WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
Raymond Lasmanis, State Geologist

GEOLOGY OF THE TWISP RIVER-CHELAN DIVIDE REGION, NORTH CASCADES, WASHINGTON

BY

ROBERT B. MILLER

WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES

OPEN FILE REPORT 87-17

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This report has not been edited or reviewed for conformity with Division of Geology and Earth Resources standards and nomenclature.

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Brian Boyle - Commissioner of Public Lands
Art Stearns - Supervisor

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GEOLOGY OF THE TWISP RIVER - CHELAN DIVIDE REGION

by

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INTRODUCTION

This report provides a summary of rock units and structures that accompanies a geologic map and cross sections of the Twisp River-Chelan Divide region. Much of the map area lies within or adjacent to the Ross Lake fault zone. This fault zone is a major crustal boundary which separates crystalline rocks of the Skagit core of the North Cascades from mainly sedimentary and volcanic rocks of the Methow basin (Misch, 1966). Mapping focused on the crystalline rocks; most of these are undated but, by comparison with rocks elsewhere in the Skagit core, are probably Cretaceous to Eocene in age (Mattinson, 1972; Hoppe, 1982).

ROCK UNITS IN THE ROSS LAKE FAULT ZONE, TWISP RIVER-CHELAN DIVIDE REGION

Volcanic and Volcaniclastic Rocks (Newby Group?): Keratophyres and greenstones on the northeast side of the Foggy Dew fault from Foggy Dew Ridge to the Mission Peak area. These mostly massive rocks presumably represent flows and possibly some shallow intrusive rocks. Breccias are locally present. Low-grade metamorphism (albite-chlorite-epidote-calcite-quartz) makes it difficult to determine the original composition of these rocks, but the color index suggests that many were andesites.

The stratigraphic position of these rocks is unclear. Barksdale (1975) mapped some of them as Midnight Peak Formation and others as Newby Group. I find no reason to map them as separate units. Some hornblende-phyric keratophyres resemble parts of the North Creek Volcanics.

Twisp Valley Schist: Mainly biotite schists, phyllites and impure quartzites (metacherts), with some amphibolites and greenschists, and minor marbles, calc-silicates and metaperidotites. Local metamorphosed thin-bedded (2-10 cm) siltstones and shales may represent distal turbidites. The marbles and metaperidotites occur as lenses that are elongate parallel to foliation and range from <1 m to about 50 m in width. The interleaving of the metaperidotites with supracrustal rocks suggests that significant tectonic mixing predated the

complicated folding and metamorphic history of the Twisp Valley Schist.

Metamorphism was in greenschist and amphibolite facies and apparently of the low P/T Buchan- or Abukuma-type facies series. Andalusite porphyroblasts occur in several biotite schists near Scaffold Peak. Inclusions in the porphyroblasts define an internal fabric that is discordant to the external foliation. The andalusite has been partially replaced by sillimanite and muscovite. Sillimanite helps define the foliation which wraps around the andalusite porphyroblasts.

Foliation is prominent throughout the unit. S_1 is typically tightly to isoclinally folded (F_2), and an axial-planar foliation (S_2) is the dominant fabric element in the Twisp Valley Schist. Open to tight folds (F_3) of S_2 are common and generally have wavelengths ranging from 5 cm to 3 m, but locally reaching at least 30 m. F_3 folds are typically non-cylindrical and have axes which curve significantly. The refolding of F_2 structures apparently accounts for the highly varied orientation of F_3 axes. A mineral lineation is commonly parallel to F_2 axes and is folded by F_3.

The age of this unit is unknown, but the unit possibly is correlative with the upper chert-rich section (refer to Ray, 1986) of the Permian to Jurassic Hozomeen Group.

Rainbow Lake Schist: Biotite schists and quartzites (meta-cherts?), less common amphibolites, marbles and calcsilicates, and rare metaperidotites. The most diagnostic rock type is a staurolite-garnet biotite schist which also crops out along strike with the Rainbow Lake Schist north of the map area (P. Misch, oral commun., 1985). Sillimanite-bearing staurolite schists occur locally near Rainbow Lake. Leucocratic sills and pegmatites intrude the Rainbow Lake Schist; some of them have been folded with the schists. Tight folds of foliation are common in the Rainbow Lake Schist. An axial-planar foliation is well developed, and a mineral lineation commonly is parallel to fold axes.

Battle Mountain gneiss: Strongly foliated and lineated, medium- to coarse-grained, commonly mylonitic orthogneiss. The dominant metamorphic assemblage is hornblende-biotite-epidote-plagioclase-quartz. Plagioclase commonly occurs as porphyroclasts. These rocks have a higher color index and are coarser grained than adjacent gneisses. Thickness is varied; in some places the gneiss occurs as screens within Tuckaway Lake gneiss and less commonly within Lake Juanita leucogneiss.

The Battle Mountain gneiss resembles somewhat the Reynolds Peak phase of the Black Peak batholith, and the two conceivably were once part of the same body. The two are in close proximity northeast of Battle Mountain, and the nature of the northern termination of the Battle Mountain gneiss is not clear.

Tuckaway Lake gneiss: Strongly foliated and lineated, medium-grained, mylonitic orthogneiss. Metamorphic assemblage is biotite-plagioclase-quartz. Thin (<10 m) sheets of this gneiss are intrusive into the Battle Mountain gneiss.

Lake Juanita leucogneiss: Coarse-grained trondhjemitic and leucogranodioritic orthogneiss. Most of the unit is lineated, but it displays only a weak foliation. However, the unit is moderately strongly foliated near its contact with the Tuckaway Lake gneiss. Pegmatites and other silicic dikes are common. Small bodies of massive plutonic rocks, ranging in composition from granite to diorite, are volumetrically important in places and appear to intrude the leucogneiss. Xenoliths and rafts of biotite schist are locally present. The leucogneiss has a significantly lower color index than the Battle Mountain gneiss and Tuckaway Lake gneiss, both of which it intrudes.

Southern heterogeneous crystalline complex: Markedly heterogeneous unit consisting of both unmetamorphosed and metamorphosed plutonic rocks. The dominant rock type is a weakly deformed trondhjemitic gneiss that probably is equivalent to the Lake Juanita leucogneiss. The presence of numerous bodies of massive and foliated tonalite and granodiorite distinguishes this unit from the leucogneiss; nevertheless, the contact between these two units is gradational and somewhat arbitrarily drawn. Clearcut intrusive contacts indicate that the trondhjemite is younger than most of the other granitoids. Numerous xenoliths and rafts of biotite schist occur in the southern part of the heterogeneous complex, particularly on the ridge between Martin Creek and Foggy Dew Creek.

Northern heterogeneous crystalline complex: Crystalline complex consisting of both unmetamorphosed and metamorphosed plutonic rocks. The trondhjemitic orthogneiss that dominates this complex resembles the Lake Juanita leucogneiss, and the two units are mapped separately only because of the increased amount of directionless granitoids and the greater variation in orthogneiss compositions in the heterogeneous complex. Thus, the contact between these two units is gradational and somewhat arbitrarily drawn. The heterogeneous complex contains some banded tonalitic gneisses, and local zones of injected migmatitic gneiss. An orthogneiss in the complex along Bridge Creek has yielded a 50-m.y. zircon (U-Pb) age (Hoppe, 1982). This orthogneiss is only

weakly foliated and presumably is one of the younger intrusive bodies in the crystalline complex. Misch (1966) has mapped the northern part of this unit (north of Bridge Creek) as part of the Skagit Gneiss.

Twisp River-Foggy Dew fault mylonites: An approximately 1-km-wide zone west of the Twisp River-Foggy Dew fault consisting mainly of mylonitic tonalitic orthogneisses, amphibolites, and phyllonites. Biotite schists and greenschists are present in minor amounts. These rocks characteristically display a strong mineral lineation, and the mylonitic foliation commonly marks asymmetric folds. Steep faults with small (<5 m) offsets are common locally and are oriented nearly perpendicular to the foliation.

Some of the orthogneisses are clearly derived from the Oval Peak batholith, whereas amphibolites and schists are of uncertain origin. They may represent reworked Twisp Valley Schist or upgraded Newby Group. Pre- or syn-mylonitization intrusive contacts between mylonitic Oval Peak gneisses and amphibolites are preserved in several places. Boudinaged mylonitic Oval Peak dikes are clearly discordant to foliation in the amphibolites. Intrusive tongues of Oval Peak gneiss in amphibolites are >10 m thick in a few localities.

Oval Peak batholith: This tonalitic pluton is subdivided into a well-foliated unit and a directionless-weakly foliated unit. These units have a gradational contact, and within the area mapped as the directionless-weakly foliated unit there are local domains of stronger foliation, particularly in the northern tongue of Oval Peak in the War Creek area. Both units consist of plagioclase, biotite, quartz, and sphene. Epidote is common in all but the southernmost portion of the pluton. Hornblende and orthoclase are present in minor amounts in a few samples. Aplites and garnet-bearing pegmatites are common locally, particularly in the foliated margins of the pluton. Foliation is defined by alignment of biotite. A mineral-aggregate lineation occurs within 50 m of the southern and western margins of the pluton and adjacent to the Twisp River-Foggy Dew mylonite zone.

A weakly foliated sample of the batholith yields a U-Pb sphene age of 65.3 m.y., which may approximate the original crystallization age of the pluton (Miller and Walker, 1987).

Black Peak batholith

Directionless-weakly foliated phase: This dominantly tonalitic phase typically consists of hornblende-biotite-plagioclase-quartz-sphene. Epidote is common along fractures. The weak

fabric in parts of the directionless phase probably represents an igneous flow foliation, although a tectonic fabric is superimposed on the western and southern margins of the phase. Ductile shear zones, generally <2 m thick, cut the directionless rocks in numerous places, but are less abundant than in the Reynolds Peak phase.

The directionless rocks yield a 90-m.y. K-Ar hornblende age near Roads End Campground (Misch, 1963), and a 90-m.y. zircon (U-Pb) age has been determined for rocks northeast of the map area along Washington Highway 20 (Hoppe, 1982).

Mafic phase: This typically, but not exclusively, well-foliated dioritic gneiss occurs on the east side of the Black Peak batholith. Adams (1961) originally mapped it as a mafic border phase which he thought was formed by metasomatic transformation of the tonalitic phase of the batholith. Field relations suggest, however, that the tonalite intrudes the dioritic gneiss.

Reynolds Peak phase: This phase, herein named for the prominent peak on the Lake Chelan-Twisp River divide, forms the southernmost portion of the Black Peak batholith. It is characterized by a moderately developed tectonic foliation and is best described as a tonalitic gneiss. The dominant assemblage in these rocks is biotite-plagioclase-quartz-epidote-sphene±hornblende. The ubiquitous epidote replaces plagioclase. Mafic enclaves are abundant locally, particularly between Tony Basin and Williams Butte.

The Reynolds Peak phase is riddled with ductile shear zones ranging from <5 cm to about 4 m in thickness. Significant recrystallization and grain-size reduction occurred in these zones, producing mylonites and, locally, ultramylonites. Asymmetric folds of the mylonitic foliation occur rarely. Gently dipping mylonite zones with a down-dip lineation are common in the Boulder Creek drainage, whereas steeper ductile shear zones occur in the Reynolds Creek drainage. Foliation in the Reynolds Peak phase is commonly rotated into parallelism with the fabric in the ductile shear zones. These foliation trajectories and S-C-surface (see Berthe and others, 1979) relations in mylonites (7 localities) suggest that reverse dip-slip motion occurred in many of the ductile shear zones.

The Reynolds Peak phase is distinguished from the weakly foliated-directionless phase of the Black Peak batholith by its stronger fabric and apparently slightly higher color index. The Reynolds Peak phase is coarser grained and also has a higher color index than the War Creek Gneiss, and commonly contains hornblende in contrast to the latter unit. The War Creek Gneiss intrudes the Reynolds Peak phase, as best seen on the ridge northeast of Camels Hump, and large inclusions and screens of the latter phase occur within the War Creek Gneiss.

Gabriel Peak tectonic belt: This term is herein introduced for a zone of strongly deformed, in part mylonitic, rocks which occurs in the northwestern part of the map area. Deformation is concentrated along the fault contacts between Rainbow Lake Schist, Lake Juanita leucogneiss and "northern heterogeneous crystalline complex" on the west, and Gabriel Peak Orthogneiss and War Creek Gneiss on the east. Deformation intensity decreases sharply to the west, but much more gradually to the east. This deformed zone is generally about 2.5 km wide, and it extends for at least 35 km, from the northern boundary of the map area to at least as far south as Sun Mountain. The zone is also nearly on strike with the strongly deformed western margin of the Oval Peak batholith.

The tectonic belt has been the locus of considerable plutonism. The geology as presently mapped is undoubtedly simplified owing to the intensity of deformation and the commonly subtle differences between these mostly tonalitic orthogneisses.

Gabriel Peak Orthogneiss: Moderately foliated and lineated tectonite to mylonite; generally fine- to medium-grained. This tonalitic orthogneiss has a U-Pb zircon age of about 65 m.y. (Hoppe, 1982). The typical metamorphic assemblage is hornblende-plagioclase (albite to oligoclase)-biotite-epidote-quartz-sphene.

The Gabriel Peak Orthogneiss is present along the west side of the Black Peak batholith and grades eastward into weakly deformed rocks. It is thus interpreted to be the deformed margin of the batholith (Misch, 1977; Hoppe, 1982; Miller and others, 1985). There are some compositional differences, however, within rocks mapped as Gabriel Peak, and it is possible that the protolith for this unit also includes small pluton(s) younger than the Black Peak batholith. The southern "tail" of the Gabriel Peak Orthogneiss is distinguished from the War Creek Gneiss by the generally weaker foliation and lower color index of the latter unit.

War Creek Gneiss: Medium-grained, leucocratic orthogneiss, dominantly tonalitic to trondhjemitic. The dominant assemblage is quartz-plagioclase-biotite-sphene. The small, but distinct differences in composition and grain size within the unit suggest that it represents several metamorphosed plutons. This gneiss generally is strongly foliated and lineated in the southwest, near the tectonic contact with the Lake Juanita leucogneiss, but only weakly to moderately well-foliated in the northeast.

INTERPRETATION OF CROSS SECTIONS

Structural relations between rock units can perhaps be best summarized by a discussion of the cross sections constructed through the map area.

Cross Section A-A'

This section illustrates structural relations of part of the Black Peak batholith and adjacent units. Black Peak tonalites are directionless in the eastern half of the section, but to the west they grade progressively into well-foliated gneisses and then into mylonites of the Gabriel Peak Orthogneiss (Misch, 1966). Gabriel Peak mylonites structurally overlie the Rainbow Lake Schist, which in turn overlies Lake Juanita leucogneiss. Structural discordance (not shown in this section) across both the Lake Juanita-Rainbow Lake Schist contact and the Rainbow Lake Schist-Gabriel Peak contact indicate that both of these fault contacts formed after penetrative deformation in all of the units. Movements on the former contact apparently were relatively minor because weakly foliated leucocratic rocks similar to the Lake Juanita leucogneiss clearly intrude the Rainbow Lake Schist.

The displacement directions on these faults are uncertain. The dominance of subhorizontal stretching lineations to the north in the Gabriel Peak suggests that strike-slip displacement occurred during the earlier mylonitization. The fault contacts are younger than 65 m.y., the U-Pb age of the Gabriel Peak Orthogneiss (Hoppe, 1982).

Cross Section B-B'

This section focuses on the eastern margin of the Black Peak batholith. Contacts dip to the northeast, as in Section A-A'. Poorly to generally moderately well-foliated tonalitic gneiss of the Reynolds Peak phase apparently intrudes overlying well-foliated dioritic gneisses of the mafic phase of the Black Peak batholith. Steep, generally west-dipping, ductile shear zones cut the foliation in both phases of the Black Peak. The mafic phase is intrusive into the Twisp Valley Schist. The contact is concordant to the dominant axial-plane foliation (S_2) in the Twisp Valley Schist.

In summary, cross sections A-A' and B-B' demonstrate the structural heterogeneity of the Black Peak batholith.

Cross Section C-C'

This section illustrates the variety of plutonic and metamorphic units present in the map area. Relations in the westernmost part of the section are similar to those in section A-A'. In particular, the Rainbow Lake Schist forms a fault-bounded screen between the Gabriel Peak Orthogneiss and Lake Juanita leucogneiss. In this section, however, the Gabriel Peak is a narrow, strongly deformed body which has been concordantly intruded by the War Creek Gneiss. Deformation intensity in the War Creek Gneiss drops off gradually to the northeast, as shown schematically by the spacing of foliation in the section. The strong down-dip mineral lineation in the Gabriel Peak and War Creek indicates that dip-slip motion dominated in this part of the Gabriel Peak tectonic belt.

On the northeast, the War Creek Gneiss has intruded the Reynolds Peak phase of the Black Peak batholith. Concordant intrusive bodies of War Creek Gneiss also occur within the Reynolds Peak phase, as shown schematically in this section. The Reynolds Peak phase has, in turn, intruded the Twisp Valley Schist. This intrusive contact may locally have been modified by faulting, not shown on the map or section, as indicated by deformation intensity of the schists that apparently increases toward the contact.

The Twisp Valley Schist has been intruded on the east by the Oval Peak batholith, which truncates the axial-plane foliation in the schists. This is the only markedly discordant contact in the section. The Oval Peak is weakly, but fairly consistently, foliated in the line of section. The Oval Peak also intrudes the Twisp Valley Schist on the east, but this contact apparently is essentially concordant. The Twisp Valley Schist is cut by the steeply dipping mylonite zone associated with the Twisp River fault. Stretching lineations in phyllonitized intrusive rocks in the mylonite zone are subhorizontal and presumably reflect strike-slip displacement.

Cross Section D-D'''

This cross section illustrates structural relations between the Oval Peak batholith and adjacent units. The batholith is strongly foliated, recrystallized, and locally lineated near its western contact. Foliation weakens to the east, until the Oval Peak is essentially a directionless granitoid (Libby, 1964). On the west, the batholith structurally overlies the Twisp Valley Schist along a sharp east-dipping (30-60°) contact. The schist forms a thin envelope to the Oval Peak and overlies concordantly, in descending order, the Battle Mountain gneiss, Tuckaway Lake gneiss, and Lake Juanita leucogneiss. The Battle Mountain and Tuckaway Lake gneisses are both mylonitic. The Lake Juanita

leucogneiss is strongly foliated and lineated near its contact with the Tuckaway Lake gneiss, but deformation intensity drops off rapidly at structurally lower levels.

The increase in deformation toward the western contact of the Oval Peak in both the batholith and underlying units indicates that this contact is tectonic. The general parallelism of the contact and foliation in all units, plus the strong down-dip mineral-streaking lineation in the mylonitic orthogneisses, suggest that distributed dip-slip movement occurred on both sides of the contact. In short, the Oval Peak batholith probably was emplaced diapirically in the solid state, carrying its envelope of Twisp Valley Schist, onto the orthogneiss units.

The tectonic significance of the Battle Mountain gneiss is less clear. Its contact with the Twisp Valley Schist is everywhere sharp, which, combined with the commonly mylonitic deformation of the gneiss, suggests that this contact is also a fault. The similarity of the Battle Mountain gneiss and Reynolds Peak phase of the Black Peak batholith may indicate that the former is a detached slice or intrusive remnant of the Black Peak batholith which was later intruded by the Tuckaway Lake gneiss and Lake Juanita leucogneiss and subsequently deformed during emplacement of the Oval Peak batholith.

Northeastward along line D-D''', a large pendant(?), or possibly an infolded body, of Twisp Valley Schist occurs within directionless Oval Peak. Both {not clear what both} contacts of the schist and the batholith are clearly intrusive; there is no significant increase in deformation in the Oval Peak as these contacts are approached. The macroscopic folds in the Twisp Valley Schist are F_3 structures as they fold the dominant axial-plane foliation in the schists.

Farther east in the section, the Oval Peak is in contact with a narrow belt of mylonites which presumably are related to the Twisp River-Foggy Dew fault. Dominant lithologies in this zone are mylonitic gneisses and amphibolites, with minor greenschists and biotite schists. At least some of the gneisses are deformed Oval Peak, whereas the other mylonites may have been derived from the Twisp Valley Schist or Newby(?) volcanic rocks. Intrusive contacts between metaplutonic rocks and amphibolites are preserved locally in less deformed domains.

The foliation in this zone, as well as in mylonitic Cretaceous (Virginia Ridge Formation) conglomerates on the east side of the Twisp River fault, dips moderately to steeply to the east. The plunge of the mineral-streaking lineation in the mylonites generally lies between horizontal and 35° to the southeast. These orientations are most compatible with oblique strike-slip motion. Dextral slip is indicated at 11 localities

by S-C-surface relations, shear bands, foliation fish (refer to Hanmer, 1986), and asymmetric folds.

In summary, along section D-D"' the Oval Peak batholith apparently was tectonically emplaced above the Twisp Valley Schist and orthogneisses on the west, but it shows "typical" intrusive contacts with the pendant(?) of schist. The easternmost Oval Peak is intrusive into the protolith of the mylonitic amphibolites and experienced superimposed mylonitization related to dextral motion on the Twisp River-Foggy Dew fault.

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MAP ERRATA: EXPLANATION (all sheets)

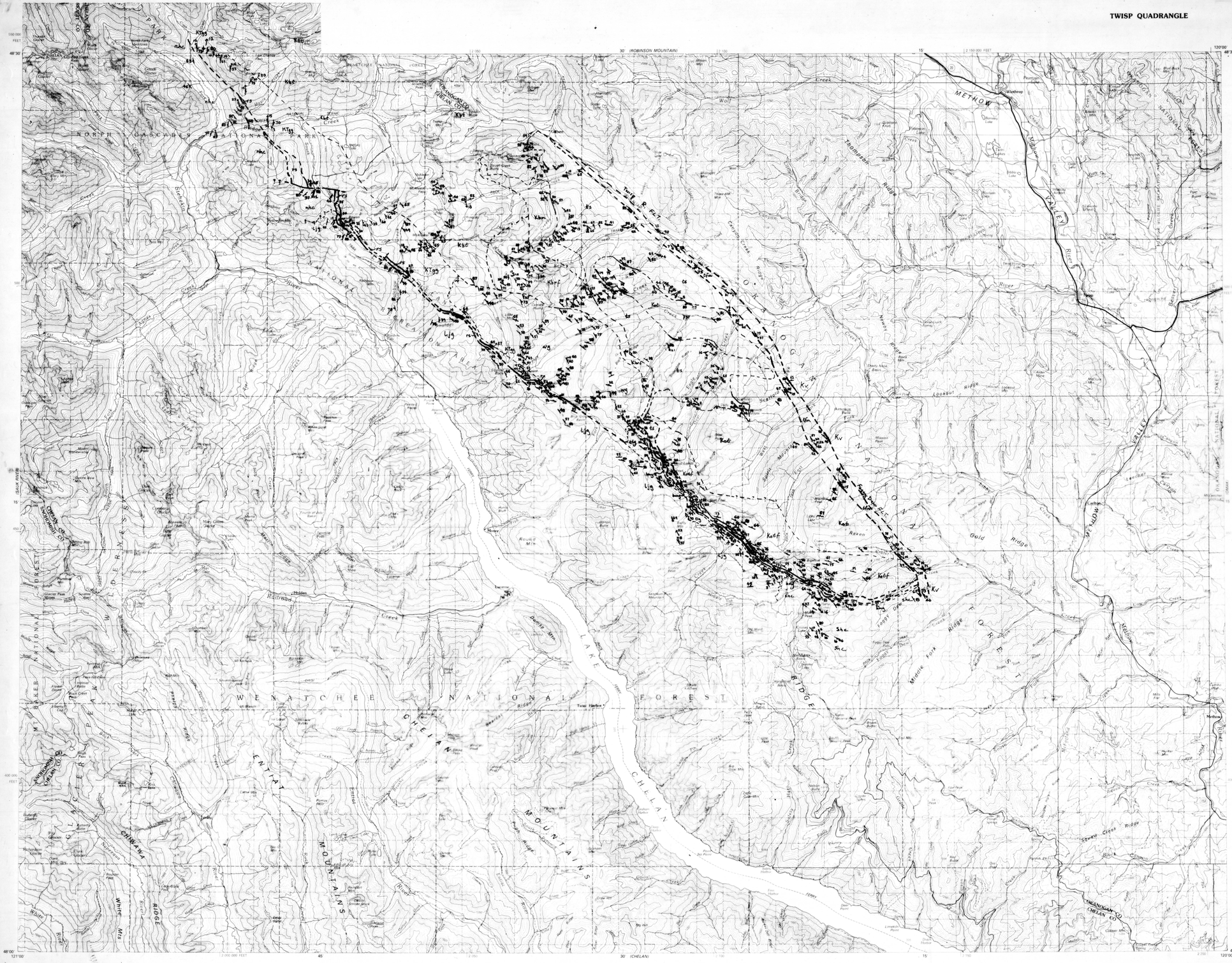
The following units are informal:

- Volcanic and volcaniclastic rocks (Newby Group?)
- Ultramafic rocks in Twisp Valley Schist
- Battle Mountain gneiss
- Tuckaway Lake gneiss
- Lake Juanita leucogneiss
- Southern heterogeneous crystalline complex
- Northern heterogeneous crystalline complex
- Twisp River-Foggy Dew mylonites
- Oval Peak batholith - well-foliated unit
- Oval Peak batholith- directionless - weakly foliated unit
- Black Peak batholith - directionless - weakly foliated phase
- Black Peak batholith - mafic phase
- Black Peak batholith - Reynolds Peak phase

For Rainbow Schist, read Rainbow Lake Schist

Not all units listed in the explanation appear on all sheets.

TWISP QUADRANGLE



OPEN FILE REPORT 87-17
PLATE 1 OF 12

GEOLOGIC MAP OF THE TWISP RIVER - CHELAN DIVIDE REGION, WASHINGTON

by

ROBERT B. MILLER

1987

EXPLANATION

Kv	Volcanic and Volcaniclastic Rocks (Newby Group?)
ts	Twisp Valley Schist
tu	Ultramafic Rocks in Twisp Valley Schist
rs	Rainbow Schist
bma	Battle Mountain Gneiss
tla	Tuckaway Lake Gneiss
ljs	Lake Juanita Leucogneiss
shc	Southern Heterogeneous Crystalline Complex
nhc	Northern Heterogeneous Crystalline Complex
tfm	Twisp River-Foggy Dew Mylonites
Kotf	Oval Peak Batholith-Foliated Unit
Kot	Oval Peak Batholith-Directionless-Weakly Foliated Unit
Kbt	Black Peak Batholith-Directionless-Weakly Foliated Phase
Kbm	Black Peak Batholith-Mafic Phase
Kbrf	Black Peak Batholith-Reynolds Peak Phase
Ktgn	Gabriel Peak Orthogneiss
wg	War Creek Gneiss

SYMBOLS

- Strike of vertical foliation
- Inclined foliation
- Inclined foliation with mineral lineation in the plane of the foliation
- Strike and Dip of Foliation
- Trend and plunge of mineral lineation
- Trend and Plunge of F_3 Axes in Twisp Valley Schist
- Contact: dashed where approximate; queried where uncertain
- Fault Contact: dashed where approximate; queried where uncertain

STATE OF WASHINGTON
DEPARTMENT OF NATURAL RESOURCES
BRIAN J. BOYLE, Commissioner of Public Lands
ART STEARNS, Supervisor

DIVISION OF GEOLOGY AND EARTH RESOURCES
RAYMOND LASMANIS, State Geologist

SCALE 1:100 000

1 0 1 2 3 4 5 6 7 8 9 10 KILOMETERS

0 1 2 3 4 5 MILES

5000 0 5000 10000 15000 20000 25000 FEET

WASHINGTON

QUADRANGLE LOCATION

ROAD CLASSIFICATION

- Primary highway, hard surface
- Secondary highway, hard surface
- Light-duty road, hard or improved surface
- Street or unimproved road
- Trail
- Interstate Route
- U.S. Route
- State Route

TWISP, WASH.

SE/4 CONCRETE (NM 10-12) 1:250 000-SCALE MAP

N4800—W12000/30X60

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

MC GREGOR MTN. QUADRANGLE
WASHINGTON–CHELAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

OPEN FILE REPORT 87-17
PLATE 2 OF 12

GEOLOGIC MAP OF PART OF THE McGREGOR MTN. QUADRANGLE, WASHINGTON

by
ROBERT B. MILLER
1987

EXPLANATION

Kv	Volcanic and Volcaniclastic Rocks (Newby Group?)
ts	Twisp Valley Schist
tu	Ultramafic Rocks in Twisp Valley Schist
rs	Rainbow Schist
bmg	Battle Mountain Gneiss
tlg	Tuckaway Lake Gneiss
ljg	Lake Juanita Leucogneiss
shc	Southern Heterogeneous Crystalline Complex
nhc	Northern Heterogeneous Crystalline Complex
tfm	Twisp River-Foggy Dew Mylonites
Kotf	Oval Peak Batholith-Foliated Unit
Kot	Oval Peak Batholith-Directionless-Weakly Foliated Unit
Kbt	Black Peak Batholith-Directionless-Weakly Foliated Phase
Kbm	Black Peak Batholith-Mafic Phase
Kbrf	Black Peak Batholith-Reynolds Peak Phase
KTgg	Gabriel Peak Orthogneiss
wg	War Creek Gneiss

SYMBOLS

- Strike of vertical foliation
- Inclined foliation
- Inclined foliation with mineral lineation in the plane of the foliation
- Strike and Dip of Foliation
- Trend and plunge of mineral lineation
- Trend and Plunge of F_3 Axes in Twisp Valley Schist
- ? Contact: dashed where approximate; queried where uncertain
- ? Fault Contact: dashed where approximate; queried where uncertain

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Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1958. Field checked 1963

Polyconic projection. 1927 North American datum
10,000-foot grid based on Washington coordinate system, north zone
1000-meter Universal Transverse Mercator grid ticks, zone 10, shown in blue

Where omitted, land lines have not been established

UTM GRID AND 1963 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET (GN, MN; 1°38' 29 MILS; 22° 391 MILS)

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

ROAD CLASSIFICATION
Light-duty — Unimproved dirt

WASHINGTON
QUADRANGLE LOCATION

MC GREGOR MTN., WASH.
N4822.5—W12045/7.5
1963
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