Northwest Geological Society

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Society Field Trips in Pacific Northwest Geology

Guide to the Geology in the Vicinity of Swauk and Snoqualmie Passes

Central Cascade Mountains, Washington

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INTRODUCTION

PURPOSE

The area along Interstate 90 and Highway 97 between Snoqualmie Pass, Ellensburg, and Leavenworth displays a wide range of rock types, structural relations, and scenic views. The depositional, stratigraphic, and structural relationships of both the pre-Tertiary and Tertiary rocks are complex and controversial. The primary design of this field trip is to observe the diverse (and similar) rock units in this area. A secondary purpose is not necessarily to provide answers to the questions regarding the complex geologic histories, but to better define the questions. Thus, we look forward to spirited discussions at most outcrops!

ITINERARY

The first day of the field trip will focus on geologic units in the vicinity of Swauk Pass, Cle Elum, and Ellensburg along Highway 97 and SR 10. These units include the pre-Tertiary Ingalls Tectonic Complex, Eocene-Oligocene subaerial sedimentary and volcanic units, and the Miocene Ellensburg Formation.

The second day will start with a scenic and structural overview at Peoh Point overlooking Cle Elum. This is followed by an examination of some pre-Tertiary basement rocks and more subaerial Eocene sedimentary and volcanic units, with implications on the location and history of the Straight Creek Fault in the vicinity of I-90. Time permitting, we will conclude with several stops in the Snoqualmie Pass area.

REGIONAL GEOLOGIC RELATIONS

Most of the pre-Tertiary rocks of the Cascade Mountains arrived at the western margin of North America sometime after their geologic birth, and were subsequently sutured or accreted to the “craton” (Fig. 1). Numerous such “exotic” terranes occur from California to Alaska. In the Cascades, the picture is further complicated by the fact that mostly northwest-trending transpressional dextral faults have segmented these terranes (Haugerud, 1989) (Fig. 2). Terranes to be observed on this field trip include the Ingalls Tectonic Complex, the Easton Metamorphic Suite, and the Eastern Melange Belt.

Geologic relations between terranes are further obscured by post-accretion sedimentary and volcanic rocks. Even the Tertiary history is difficult to decipher due to lack of dating control, lithologic similarities, and potential syntectonic deposition. Early workers concluded that various Eocene sedimentary and volcanic units, such as the Chumstick in the Chiwaukum graben, and the Swauk in the vicinity of Cle Elum, were deposited in separate basins. An alternative view is that sedimentation and volcanism since and including the Eocene are bounded by four major interregional and even more numerous regional unconformities (Cheney, 1994) (Figure 3). In this view, interregional and regional sequences are laterally discontinuous not due to deposition in separate sedimentary basins, but due to multiple periods of uplift, post-depositional folding and faulting, and erosion, and are therefore preserved today in separate structural basins.

The concepts of sequence stratigraphy traditionally have been applied to cratonic rather than to marginal and deep marine settings or Tertiary terrestrial strata. The idea of interregional and regional unconformities (i.e. unconformity-bounded sequences) may be applicable to the Pacific Northwest, even though they are near the present continental margin, because the pre-Tertiary accreted terranes formed a “cratonic” basement.

According to Cheney (1994), four unconformity-bounded sequences occur in Washington (Fig. 3). Each of these is bounded by unconformities that have a strike length at least equal to the length of Washington and that somewhere cause the overlying sequence to rest on pre-Tertiary intrusive or metamorphic rocks. These sequences are the Challis, Kittitas, Walpapi, and High Cascade (Figure 3). Figure 4 shows the state¬wide distribution of these sequences.

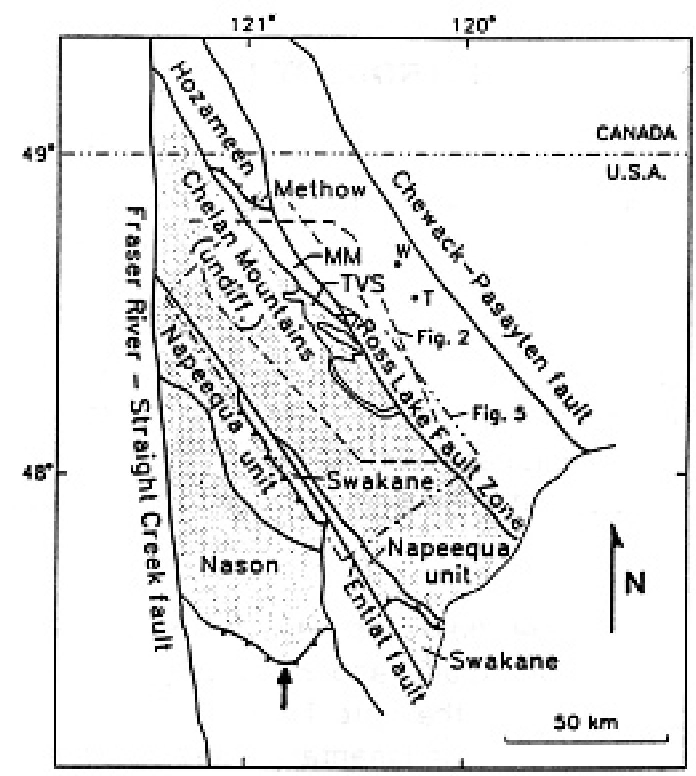


Figure 1. Terranes of the northern Cascades. Note the Windy Pass thrust at the south end of the Nason Terrane of the northeastern Cascades (arrow). The Ingalls Peridotite, Hawkins Formation, and the Peshastin Formation are in the upper plate of this thrust. The 93-90 Ma Mt. Stuart batholith intrudes this thrust (after Miller, et al., 1994)

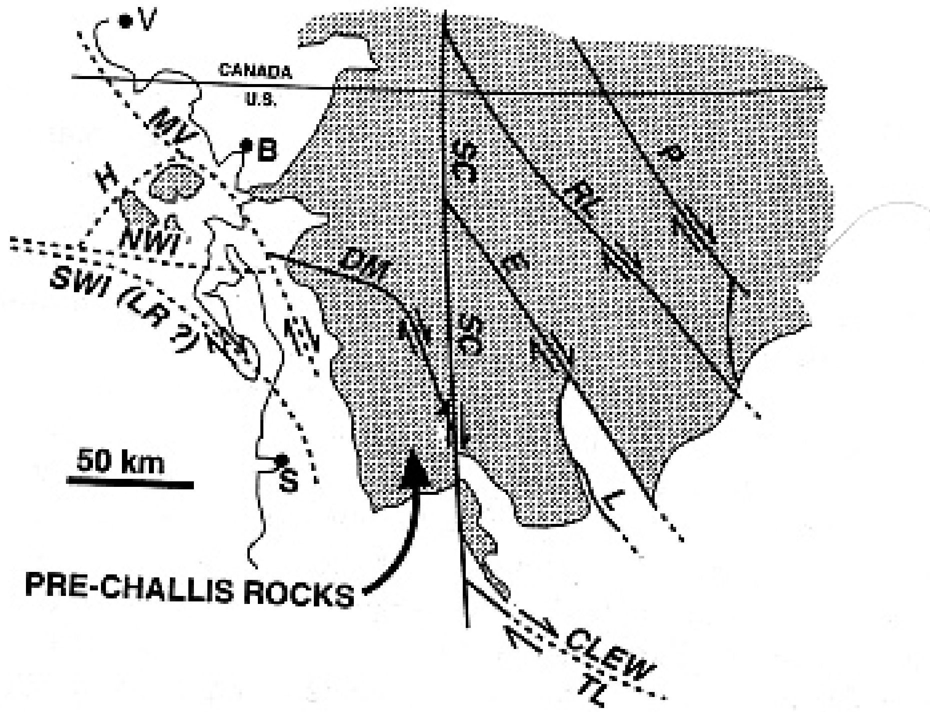


Figure 2. Post-metamorphic faults in the northern Cascades of Washington. Note that the northerly trend of the Straight Creek Fault is unique. Compare with Figure 1 to see terrane boundaries.

Wheeler and Mallory (1963 & 1970) Sequences	Armstrong (1979) Volcanic Episodes	Armentrout (1987) Sequences	This Paper Sequences	Examples of Lithostratigraphy	Age Ma
unnamed	High Cascade	V	High Cascade	Vashon Drift Logan Hill Fm.	2
Walpapi	unnamed Columbia	IV	Walpapi	Columbia River Basalt Group	19
unnamed	Cascade	III	Kittitas	Fifes Peak Fm. Ohanapecosh Fm.	36
unnamed	Challis	II	Challis	Wenatchee Fm. Roslyn Fm. Teanaway Fm. Taneum Fm. Swauk Fm.	55

Figure 3. Unconformity-bounded sequences of Tertiary rocks of Washington (from Cheney, 1994).

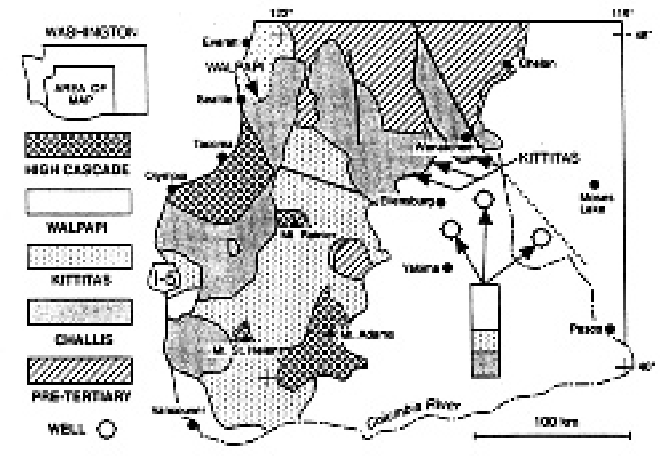


Figure 4. The distribution of four interregional sequences in south-central Washington (from Cheney, 1994).

The Challis is an unconformity-bounded sequence of Eocene arkosic and volcanic rocks which has been referred to by previous workers as the "Challis volcanic episode." Rocks in this episode are 55-36 Ma and are widespread throughout Washington (Fig. 4). The well known O'Brien Creek Formation, the Sanpoil Volcanics, and Klondike Mountain Formation near Republic in northeastern Washington are in this sequence. In the vicinity of this field trip, Challis units east of the Straight Creek Fault include the Swauk Formation, Taneum Formation, Teanaway Basalt, the Roslyn, Formation, and the lower part of the Wenatchee Formation. The Naches Formation is a Challis unit here reputed to be on both sides of the Straight Creek Fault. Figure 5 shows the regional correlation of Challis units, and Figure 6 shows the distribution of Challis rocks in the vicinity of this field trip.

The post-Challis sequence of intermediate to felsic volcaniclastic rocks is best exposed in the southern Cascade Range (Figure 4) as the Oligocene Ohanapecosh Formation and the Oligocene/lower Miocene Fifes Peak Formation. Because units of this sequence between 36 to 20 Ma are not restricted to today's Cascade Mountains, and to avoid confusion with the present Cascade volcanoes and topography, Cheney (1994) proposed the name Kittitas for this sequence. This field trip does not examine the Kittitas sequence, however, it may be viewed from a distance at an optional stop on the second day. Figure 4 shows the state-wide distribution of Kittitas rocks, and Figure 5 shows their distribution in the vicinity of this field trip.

An interregional mid-Miocene unconformity has long been known. Above this is the 20 to 2 Ma Walpapi sequence. In central and eastern Washington, the most voluminous unit of the Walpapi is the Columbia River Basalt Group (CRBG). This sequence also includes the Ellensburg Formation. Both Grande Ronde Basalt of the CRBG and the Ellensburg Formation will be observed on this field trip. Figure 4 shows the state¬wide distribution of Walpapi rocks, and Figure 5 shows their distribution in the vicinity of this field trip.

The regional unconformity above the Walpapi sequence is underappreciated, possibly because the CRBG is commonly regarded as undeformed. The large number of folds and faults in the CRBG clearly demonstrates deformation. In addition, the CRBG has a regional easterly dip along the eastern margin of the Cascade Range (Figure 7).

In the Cascade Range of southern Washington, rocks younger than 2 Ma rest unconformably on Walpapi and older rocks including pre-Tertiary basement. Sources of the volcanic and volcaniclastic rocks of the sequence include the present stratovolcanoes in the Cascade Range. However, glacigene sediments are the most widespread component. The post-2 Ma rocks have been referred to as the High Cascade sequence (Cheney, 1994). Figure 4 shows the state-wide distribution of High Cascade rocks. No stops are planned within this sequence on this field trip.

ROCK UNITS

ROCKS EAST OF THE STRAIGHT CREEK FAULT

Pre-Tertiary Basement

Inaalls Tectonic Complex

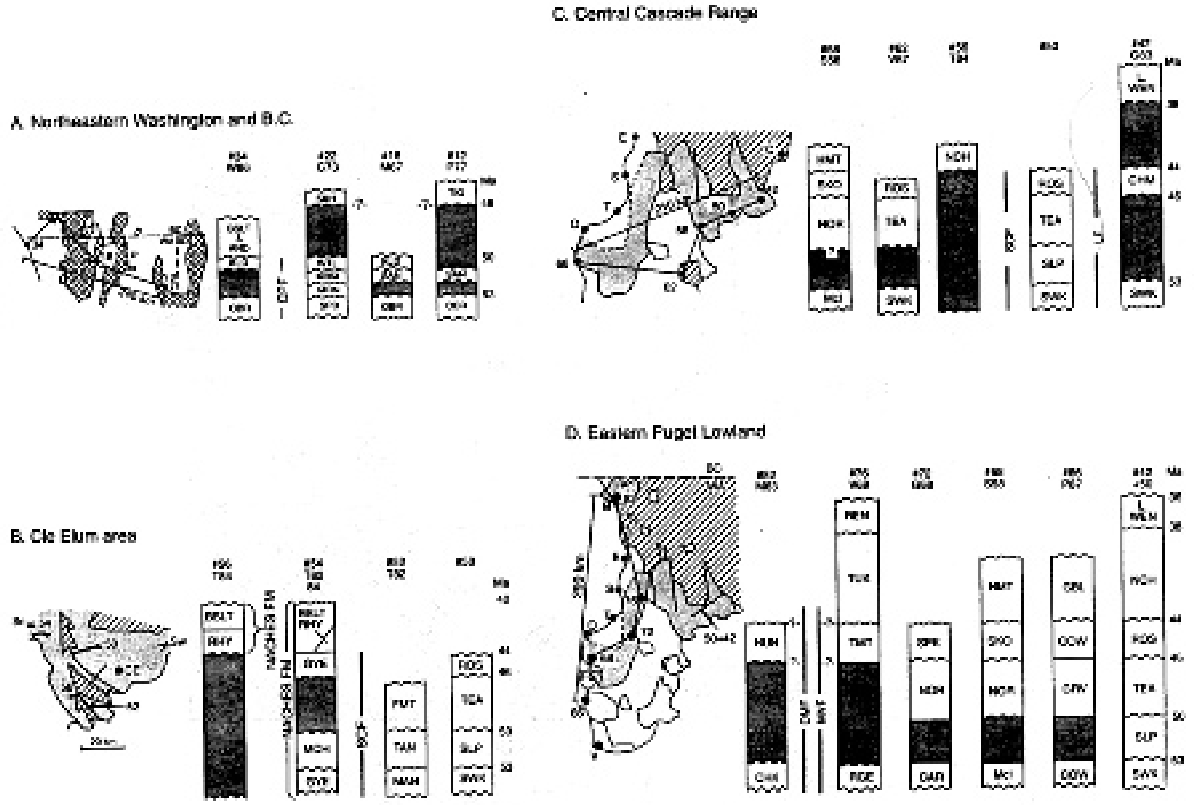
The Ingalls Tectonic Complex is a slice of Jurassic-Cretaceous crustal and subcrustal rocks intruded by of 93 to 90 Ma the Mount Stuart Batholith. The complex contains foliated and massive serpentinite, serpentinized peridotite; diabase, diabase and gabbro, metabasalt (greenstone), amphibolite, and argillite (Tabor, et al., 1982). The ultramafic units are an ophiolite assemblage.

Easton Metamorphic Suite

The Easton Metamorphic Suite forms a northwest-trending belt approximately 5 km wide extending from Cle Elum to Easton, and a slightly narrower north-trending belt east and north of Lake Kachess. The suite has two major subdivisions: greenschist and pelitic phyllite.

The greenschist is very fine-grained albite-epidote-chlorite schist with a well-developed foliation. This unit is associated with minor biotite gneiss, hornblende gabbro, and quartz plagioclase gneiss, as well as blue amphibole schist.

The pelitic phyllite is mostly fine-grained, black to gray, crinkled and isoclinally folded. Foliation is well-developed. The unit contains many quartz lenses and veins, which have been ptygmatically folded.



Sources of data:

C73	Church, 1973
G68	Gard, 1968
G83	Gresens, 1983
M63	Miller and Misch, 1963
M67	Muessig, 1967
P77	Pearson and Obradovich, 1977
P87	Phillips, 1987
S58	Snavely and others, 1958
T82	Tabor and others, 1982a
T84	Tabor and others, 1984
V69	Vine, 1969
V87	Vance and others, 1987
W86	White, 1986

Abbreviations for formations:

CAR	Carbonado Formation
CHK	Chuckanut Formation
CHM	Chumstick Formation
COW	Cowlitz Formation
FMT	basalt of Frost Mountain
GBL	Goble Volcanics
GRV	Grays River volcanic rocks of the Cowlitz Formation
GYE	Guye Formation
HMT	Hatchet Mountain Formation
HUN	Huntingdon Formation
KLD	Klondike Mountain Formation
MAN	Manastash Formation
MCH	Mount Catherine Rhyolite
McI	McIntosh Formation
MRM	Marama Formation
MRN	Marron Formation
NCH	Naches Formation
NOR	Northcraft Formation
OBR	O'Brien Creek Formation
REN	Renton Formation
RGE	Raging River Formation
ROS	Roslyn Formation
SAN	Sanpoil Volcanics
SKH	Skaha Formation
SKO	Skookumchuck Formation
SLP	Silver Pass volcanic rocks
SPB	Springbrook Formation
SPK	Spiketon Formation
SWK	Swauk Formation
TAN	Taneum Formation
TEA	Teanaway Formation
TIG	Tiger Formation
TMT	Tiger Mountain Formation
TUK	Tukwila Formation
WTL	White Lake Formation
WEN	lower member of the Wenatchee Formation

Geographic abbreviations:

B	Bellingham
BC	British Columbia
C	Chelan
CE	Cle Elum
E	Everett
ID	Idaho
I-5	Interstate Highway 5
O	Olympia
S	Seattle
Sn	Snoqualmie Pass
Sw	Swauk Pass
T	Tacoma
V	Vancouver
WA	Washington

Abbreviations for faults:

CPF	Chewack–Pasayten
DMF	Devils Mountain
LF	Leavenworth
MVF	Mount Vernon
SCF	Straight Creek

Abbreviations for rock types:

AND	andesite
BSLT	basalt
RHY	rhyolite

Figure 5. Regional correlation of Challis sequences (from Cheney, 1994).

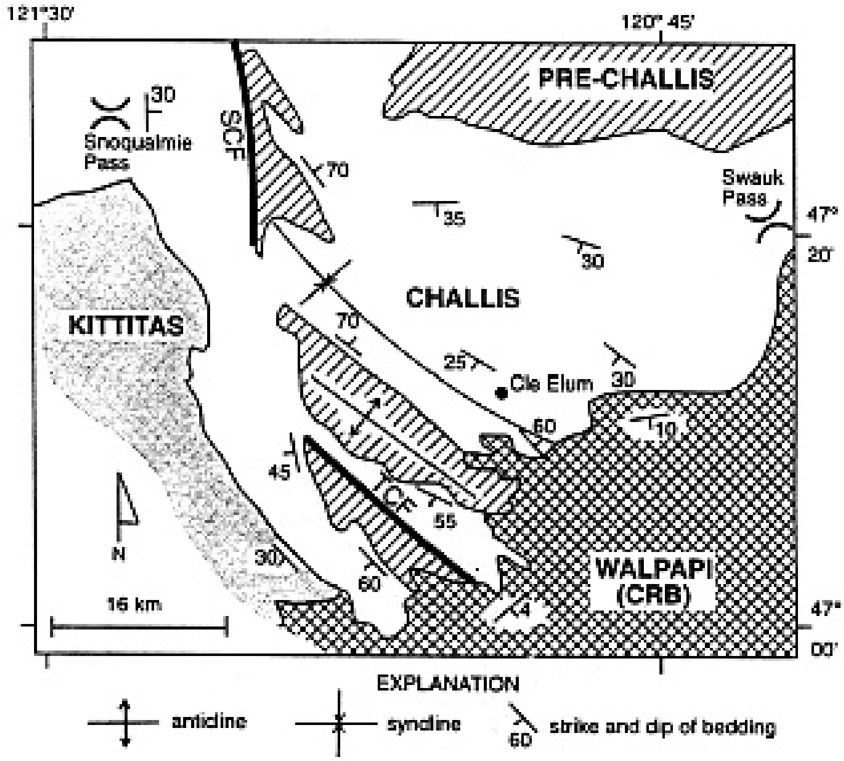
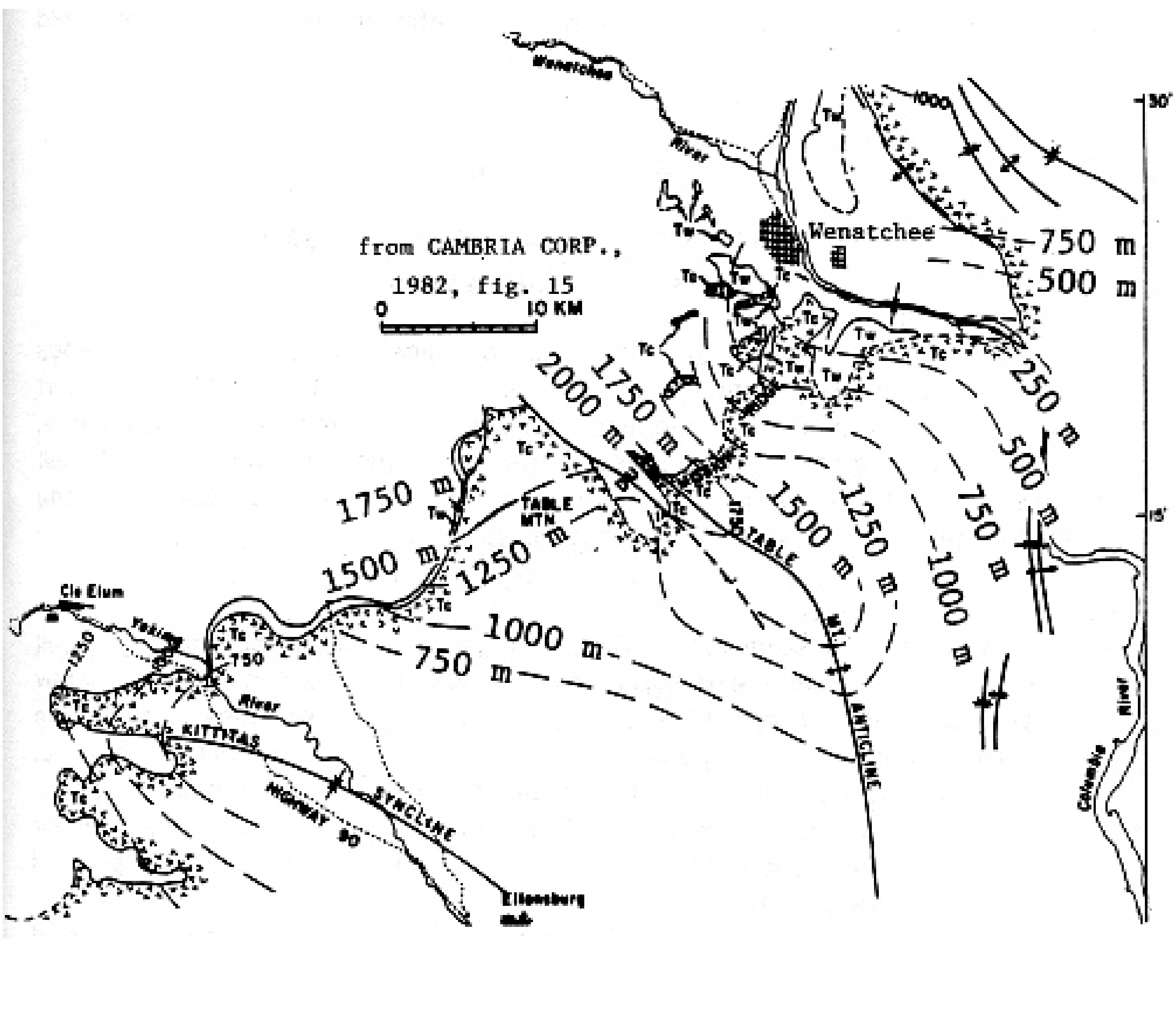


Figure 6. (Left) Distribution of the unconformity-bounded sequences in the vicinity of this field trip (from Cheney, 1994).

Figure 7. (Below) Structure contours on the base of the Grande Ronde Basalt in the Wenatchee/Ellensburg area. Note the major folds and regional southeasterly dip.



The Easton Metamorphic Suite is interpreted to be the offset equivalent of the Shuksan Greenschist and Darrington Phyllite west of the Straight Creek Fault in the Skagit Valley. These units have a Late Jurassic protolith age and an Early Cretaceous metamorphic age. The relationship between the Ingalls and Easton rocks are obscured by the wide belt of Challis rocks north of Cle Elum.

Challis Sequence

The Challis sequence occurs in several successions. The eastern succession is in the Chiwaukum graben between Leavenworth and Wenatchee. The western succession is between Leavenworth, the Yakima River, and the Straight Creek Fault. The southwestern succession is south of the Yakima River and east of the Straight Creek Fault. The Naches Formation occurs on both sides of the Straight Creek Fault, but heretofore has been considered to be only west of the fault. Historically, different stratigraphic names have been given to lithostratigraphic units in each of these four successions, but many of the units may prove to be representatives of the same unconformity-bounded units.

Western Succession

Swauk Formation

The Swauk Formation is exposed between Leavenworth and Cle Elum. It consists of several fluvial facies, dominated by zeolitic feldspathic to lithofeldspathic sandstone, but also includes the shale facies of Tronsen Ridge, conglomerate, fanglomerate, and minor nickel-rich laterite at its contact with the Ingalls Complex. According to Tabor, et al. (1982), the white arkosic facies is compositionally similar to the Chumstick Formation exposed northeast of the Leavenworth Fault Zone. Parts of the Swauk are intruded by numerous dikes of the Teanaway Basalt, whereas the Chumstick is not.

Silver Pass Volcanic Rocks: Silver Pass Volcanic Rocks consist of dacitic to andesitic tuff and breccia interbedded with arkosic sandstone like the Swauk Formation. These rocks are exposed mostly west of Swauk Pass and have yielded early Eocene zircon fission-track ages. The Silver Pass is unconformable on pre-Tertiary rocks and the Swauk Formation.

Teanawav Basalt

The Teanaway Basalt is unconformable on the Swauk and Silver Pass and is exposed in a northwest-trending belt of rocks approximately 2-5 km wide on the north side of Teanaway Valley. Other exposures occur in the vicinity of Cle Elum Lake, Lake Kachess, and on the southwest side of Easton Ridge. The unit consists of basalt, basaltic tuff, and breccia, but also includes andesite, dacite, and rhyolite. Whole-rock K-Ar analyses are about 47 Ma.

The Teanaway Basalt forms numerous northwest-trending, reddish-brown weathering basalt and diabase dikes in parts of the Swauk Formation. These dikes are easily observed along Swauk Creek during this field trip.

Roslyn Formation

The Roslyn Formation lies nearly conformably on the Teanaway Basalt and hence its aerial distribution is similar to that of the Teanaway. The Roslyn is subdivided into three members, all of which contain nonmarine micaceous lithofeldspathic sandstone with lesser siltstone, and conglomerate. The upper member contains coal seams up to 6 m thick, whereas the middle member contains only very minor coal stringers, and the lower is devoid of coal. According to Frizzell, et al. (1984), the upper member is, in part, zeolitic. Age of the Roslyn is middle and late Eocene and generally correlative with the Chumstick Formation of the eastern succession described below.

Southwestern Succession

Manastash Formation

Exposures of the Manastash Formation occur south of Cle Elum. This formation consists of nonmarine feldspathic quartzose to subquartzose sandstone, with thin siltstone and conglomerate interbeds. The Manastash Formation is about 50 Ma and, according to Tabor, et al. (1982), is equivalent to the early Eocene Swauk Formation.

Taneum Formation

This unit is of early Eocene age based on zircon fission-track ages and its stratigraphic position. It consists of andesitic, dacitic, to rhyolitic volcanic rocks, tuffs, and breccia. The andesite of Peoh Point, approximately 5 km south of Cle Elum, is hornblende-hypersthene dacite porphyry and probably is part of the Taneum.

Basalt of Frost Mountain

This predominantly basaltic interval south of the Yakima River may correlate with the Teanaway Basalt. However, this predominantly basaltic unit does contain minor felsic volcanic rocks similar to the Naches Formation and minor arkosic sandstone similar to the Swauk and Manastash Formations.

Naches Formation

The Naches Formation extends 60 km from near Snoqualmie Pass to approximately 30 km south of Easton. This Eocene unit consists of rhyolite, andesite, basalt, feldspathic subquartzose sandstone, siltstone, and rare coal. The only rock type which may be observed on this field trip is rhyolite. Rhyolites are typically aphanitic and white and limonitic weathering; rare fresh outcrops are gray. Because a few outcrops display flow banding, welding, or have abundant centimeter-scale felsic fragments, at least some of the rhyolites probably were pyroclastic flows. No source is yet known for such flows.

Eastern Succession

Chumstick Formation

The Chumstick Formation is exposed northeast of the Leavenworth Fault Zone and southwest of the Entiat Fault in what has been termed the Chiwaukum "graben." It consists of several facies, but is dominated by fluvial micaceous arkosic sandstone with lesser amounts of shale, and conglomerate. Other facies include "fanglomerate," which will be observed on this trip, and siliceous tuff. According to Tabor, et al. (1982), the white arkosic facies of the Swauk is difficult to distinguish from the Chumstick. The Camas Land Diabase is considered to be a sill within the Chumstick Formation, approximately 14 km north of Swauk Pass. The sill is composed of ophitic black diabase and gabbro.

Wenatchee Formation

In the Chiwaukaum graben, the lower part of the Wenatchee Formation unconformably overlies the Chumstick. The lower part consists of biotite-bearing sandstone, shale and siltstone, much like other Challis formations . The upper part consists of tuffaceous units much like the Kittitas sequence and extends beyond the graben.

Walpapi Sequence

Columbia River Basalt Group

The Miocene Columbia River Basalt Group (CRBG) is exposed throughout much of eastern Washington, northeastern Oregon, and parts of the Idaho panhandle. The CRBG in central Washington is subdivided, from oldest to youngest, into the Grande Ronde, Wanapum, and Saddle Mountains Basalts. Only parts of the Grande Ronde will be observed on this field trip.

Grande Ronde Basalt is composed of numerous individual flows which are grouped into two units: upper flows of normal magnetic polarity, and two lower flows of reversed polarity. In general, Grande Ronde Basalts are fine- to medium-grained nonporphyritic basalt flows. The units display complex columnar jointing and, in places, pillow structures. Only the upper two units of Grand Ronde occur in the Cle Elum-Wenatchee area.

Ellensburg Formation

The Ellensburg Formation is a coarse mostly fluvial unit with abundant felsic volcanic clasts. Because it is interbedded with and overlies the Grande Ronde, it is exposed in similar areas. The Ellensburg Formation is generally weakly lithified and subject to landsliding. In the field trip area in the vicinity of the Kittitas Valley, it is divided into two informal units (Tabor, et al., 1982). One unit in and southwest of the Kittitas Valley is tuffaceous sandstone, siltstone, and conglomerate. Lahar deposits are also present. Pumice clasts are common, and Tabor, et al. (1982) interpret this member to have been derived from freshly erupted volcanoes in the ancestral Cascade Range. The other unit, exposed to the northeast of the Kittitas Valley, is micaceous feldspathic sandstone and siltstone with little volcaniclastic material. This unit is interpreted to have been derived from older rocks to the north, such as Swauk, Chumstick, and the Swakane Biotite Gneiss.

CRYSTALLINE ROCKS WEST OF THE STRAIGHT CREEK FAULT

Eastern and Western Melange Belt

The **Western Melange Belt** is a zone of technically emplaced blocks of all sizes containing argillite, graywacke, metavolcanic rocks, metagabbro, and ultramafic rocks. It lies along the western margin of the present-day Cascade Mountains southwest of the Darrington-Devils Mountain Fault Zone, and west of the Eastern Melange Belt. Rocks of the Western Melange Belt are in greenschist facies and are typically highly deformed and sheared. Where intruded by Tertiary plutons, such as the Snoqualmie Batholith, these rocks are hornfels.

The Eastern Melange Belt, like its western equivalent, was also technically emplaced. It lies along the western margin of the present-day Cascade Mountains east of the Western Melange Belt. It consists of technically mixed and metamorphosed chert, argillite, greenstone, greenstone breccia, and marble. Whereas the Western Melange Belt appears to be mostly composed of Mesozoic rocks, the East Belt also contains Paleozoic rocks.

Snoqualmie Batholith

The composite Snoqualmie Batholith intrudes pre-Tertiary and Challis and Kittitas volcanic and sedimentary rocks in the vicinity of Snoqualmie Pass.Mapable phases are medium-grained, mostly equigranular granodiorite and tonalite; light-colored, fine-grained quartz monzonite; medium-grained granodiorite; and minor biotite-hornblende diorite and gabbro (Frizzell, et al, 1984). The Snoqualmie Batholith intrudes the Straight Creek Fault.

The batholith probably was one of the sources of the Kittitas sequence. Because intrusive, extrusive, and volcaniclastic rocks of this age extend from southern British Columbia, through Nevada, to central Mexico, referring to these rocks as the Cascade volcanic arc is (1) too provincial, and (2) confuses them with Plio-Pleistocene topography and stratovolcanoes of the present (<2 Ma) Cascade arc.

ROAD LOG

INTRODUCTION

This road log uses mileposts (MP) as a reference unless otherwise stated. The mileposts are green, numbered in white, and placed on the side of the road on small metal poles. MP's are given in the left margin; point-to-point mileages are in parentheses. Figure 8 (back page) shows the field trip route and stops, as well as the general geology.

DAY ONE: SWAUK PASS

EXIT 15 (0.0) I-90. Meet at the Issaquah Park and Ride, 8:30 AM, June 8, 1996. Proceed east on I-90.

MP 62.0 (62.0) We will take a short break here while the field trip leaders make a quick jaunt to STOP 2-7B to determine if the water level on Lake Kachess has receded enough to see the outcrops there tomorrow without the use of scuba gear.

Continue eastbound on I-90.

MP 85.6 (23.6) Take Exit 85; Hwy 970 to Wenatchee.

reset. odometer at end of exit ramp.

0.0 (0.0) Turn north (left) across I-90.

0.4 (0.4) Turn east (right) on SR 970, following the signs to Wenatchee.

New milepost series beginning at MP 0.3.

MP 8.2 (7.9) Crossing pre-Wisconsin (?) glacial moraine for next 1.4 miles, marking terminus of the glacier which advanced southeastward down Teanaway Valley.

MP 10.3 (2.1) Junction SR 970/U.S. 97. Proceed straight, traveling north on U.S. 97. Entering Swauk Creek Valley. Note the piles of gravel due to dredging for gold in the 1920's.

New milepost series beginning at MP 149.7

MP 150.5 (0.8) Teanaway Basalt outcrops on right for 2 miles (Margolis, 1994).

MP 152.5 (2.0) Swauk and Silver Pass Formations (Margolis, 1994). North of here, Swauk arkose at various high dips is cut by abundant rusty-weathering Teanaway dikes.

MP 163.9 (11.4) Swauk Pass (sign at summit incorrectly indicates "Blewett Pass").

MP 172.1 (8.2) Pull of into parking area on west (left) side.

STOP 1-1: INGALLS TECTONIC COMPLEX:

Walk to outcrop at north end of parking area on west side of highway. This is metabasalt with minor serpentinite of the Ingalls Complex. Note that it contains minor sulfides (<1%), has a felty texture, and is slightly magnetic. Also present is dark gray to black argillite of the Peshastin Formation, which is also part of the Ingalls. A boulder of talc-like material may still be here, providing further evidence of the ultramafic nature of the rocks in this vicinity. Also look for small boulders of the Mt. Stuart Batholith.

Walk across to the east side of the highway and note the outcrops extending southward for -200 m. At the north end, note the fault between Ingalls rocks to the north and Swauk conglomeratic rocks to the south. Walk southward - 200 m into the Swauk formation and note the photogenic north-dipping normal fault which has been intruded by a Teanaway dike. Is the dike slightly offset along a younger, south-dipping reverse fault?

Continue north on Hwy 97.

MP 173.8 (1.7) Turn east (right) onto the remnants of the old highway and drive back to the south -0.2 miles. Walk to the outcrop just to the south on the east side of U.S. 97.

STOP 1-2: PESHASTIN FORMATION:

At the north end of the outcrop are light-colored, fine-grained felsic metavolcanic rocks. Note the cleavage (feldspar?) and rare quartz "eyes" and muscovite. The abundant Liesegang rings presumably were produced by meteoric weathering of sulfides. Rocks like this (and metamorphic equivalents) are the usual host for volcanogenic massive sulfide (Fe, Zn, Cu, Au, Ag) or oxide (Fe, Ba, Au) deposits in Archean to Miocene greenstone belts.

To the south is greenstone with calcite veinlets. The calcite is produced as Ca*2 is released from plagioclase during metamorphism.

Return to Hwy 97 northbound. MP 174.0 (0.2) Pull off on right at Historical Marker.

STOP 1-3: BLEWETT TOWNSITE AND ARRASTRA:

Relive the glory days of the Blewett Mining District. Be sure to visit the arrastra on the west side of the highway.
Activity in the Blewett Mining District began in 1860 with placer operations along Peshastin Creek, and was supplanted by lode mining between 1897 and 1910 (Margolis, 1994). Gold mineralization occurs in sulfide-bearing veins up to 15 feet wide in serpentinized peridotite of the Ingalls Tectonic

Complex.

Continue northbound on Hwy 97.

MP 178.7 (4.7) Pull off onto the right side just past Old Blewett Road next to the outcrop.

STOP 1-4: BASAL CHUMSTICK "FANGLOMERATE:"

This outcrop is mapped by Tabor, et al. (1982) as a fanglomerate unit within the Chumstick, interpreted to have been syntectonic detritus associated with uplift along the Leavenworth Fault Zone. However, the origin of this unit should be hotly debated by the participants of this trip!

Continue northbound on Hwy 97.

MP 179.9 (1.2) Turn east (right) on Camas Creek Road. Reset odometer at intersection.

2.6 (2.6) Outcrop on north (left). Pull off on south (right) side.

STOP 1-5: CHUMSTiCK FORMATION:

This is a typical outcrop of Chumstick, probably the Clark Canyon Member of Evans (1988). Note the general composition and appearance of the arkose. Do collect a hand sample for comparison with rocks at later stops.

Continue east on Camas Creek Road.

2.8 (0.2) Turn right on FS 120 into quarry.

STOP 1-6: CAMAS LAND DIABASE:

The quarry exposes a portion of the Camas Land diabase with spectacular columnar jointing. According to Southwick (1966), the diabase is 50 to 500 feet thick, 3.5 miles long, 1.75 miles wide, petrographically and chemically unlike Teanaway basalt, but similar to some parts of the CRBG. Significantly, the diabase is only assumed to be a sill; Southwick (1966) did not find any outcrops of the upper contact. Note that olivine is present in the lower basaltic: zone but that the rest is subophitic diabase without olivine.

Invasive CRBG sills are now well known (Tabor, et al., 1982).j Since Southwick's work, much insight has been gained about the stratigraphy and geochemistry of the CRBG. Modern geochemical methods could be used to determine if the diabase (whether intrusive or extrusive) matches any of the units ini the CRBG. It certainly is interesting to speculate how close to the diabase the CRBG may have been before the CRBG was eroded.

Retrace route to Hwy 97 and proceed south (left).

Resume Hwy 97 milepost series.

MP 175.1 (4.1) Pull off into large parking area on west (right) side of highway.

OPTIONAL STOP A: SERPENTINITE & BLACK ARGILLITE:

This outcrop displays typical lithologies in the Ingalls Tectonic Complex.

Continue south on Hwy 97.

MP 152.5 (22.6) Turn east (left) on Liberty road. Reset odometer at intersection.

1.4 (1.4) Turn north (left) on FS 9712, noting placer gold operations along Liberty Creek to the south.

1.9 (0.5) Park at FS 113. Walk to the south along FS 9712 to outcrop.

STOP 1-7: HYDROTHERMALLY ALTERED SWAUK FORMATION:

According to Margolis (1994), the Swauk Formation here is weakly sericitized, contains minor calcite and quartz veins, and is limonite-stained. To the south, Margolis (1994) noted that the Swauk Formation is weakly propylitized, with epidote replacing plagioclase and sericite replacing biotite. The biotite grains to the south should be fresher compared to those in the "subtle altered zone" (Margolis, 1994, p. 3), which is weakly anomalous in gold.

The source of the placer gold in the Liberty Mining District is quartz veinlets in the Swauk, the overlying Silver Pass Formation, and in Teanaway dikes. Hydrothermal alteration occurs within a 300 m massive sandstone unit in the lower part of the Swauk, however, this is below the level where the veins are exposed. Sandstone in the vicinity of these veinlets is relatively unaltered. Hydrothermally altered sandstone is traceable for at least 9 km along a west-northwest-trending anticline (Margolis, 1994). However, these altered rocks are poorly mineralized.

Production from the Liberty District, which includes activity in Williams Creek near Liberty and Swauk Creek, has been primarily in the form of placer mining and dredging. Gold was discovered along Swauk Creek in 1874.
/"""
Collect a sample of the least altered sandstone for comparison with samples from 1-5, 1-8, 2-2, and 2-6.

Retrace route to Hwy 97, turn south (left). Resume Hwy 97 milepost series.

MP 149.3 (3.2) Junction U.S. 97/ SR 970. Proceed straight ahead on SR 970 to Cle Elum.

Start new milepost series at 10.3.

MP 6.9 (3.4) Turn north (right) onto Teanaway River Road.

Reset odometer at intersection.

5.9 (5.9) Pull off on north (right) near large white outcrop on north.

STOP 1-8: ROSLYN FORMATION:

Observe the character of this arkosic rock, which is in the lower member of the Roslyn Formation. Compare and contrast this unit with the hand samples from the Chumstick Formation at STOP 1-5. Collect a hand sample from 1-8 for comparison at other stops during this field trip.

Retrace route to SR 970.

Turn west (right). Resume SR 970 MP series at 6.9.

MP 2.6 (4.3) Turn east (left) onto SR 10. New milepost series.

MP 93.5 (5.1) Note Grande Ronde Basalt of Columbia River Basalt Group on north (left).

MP 98.3 (4.8) Pull off on south (right) side of road just past guard rail, across from large outcrop on north (left).

STOP 1-9: ELLENSBURG FORMATION:

This is a photogenic exposure of the Ellensburg Formation, a partially fluvial clastic unit interbedded with CRBG. Note that the poorly-indurated, fairly massive volcaniclastic material in the lower part, is underlain and overlain by bedded units. At other localities, the Ellensburg is noted for its abundance of pumice fragments. They appear to be rare here.

Continue east on Hwy 10.

MP 105.3 (7.0) Turn southeast (right) at 4-way stop, following signs for Hwy 97.

Reset odometer at intersection.

1.2 (1.2) Turn southwest (right) at 4-way stop and proceed across I-90.

1.6 (0.4) Turn south (left) onto Thorp Highway, then take immediate left into KOA where we will camp for the night. Those with reservations at the I-90 Inn Motel will be shuttled following dinner.

END OF DAY ONE.

DAY TWO: CLE ELUM TO SNOQUALMIE PASS

From the KOA, return to 1-90 and proceed westbound.

Start milepost series at MP 106.0.

84.4 (21.6) Take Exit 84 to South Cle Elum and Cle Elum.

Reset odometer at end of exit ramp.

0.0 (0.0) Turn north (right) at end of exit ramp.

0.4 (0.4) Proceed to stop sign in downtown Cle Elum. Turn west

(left) on First St. W.

0.6 (0.2) Turn south (left) onto South Cle Elum Road.

1.4 (0.8) Turn west (right) onto Madison. Follow this main road southwestward through South Cle Elum.

3.9 (2.5) Turn south (left) onto FS 3350, Peoh Point Road.

Reset odometer at intersection.

2.0 (2.0) Note small outcrops of black phyllite on south (left) side of road.

3.0 (1.1) More black phyllite.

6.0 (2.9) Turn west (right) onto spur road, FS 211 into quarry.

STOP 2-1 A: GRANDE RONDE BASALT:

According to Tabor, et al. (1982), this is upper Grande Ronde basalt flows of normal polarity (Tgn2). For future reference, infer the shallow dip here and that we are near the base of the Grande Ronde at an elevation of 1250 feet.

6.2 (0.2) Return to FS 3350 and proceed in the same direction as before.

6.7 (0.5) Turn north (left) onto FS 115.

STOP 2-1B: DARRINGTON PHYLLITE:

Note variable foliations and lenses of quartz. What did we cross between STOP 2-1A and 2-1B?

6.9 (0.2) Stop at outcrop on south (right) side.

STOP 2-2: MANASTASH FORMATION:

This biotite-quartz-feldspar sandstone, mapped by Tabor, et al. (1982) as Manastash Formation, is part of the southwestern succession. Collect a hand sample for comparison with stops 1-5, 1-7, 1-8, and 2-7. What did we cross between the black phyllite and here? Is this the same contact as the one between 2-1A and 2-1 B?

7.1 (0.4) Backtrack to FS 3350. Turn east (left).

7.4 (0.3) On north (left) side of road, note white tuffaceous sedimentary material exposed in soil above culvert. This is Wenatchee Formation, or is it Ellensburg?

7.6 (0.2) Turn north (left) onto FS 114, Peoh Point Road. Note minor exposure of CRBG here (Tgn2 again).

9.5 (1.9) Proceed to Peoh Point at end of road.

STOP 2-3: PEOH POINT LOOKOUT:

The primary reason for this stop is to discuss the regional geologic relationships of the pre-Tertiary, Challis, and CRBG rocks visible from here (stand back!). However, the rocks at Peoh Point may also be of interest. The Peoh Point Andesite as described by Tabor, et al. (1982), is a hornblende-hypersthene dacite. Compare its stratigraphic position (with respect to the Manastash) with the position of the Silver Pass rocks (with respect to the Swauk Formation).

Retrace route back to downtown Cle Elum. Turn west (left) from South Cle Elum Road onto First St. W. Proceed through town to I-90 and travel west.

Resume 1-90 milepost series at MP 82.7.

MP 71.8 (10.9) Take exit 71.

Reset odometer at beginning of exit ramp.

0.1 (0.1) Turn south (left) at end of exit ramp, to Easton.

0.6 (0.5) At 4-way stop, proceed straight on Cabin Creek Road, and continue across railroad tracks.
(Follow the subsequent directions to proceed to the Optional Stop which follows. Otherwise, skip to the directions which begin with "Return to Cabin Creek Road and turn west (right)," which start at this same point. Reset odometer.

0.7 (0.1) Veer right onto dirt road which follows old railroad grade.

0.8 (0.1) Green phyllite in railroad cut.

1.1 (0.3) Large outcrop on left.

OPTIONAL STOP B: EASTON SCHIST:

This is a relatively good place to observe the greenschist in the Easton Schist.

Return to Cabin Creek Road and turn west (right). Reset odometer at intersection.

0.7 (0.7) Small dirt road veers to northwest (right). Park here for overview of geology in valley to north.

STOP 2-4: OVERVIEW OF LAKE EASTON AREA:

We are standing on felsic volcanic rocks of the Naches Formation. The rocks on the north side of Lake Easton below us are green phyllite. Across the Yakima River, Teanaway Basalt dips less steeply than the underlying rocks of the Silver Pass Formation.

Retrace route to 4-way stop in Easton.

Reset odometer at intersection.

0.0 (0.0) Turn west (left) on Railroad Street.

0.8 (0.8) Turn south (left) into Easton State Park. Proceed to stop sign and turn west (right).

1.8 (1.0) Turn south (left) at fork and park at picnic area. Walk to outcrop 100 m west of beach.

STOP 2-5: EASTON SCHIST:

Note the steeply-dipping foliation here. Some quartz veins can be found here, but on the hill 100 m northwest of here, numerous folded veins may be found. Here, we are within a few hundred meters of the western-most known exposure of the Easton Schist southwest of Lake Kachess. The railroad grade on the south shore of Lake Easton is in arkosic sandstone. Because the Swauk Formation and Easton Schist are supposed to be east of the Straight Creek Fault, this stop and 2-6 have important implications regarding the location of the Straight Creek Fault.

Retrace route back to entrance to Easton State Park.

Reset odometer at intersection.

0.0 (0.0) Turn west (left).

0.7 (0.7) Follow this road to the north side of I-90 (crossing Exit 70 overpass), then turn west (left) at the "T."

1.4 (0.7) Bridge. Note old bridge on south side of I-90 here to left.

Good exposures of Easton Schist on the east side of the bridge! are the western-most known exposure of this unit.

1.8 (0.4) Turn left. Proceed to the turn-around at the end of the road and return to the northern freeway overpass (westbound lanes). Park here and observe the outcrop just south of this overpass, on the west side of our road.

STOP 2-6: NACHES FORMATION (AS MAPPED):

This outcrop consists of arkosic sandstone and black siltstone, mapped by Frizzell, et al., (1984) as Naches Formation. Compare the sandstone with samples from STOPS 1-5, 1-7, 1-8, and 2-2. The contact between this sandstone and the Easton greenschist at STOP 2-5 trends northwest through western¬most Lake Easton. Note that 2-5 and 2-6 are southwest of the! trace of the Straight Creek Fault as mapped by Frizzell, et al. (1984). Also contemplate whether the contact between these rocks of 2-6 and the greenschist of 2-5 could be something! other than a major fault.

Retrace route to I-90, Exit 70. Proceed west. Resume 1-90 milepost series.

Note: If it was found on the previous day that the water level! at Lake Kachess is low enough, proceed directly to STOP 2-761 and skip STOP 2-7A. If the water level at Lake Kachess is tool high to permit observations, proceed directly to STOP 2-7A and! then skip STOP 2-7B.

Proceed westbound up grade with three lanes.

For STOP 2-7A:

MP 67.4 (2.7) Near top of hill, move into left lane and carefully pull ofi into turn-around area located between east and westbound lanes. Park here and carefully cross eastbound lanes on foot to outcrop on south side.

STOP 2-7A: STRAIGHT CREEK FAULT:

The rocks here consist of limonitic, aphanitic, white-weathering felsite with disseminated pyrite. Note that the eastern end of the exposure has felsic clasts in a felsic matrix, dark volcaniclastics, and black siltstone. Frizzell, et al (1984) mapped this as Naches Formation. The rhyolites here are typical of the Naches.

After inspecting this outcrop, cross back to the north side of the eastbound lanes. Walk east down the hill -0.4 miles across a covered interval to the outcrop. Speculate as to the nature of this covered interval.

This outcrop consists of a succession of northwest-striking rocks dipping steeply to the southwest. The structurally upper unit, at the west end of the outcrop, is basalt. The lower unit is a pale green felsic fragmental unit. These upper and lower units are probably Teanaway Basalt and Silver Pass/Taneum volcanics, respectively, units that occur east of the Straight Creek Fault. Because Naches felsites similar to those at I-90 occur on the hillsides north and south of the freeway, the contact between them and the northwesterly-striking basalt and green felsic unit trends northerly; that is these units strike into the contact with the Naches felsite. Therefore, the covered interval between here and the first outcrop probably is the Straight Creek Fault! That is, the trace of the fault, rather than curving southeastward down Lake Kachess, continues southward west of the lake.

For STOP 2-7B:

MP 62.2 (4. 4) Take Exit 62, Lake Kachess.

reset odometer at beginning of exit ramp.

0.1 (0.1) Turn north (right) at end of exit ramp to Lake Kachess.

3.1 (3.0) Turn southeast (right) onto Via Lake Kachess Road.

3.5 (0.4) Park in road near clubhouse (do not park in private parking lot). Walk down the driveway to the beach, then north along the beach to the outcrop.

STOP 2-7B: SWAUKOID SANDSTONE AND FELSITE OF NACHES FORMATION:

These rocks were mapped as Naches Formation (Frizzell, et al., 1984). Walk northward along beach, noting textures in sandstone and felsite and dips of the sandstone. Read the text for STOP 2-7A. Contemplate the nature of the covered interval between the two lithologies.

Trace route back to I-90. Proceed westbound.

Resume 1-90 milepost series.

MP 55.1 (8.0) Take Exit 54: Hyak.

Reset odometer at beginning of exit ramp.

0.4 (0.4) Turn east on Gold Creek Road.

0.9 (0.5) Pull off onto side road on north (left) side. Walk back to large outcrop to west.

OPTIONAL STOP C: MT. CATHERINE RHYOLITE:

This outcrop is mapped by Frizzell, et al. (1984) as Eocene Mt. Catherine Rhyolite member of the Naches Formation. Here it is an aphanitic, gray crystal-lithic tuff with some flattening & welding of clasts. Because the rhyolite is stratigraphically between two arkosic units, it may be correlative with the Taneum, not the Naches (Cheney, 1994).

Retrace route back to I-90, but cross to south side of freeway to stop sign. Turn northwest (right).

Reset odometer at intersection.

1.0 (1.0) Pull off into parking area on west (left) side of road.

OPTIONAL STOP D: PHOTO STOP OF RAMPART RIDGE; BLACK ARGILLITE OF EASTERN MELANGE BELT

There are two reasons for this stop. The first is the view of Rampart Ridge on the skyline almost due east of here. The top portion is composed of Oligocene/Miocene volcanic units of the Kittitas sequence, whereas the lower portion is composed of the Naches Formation of the Challis sequence. The contact between the two units, therefore, is the Challis/Kittitas unconformity. If the weather is kind, this is a good photo opportunity of this relationship.

The second reason for this stop is an outcrop at the southwest end of the parking area. Note the black argillite which is weakly phyllitic, probably of pre-Tertiary age.

Continue north on the same road through Snoqualmie Pass summit area.

3.0 (2.0) Cross under 1-90. Continue straight on Alpental Road.

4.0 (1.0) Stop at outcrops in stream, ~ 150 m south of Alpenrose condominiums.

OPTIONAL STOP E: SNOQUALMIE BATHOLITH AND BLACK ARGILLITE OF EASTERN MELANGE BELT:

There are several items of interest here. On the east side of the road in the stream are large boulders of coarse elastics of the Naches Formation containing igneous clasts. Across the stream is an outcrop of hornfels produced as the Snoqualmie Batholith thermally metamorphosed pelitic rocks of the Eastern Melange Belt.

On the west side of the road is an outcrop of the Preacher Mountain quartz monzonite phase of the Snoqualmie Batholith. Note the rounded quartz phenocrysts and probable graphic (mermekitic) intergrowths of quartz and feldspar. Smaller grains of quartz are angular. This phase is considered to be older than the main or southern phases (see Tsgg in Frizzell, et al, 1984).

Retrace route to 1-90 westbound. Resume 1-90 mileposts. MP 48.0 (4.1) Take Exit 47, Denny Creek. Reset odometer at end of exit ramp.

0.0 (0.0) Turn north (right) at end of exit ramp, then take immediate turn east (right) at stop sign, follow signs to Denny Creek.

0.3 (0.3) Turn north (left) onto FS 58.

1.4 (1.1) Pull off on east (right) side of road at outcrop.

OPTIONAL STOP F: SNOQUALMIE BATHOLITH:

This outcrop is mapped as the southern granodiorite and tonalite unit of the Snoqualmie Batholith. Here it is a medium-grained, equigranular hornblende-biotite granodiorite. In places, such as near MP 50 of the eastbound lanes of I-90, it displays spectacular blocky joints, which are somewhat less evident here. Note that float of the Preacher Mountain quartz monzonite also can be found here.

Retrace route to I-90 and proceed westbound back to the Issaquah Park and Ride lot where the field trip began yesterday.

END OF DAY TWO.

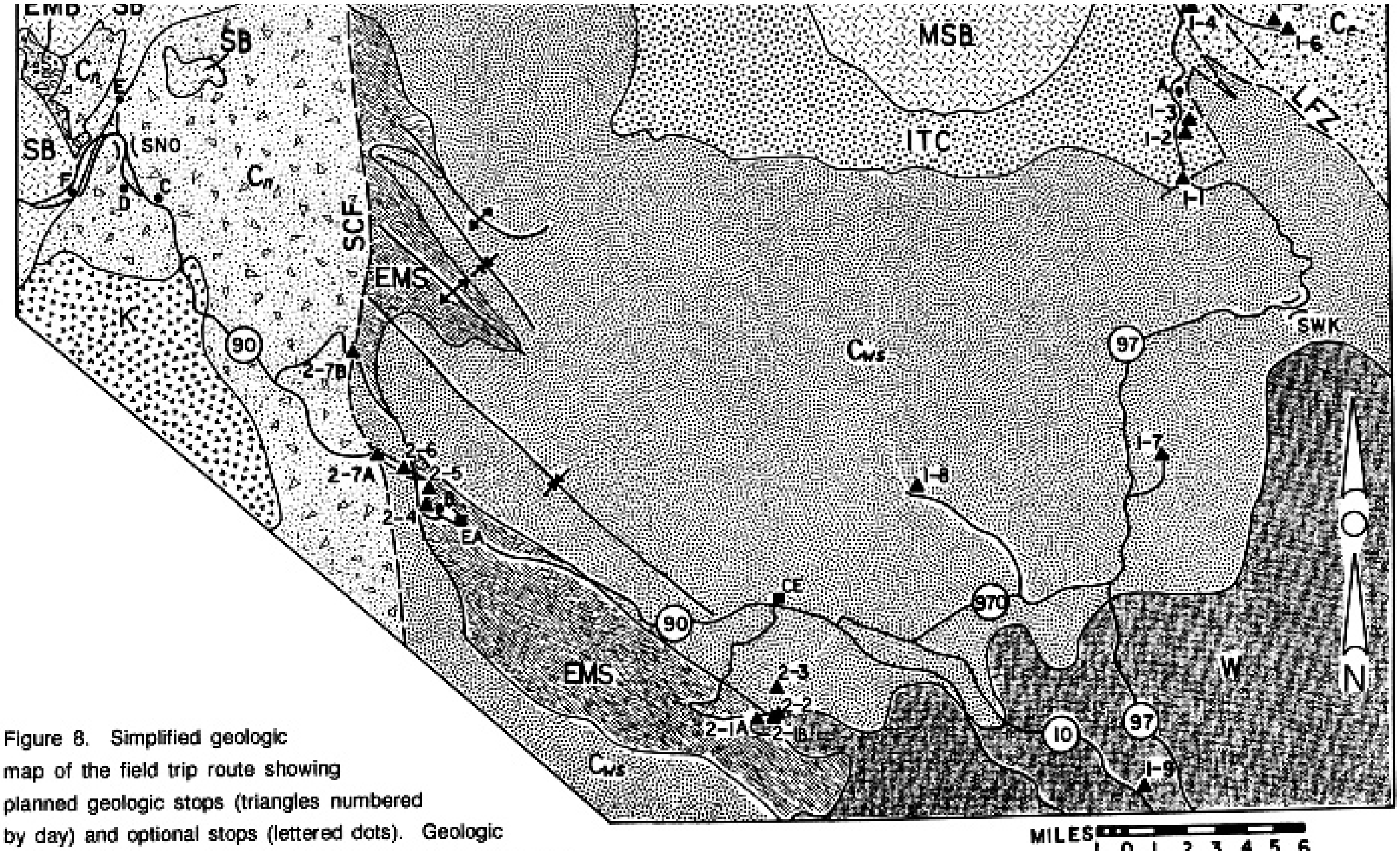


Figure 8. Simplified geologic map of the field trip route showing planned geologic stops (triangles numbered by day) and optional stops (lettered dots). Geologic abbreviations: C_e = Challis Sequence, eastern succession; C_n = Challis Sequence, Naches Formation; C_{ws} = Challis Sequence, western & southwestern successions; EMB = Eastern Melange Belt; EMS = Easton Metamorphic Suite; ITC = Ingalls Tectonic Complex; K = Kittitas Sequence; MSB = Mount Stuart Batholith; SB = Snoqualmie Batholith; W = Walpapi Sequence. Structural abbreviations: LFZ = Leavenworth Fault Zone; SCF = Straight Creek Fault. Location abbreviations: CE = Cle Elum; EA= Easton; SNO = Snoqualmie Pass; SWK = Swauk Pass. Information modified from Frizzell, et al. (1984) and Tabor, et al. (1982).

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