge

inclined

horizontal

Slickenline on slickensided fracture, fault, or cataclastic to mylonitic foliation; arrow indicates direction of plunge

inclined (p, pencil lineations)

horizontal

Stretching lineation; arrow indicates direction of plunge

inclined

inclined L1 stretching lineation (shown only in the Easton Metamorphic Suite)

horizontal L1 stretching lineation

Cartographic design and production by Keith G. Ikerd,
Washington Division of Geology and Earth Resources