UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Generalized geologic map of the Goat Rocks Wilderness and Roadless Areas (6036, Parts A, C, and D), Lewis and Yakima Counties, Washington

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GEOLOGIC SUMMARY

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geologic mapping survey of the Goat Rocks Wilderness (NF032) and the adjacent Goat Rocks Roadless Areas (6036, parts A, C, and D) in the Gifford Pinchot and Wenatchee National Forests, Lewis and Yakima Counties, Washington. The Goat Rocks Wilderness was established as a Primitive Area in 1931, reclassified as a wilderness on July 30, 1940, and established as a wilderness by Public Law 88-577, September 3, 1964. The Goat Rocks Roadless Areas were classified as further planning areas during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

Stratigraphy

The Goat Rocks Wilderness and the adjacent Goat Rocks Roadless Areas straddle the crest of the Cascade Range and contain Cenozoic volcanic rocks resting on a pre-Tertiary basement. The oldest rocks belong to the Russell Ranch Formation (Simmons, 1950) of the Rimrock Lake pre-Tertiary inlier. Graywacke and argillite (turbidites of flysch characteristics) are the main rock types, with minor pillow basalt (now greenstone), chert, and thin tuffaceous beds. All of the rocks are strongly deformed, but their metamorphic grade is below the prehnite-pumpellyite facies. Carbonaceous detritus (up to 10 volume percent of the rock) and radiolaria of "Jura-Cretaceous age" (written commun., D. L. Jones, 1979) are well preserved. The previously reported Permian age for the formation (Ellingson, 1972) is suspect, because the dated foraminiferal limestone occurs in an olistrostrome within the turbidites (oral commun., R. Miller, 1982).

The Ohanapecosh Formation rests unconformably on the Russell Ranch and is directly traceable into the type locality just north of the wilderness (Fiske, Hopson, and Waters, 1963). Preliminary radiometric dates suggest that the formation in the mapped area is of early and possibly middle Oligocene age (J. A. Vance and G. A. Clayton, unpub. data, 1982). The formation is more than 7,500 ft (2,300 m) thick, perhaps as much as 10,000 ft (3,000 m), in the mapped area. The Ohanapecosh consists mostly of altered basaltic and andesitic lava flows and bedded andesitic and dacitic volcaniclastic rocks. Rhyolitic flows and airfall and ash-flow tuffs occur sparsely throughout the section. Locally, as near the mouth of Coyote Creek and in McCall Basin, olivine-bearing basalt flows have been tentatively included in the unit; these flows resemble those of Eocene age underlying the Ohanapecosh Formation in the Summit Creek area, about 4 mi (6 km) north of the wilderness (Clayton, 1983), and more detailed work will likely result in exclusion of these basalt flows from the Ohanapecosh in the mapped area. Volcaniclastic rocks dominate the formation north of the Cispus River, but lava flows are locally prominent near major source areas, as on Angry Mountain. Basalt and andesite flows comprise most of the formation south of the Cispus; the relative freshness of these flows casts some doubt on their assignment to the Ohanapecosh, however. The depositional environment of the volcaniclastic rocks is uncertain. Fiske (1963; see also Fiske, Hopson, and Waters, 1963) interpreted laterally continuous beds in Mount Rainier National Park as products of subaqueous volcanism and deposition. However, water depths were probably not great, for lava flows in the Park as well as in the Goat Rocks area all appear to be typical nonpillowed subaerial types with rubbly basal and upper zones and vesicular tops.

Silicic ash-flow tuff, rhyolite, and related volcaniclastic rocks, all commonly quartz-bearing, overlie the Ohanapecosh in the northwestern part of the mapped area and are assigned to the upper Oligocene Stevens Ridge Formation. The contact is poorly exposed and commonly obscured by intrusions in the mapped area. Attitudes suggest that the Stevens Ridge dips somewhat less steeply than the Ohanapecosh, and hence the contact may be a slight angular unconformity. The Stevens Ridge is a maximum of about 600 ft (180 m) thick on Coal Creek Mountain. No vents were found, and all the rocks were probably erupted outside the mapped area.

No rocks of Miocene age were identified in the mapped area, although the relatively fresh andesite flows south of the Cispus River, included on the map with the Ohanapecosh Formation, are possible candidates. By early Pliocene, deep canyons had been eroded into the Paleogene and older rocks; any Miocene rocks once present may have been stripped away by this erosion. Alternatively, the absence of Miocene deposits could reflect diminished rates of volcanism, although we know that andesitic volcanism was taking place in the early Miocene in nearby areas, such as near Rimrock (7 mi [12 km] east of the mapped area), where Tieton volcano was formed (Swanson, 1966, 1978; unpub. fission-track dates by J. A. Vance, written commun., 1981)).

Coarsely porphyritic hornblende dacite (unit Tpd), some of which contains biotite and quartz, forms thick dikelike intrusions cutting the Russell Ranch Formation between Twin Peaks and Miriam Creek. An unmapped tuff interbedded with the basalt of Hogback Mountain has a similar mineralogy, as does a more widespread flow north of the mapped area (Clayton, 1983); these rocks may be erupted equivalents of the intrusive dacite. The unit is overlain unconformably by the basalt of Hogback Mountain (unit QTb) and by younger flows of hornblende andesite. Radiometric ages from lithologically similar rocks north of the mapped area (Clayton, 1983) suggest that the dacite is between about 2.8 m.y. and 3.8 m.y. old.

Thick sequences (up to 2,100 ft [650 m]) of upper Pliocene high-silica rhyolitic tuff, flows, and breccias (unit Tpr)--the Devils Horns rhyolites of Clayton (1983)--rest unconformably on the Russell Ranch Formation beneath the Devils Horns and on Bear Creek Mountain. Zircon fission-track ages for the rhyolite are about 3.2 m.y. (Clayton, 1983). The estimated volume of rhyolitic rocks possibly exceeds 4 mi^3 (20 km^3). Strongly flow-banded rhyolite and coarse autobreccia at the base of the section below the eastern ridge of Tieton Peak are probably part of one or more lava domes in the vent area. Welded tuff and accretionary lapilli tuff underlying Bear Creek Mountain are evidence of explosive eruptions. Several thick tuff units contain abundant blocks and lapilli derived from the Russell Ranch Formation, indicating extensive disruption of basement rock consistent with explosive activity. Explosive volcanism and voluminous rhyolite are features commonly associated with calderas. However, we have found no conclusive evidence for a caldera in the mapped area.

The Devils Washbasin basalt of Clayton (1983) (unit Tpb) occurs as agglomerate, agglutinate, flows, dikes, and tuff that overlie the Devils Horns rhyolites of Clayton (1983) and are intercalated with the lower flows of pyroxene andesite in unit QTa. The olivine basalt was erupted from a vent centered at Devils Washbasin, a small tarn just north of the pinnacles of the Devils Horns, which themselves are composed of bedded pyroclastic rocks and related basalt flows. Xenoliths of mafic and ultramafic plutonic rocks are common. Stratigraphic relations, radiometric ages, and magnetic polarities taken together suggest an age of about 3 m.y. for the basalt.

Many of the high ridges of the mapped area are capped by orogenic, high-K_2O pyroxene andesites (Clayton, 1983) of late Pliocene and Pleistocene age (unit QTa). A few flows of hornblende andesite are interbedded in the dominantly pyroxene andesite sequence. In the core of the Goat Rocks, between Tieton, Gilbert, and Johnson Peaks, the pyroxene andesite flows are laterally discontinuous, intercalated with volcanic breccias and lahars, and locally highly altered. They commonly have primary dips of 10-20 degrees. Away from the core, thick sequences of shallow-dipping valley-filling flows are preserved on modern ridges as good examples of inverted topography. These rocks are interpreted as remnants of a major composite volcano (the Goat Rocks volcano of Ellingson [1969]) that underwent deep erosion during periods of volcanic quiescence; episodic eruptions filled valleys with thick lava flows and laharic deposits. Several likely vent areas of different age may be located on the basis of abundance and orientation of dikes, degree of alteration, and the attitudes of flows and pyroclastic deposits. The youngest vent (late Matuyama and early Brunhes age) is marked by a dike-plug complex about 1.5 mi (1 km) west-northwest of Gilbert Peak. A radial dike swarm centered on Upper Lake Creek basin cuts the youngest flows on Johnson Peak and is probably of either Brunhes or Gauss age. North-northwest-trending pyroxene andesite dikes near Chimney Rock and east-trending dikes northeast of Tieton Peak may be part of the radial swarm. West of Johnson Peak, a threefold subdivision of the pyroxene andesite on the basis of magnetic polarity (normal-reversed-normal) can be made; the youngest normal unit is of either Brunhes or Gauss age. Hydrothermal alteration of the pyroxene andesite is most intense in an area between Cispus Pass and Tieton Peak; this alteration affects all rocks older than the those of Brunhes age and may be associated with intrusion of a pluton near Cispus Pass, possibly about 1 m. y. old on the basis of a single fission-track age (Clayton, 1983). Local alteration of the pyroxene andesite in Goat Lake cirque and near Heart Lake is also notable.

Eruption of more than 200 olivine-bearing basalt and basaltic-andesite lava flows (unit QTb) during the late Pliocene and early Pleistocene built a 3 mi (5 km) wide and 2,300 ft (700 m) high shield volcano centered at Hogback Mountain. Lava flows from this volcano and the Goat Rocks composite volcano are intercalated in some north-draining paleovalleys. The thin (0.5-5 m thick), fluid basalt flows buried several hornblende andesite lava domes erupted at the margins of the shield and poured as far as 18 mi (30 km) down valleys. A magnetic reversal (reversed to normal) in the upper part of the shield is inferred to mark the base of the Olduvai event (Clayton, 1983).

Sparsely porphyritic hornblende andesite flows (unit Qah) younger than the domes on Hogback Mountain and the pyroxene andesite of Goat Rocks volcano advanced down ancestral valleys of many present streams. The flows are fresh, have normal magnetic polarity, and are overlain by several feet or more of glacial till (not mapped). Most of the flows are probably of late Pleistocene age. Vent areas occur on Round Mountain, on the ridge north of Coyote Lake (source of the andesite of Clear Fork Cowlitz River), and in the Old Snowy Mountain-Ives Peak complex (source of extensive flows along the Cispus River and Upper Lake Creek).

Olivine basalt (unit Qob) was erupted during the late Pleistocene from Lakeview Mountain shield volcano and several vents west of Coleman Weedpatch. The ridge southwest of Walupt Lake is a remnant of an eroded subglacial volcano (Hammond, 1980), which shows no evidence of younger glaciation and hence may be as young as about 14,000 yrs. Hyaloclastic debris of olivine basalt capping the ridge between Lava and Little Lava Creeks in the north part of the wilderness may be the product of a subglacial eruption, probably predating the valley-filling hornblende andesite of Clear Fork Cowlitz River.

Several thin, unmapped deposits of tephra produced by Quaternary eruptions of Mount Rainier and Mount St. Helens occur in the area. The most recent tephra, from the May 18, 1980, eruption of Mount St. Helens, forms a layer that blankets the entire area and increases systematically in thickness from about 1.5 cm at the north boundary to about 4 cm near Walupt Lake (Waitt and Dzurisin, 1981).

Intrusive bodies are common in the mapped area. The larger plutons include a microdiorite in the Beargrass Butte area that intrudes the Stevens Ridge Formation and a microdiorite-porphyritic andesite cutting the Ohanapecosh Formation between Jordan and Goat Creeks. The base of both of these intrusions is roughly concordant with bedding, but each body as a whole is cross-cutting. Numerous smaller dikes, sills, and stocks, generally of pyroxene andesite and microdiorite, occur throughout the area. Most of the larger intrusions, and many of the smaller, pre-Pliocene bodies, show some degree of propylitic or quartz-sericite-pyrite alteration. Pliocene and younger dikes and plugs are generally fresh except for devitrification, but areas of hydrothermal activity are marked by quartz veins and propylitic, phyllitic, and pyritic alteration.

Ellingson (1968) recognized a body of quartz monzonite just north of Cispus Pass and named it the Cispus Pass pluton. Our mapping suggests that much of what he included in the pluton may instead be altered pyroxene andesite of the Ohanapecosh Formation. Further work is necessary to define adequately the extent of the pluton and its alteration halo. A relatively fresh diorite(?) forms prominent cliffs south and west of Cispus Pass and may be related to the Cispus Pass pluton.

Structure

The Russell Ranch, Ohanapecosh, and Stevens Ridge Formations are tectonically deformed, but clear evidence of such deformation in Neogene rocks is missing. The Russell Ranch was pervasively sheared, locally boudinaged, and cut by major north-trending faults before deposition of the Paleogene rocks. The Ohanapecosh is folded along a north-northwest trend and dips away from the uplifted Russell Ranch Formation at angles of 30-50 degrees. The troughline of a broad, open syncline in the Ohanapecosh crosses the upper reaches of Middle Fork Johnson Creek and may extend farther north and south beneath Pliocene and younger rocks. The crestline of a major open anticline occurs just west of the mapped area in the upper Johnson Creek drainage. Minor shallow folds warp the formation near Chimney Rock and in the headwaters of Upper Lake Creek. The Stevens Ridge formation was folded together with the Ohanapecosh; most dips are gentler than those in the Ohanapecosh, and attitudes in nearby outcrops of the two formations just southeast of Beargrass Butte suggest an angular unconformity. Localized deformation of Paleogene rocks near intrusions is common, and primary dips of 10 degrees or more in vent areas such as on Angry Mountain complicate the tectonic pattern.

Significant faults were looked for but not found, contrary to our preconceptions that major northwest-trending faults would cross the area. The contact between the Ohanapecosh and Russell Ranch is very poorly exposed in the valley of the Clear Fork Cowlitz River, owing to extensive landsliding, and conceivably could be the Cortright fault of Hammond (1980; called the Clear Fork fault zone by Ellingson [1972]). Several small faults, with vertical displacements of less than a few yards, were mapped in the Ohanapecosh. These fall into two sets, one with a northeast strike, the other with a northwest strike. Subhorizontal slickensides were observed on most of these faults, but the sense of motion (right or left lateral) is indeterminate.

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DESCRIPTION OF MAP UNITS

Qls LANDSLIDE DEPOSIT (PLEISTOCENE)--Mapped only where contact relations of bedrock units are obscured. Other surficial deposits, such as alluvium and glacial drift, not mapped

Qob OLIVINE BASALT (PLEISTOCENE)--Flows and tephra of gray, commonly diktytaxitic olivine and olivine-bearing basalt. Plagioclase phenocrysts present in most flows. Includes hyaloclastic deposits on ridge between Lava and Little Lava Creeks and on hill southwest of Walupt Lake

Qah HORNBLENDE ANDESITE (PLEISTOCENE)--Light gray, commonly oxidized flows and minor tephra of hornblende and hornblende-bearing andesite. Includes pyroxene andesite near Ives Peak and along Klickton Divide. Generally contains sparse plagioclase phenocrysts

Qai ANDESITIC INTRUSIONS (PLEISTOCENE)--Plugs and dikes of hornblende and pyroxene andesite. Feeders for unit Qah and younger pyroxene andesite flows in unit QTa

QTb BASALT OF HOGBACK MOUNTAIN (LATE PLIOCENE AND EARLY PLEISTOCENE)--Olivine-bearing basalt and basaltic andesite flows, generally thin, forming a shield centered on Hogback Mountain. Radiometric ages range from about 3.1 m. y. near the base of the shield to 1.5 m. y. near the top of the shield. Interbedded with pyroxene andesite of unit QTa

QTa PYROXENE ANDESITE (PLEISTOCENE AND PLIOCENE)--Mostly flows and minor tephra of porphyritic andesite and basaltic andesite. Plagioclase, hypersthene, and clinopyroxene generally present as phenocrysts. Hornblende occurs in some rocks. Unit includes Tieton Andesite, which has K-Ar age of about 1 m.y. At least three magnetostratigraphic units have been recognized, the youngest being of normal polarity and probably of Brunhes age. Generally fresh, but many flows, particularly the older ones, show evidence of hydrothermal alteration, which is most intense in Lily Basin and the headwaters of Middle Fork Johnson, Jordan, Goat, and Upper Lake Creeks.

QTai ANDESITIC AND BASALTIC ANDESITIC INTRUSIONS (PLEISTOCENE AND PLIOCENE)--Plugs and dikes of pyroxene andesite, basaltic andesite, and hornblende andesite, at least in part related to unit QTa. Includes hornblende andesite domes 2 mi (3 km) south-southwest of Hogback Mountain. Dikes of pyroxene andesite and basaltic andesite in central part of area show radial pattern centered on Upper Lake Creek

Tpb DEVILS WASHBASIN BASALT OF CLAYTON (1983) (PLIOCENE)--Thin flows, bedded pyroclastic rocks, and narrow dikes of olivine basalt erupted from a vent near Devils Washbasin and making up the spires of Devils Horns. Interbedded with lower pyroxene andesite flows of unit QTa and overlies Devils Horns rhyolites of Clayton (1983). About 3 m. y. old

Tpr DEVILS HORNS RHYOLITES OF CLAYTON (1983) (PLIOCENE)--Thick deposits of domes, ash-flow tuff, air-fall tuff, and breccia of high-silica rhyolite beneath Devils Horns, on the flank of Bear Creek Mountain, and in the drainage basin of the South Fork Tieton River. Overlain by the Devils Washbasin basalt of Clayton (1983). Radiometric age about 3.2 m. y.

Tpd HORNBLENDE DACITE INTRUSIONS (PLIOCENE)--Light-colored, coarsely porphyritic, fine-grained dacite. Phenocrysts are dominantly plagioclase and hornblende; some rocks also contain phenocrysts of biotite and quartz. Occurs as dikelike bodies between Miriam Creek and Twin Peaks. Age probably between about 2.8 and 3.8 m.y.

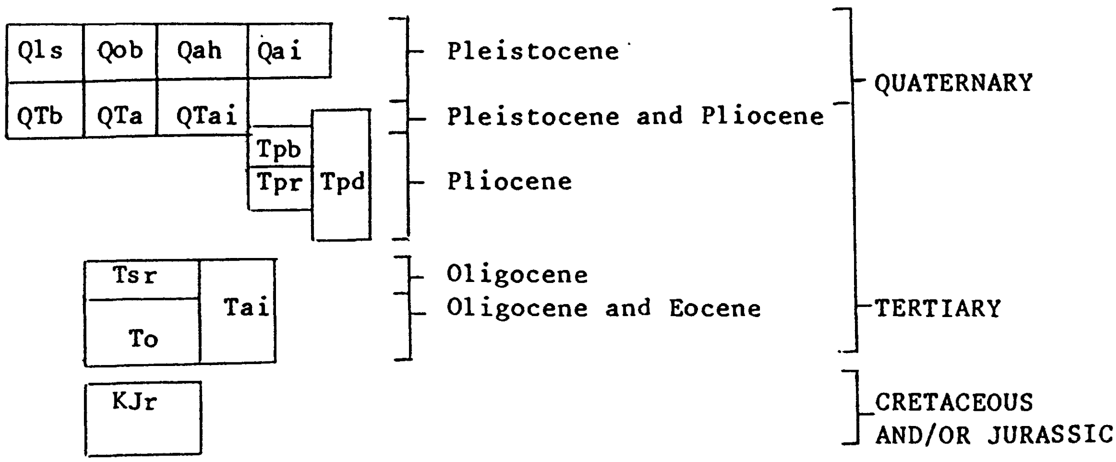
Tsr STEVENS RIDGE FORMATION (OLIGOCENE)--Light colored, silicic ash-flow tuff and associated bedded tuff and rhyolite flows. Quartz phenocrysts common. Secondary minerals, especially clay, calcite, quartz, and zeolites abundant

To OHANAPECOSH FORMATION (OLIGOCENE AND EOCENE)--Chiefly altered basaltic and andesitic lava flows and bedded volcaniclastic rocks. Also includes silicic flows and tuffs, as well as small intrusive bodies of mafic to silicic compositions. Unit consists dominantly of lithic tuffs, lapilli tuffs, and breccias in north half of area and of andesitic lava flows in south half of area. Zeolites, quartz, calcite, and clay minerals abundant; rocks commonly have a green or violet cast. Flows are generally less strongly altered than volcaniclastic rocks and show so little alteration on Nannie Peak and south of Walupt Lake as to suggest a younger age than for most of the formation. Basalt flows near base of formation along Clear Fork Cowlitz River and in McCall Basin area may be Eocene and may be separated from overlying Ohanapecosh by an angular unconformity

Tai INTRUSIVE ROCKS OF MAFIC AND INTERMEDIATE COMPOSITIONS (TERTIARY)--Dikes, sills, plugs, and shallow-seated plutons, dominantly of porphyritic pyroxene andesite but including diorite and quartz monzonite. Age range probably great, including feeders for flows and tuffs in the Ohanapecosh Formation as well as upper Tertiary bodies. Generally altered, with clays and calcite especially common

KJr RUSSELL RANCH FORMATION (CRETACEOUS AND/OR JURASSIC)--Graywacke, argillite, and less abundant basaltic flows, most of which are pillowed. Sheared in most places. Most flows metamorphosed to greenstone

CORRELATION OF MAP UNITS



EXPLANATION

CONTACT--Approximately located

HIGH-ANGLE FAULT--Bar and ball on downthrown side

STRIKE-SLIP FAULT--Sense of displacement indeterminate; dashed where approximately located

ANTICLINE--Showing trace of crestline and direction of plunge; dotted where concealed

SYNCLINE--Showing trace of troughline and direction of plunge; dotted where concealed

STRIKE AND DIP OF BEDS

24 Inclined

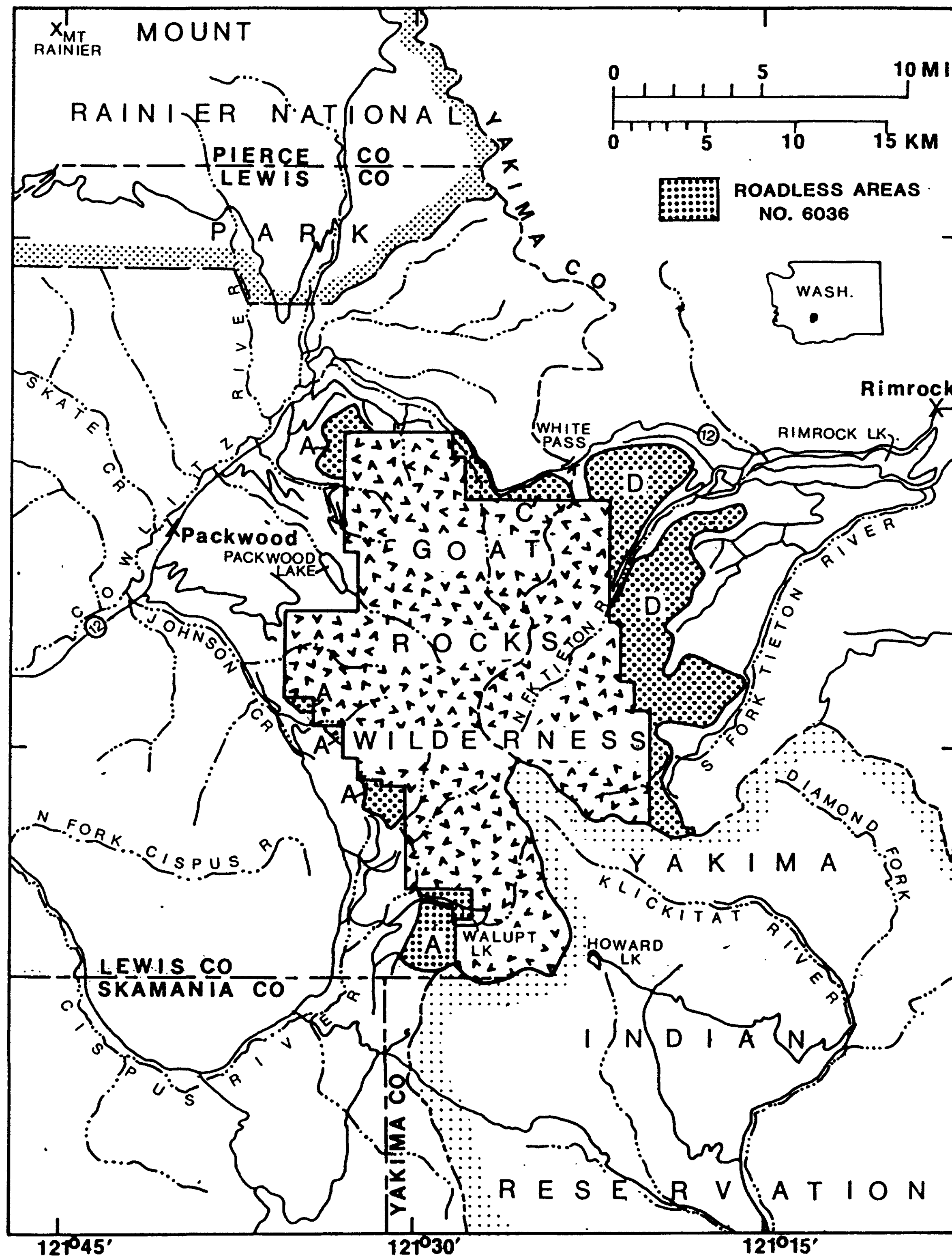
Horizontal

7 APPARENT DIP OF NEOGENE LAVA FLOWS

Tai

DIKE WITH MAP SYMBOL OF UNIT FED BY OR RELATED TO DIKE

AREAS OF HYDROTHERMALLY ALTERED ROCKS



MT RAINIER
MOUNT RAINIER NATIONAL PARK
PIERCE CO
LEWIS CO
YAKIMA CO
0 5 10 MI
0 5 10 15 KM
ROADLESS AREAS NO. 6036
46°45'
WASH.
Rimrock
RIMROCK LK.
WHITE PASS
12
COWLITZ RIVER
SKATE CR
Packwood
PACKWOOD LAKE
JOHNSON CR
GOAT ROCKS WILDERNESS
N FK TIETON R
TIETON RIVER
S FORK TIETON RIVER
A
C
D
46°30'
DIAMOND FORK
YAKIMA
KLICKITAT RIVER
N FORK CISPUS R
WALUPT LK
HOWARD LK
LEWIS CO
SKAMANIA CO
CISPUS RIVER
YAKIMA CO
INDIAN RESERVATION
121°45'
121°30'
121°15'