THE PRE–TERTIARY RIMROCK LAKE INLIER, SOUTHERN CASCADES, WASHINGTON

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**ILLUSTRATIONS**

Plate 1  Geologic Map of pre-Tertiary rocks in the Mount Rainier 1:100,000 quadrangle.  Separate sheet

Figure 1a  Structural section along spur "E" of Wenatchee National Forest Road No. 1443  12
Figure 1b  Continuation of structural section shown in figure 1a  13
ABSTRACT

The Rimrock Lake inlier represents the southernmost pre-Tertiary rocks in the Cascade Mountains. It consists of NNW-trending lithological belts that are separated by steep faults. The inlier is dominated by the Russell Ranch unit of probable Jura-Cretaceous age. The Russell Ranch includes: a clastic subunit consisting mainly of lithic arkose and mudstone, plus minor conglomerate, pillowed greenstone and chert; and a chert-tuff subunit characterized by radiolarian cherts, green tuffs and red shales, in addition to containing rocks identical to those of the clastic subunit. Both subunits are strongly deformed. Local ductile (pre-lithification?) flattening was followed by intense, widely distributed faulting, resulting in a tectonic melange. Cherts and greenstones were juxtaposed against clastic rocks by faulting and the various rock types may have originally formed at a considerable distance from each other.

The Jurassic Indian Creek complex consists mainly of directionless plutonic rocks and orthogneisses metamorphosed to epidote-amphibolite facies. Compositions range from gabbroic to trondhjemitic, but tonalitic rocks predominate. The gneisses are deformed and metamorphosed equivalents of the directionless rocks.

Two small metavolcanic units of unknown age also occur within the inlier. A 1-km-wide, fault-bounded belt of pillowed greenstone occurs in the eastern portion of the inlier, and an enigmatic silicic volcanic unit occurs as fault(?) slices within the Russell Ranch clastic subunit.

Steep faults separate the major units and postdate internal structures. At least one of these faults probably was responsible for significant strike-slip displacement, juxtaposing the Russell Ranch unit and Indian
Creek complex. Eocene arkoses cover the steep faults, and contacts between pre-Tertiary and Cenozoic rocks are generally pronounced angular unconformities that only locally show minor modification by faulting.
INTRODUCTION

The Rimrock Lake inlier represents the southernmost pre-Tertiary rocks in the Cascade Mountains and occupies a critical position in the "Columbia Embayment" between the Blue Mountains and the North Cascades. The inlier consists of NNW-trending lithological belts that are separated by steep faults. Pre-Tertiary units in the inlier include the supracrustal Russell Ranch unit, the plutonic and metamorphic Indian Creek complex, the Eastern greenstone unit, and a silicic metavolcanic unit. These rocks are overlain by, and locally are in fault contact with, a variety of Eocene to Quaternary sedimentary and volcanic rocks.

Russell Ranch Unit

The Russell Ranch unit (Simmons, 1950; Ellingson, 1972; Swanson, 1978; Clayton, 1983) is a voluminous, chaotically deformed supracrustal sequence of probable Jura-Cretaceous age (see below). It is referred to as a unit, rather than a formation, because many contacts between rock types are faults, and the various rock types probably did not form as part of a single stratigraphic sequence. The Russell Ranch has been divided into two subunits: a clastic subunit dominated by sandstone and mudstone, with minor conglomerate, greenstone and chert; and a chert-tuff subunit that contains radiolarian cherts, green tuffs and red shales, in addition to sandstones, mudstones and greenstones identical to those of the clastic subunit. Both subunits are strongly deformed, but only weakly metamorphosed. Primary minerals and textures commonly are preserved.

The Russell Ranch unit crops out in two belts that are separated by a large slice of the crystalline Indian Creek complex. The western belt
consists solely of the clastic subunit, whereas the eastern belt contains both subunits. Greenstones are much more abundant in the eastern belt.

**Clastic subunit**

This unit is dominated by sandstone and mudstone, with significant amounts of conglomerate and greenstone, minor chert and very rare green tuff. Sandstones are lithic arkoses that contain abundant clasts of plutonic plagioclase. The arkoses commonly occur as thick, massive bodies. Sequences of interbedded sandstone and shale generally show high sandstone-to-shale ratios. Sedimentary structures are uncommon; graded bedding, convolute laminations and channels occur locally.

Conglomerates commonly form interbeds (< 5 m thick) within sandstones; however, one body southeast of the South Fork of the Tieton River is > 50 m thick and has been traced along strike for > 80 m. Many of the conglomerates are rich in chert clasts. Limestone cobbles occur in a few places and are also prominent in an olistrosomal boulder breccia on Short and Dirty Ridge. These clasts are significant because Ellingson (1972) collected fusulinids of probable Permian age from limestone float at one locality. Thus, the clastic subunit presumably is no older than Permian.

Tectonic blocks of greenstone are widespread in the clastic subunit between the western belt of the Indian Creek complex and the chert-tuff subunit of the Russell Ranch unit. Most blocks are small, but larger (> 100 m²) lenses of pillowed greenstone are concentrated in a 1.5 km-wide zone near the Indian Creek complex. Amygdaloidal rocks occur in less than half of the blocks. The primary mineralogy of the greenstones was augite and calcic plagioclase; metamorphic phases are albite-chlorite-quartz-calcite-epidote.
Chert-tuff subunit

This subunit is distinguished from the clastic subunit by the abundance of chert. Thin stringers of altered green tuffs and red shales within chert-rich horizons are also diagnostic. Radiolaria of probable Jurassic or Cretaceous age have been reported from one of the chert localities (D.L. Jones, pers. commun., 1980). The green tuffs are typically < 0.5 m thick and appear to be reworked, water-laid ash falls. They consist mainly of chlorite, with less abundant calcite, sericite and turbid material that is irresolvable under a standard microscope.

Internal structure of the Russell Ranch unit

The Russell Ranch unit has been strongly deformed. The earliest deformation is local ductile (pre-lithification?) flattening of thin-bedded sandstone and mudstone that results in boudinage and pinch-and-swell structure. This deformation was followed by intense faulting (Miller, 1982). Faults pervasively cut sandstone-mudstone sequences in addition to occurring at contacts of clastic rocks with cherts and greenstones. The faults have variable orientations and senses of slip (see Figures 1a & 1b). The magnitude of slip is generally difficult to interpret; movement of a few meters can be demonstrated for some faults within the clastic subunit.

The intense faulting has resulted in abrupt changes in bedding attitudes (Figures 1a & 1b), although bedding shows a general tendency to strike N-S with steep dips in either direction. Faulting was concentrated in mudstone. Many blocks of sandstone, as well as chert and greenstone, are immersed in mudstone. An anastomosing cleavage defined in part by shear planes is developed in the more intensely deformed mudstones. Taken as a whole, the Russell Ranch unit can perhaps best be described as a tectonic melange.
Folds are heterogeneously distributed in the clastic rocks. Many are concentrated in shales and may be "drag folds" as they typically are localized near faults. The axes of these folds lack a consistent orientation. Open to tight folds are common in cherts; these folds are truncated by fault contacts suggesting that they formed prior to juxtaposition with the clastic rocks.

Depositional environment and tectonic interpretation

A key question for the interpretation of the Russell Ranch unit is what was the original relationship of the clastic rocks to the cherts, pillowed greenstones and green tuffs? The high sandstone-to-shale ratios in the clastic subunit, plus the widespread conglomerates, suggest that the clastic rocks are probably relatively proximal marine deposits. In contrast, the cherts formed in a deeper water and lower energy environment. Small blocks of pillowed greenstone presumably have been transported to their present positions, because it is difficult to envision basaltic eruptions producing numerous lenticular masses of < 50 m³.

These admittedly simplistic arguments, combined with the observations of generally clear-cut fault contacts between rock types, suggest that the cherts and greenstones were brought into contact with the clastic rocks by faulting and that the various rock types originally formed at a considerable distance from each other.

Indian Creek Complex

The Indian Creek complex crops out in two major belts and a small fault block of the complex occurs within the Russell Ranch unit north of Rattlesnake Peaks. The complex consists of a variety of plutonic and metamafic rocks ranging from gabbroic to trondhjemitic in composition.
The average composition of the complex is probably that of a tonalite. The Indian Creek has been divided into a foliated and a directionless phase on the map, but these phases show gradational contacts. It appears that the foliated rocks are more deformed and metamorphosed equivalents of the directionless rocks, rather than the directionless rocks being younger.

Several intrusive phases in the directionless unit are well displayed in the stream-polished bedrock of Indian Creek. Gabbros and diorites are the earliest rocks and they are intruded by voluminous tonalites that contain abundant mafic xenoliths. Aplitic trondhjemite dikes intrude both the tonalites and more mafic rocks. All of the rock types at least locally display a weak fabric.

The foliated unit consists mainly of gneisses metamorphosed to the epidote-amphibolite facies. These gneisses locally preserve the sequence recognized in Indian Creek of early mafic rocks intruded by progressively more leucocratic rocks. Sills and irregular veinlets of tonalitic gneisses cut medium-grained dioritic gneisses and locally amphibolites. Thin sills (< 25 cm thick) and rare dikes of pegmatitic trondhjemitic gneisses intrude both the tonalitic and mafic gneisses. Mattinson (1972) argued that these pegmatitic rocks were intruded during metamorphism. Zircons dated by the U-Pb method are Jurassic in age (Mattinson, 1972) and metamorphism and plutonism probably record a single Jurassic thermal event. Amphibolites are the only rocks in the complex that may not have an intrusive igneous affinity, although they possibly are strongly tectonized metagabbros.

Foliation in the Indian Creek typically strikes NNW, slightly discordant to the fault contacts of the complex. Mesoscopic folds of foliation are mainly restricted to amphibolites. A gently plunging mineral lineation occurs in some of the more strongly deformed rocks.
Eastern Greenstone Unit

A narrow (1 km wide) fault-bounded block of greenstones separates the eastern belt of the Russell Ranch from the eastern belt of the Indian Creek complex. This unit consists almost entirely of pillowed flows; shale interbeds (fault slices?) occur rarely. These rocks have been statically metamorphosed, but retain their igneous textures. The dominant metamorphic assemblage is albite-chlorite-calcite-hematite.

The rocks in this unit strongly resemble the greenstones within the Russell Ranch unit, and the two may be correlative. The Eastern pillow basalts are placed into a separate unit, however, for the following reasons.

(1) The eastern greenstones occur as a long, continuous outcrop belt interrupted only by Cenozoic rocks, whereas the greenstones within the Russell Ranch unit occur as relatively small tectonic blocks within clastic rocks.

(2) Sedimentary interbeds occur rarely within the eastern greenstones, but are relatively common within the tectonic blocks.

(3) The eastern greenstone unit consists almost entirely of pillowed flows, whereas both massive and pillowed flows are abundant in the tectonic blocks.

Silicic Metavolcanic Unit

An enigmatic altered silicic volcanic unit is tentatively assigned to the Rimrock Lake inlier. This unit is of unknown thickness and crops out in two main areas. The rocks of this unit show a strong foliation defined by aligned muscovite that wraps around relict quartz phenocrysts. This fabric may be mimetic after an original flow foliation or eutaxitic texture. The foliation has been locally deformed into sharp-hinged folds with wavelengths of < 25 cm.
These rocks were originally assigned a Tertiary age by Clayton (1983), but he (pers. commun., 1984) now considers them to be pre-Tertiary. There are several lines of evidence for the pre-Tertiary designation.

(1) Southeast of Twin Sisters Lakes, the foliation in the silicic volcanic rocks is subparallel to bedding and cleavage in the nearby Russell Ranch clastic subunit that apparently overlies the volcanic rocks.

(2) South of Clear Lake, clastic rocks of the Russell Ranch unit occur on both sides of the silicic volcanic rocks. The contacts are steep and may be faults.

(3) Small, tight mesoscopic folds, such as occur in the silicic volcanic rocks, are absent in known Tertiary rocks in the southern Washington Cascades. The folds in the silicic volcanic rocks are relatively harmonic and do not appear to be relict flow folds of igneous origin.

A Tertiary age for these rocks cannot be totally precluded. Contacts between the silicic volcanic rocks and the Russell Ranch unit are not exposed, and may be faults. Such an interpretation is particularly likely for the outcrop belt south of Clear Lake. Thus, it is possible that these rocks have been down-faulted into the Russell Ranch. Furthermore, the strong fabric in the altered volcanic rocks conceivably is totally mimetic after a primary igneous fabric, negating the argument that these rocks are more strongly deformed than the Cenozoic rocks in the area.

Summary and Discussion of Structural Relationships within the Rimrock Lake Inlier

Steep (>75°) faults separate all of the major units within the Rimrock Lake inlier. The directions of movement on these structures is generally not known. However, the fault separating the Indian Creek complex and
Russell Ranch unit on the north shore of Clear Lake apparently was responsible for significant strike-slip movement. Indian Creek gneisses show intense mylonitization and retrogression to chlorite-rich rocks for a distance of about 50 m from this fault. Strike-slip movement is indicated by the strong sub-horizontal lineation present in both Indian Creek and Russell Ranch mylonites adjacent to the nearly vertical fault contact. It is tempting to postulate that the other steep fault contacts within the inlier also experienced major strike-slip displacement. However, mylonitization has not been recognized next to other fault contacts, perhaps indicating that they originated at higher levels than the structures at Clear Lake.

The minimum age of these faults is constrained by mid-Eocene arkoses that cover fault contacts on the ridge between Arnesons Peak and McNeil Peak (Clayton, 1983) and in the area between Hindoo and Rattlesnake Creek (Schrieber, 1981). The Jurassic age of Indian Creek metamorphism and the presence of Jurassic or Cretaceous cherts in the Russell Ranch provide a maximum age limit. The steep faults clearly formed subsequent to the internal deformation of both the Russell Ranch unit and Indian Creek complex.

The magnitude of movement on these faults is difficult to assess. One interpretation is that the Russell Ranch unit and eastern greenstone unit originally accumulated on a basement consisting of the Indian Creek complex, and that subsequent faulting of relatively minor magnitude shuffled the original contacts. A second, very different interpretation, is that the Russell Ranch unit and Indian Creek complex originated at a considerable distance from each other, and that they were juxtaposed as a result of large-scale movement on strike-slip faults. I tentatively favor
the second interpretation. All contacts between units are faults and the presence in a relatively small area of rocks formed in a variety of tectonic settings (i.e., magmatic arc rocks versus pelagic sedimentary rocks) suggest major movement.

**Contact Relations of the Rimrock Lake Inlier**

The Rimrock Lake inlier is a dome-like uplift (Clayton, 1983). Eocene and Oligocene rocks dip away from the margins of the dome on all sides. The contacts between pre-Tertiary and Cenozoic rocks are generally pronounced unconformities, as is obvious from the map pattern. However, the unconformity above the pre-Tertiary rocks is at least locally faulted. I will briefly discuss below a few of these faults.

The northernmost outcrops of the eastern Indian Creek belt on Nelson Butte are bounded on both the east and west by steep faults that involve Oligocene (Wildcat Creek) strata. These faults are probably of only minor significance, as they have not been recognized to the south. I therefore do not subscribe to Schreiber's (1981) interpretation that these north-south faults are major splays of the Straight Creek fault.

The inlier is also partly bounded on the north (north of Rattlesnake Peaks) by an ENE-striking fault that separates the Russell Ranch from Oligocene volcanic rocks. My joint observations with G. Clayton support Schreiber's (1981) contention that there is significant disruption of volcanic rocks near this fault. Clayton (1983) also suggested that there may be an E-W Tertiary cross-fault with significant strike separation that offsets the Indian Creek gneisses on Hindoo Creek from those exposed on the south side of Bismarck Peak. My mapping, however, clearly shows that there are two separate continuous belts of the Indian Creek complex and that there is no evidence for this cross-fault.
The western contact of the Rimrock Lake inlier in part corresponds to the Cortright Creek fault mapped by Ellingson (1972). The strictness of the map pattern for much of this contact is compatible with a steep fault. However, I have seen little evidence to indicate that there has been anything more than minor movement along this contact. Stratigraphic continuity is maintained across the "Cortright Creek fault." Eocene basalts of the basal Tertiary section occur discontinuously next to the inlier for a distance of 19 km, cropping out in the canyon of the North Fork of the Tieton River, along U.S. 12, and on the north side of Summit Creek. In summary, there appears to have been only minor modification by faulting of the unconformity at the top of the pre-Tertiary rocks.

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REFERENCES CITED


Figure 1a. — Structural section along spur “E” of Wenatchee National Forest road No. 1443. View looking north on north side of White Pass highway (US 12) and east of Russell Creek near elevation 3,800 feet. Section begins approximately 800 feet (244 m) east of intersection of spur “E” and road 1443.
Figure 1b. — Continuation of structural section shown in Figure 1a.
GEOLOGIC MAP EXPLANATION

CENOZOIC

Q Quaternary
T Tertiary
U Undifferentiated

PRE-TERTIARY

Russell Ranch unit (Jurassic-Cretaceous)

KJr Clastic subunit
KJrg Greenstone blocks
KJrc Chert-tuff subunit
pTv Silicic metavolcanic unit
pTgr Eastern greenstone unit

Indian Creek complex (Jurassic)

Jid Directionless to weakly foliated plutonic rocks
Jif Well-foliated metaplutonic rocks
Jiu Undifferentiated crystalline rocks

GEOLOGIC MAP SYMBOLS

strike and dip of bedding
strike and dip of cleavage in Russell Ranch unit and foliation in metamorphic rocks
lineation in Indian Creek complex
dip of fault plane
Geologic Map Cross Section B-B'
(no vertical exaggeration)

Geologic Map Cross Section C-C'
(no vertical exaggeration)