U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

GEOLOGIC MAP OF THE TWIN LAKES 15' QUADRANGLE, FERRY COUNTY, WASHINGTON

by

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Open-File Report 93-715

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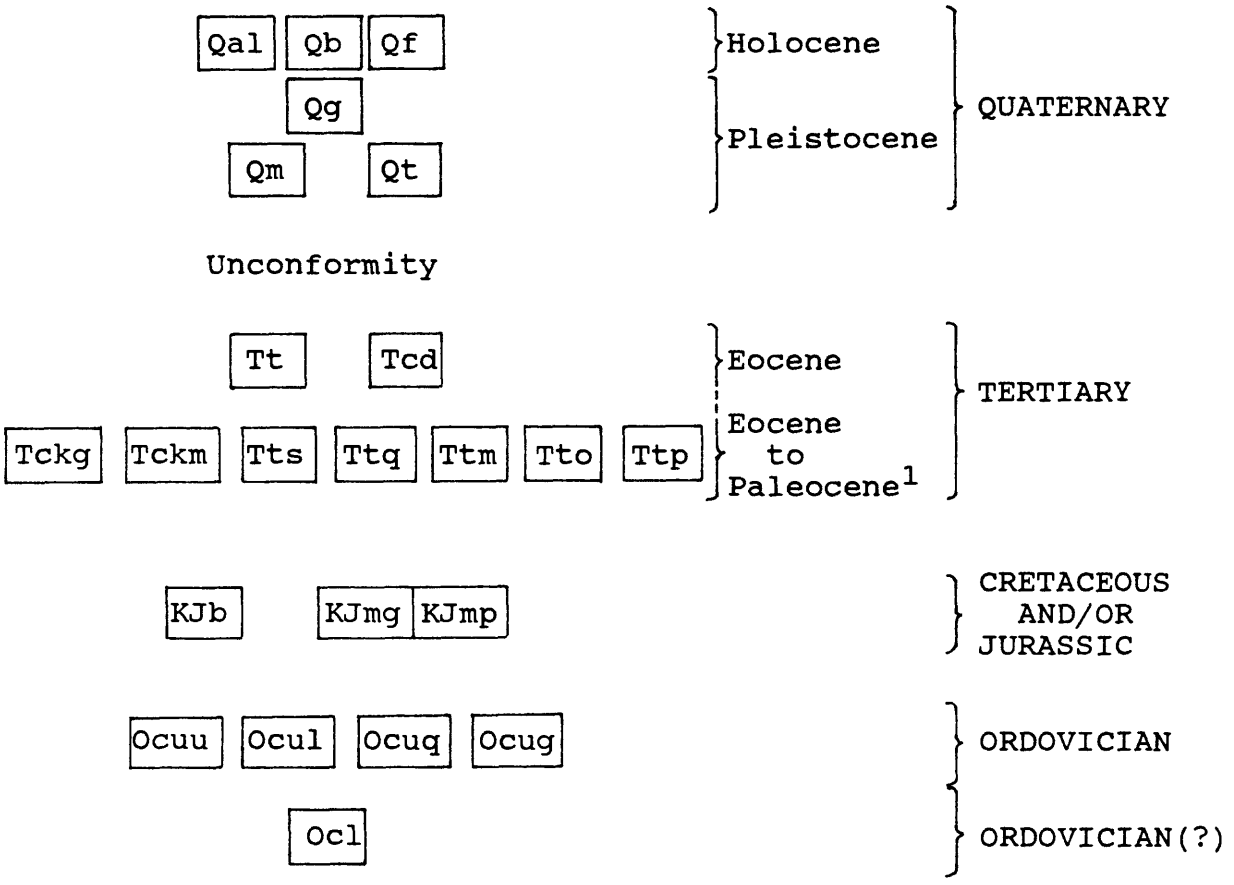
CORRELATION OF MAP UNITS



[1] With respect to units Tckm, Tts, Ttq, Ttm, Tto, and Ttp, refers to age of penetrative dynamic and thermal metamorphism. Protolith of these units likely includes parts of the Covada Group, plutonic rocks of probable Cretaceous and/or Jurassic age, and granitic and migmatitic dikes and sills generated chiefly through partial melting during Paleocene and Eocene and related to the Colville batholith (units Tckg and Tcd)

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qal **Alluvium (Holocene)**--Stream gravel, sand

Qb **Bog, marsh, and alluvial deposits (Holocene)**--peat, clay, silt, sand

Qf **Fan deposits (Holocene)**--Chiefly silt, sand, and gravel

Qg **Outwash (Pleistocene)**--Stratified water-laid deposits of variably sorted silt, sand, and bouldery gravel covering valley floors and partially mantling upland surfaces. Unit locally includes conspicuous lateral moraines (near the inferred boundary between glaciated and unglaciated terrane on the northeast flank of Grizzly Mountain, south of the crest of Sitdown Mountain, and north of the crest of Johns Mountain). Also includes a thick deposit of lacustrine silt forming the dissected terrace outlined by the 1840 foot contour south of Lakeside Grange (southeastern corner of the quadrangle). Unit was deposited chiefly from meltwater streams and lakes ponded along the flanks of the receding Columbia lobe of the Cordilleran ice sheet.

Qm **Morainal deposits (Pleistocene)**--Cobbly gravel and sand. Poorly exposed. Forms low ridges trending orthogonal to inferred direction of ice flow north of Granite Creek, and south of Lynx Creek

Qt **Till (Pleistocene)**--Pebbles and cobbles in matrix of brownish gray clay and silt. Pebbles and cobbles typically rounded to disc-shaped; composed chiefly of lithologies present within the Covada Group and the Kettle gneiss dome. Clay is locally platy with conchoidal to hackly fracture. Distinguished from glacial outwash by lack of sorting and predominance of clay. Poorly exposed. Typically forms layer as much as several meters thick mantling bedrock. Between Moon Mountain and South Twin Lakes, boulders littering surface of deposit locally reach 2 m in diameter.

HYPABYSSAL INTRUSIVE ROCKS

Tt **Trachyte (Eocene)**--Light gray to dark greenish gray very fine grained trachyte. Forms dikes cutting older rocks. Commonly porphyritic, with hornblende and biotite phenocrysts set in an aphanitic matrix. Locally vesicular; margins finer-grained (chilled). Typically composed of K-feldspar, minor plagioclase, trace of quartz, phenocrystic biotite and hornblende. Commonly partially altered to chlorite and clay minerals.

PLUTONIC AND HIGHLY METAMORPHOSED ROCKS

Colville batholith (Eocene and Paleocene)

Tcd **Devils Elbow suite (informal usage of Holder and Holder, 1988)**--Medium to dark-gray, mafic (color index approximately 25), fine-grained hornblende-biotite monzodiorite containing approximately 5 percent intergranular K-feldspar; locally cut by mineralogically similar but more leucocratic (color index approximately 15) monzodiorite. Prominent crystals of yellow titanite common; contains mafic schlieren and abundant dark gray, blocky xenoliths of diorite; commonly slightly to moderately mylonitized and lineated in zones 4 to 7 cm in thickness, spaced 15 to 20 cm apart.

Keller Butte suite (informal usage of Holder and Holder, 1988)

Tckg **Light gray, coarse to fine-grained, leucocratic (color index 5 to 10) massive granite grading to mylonitic and lineated gneiss**--Composed chiefly of oligoclase, orthoclase, quartz, and minor biotite (locally partially altered to chlorite) with accessory allanite, apatite, and monazite; muscovite is a common constituent at Johns Mountain and Oregon City Ridge, but is only rarely present north of Grizzly Mountain and at Dollar Mountain and Onion Ridge. Commonly megacrystic.

At Grizzly Mountain, Johns Mountain, and Oregon City Ridge unit is locally composed of a mixture of fine-grained granitic and coarse-grained pegmatitic phases with seriate textures (illustrated in Fox, 1994, fig. 6). Within Kettle gneiss dome, commonly a lineated and mylonitic gneiss (Cheney, 1976; Fox and Wilson, 1989, and Fox, 1994), and where megacrystic, is an augen gneiss. Contact between massive and mylonitic facies (in southwestern part of quadrangle) is gradational over several hundred meters. This contact represents the southern boundary of the Kettle gneiss dome. The contact is truncated by the Kettle River fault on the east.

Both the massive and mylonitic facies are cut by multiple generations of dikes of pegmatite and of pegmatite mixed with fine-grained alaskitic granite. On Oregon City Ridge, the mylonitic facies is also cut by irregularly shaped bodies of massive to moderately mylonitic aplitic to alaskitic granite, which along with their host, are cut by dikes as described above. Within the Kettle gneiss dome, the oldest dikes are mylonitized along with their host and translated to shallow or subhorizontal inclinations, whereas the several younger generations are progressively more massive and more steeply dipping. In southwestern sector of quadrangle unit forms part of Daisy Trail pluton (informal usage of Holder and Holder, 1988)

Tckm **Interlayered, light-gray, fine-grained, variably lineated and mylonitic granitic gneiss, dark-gray biotite schist, white quartzite, and biotite (muscovite) granite mixed with pegmatite**--Primary texture of the mixed fine-grained granite and pegmatite is seriate, as described above. The seriate granite-pegmatite and mylonitic granite gneiss are similar to and likely a continuation of the granitic rocks included within unit Tckg. Layers of the various lithologies composing unit Tckm range in thickness from several centimeters to 10 meters. Contacts between granitic and metasedimentary layers are feathery or gradational over thicknesses of 1 to 2 centimeters. Proportion of granitic to metasedimentary rocks within much of the unit ranges from 1 to 3 to 3 to 1. Unit grades to unit Tckg through diminution in abundance of layers of metamorphic rock, and to the metamorphic rocks of Tenas Mary Creek, through diminution in abundance of layers of granite and pegmatite.

The layers of mixed granite and pegmatite and of granitic gneiss are grossly conformable with compositional layering within the intercalated schist and quartzite. In detail, however, the granitic gneiss commonly cuts compositional layering within the schist and quartzite at shallow angles, suggesting that the layers of granitic gneiss include transposed dikes as well as sills. Layers of mylonitic granite gneiss and mixed granite and pegmatite are commonly infolded with the intercalated schist and quartzite, locally forming highly appressed isoclines. However, the youngest of the several generations of variably gneissic mixed granite and pegmatite dikes cut the infolded older mixed granite-pegmatite, granitic gneiss, schist and quartzite.

Metamorphic rocks of Tenas Mary Creek (Eocene and Paleocene)

Tts **Thinly interlayered, lineated, dark-gray micaceous schist and white (locally light- to dark gray) quartzite with micaceous laminae**--Schist composed of fine-grained intertwining shreds of biotite, muscovite, and quartz, locally with scattered grains of orthoclase, sericitic plagioclase, and rarely, poikiloblastic red garnet. Quartzite consists chiefly of variably recrystallized, fine-grained, mylonitic quartz with intergranular shreds of muscovite and biotite, subhedral tourmaline, and rounded to subhedral red to reddish brown prisms of monazite. Sillimanite (variously fribrolitic, elongate prismatic, or granulated) is commonly present north of Hall Creek, and kyanite was observed at scattered localities south of Hall Creek. Biotite in these rocks is locally altered to chlorite and nontronite.

Ttq **Finely lineated, fine-grained, white quartzite with conspicuous laminae of mica and indistinct fine laminae of gray to brownish gray, finer grained quartzite, locally interlayered with feldspathic quartzite**--Composed chiefly of fine-grained to very fine-grained interlocking grains of quartz (variably recrystallized mylonite), feldspar (in some layers) with scattered intergranular shreds and sheaves of muscovite. Micaceous laminae commonly spaced 1 to 50 cm apart, and composed of muscovite and/or biotite, and north of Hall Creek, sillimanite. Laminae locally peppered with black tourmaline. Quartzite commonly contains tiny red to reddish-brown crystals of monazite. Lineation defined by fine striation in quartzite, and parallism of elongate minerals (biotite, muscovite, sillimanite) within micaceous laminae. Laminations commonly define highly appressed isoclinal folds with fold axes parallel or subparallel to the lineation.

Ttm **Interlayered white dolomitic and/or calcitic marble, gray calc-silicate gneiss, and dark gray schist**--Marble ranges from coarsely crystalline and massive to fine-grained and foliated. In western part of section 4, T.34 N., R.35 E. (Buckhorn Creek area) dolomitic marble contains disseminated olivine, diopside, spinel, and megascopic crystals of amber chondrodite. In southern part of section 2, T.35 N., R.36 E. (Barnaby Creek area) calc-silicate gneiss is laminated, with layers composed of quartz sandwiched between layers composed of garnet, diopside, and minor sphene.

Tto **Greenish gray mylonitic orthogneiss**--Scattered rounded to lenticular augen of K-feldspar entrained in thinly laminated matrix of mylonitic quartz, plagioclase, K-feldspar, hornblende, biotite, and accessory sphene. Mafic minerals partially chloritized. Shallow-dipping, early penetrative mylonitic fabric intersected, dragged, and rotated between later set of anastomosing, steeply-dipping, shear zones (to several millimeters thick, with diffuse boundaries) and surfaces spaced one to ten centimeters apart, commonly healed by epidote,

Ttp **Thinly interlayered, weakly lineated, dark-gray, very fine-grained schist (locally phyllite, and in places, slate) and white (locally light- to dark gray) quartzite with phyllitic laminae and partings speckled with tiny flakes of muscovite (barely large enough to be distinguished with the naked eye)**--Schist composed of quartz, muscovite, biotite, minor orthoclase, and accessory tourmaline, monazite, sphene, and zircon. Unit distinguished from Covada Group by presence of penetrative lineation and mylonitic fabric, and from unit Tts by lower metamorphic grade.

KJb **Barnaby Creek pluton (Cretaceous or Jurassic)**--Greenish gray, chloritic, biotite granite. Closely fractured, with fracturing increasing in intensity toward the Kettle River fault.

Meteor pluton (Cretaceous or Jurassic)

KJmg **Greenish-gray to medium gray, fine- to medium grained, massive hornblende-biotite granodiorite**--Locally grades to monzodiorite along eastern contact. Color index 10 to 20, locally increasing to as much as 50 along eastern contact. Contains scattered crystals of yellow-brown titanite. Mafic inclusions locally present. Commonly closely jointed and altered, with chlorite, epidote, and calcite coating joints and replacing primary hornblende and biotite. Altered zones locally contain scattered crystals of pyrite. Cut by granitic rocks of Keller Butte suite (unit Tckg).

KJmp **Light-gray, massive, medium-grained, porphyritic granite**--Fine-grained, weakly porphyritic granite at Moon Mountain. Color index typically 5 to 10. Contains hornblende and biotite, and scattered small, pinkish gray, equant, euhedral to subhedral phenocrysts of K-feldspar (commonly approximately one-half cm across).

WEAKLY TO MODERATELY METAMORPHOSED ROCKS

Covada Group

Upper part (Ordovician)

Ocuu **Undivided**--Thickly interbedded dark gray to dark bluish gray phyllite, fine sand to silt-size wacke (locally with abundant fine-grained muscovite), black slate, greenish gray limy phyllite, light-gray to black quartzite with phyllitic laminae, massive bluish-gray quartzite, limy greenschist, and steel gray to black limestone--Complexly folded and refolded. Thicker beds of massive bluish-gray quartzite shown as unit Ocuq. Distinguished from rocks of the lower part of the Covada Group by presence of limestone and limy phyllite, and absence of coarse sand to grit-size wacke. The basal contact of the upper member is closely bracketed by outcrops on Rainy Ridge. The contact is arbitrarily placed at a stratigraphic horizon marked variously by the base of the lower of two prominent quartzite units (described below), or at the base of a limestone unit locally deposited in lieu of the quartzite. South of Abraham Canyon neither the quartzite nor limestone was recognized. In this area the contact was placed at the base of a distinctive calcareous greenstone unit (described below). The upper part of the Covada Group is probably correlative with parts of the Covada Group containing Lower Ordovician fossils in the Inchelium quadrangle to the east (Snook and others, 1981; 1990).

Ocul **Sooty black fine-grained graphitic limestone, light bluish gray to light gray silty to sandy limestone, and orange-brown-weathering dolomite**--Dolomite locally siliceous, and commonly contains thinly laminated interbeds of silty limestone. Limestone locally cherty. Thinly interlayered with limy phyllite on western flank of Rainy Ridge.

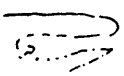
Ocuq **Quartzite**--Massive, bluish-gray quartzite, cut by numerous thin veins of milky white quartz. Bedding typically not discernible. Composed of fine- to medium-grained quartz sand. Commonly forms two prominent but discontinuous marker horizons.

Ocug **Greenish-gray, coarse- to fine-grained schistose greenstone**--Contains abundant chlorite and calcite. Lenses of light yellowish gray dolomite present along basal contact on Rainy Ridge. On Onion Ridge, unit includes massive, dark greenish gray, coarsely crystalline greenstone as well as fine-grained greenstone and calcareous greenschist. Unit forms marker horizon in the interval between the two quartzite horizons discussed above.

Lower part (Ordovician(?))

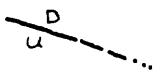
Ocl **Thickly to thinly interbedded coarse- to fine-grained olive gray wacke, light-gray to greenish-gray medium-grained quartzite, dark gray phyllitic slate and dark gray to black slaty argillite**--Wacke characteristically composed of fine sand to grit-size angular to subrounded quartz, blocky feldspar, and platy muscovite. Quartz commonly clear to smoky. Feldspar commonly potassic. Carbonate typically absent. Beds commonly 2 cm to 15 cm thick, rarely several meters thick. Graded beds common.

Base of unit not recognized in the Twin Lakes quadrangle. Unit is probably several kilometers thick, and is divisible into three intergrading parts. The uppermost, approximately 1 km thick on Rainy Ridge, is composed chiefly of argillite and phyllite. The middle part of the unit, exposed on Rainy Ridge and in the adjacent Inchelium 15' quadrangle (Snook and others, 1990), consists chiefly of wacke and is approximately 1.3 km thick. The lower part, exposed in stratigraphic sequence below the upper part in the Inchelium 15' quadrangle and out of sequence in the structural block in sections 19 and 30, T.33 N.,R.36 E., consists chiefly of the light gray to greenish gray quartzite, and is likely several hundred meters thick. Fossils have not been reported from the lower member. It is assumed to be Ordovician on the basis of its apparent conformability with the fossiliferous upper member.



Contact--Long dashed where inferred, short dashed where gradational, querried where doubtful, dot-dashed where interfingering (shown diagramatically), dotted where covered by surficial deposits

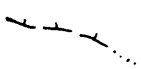
Faults--Dashed where inferred, dotted where covered by surficial deposits



Normal--D, down; U, up

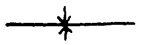
Low-angle extensional--Teeth toward upper plate. In cross sections: T, toward; A, away

Reverse and thrust--Teeth toward upper plate

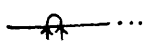


Structural facies boundary--Dotted where covered by surficial deposits. Approximate location of shallowly dipping gradational zone between lineated, mylonitic granitic rocks (mylonite, protomylonite, blastomylonite) of Kettle gneiss dome and non-lineated, non-mylonitic (massive) granitic rocks outside of gneiss dome. The granitic rocks, both mylonitic and nonmylonitic, are part of the Keller Butte suite (unit Tck) of the Colville batholith. The gradational zone is as much as a kilometer wide, and several hundred meters thick. Massive rocks form an upper plate, overlying the mylonitic rocks of the gneiss dome (see discussion by Fox, 1994). Tics point towards upper plate

Fold (major)--Amplitude in excess of 100 m

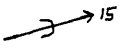


Syncline--Showing trace of fold axis

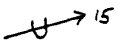


Syncline, overturned--Showing trace of fold axis. Dotted where concealed

Fold (intermediate scale)--Amplitude 1 to 100 m



Anticline--Showing bearing and plunge of fold axis



Anticline, overturned--Showing bearing and plunge of fold axis

Syncline--Showing bearing and plunge of fold axis

Fold (minor)--Amplitude less than 1 m. Showing bearing and where inclined, the plunge of fold axis. May be combined with other symbols. Plunge not shown where fold axis lies in plane of associatied foliation

Inclined

Horizontal

Bedding--Showing strike and dip

Facing direction known from depositional features

Upright

Overturned

Facing direction inferred from bedding-cleavage relationship

Overturned

Facing direction inferred from stratigraphic sequence

Upright

Overturned

Facing direction unknown or unstated

Inclined

Horizontal

Vertical

Foliation (cleavage and schistosity) in low-grade metamorphic rocks--Showing strike and dip

Inclined

Vertical

Horizontal

Mylonitic foliation--Showing strike and dip

Inclined

Inclined, variable strike

Vertical

Horizontal

Undulatory, but approximately horizontal

Compositional layering--Showing strike and dip

Inclined

Vertical

Shear bands, shear zones, and shear surfaces--Showing strike and dip. Closely to widely spaced (commonly 5 cm to 3 m) sub-planar to gently curving and anastomosing non-penetrative layers, zones and surfaces (layers and zones commonly 1/2 cm to 5 m-thick) cutting earlier folded to contorted penetrative mylonitic foliation and/or compositional layering. Shear bands composed of lineated, fine-grained granitic gneiss (recrystallized mylonite). Shear zones are zones of closely-spaced lineated mylonitic foliation.

Lineation--Showing bearing and where inclined, the plunge of lineation. May be combined with other symbols. Plunge not shown where lineation lies in plane of associatied foliation (R, rodding)

Inclined

Horizontal

Joints--Showing strike and dip

Inclined

Vertical

Compound set

Crumpled bedding

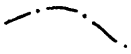
Brecciated rock

Sheared rock

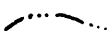
Area of many inclusions of metamorphic rocks in granitic rocks

Features related to glaciation

Glacial striae



Approximate maximum upper extent of Columbia lobe of Cordilleran ice sheet--Marked by highest glacial erratics and outwash, and in places, by lateral moraines,



Approximate maximum upper extent of late valley glacier flowing eastward down Hall Creek valley--Defined by terminal moraine, u-shaped valley profile, and hanging valleys

Gravel pit

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