GEOLOGIC MAP OF A PART OF THE CASCADE RANGE BETWEEN LATITUDES 43°–44°, CENTRAL OREGON

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INTRODUCTION

The Cascade Mountain system extends from northern California to British Columbia. In Oregon, the Cascade Range is a Cenozoic volcanic province divided by physiography into the Western Cascades and High Cascades (Callaghan and Buddington, 1938); parts of each are included on this map. The Western Cascades subprovince is a terrane of moderately dissected Oligocene to lower Pliocene tuff, tuffaceous sedimentary rocks, lava, and intrusions; whereas the High Cascades is built mainly of Pliocene to Holocene lava and includes some of the young, majestic volcanoes of the Pacific Northwest.

VOLCANIC AND SEDIMENTARY ROCKS EXPOSED IN THE WESTERN CASCADES

LITTLE BUTTE VOLCANICS

The oldest rocks in the map area form a diverse sequence of air-fall and ash-flow tuff, tuffaceous sandstone and siltstone, debris-flow deposits, lava flows and domes, and a few shallow intrusions. These rocks are part of a north-trending belt of volcanic and volcaniclastic rocks exposed in the western part of the Cascade Range throughout Oregon. They were assigned to the Little Butte Volcanics (previously called the Little Butte Volcanic Series by Peck and others, 1964). Regionally the Little Butte records a history of ancestral Cascade volcanism and sedimentation that lasted from about 35 to 17 Ma. The oldest rocks at the western margin of the belt interfinger with marine sandstone, and the eastern margin is buried beneath younger rocks of the Cascade Range.

The name "Little Butte" has fallen into disfavor because it is poorly defined and obscures the diversity of rocks deposited during an interval of 18 million years. However, I contribute few new details to previous mapping of the sequence, so the name "Little Butte" is retained to avoid confusion. The broadly defined Little Butte Volcanics served a purpose 25 years ago, but modern applications of volcanology, sedimentology, and isotopic dating will ultimately lead to a new understanding of these rocks and their history.

In the map area, the Little Butte Volcanics consists of andesitic to rhyodacitic tuff, lapilli tuff, and tuffaceous strata (80 percent); basaltic to andesitic lava flows, domes, and intrusions (about 20 percent); and dacitic to rhyodacitic lava flows and domes (less than 1 percent). Peck and others (1964) estimated a total thickness ranging from 1.8 to 4.5 km regionally; the unit is at least 1 km thick in the map area. Tuffaceous rocks in the Little Butte Volcanics are pervasively altered to celadonite, montmorillonite, and zeolites in most exposures, although fresh or only intermittently altered rocks crop out in the uppermost 250 m of the group. Most of the alteration results from very low grade burial metamorphism. Propylitic alteration is present locally.

Basalt and basaltic andesite in the Little Butte Volcanics are slightly porphyritic, with small phenocrysts (1-2 mm) of olivine, plagioclase, and locally clinopyroxene. Andesite is slightly to moderately porphyritic with plagioclase as ubiquitous phenocrysts, orthopyroxene typically more abundant than clinopyroxene, amphibole appearing only as small opacitized relicts, and olivine (where present) forming cores suurounded by reaction products. Dacite and rhyodacite lava flows and virtually all the primary volcaniclastic rocks contain clinopyroxene and orthopyroxene, commonly small amounts of opacitized amphibole, and less commonly, embayed blebs of quartz. Neither sanidine nor biotite occurs as phenocrysts in Little Butte rocks from this part of the Cascade Range.

Age

The Little Butte Volcanics is chiefly lower Miocene in the map area, probably ranging in age from 22 to 17 Ma, on the basis of K-Ar ages from its uppermost 300 m (Nos. 43 and 45, fig. 1, table 1) and ages of about 25 to 22 Ma from pyroclastic flows farther north and west that project beneath the gently east-dipping Little Butte strata in the map area (Walker and Duncan, 1989; N.S. MacLeod and D.R. Sherrod, in Sherrod and Smith, 1989). There may be some unrecognized structural complications north of Oakridge, however, and upper Oligocene rocks presumably are exposed locally there.

BASALT AND ANDESITE OF THE WESTERN CASCADES

Accumulations of lava flows, breccia, and minor tuff and lapilli tuff 600 to 1,000 m thick overlie the Little Butte Volcanics throughout the map area. These rocks are mostly basalt, basaltic andesite, and andesite, although dacite and rhyodacite are present locally. They are assigned here to the informally designated basalt and andesite of the Western Cascades. The base of the sequence is about 17 Ma and the top is probably not younger than 8.5 Ma.

Rocks in any one area are either predominantly basaltic (basalt and basaltic andesite, assigned to unit **Twb**) or andesitic (andesite with subordinate basaltic andesite,

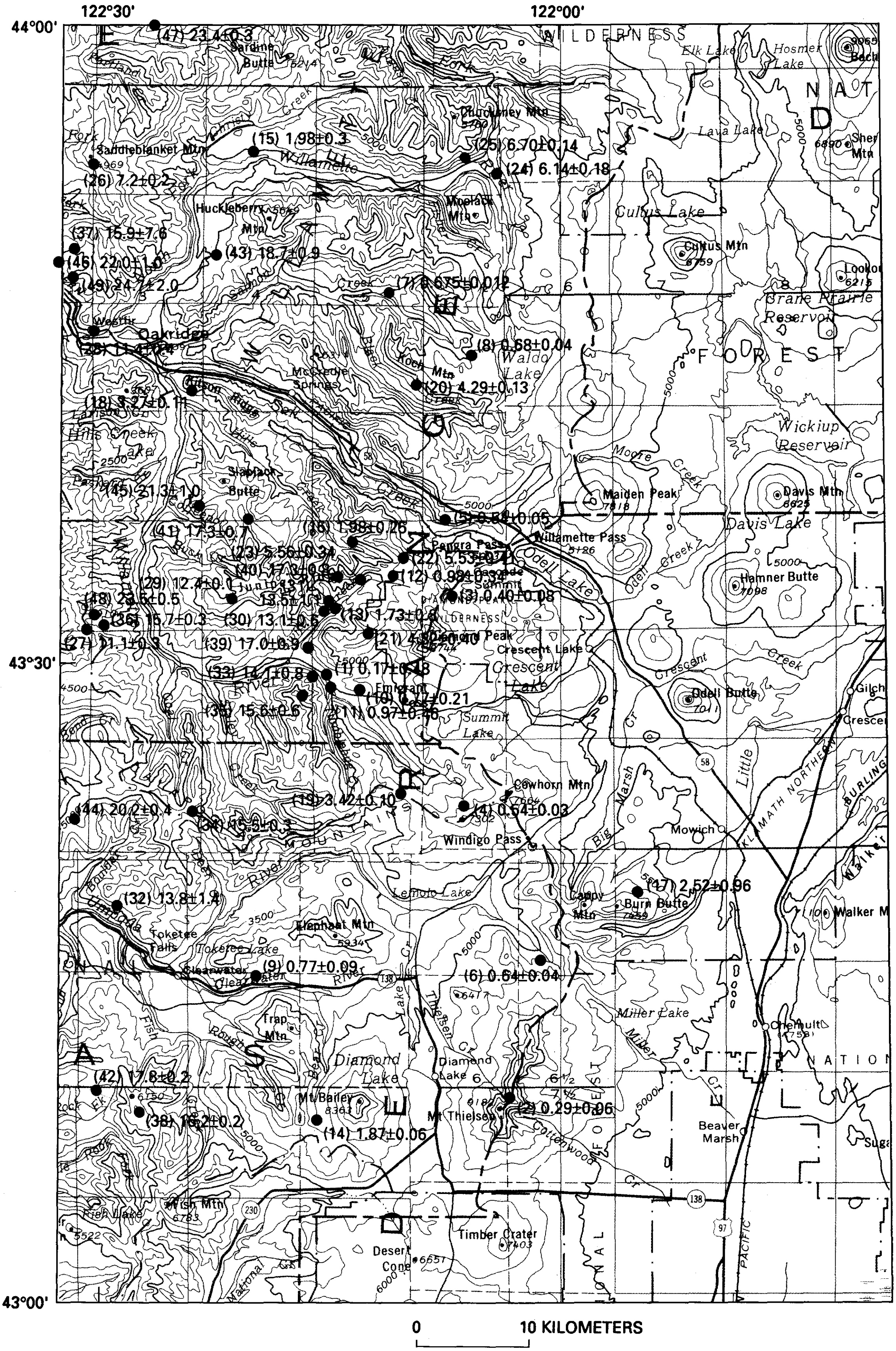

Figure 1. Sample localities, map numbers (in parentheses; as in table 1), and K-Ar ages (in Ma) for rocks in and near the map area

dacite, and rhyodacite, assigned to unit **Twa**). A few large dacite domes are sufficiently exposed to map separately (**Twd**), as are distinct lenses of tuffaceous volcaniclastic material (**Twt**). The rocks are variably altered near the base of the sequence but fresh in the upper part, owing to their shallower depth of burial.

The basalt and andesite of the Western Cascades is concordant above the Little Butte Volcanics. The contact probably ranges from conformable to disconformable, as indicated by the few exposures and available isotopic ages. It dips gently 1° to 5° eastward and commonly coincides with a marked physiographic break-in-slope resulting from differential erosion between easily eroded tuffaceous rocks in the Little Butte and resistant lava that dominates the overlying basalt and andesite of the Western Cascades.

Basalt and basaltic andesite (**Twb**) chiefly form a monotonous stack of slightly porphyritic lava flows and breccia in the middle and southern parts of the map area. Phenocrysts are small (less than 2 mm) and comprise olivine, plagioclase, and locally clinopyroxene (table 2). Andesite and related rocks (**Twa**), which are exposed mostly in the northern part of the map area, are slightly to moderately porphyritic, with small phenocrysts of plagioclase, orthopyroxene, and clinopyroxene 1-3 mm in size. Opacitized amphibole and much-altered olivine are found in some rocks; quartz is rare.

Tuffaceous volcaniclastic rocks (**Twt**) are shown separately where sufficiently extensive. Most common are coarse, poorly sorted debris-flow deposits, coarse- to fine-grained sandstone, and minor breccia. A second main type is primary pyroclastic rocks, including beds of air-fall pumice and partially welded pyroclastic flows. Elsewhere, however, the clastic rocks are undivided from the andesite unit (**Twa**), which locally contains 30 to 50 percent tuff breccia, lapilli tuff, and tuff. The tuff breccia and tuff in unit **Twa** are commonly found near silicic lava flows and domes and probably formed as hot dry avalanche deposits.

Age

Potassium-argon ages from the basalt and andesite of the Western Cascades in the map area range from 17.3 to 12.4 Ma (table 1). Internal disconformities probably separate some younger strata in the northern part of the map area. Similar rocks with K-Ar ages as young as about 8.5 Ma were mapped by Priest and others (1988) north of lat 44° N.

RIDGE-CAPPING BASALT

Basalt and basaltic andesite disconformably overlie the basalt and andesite of the Western Cascades in about two-thirds of the map area. This younger sequence of lava flows and breccia forms an extensive continuous wedge ranging from 350 to 900 m thick in the northern half of the map area but is preserved only as isolated ridge-capping strata 100-200 m thick in the southern half. The unit, which yields late Miocene and early Pliocene K-Ar ages, is informally called ridge-capping basalt (**Trb**) to describe its common topographic setting at the tops of ridges in the Western Cascades physiographic subprovince adjacent to the High Cascades.

Ridge-capping basalt is slightly porphyritic, with small phenocrysts (less than 2 mm) of olivine, plagioclase, and locally clinopyroxene (table 2). It is generally the youngest bedrock unit in the Western Cascades, but is onlapped by Pliocene and Pleistocene lava flows along the boundary between Western and High Cascades. Erosional relief in the upper contact of the ridge-capping basalt has increased greatly since Pliocene time. Upper Pliocene(?) basalt and andesite (in units **QTb** and **QTa**) are conformable to disconformable above ridge-capping basalt; whereas upper Pleistocene lava flows drape down the walls of canyons that were incised 300-850 m into ridge-capping basalt and older rocks in the Western Cascades.

Age

Ridge-capping basalt in the map area is at least as old as 7.2 Ma and as young as 3.23 Ma, on the basis of K-Ar geochronology. An age of 7.2±0.2 Ma was obtained from a sample about 0.5 km west of the map area near Saddleblanket Mountain (No. 26, table 1); the easternmost flows from Saddleblanket Mountain appear in the northwest corner of the map. Ages of 6.82±0.21 and 6.60±0.20 Ma (No. 25, table 1) are from a sample at the top of the unit in the northern one-third of the map area, so the base of the unit must be slightly older than about 7 Ma there. Though inadequately dated, the overall pattern of isotopic ages indicates that the unit is progressively younger from north to south in the map area. The age of the sequence is tentatively bracketed between approximately 8 and 3.2 Ma.

UPPERMOST PLIOCENE AND LOWER PLEISTOCENE INTRACANYON LAVA FLOWS

BASALT OF HIGH PRAIRIE

The basalt of High Prairie was first mapped by Callaghan and Buddington (1938) and informally named by Brown and others (1980). It consists of intracanyon lava flows that cap a bench for more than 30 km along the North Fork of the Willamette River. The basalt can be traced from the North Fork upstream along a tributary, Christy Creek. The vent location is unknown but probably lies buried beneath an alluvial fan of glacial outwash deposits (**Qgo**) at the confluence of Christy and Lowell Creeks.

The sequence comprises separate flows 6-20 m thick of vesicular, diktytaxitic olivine basalt. Together, these flows are in excess of 100 m thick. Olivine (5-10 percent) forms small phenocrysts less than 2 mm across. A sample of basalt from Christy Flats gave a K-Ar age of 1.98±0.13 Ma (table 1).

BASALT OF TOKETEE

The basalt of Toketee is an intracanyon sequence of lava flows and breccia that form cliffs along canyon walls of the North Umpqua River and its tributary, Clearwater River. The sequence is informally named for exposures near Toketee Reservoir (Toketee Falls is a cascade over a much younger intracanyon lava flow). The lava is vesicular, diktytaxitic olivine basalt that is petrographically and chemically similar to the basalt of High Prairie (**QTbh**). Platy plagioclase phenocrysts are as long as 5 mm in some flows.

The basalt of Toketee extends from Toketee Reservoir for 15 km up the Clearwater River, where it is buried beneath Holocene ash-flow deposits (**Qaf**). The vent may be in the area of these upstream exposures, which is at the boundary between the High Cascades and Western Cascades subprovinces. The basalt of Toketee has K-Ar ages of 0.78±0.12 and 0.76±0.15 Ma (table 1), and is reversely polarized (first noted by Barnes, 1978).

VOLCANIC ROCKS IN THE HIGH CASCADES

Volcanic rocks exposed in the High Cascades subprovince of the map area consist mainly of basalt and basaltic andesite lava flows that were erupted from numerous small- to medium-sized (4-20 km^3) shield volcanoes and myriad cinder cones. Although no youthful andesitic to dacitic stratovolcanoes are found in the map area, a deeply eroded volcanic center in the area of Tolo and Mule Mountains is probably a latest Pliocene or early Pleistocene stratocone-dome complex.

The oldest rocks exposed in the High Cascades form interlayered lava flows of basalt (**QTb**) and andesite (**QTa**). These rocks, which are exposed mainly in the canyon walls near the subprovince boundary, are undated by isotopic methods. Their Pliocene(?) and early Pleistocene age is inferred from stratigraphic position: they underlie reversely polarized, lower Pleistocene basalt and basaltic andesite (**Qob**, **Qoba**), and they overlie the upper Miocene and Pliocene ridge-capping basalt (**Trb**).

Andesite of uncertain age at Tolo Mountain is also assigned to unit **QTa**. It forms a thick, poorly exposed sequence of tuff breccia and lava, presumably a deeply eroded stratovolcano. Dacite domes at nearby Mule Mountain (**QTd**) as well as rhyolite domes exposed 5 km to the east at Burn and Clover Buttes (east of map) are interpreted as part of this volcanic complex. Dacite near Mule Mountain has a K-Ar age of 0.64±0.04 Ma (table 1), whereas the rhyolite at Burn Butte has a K-Ar plagioclase age of 2.52±0.96 Ma (table 1). Although the ages perhaps indicate that intermediate and silicic volcanism in the Tolo Mountain-Burn Butte area spanned nearly 2 million years, it seems more likely that one (or both) of the K-Ar ages is incorrect. This problem remains unresolved without further isotopic dating.

Elsewhere in the subprovince, the most widely exposed rocks are lava flows and breccia of fresh olivine basalt, basaltic andesite, and andesite. These rocks have been assigned to relatively older and younger Pleistocene units, using criteria of (1) K-Ar dating, (2) relative dissection of vent deposits (geomorphology), (3) thermal remanent magnetization, (4) the relation of volcanic rocks to glacial deposits, and (5) the degree of topographic inversion shown by intracanyon lava flows.

Samples for K-Ar ages (table 1) were collected from shield volcanoes and lava flows mapped as older basaltic andesite (**Qoba**). Geomorphically, the youngest of the shield volcanoes in unit **Qoba** is Mount Thielsen, a normally polarized basaltic andesite shield active about 0.29 Ma. Reversely polarized basaltic andesite (older than 0.73 Ma) forms a shield near Mount Ray and underlies normally polarized lava at several other locales. Thus, older basaltic andesite (unit **Qoba**) and its basalt and andesite subunits (**Qob** and **Qoa**) include normally polarized, dated rocks erupted between 0.73 Ma and about 0.29 Ma, reversely polarized rocks that are older than 0.73 Ma, and rocks of uncertain age. Presumably, none of the latter rocks is as old as Pliocene.

Two lines of evidence help to rule out Pliocene or older rocks in unit **Qoba**. First, the erosional dissection of the volcanoes associated with undated lava flows in units **Qob**, **Qoba**, or **Qoa** is not much greater than the dissection of dated Pleistocene volcanoes younger than 0.73 Ma. By inference, the older volcanoes are early Pleistocene but not older. Second, no intracanyon lava that can be traced back to the High Cascades subprovince is perched nearly as high as, and therefore is older than, the basalt of High Prairie (**QTbh**), which is about 1.98 Ma (see table 1). This line of evidence assumes that intracanyon flows are an adequate sampling of Quaternary eruptions in the High Cascades subprovince. I conclude that all the magnetically reversed and normally polarized intracanyon lava flows erupted from vents in the High Cascades of the map area are younger than 2 Ma and are probably younger than 1 Ma.

Several other volcanic centers are distinctly less eroded and therefore much younger than volcanoes in unit **Qoba**. These younger lava flows and vent rocks were mapped separately as younger basaltic andesite (**Qyba**) and its compositional subunits (**Qyb** and **Qya**). They are provisionally assigned an age younger than 0.25 Ma because they are substantially less eroded than Mount Thielsen's shield.

Basalt in unit **Qyb** includes possible Holocene lava flows erupted from very youthful cinder cones at Cinnamon Butte and Thirsty Point. The lava and cinders are overlain by Holocene silicic pumice and ash (**Qpf**, **Qaf**). Cinnamon Butte and Thirsty Point have well-preserved summit craters, and the lava flows appear unglaciated, suggesting that they are younger than 11 ka (end of last glaciation). The mantling ash deposits, however, preclude searching for glacial erratics on the flows and obscure the age of lava relative to adjacent till.

Basalt and basaltic andesite in the High Cascades are similar to compositionally equivalent, older rocks in the Western Cascades (Sherrod, 1986). High Cascades rocks are slightly porphyritic with small phenocrysts 1 to 2 mm in size (table 2). Olivine (1-3 percent) and plagioclase (2-8 percent) are nearly ubiquitous phenocrysts in basalt and basaltic andesite; whereas clinopyroxene (1-4 percent) is a phenocryst in less than 10 percent of the flows sampled. Microphenocrysts of orthopyroxene (0.5-1.0 mm) are present in small amounts (less than 1 percent) in basaltic andesite with more than 55 percent SiO_2. Andesite is slightly porphyritic. Phenocrysts are less than 2 mm in size and consist of plagioclase, orthopyroxene, clinopyroxene, and much-altered olivine. Dacite is mineralogically similar to andesite but lacks olivine and commonly contains amphibole phenocrysts or rims of amphibole around clinopyroxene phenocrysts.

PUMICE-FALL AND ASH-FLOW DEPOSITS

An unconsolidated silicic air-fall tephra blankets the southeast corner of the map area. It was erupted about 6,845 ^{14}C-yr ago from Mount Mazama (Crater Lake), 3 km south (Williams, 1942; Bacon, 1983), and is so thick along parts of the Cascade crest that it completely conceals most underlying rocks and deposits (see isopachs on map). Widely known as Mazama ash (for example, Powers and Wilcox, 1964, their fig. 1 caption; Williams and Goles, 1968), the unit has never been formally named and is only now being studied in any detail (C.R. Bacon, U.S. Geological Survey, oral commun., 1989).

The air-fall deposits (**Qpf**) consist of very pale gray pumiceous ash and lapilli (95 percent), accidental lithic fragments (less than 5 percent), and crystals (less than 1 percent) of plagioclase, orthopyroxene and clinopyroxene, and hornblende. Similar crystals are found within the pumice lapilli, the composition of which is about 70-71 percent SiO_2 (Bacon, 1983).

Overlying ash-flow deposits (**Qaf**), also from Mount Mazama, are the youngest volcanic unit in the map area. They consists mainly of unsorted, pale-grayish-white ash containing 10 to 30 percent pumiceous lapilli and bombs. Most exposures are grayish pink in their uppermost 2-3 m, owing to oxidation that accompanied post-emplacement degassing. Some deposits apparently formed when slope-mantling ash was remobilized. For example, a 10- to 15-m-thick ash-flow deposit in the cirque floor north of Mount Thielsen ranges from unsorted to moderately sorted, contains blocks of basaltic andesite as large as 40 cm across (derived from talus), and lacks the pinkish oxidized cap.

The ash-flow deposits were mostly topographically controlled as they moved radially away from Mount Mazama. At Diamond Lake the flows ponded in excess of 12 m, as interpreted from water-well cuttings (Purdom, 1963); the approximately 12-m-deep lake is probably floored by ash flows. Ash-flow deposits are strikingly displayed in road cuts along the North Umpqua River Highway (State Route 138) and can be traced discontinuously to the confluence of the North Umpqua River and Apple Creek, which is 15 km west of the map and about 80 km along stream line from Crater Lake. Doubtless, the ash flows generated debris flows in lower parts of the North Umpqua, including the area around Roseburg and Sutherlin, though no deposits are reported.

Some isolated fine pink ash (patterned in unit **Qaf**) was probably deposited from clouds that billowed from the valley-filling flows. These deposits, which contain minor pumiceous lapilli smaller than 1 cm, are commonly found in streams and flattish areas that are separated from the valley-filling deposits by topographic obstructions as high as 275 m.

UPPER PLIOCENE AND QUATERNARY SEDIMENTARY DEPOSITS (EXPOSED IN WESTERN AND HIGH CASCADES)

Much of the Cascade Range is covered by unconsolidated or only slightly indurated sedimentary deposits such as till, outwash, landslide debris, and alluvium. The Description of Map Units adequately explains units such as landslides (**Qls**) or the sand and gravel deposited by active streams (**Qal**). Discussed here are glaciogenic deposits (units **Qgd, Qgo, Qys**) and geologically trivial but interesting pumiceous sand and gravel (**Ql**) deposited in an ancestral Diamond Lake. Diamond Lake perhaps formed when Holocene pyroclastic flows from Mount Mazama blocked a headwater tributary of the North Umpqua River.

DRIFT AND OUTWASH

Stratified and unstratified drift buries much of the middle elevations (1,000-2,000 m, 3,000-6,000 ft) of the High Cascades. In the Western Cascades, areally restricted deposits of till also attest to glaciation at high elevations (Callaghan and Buddington, 1938; Williams, 1942; Peck and others, 1964). The drift was grouped in one map unit (**Qgd**), whereas some sizable areas of moderately sorted sand and gravel that form terrace deposits were interpreted as outwash (**Qgo**). Outwash is well exposed along the North Umpqua River and near Oakridge, which is near the confluence of Salmon, Salt, and Hills Creeks.

The drift is present chiefly as lodgment and ablation till in lateral and ground moraines and locally is as thick as 40 m. Odell and Crescent Lakes, parts of which are shown along the east edge of the map, are dammed by large terminal moraines 3-4 km to the east (Russell, 1905; N.S. MacLeod and D.R. Sherrod, in Sherrod and Smith, 1989). In the Western Cascades, terminal and lateral moraines are greatly modified by erosion. A facies of laminated clay and silt is found locally within massive drift. It is limited in extent and probably developed as lacustrine deposits in subglacial pockets of meltwater.

Surface oxidation has resulted in pale- to moderate-orange coloration in the uppermost 30 cm of most exposures of till and outwash. Weathering rinds on lithic fragments are mostly less than 1 mm. These thicknesses are characteristic of glaciogenic deposits of the Cabot Creek and Jack Creek Formations of Scott (1977) in the High Cascades of north-central Oregon. The Cabot Creek Formation is younger than 40 ka; the Jack Creek was tentatively assigned to either the interval 40-80 ka or 120-200 ka (Scott, 1977). A presumably older till with 60-80 cm of surface oxidation overlies the 0.76-Ma basalt of Toketee (**Qbt**). Its correlation remains ambiguous.

YOUNGER SURFICIAL DEPOSITS

Younger surficial deposits are mainly glaciogenic, forming neoglacial moraines, outwash, rock glaciers (Diamond Peak), and protalus ramparts near the higher summits in the central and southern parts of the map from Diamond Peak south to Mount Thielsen. The absence of pumice-fall deposits (**Qpf**) on most of the younger surficial deposits indicates their age is chiefly less than 7,500 calendar yr B.P. (6,845 ^{14}C-yr B.P.). Talus sheets that mantle some steep canyon walls and north-facing slopes in the northern part of the map are indirectly of glacial origin, because they formed when the retreat of glaciers removed support from oversteepened rock faces (Long and Leverton, 1984). Though largely Holocene in age, some talus sheets assigned to unit **Qys** may be of latest Pleistocene age.

Protalus ramparts are sharp-crested talus cones that stand slightly isolated from modern slopes and are found mostly in the north-facing cirques of the map area. They formed when ice partially filled the cirques so that rockfalls had to skid down the ice and bank up against it. When the ice melted, a resulting hollow separated the talus cone from the modern cirque wall. At Mount Thielsen, a small patch of perennial ice (Nafziger, 1974), sometimes called Oregon's southermost glacier (Anonymous, 1984), persists in the north cirque and is now named Lathrop Glacier on a recently published U.S. Geological Survey 7.5-minute topographic map (Mount Thielsen, 1985, scale 1:24,000). The unbreached talus rampart, however, indicates that the ice is immobile and therefore probably not glacial.

LACUSTRINE DEPOSITS

Well-bedded unconsolidated sand and gravel are exposed in banks and roadcuts surrounding the west, south, and southeast sides of Diamond Lake. The deposits consist predominantly of medium- to coarse-grained crystal-lithic-pumice sand that is generally medium to well sorted, thin to medium bedded, and parallel bedded. Interbedded crystal- and lithic-poor, well-rounded pumiceous sand and gravel form 25 percent of the unit. Some deposits are exposed as high as 8 m above the present-day lake level.

The crystal-rich sand and rounded pumiceous lapilli in the gravel were derived from Holocene pumice-fall and ash-flow deposits (**Qpf, Qaf**) by reworking during prehistoric high-water levels at Diamond Lake. The porous unconsolidated air-fall deposit with its low-density pumice was especially susceptible to erosion. One effect of the lake was to aid in removing most of the air-fall pumice and ash immediately around Diamond Lake. The east side of the lake, which is underlain by till, today has no pumice-fall deposits within 200 m of shore, yet is within the 2-m isopach.

Although a trivial feature of the overall geologic history of the map area, the lacustrine deposits provide evidence for the history of Diamond Lake. I suggest that there was no lake prior to interruption of drainages by ash flows 6,845 ^{14}C-yr ago. In this hypothesis, the outlet of "Diamond Valley" was perhaps 100 m west of the present bedrock spillway, in a now-flattish area about 0.5 km across that is underlain by ash-flow deposits. Ash-flows choked this drainage and impounded a new lake, forcing subsequent overflow to cut a new channel along the upper 4 km of present-day Lake Creek.

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Table 1. *Potassium-argon ages from in or adjacent to map area*

[Samples listed in order of increasing age. For locations see figure 1]

Map number (fig. 1)	Sample number	Geologic map unit	Location		Rock type[1]	Material dated	K_2O weight percent[2]	$^{40}Ar_{rad}$ x 10^{11} (moles/gm)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)[3]	References
			Latitude (W)	Longitude (N)							
1	T-210	Qyba	43°09.6'	122°15.2'	Basaltic andesite	Whole rock	0.98	0.024	1	0.17±0.48	Evans and Brown, 1981; Priest and Vogt, 1983
2	S81-57	Qoba	43°09.5'	122°04.0'	Basaltic andesite	Whole rock	(0.926)			(0.29±0.06)	Sherrod, 1986
							0.918	0.03824	1.7	0.29±0.10	
							0.933	0.03902	1.8	0.29±0.08	
3	S81-45	Qoba	43°33.5'	122°07.4'	Basaltic andesite	Whole rock	(1.216)			(0.40±0.08)	Do.
							1.209	0.05782	1.2	0.33±0.11	
							1.223	0.09154	1.4	0.52±0.26	
								0.08776	1.4	0.50±0.15	
4	S81-103	Qoba	43°23.2'	122°06.7'	Basaltic andesite	Whole rock	(1.235)			(0.54±0.03)	Do.
							1.234	0.09319	12	0.52±0.04	
							1.235	0.09958	6.2	0.56±0.05	
5	S81-02	Qoba	43°36.8'	122°08.0'	Basaltic andesite	Whole rock	(1.774)	0.1372	9.6	0.54±0.05[4]	Do.
							1.770				
							1.778				
						do[5]	(1.72)[5]	0.2109[5]	3.5[5]	0.85±0.10[5]	Do.
							1.716				
							1.725				
6	S82-73	QTd	43°16.0'	122°01.5'	Dacite	Whole rock	(1.846)	0.1695	12	0.64±0.04	Do.
							1.839				
							1.852				
7	QA-17	Qob	43°47.4'	122°11.2'	Basalt	Whole rock	0.80	0.0781	27.6	0.675±0.012	Long and Leverton, 1984
8	S81-19	Qoba	43°44.9'	122°05.8'	Basaltic andesite	Whole rock	(1.306)				Sherrod, 1986
							1.309	0.1282	8.3	0.68±0.04[4]	
							1.303	0.05638	5.1	0.30±0.06	
9	S82-29	Qbt	43°15.2'	122°20.0'	Basalt	Whole rock	(0.316)			(0.77±0.09)	Do.
							0.318	0.03465	3.3	0.76±0.15	
							0.313	0.03529	2.8	0.78±0.12	

Table 1. *Potassium-argon ages from in or adjacent to map area—Continued*
[Samples listed in order of increasing age. For locations see figure 1]

Map number (fig. 1)	Sample number	Geologic map unit	Location: Latitude (W)	Location: Longitude (N)	Rock type[1]	Material dated	K_2O weight percent[2]	$^{40}Ar_{rad}$ x 10^{11} (moles/gm)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)[3]	References
10	T-208	Qob	43°29.2'	122°13.4'[6]	Basalt	Whole rock	0.75	0.083	5	0.77±0.21	Evans and Brown, 1981 Priest and Vogt, 1983
11	T-211	Qob	43°29.3'	122°15.2'[6]	Basalt	Whole rock	0.82	0.115	3	0.97±0.46	Do.
12	P-Notch	Qoba	43°34.7'	122°10.9'[6]	Basaltic andesite	Whole rock	1.040	0.147	4	0.98±0.34	Do.
13	P-319	Twb	43°32.8'	122°15.0'	no data	Whole rock	0.52	0.130	34	1.73±0.8[7]	Evans and Brown, 1981
14	S82-72	QTba	43°08.5'	122°16.0'	Basaltic andesite	Whole rock	(1.599) 1.594 1.604	0.4313	30	1.87±0.06	Sherrod, 1986
15	S81-127	QTbh	43°54.0'	122°20.2'	Basalt	Whole rock	(0.801) 0.807 0.794	0.2285	16	1.98±0.13	Do.
16	P-22	QTb	43°35.8'	122°13.8'[6]	Basaltic andesite	Whole rock	0.86	0.244	11	1.98±0.25	Evans and Brown, 1981 Priest and Vogt, 1983
17	M4-127	not in map area	43°19.2'	121°53.3'	Rhyolite	Plagioclase	0.385	0.1395	4.6	2.52±0.96	McKee and others, 1976
18	S81-23	Trb	43°42.3'	122°25.6'	Basalt	Whole rock	(0.937) 0.938 0.935 (0.926[5] 0.926 0.925	 0.4356 0.4462[5]	 16 9.9[5]	(3.27±0.11) 3.23±0.14 3.35±0.20[5]	Sherrod, 1986
19	S82-47	Trb	43°23.9'	122°10.5'	Basalt	Whole rock	(1.741) 1.730 1.752	0.8567	37	3.42±0.10	Do.
20	S81-18	Trb	43°43.1'	122°09.2'	Basalt	Whole rock	(1.626) 1.618 1.633	1.005	49	4.29±0.13	Do.

Table 1. *Potassium-argon ages from in or adjacent to map area—Continued*
[Samples listed in order of increasing age. For locations see figure 1]

Map number (fig. 1)	Sample number	Geologic map unit	Location		Rock type[1]	Material dated	K_2O weight percent[2]	$^{40}Ar_{rad}$ x 10^{11} (moles/gm)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)[3]	References
			Latitude (W)	Longitude (N)							
21	P-616	Trb	43°31.7'	122°12.6'[8]	Basalt	Whole rock	1.51	0.937	15	4.32±0.40	Priest and Vogt, 1983
22	P-324	Trb	43°35.1'	122°10.5'[6]	Basalt	Whole rock	1.13	0.903	19	5.53±0.41	Evans and Brown, 1981 Priest and Vogt, 1983
23	P-PHL	Trb	43°34.3'	122°13.2'	Basalt	Whole rock	1.08	0.869	24	5.56±0.34	Priest and Vogt, 1983
24	S82-13	Trb	43°53.0'	122°04.2'	Basaltic andesite	Whole rock	(1.779) 1.778 1.779	1.575	33	6.14±0.18	Sherrod, 1986
25	S82-14	Trb	43°54.2'	122°06.1'	Basaltic andesite	Whole rock	(1.431) 1.423 1.438	1.362 1.407	41 55	(6.70±0.14) 6.60±0.20 6.82±0.21	Do.
26	M3-29	Trb	43°53.5'	122°30.4'	Basalt	Whole rock	0.922	0.9616	55.61	7.2±0.2	Verplanck, 1985
27	DMS-153	not in map area	43°31.5'	122°30.9'	"Basalt"	Whole rock	(0.194) 0.194 0.194	0.3101	6.1	11.1±0.3	Sutter, 1978
28	DMS-161	not in map area	43°45.7'	122°30.5'	"Basalt"	Whole rock	(1.645) 1.651 1.639	2.704	14.2	11.4±0.4	Do.
29	M3-26	Twb	43°33.2'	122°21.4'	Basaltic andesite	Whole rock	0.86	1.522	83.88	12.4±0.1	Verplanck, 1985
30	P-626	Twb	43°32.6'	122°16.2'[8]	Basaltic andesite	Whole rock	1.05	1.985	32	13.1±0.6	Priest and Vogt, 1983
31	P-624	Twb	43°32.7'	122°15.6'[8]	Basaltic andesite	Whole rock	1.07	2.095	18	13.5±1.1	Do.
32	M3-33	Tlb	43°18.6'	122°28.7'	Basaltic andesite	Whole rock	0.77	1.538	14.55	13.8±1.4[9]	Verplanck, 1985
33	T-FIZZ	Twb	43°29.4'	122°16.1'[6]	Basaltic andesite	Whole rock	0.96	1.964	26	14.1±0.8	Evans and Brown, 1981 Priest and Vogt, 1983
34	M3-34	Twb	43°23.0'	122°24.0'	Basalt	Whole rock	0.657	1.441 0.872	63.1 19.08	15.5±0.3 [4] 9.2±4.1	Verplanck, 1985

Table 1. *Potassium-argon ages from in or adjacent to map area—Continued*
[Samples listed in order of increasing age. For locations see figure 1]

Map number (fig. 1)	Sample number	Geologic map unit	Location Latitude (W)	Location Longitude (N)	Rock type[1]	Material dated	K_2O weight percent[2]	$^{40}Ar_{rad}$ x 10^{11} (moles/gm)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)[3]	References
35	T-10	Twb	43°28.5'	122°17.0'[6]	Basaltic	Whole rock	1.33	2.984	47	15.6±0.6	Evans and Brown, 1981 Priest and Vogt, 1983
36	DMS-159	not in map area	43°31.9'	122°30.0'	"Andesite"	Whole rock	1.155	2.623	10.7	15.7±0.3	Sutter, 1978
37	BB-NSH	not in map area	43°49.7'	122°31.7'[8]	Rhyodacite	Whole rock	0.290	0.668	3	15.9±7.6	Priest and Vogt, 1983
38	M3-35	Twb	43°09.0'	122°27.4'	Basalt	Whole rock	1.054	2.466	60	16.2±0.2	Verplanck, 1985
39	T-14	Twb	43°30.9'	122°16.6'[6]	Basaltic andesite	Whole rock	0.80	1.957	28	17.0±0.9	Evans and Brown, 1981 Priest and Vogt, 1983
40	P-509	Twa	43°34.1'	122°14.3'	Basaltic andesite	Whole rock	0.81	2.022	38	17.3±0.8	Priest and Vogt, 1983
41	OM-49	Tav	43°36.7'	122°20.2'[8]	"Basalt"	Whole rock	0.909	2.2824	46.9	17.3±0.7	Brown and others, 1980 Priest and Vogt, 1983
42	M3-36	not in map area	43°10.0'	122°30.5'	Dacitic ash-flow tuff	Glass	1.19	2.996	59	17.8±0.2	Verplanck, 1985
43	OM-520	Tlt	43°49.0'	122°22.5'[8]	"Rhyolitic" ash-flow tuff	Plagioclase	0.616	1.6673	33.3	18.7±0.9	Brown and others, 1980 Priest andVogt, 1983
44	M2-23	not in map area	43°22.8'	122°32.0'	Andesite	Whole rock	1.49	4.359	28	20.2±0.4	Verplanck, 1985
45	OM-5	Tld	43°37.3'	122°23.1'[8]	Rhyodacite	Plagioclase	0.410	1.2644	34.4	21.3±1.0	Brown and others, 1980 Priest andVogt, 1983

Table 1. *Potassium-argon ages from in or adjacent to map area—Continued*

[Samples listed in order of increasing age. For locations see figure 1]

Map number (fig. 1)	Sample number	Geologic map unit	Location		Rock type[1]	Material dated	K_2O weight percent[2]	$^{40}Ar_{rad}$ x 10^{11} (moles/gm)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)[3]	References
			Latitude (W)	Longitude (N)							
46	BB-35	not in map area	43°48.7'	122°32.8'[8]	Basaltic andesite	Whole rock	0.650	2.074	35	22.0±1.0	Priest and Vogt, 1983
47	GWW-81-158	not in map area	44°00.4'	122°26.5'	Ash-flow tuff	Plagioclase	0.47	1.595 1.442	82 67	23.4±0.3 [4] 21.2±0.3	Verplanck, 1985
48	M2-24	not in map area	43°32.2'	122°30.6'	Basalt	Whole rock	0.58	1.972	58	23.5±0.5	Do.
49	BB-16	not in map area	43°48.0'	122°31.7'[8]	Basaltic andesite	Whole rock	0.976	3.489	17	24.7±2.0	Priest and Vogt, 1983

[1] Based on silica content. Quotes, name unsubstantiated by chemical analysis.

[2] For multiple determinations, value in parentheses is arithmetic mean used in age calculation.

[3] For multiple extractions, value in parentheses is weighted mean age. K-Ar ages calculated using constants for radioactive decay and abundance of ^{40}K recommended by International Union of Geological Sciences Subcommission on Geochronology (Steiger and Jäger, 1977). These constants are:

$\lambda_\varepsilon = 0.580 \times 10^{-10} yr^{-1}$, $\lambda_\beta = 4.962 \times 10^{-10} yr^{-1}$, and $^{40}K/K_{total} = 1.167 \times 10^{-4}$ mol/mol.

[4] Preferred age.

[5] Same powder as previous entry but sample was treated with hydrofluoric acid.

[6] From Priest and Vogt (1983), who revised preliminary locations listed in Fiebelkorn and others (1983).

[7] Age is geologically meaningless (G.R. Priest, oral commun., 1985).

[8] Latitude and longitude measured by me from geologic map in references. Locations of these samples as reported in Priest and Vogt (1983) or Fiebelkorn and others (1983) are discrepant by as much as 15 minutes of latitude or longitude from actual locations.

[9] Age too young; must be older than 17 Ma.

Table 2. *Petrography of some basalt and basaltic andesite in map area*

[Samples within groups arranged in order of increasing SiO_2. Data summarize 500 or more points counted per thin section. Intergr, Intergranular; Por, porphyritic; Suboph, subophitic; Pilo, pilotaxitic; gm, groundmass; tr, trace; pheno., phenocryst; <, less than; <<, much less than]

Map unit	Field No.	SiO2 (weight percent)	Texture	Olivine Mode (percent)	Olivine Size (millimeter)	Plagioclase Mode (percent)	Plagioclase Size (millimeter)	Plagioclase Anorthite content (mole percent An)	Orthopyroxene Mode (percent)	Orthopyroxene Size (millimeter)	Clinopyroxene Mode (percent)	Clinopyroxene Size (millimeter)
Basalt and basaltic andesite in the High Cascades (for example, units QTb, Qoba, Qyba)												
Qob	S80-29	50.60	Intergr	-----	-----	-----	-----	-----	0	-----	-----	-----
Qyb	S80-23	50.70	Intergr/por	8	-----	17	0.5-2.0	-----	0	-----	<<1	1
Qoba	S82-15	50.70	Intergr	8	-----	-----	-----	-----	0	-----	-----	-----
Qyb	S81-44	51.04	Intergr/por	6	0.6-1.2	14	-----	-----	0	-----	0	-----
Qoba	S80-18	51.11	Intergr/por	7	-----	-----	-----	-----	0	-----	0	-----
Qob	S80-53	51.17	Intergr/por	1	<1	8	-----	58	0	-----	3	-----
Qoba	S82-48	51.68	Intergr	2	0.5-1.0	3	0.5-1.0	67	0	-----	1	0.5-1.0
Qoba	S81-11	51.73	Intergr	<1	0.2-1.2	1	1	-----	0	-----	0	-----
Qoba	S80-57	51.76	Suboph	6	-----	-----	-----	-----	0	-----	0	-----
Qoba	S80-22	52.26	Suboph	2	-----	-----	-----	-----	0	-----	0	-----
Qoba	S84-23	55.65	-----	5	-----	9	-----	-----	0	-----	0	-----
Qob	S81-19	53.18	Intergr	6	0.5-1.5	-----	-----	-----	0	-----	0	-----
Qoba	S81-2	53.62	Intergr(pilo)	6	-----	0	-----	-----	0	-----	3	-----
Qyba	S80-33	54.25	Intergr(pilo)	2	2	-----	-----	68-72	0	-----	-----	-----
Qoba	S80-62	54.71	Pilotaxitic	4	1	2	<1	-----	7	-----	0	-----
Qoba	S80-3	55.26	Intergr	<1	-----	6	-----	-----	11	-----	0	-----
Qoba	S80-52	55.41	Intergr/por	5	<1	7	seriate	-----	gm + 1 pheno		1	-----
Qoba	S81-7	55.02	Intergr	<<1	1	seriate to 1.2 mm		60	5	0.2	tr	-----
Qoba	S81-57	55.09	Intergr/por	2	0.4-0.6	2	1.0	-----	6	-----	0	-----
Qoba	S81-56	55.47	Intergr	2	0.5-1.5	3	0.5-1.0	-----	19	-----	0	-----
Qoba	S82-56	55.72	Intergr	3	<0.5-	23	0.2-1.0	-----	gm	-----	0	-----
Qoba	S81-45	55.92	Intergr/por	3	0.2-0.4	9	0.2-0.6	-----	tr	-----	tr	-----
Qyba	S81-82	55.93	Intersertal	1	.06-.15	33	0.3-1.0	-----	8	0.3-1.0	0	-----
Qoba	S82-55	56.20	Intergr	3	0.2-0.3	11	-----	67	5	0.2	0	-----
Qyba	S81-41	56.90	Intergr/por	1	-----	seriate to 1 mm		54	3	0.3-0.6	6	0.5-1.0
Qoba	S81-43	56.99	Intergr/por	3	0.4-0.6	6	0.5-0.8	-----	tr	-----	1	0.4-0.8
Qyba	S81-40	57.40	Intergr/por	1	0.2	41	0.4-1.0	62-59	5	0.2-1.0	2	0.2-0.4
Qoba	S81-39	58.21	Intergr	2	0.4-0.8	7	0.4-0.8	62-38	5	0.3-0.8	0	-----
Qoba	S80-11	59.38	Felted/por	tr	-----	seriate to 1 mm		-----	7	-----	0	-----

Table 2. *Petrography of some basalt and basaltic andesite in map area—Continued*

[Samples within groups arranged in order of increasing SiO_2. Data summarize 500 or more points counted per thin section. Intergr, Intergranular; Por, porphyritic; Suboph, subophitic; Pilo, pilotaxitic; gm, groundmass; tr, trace; pheno., phenocryst; <, less than; <<, much less than]

Map unit	Field No.	SiO2 (weight percent)	Texture	Olivine Mode (percent)	Olivine Size (millimeter)	Plagioclase Mode (percent)	Plagioclase Size (millimeter)	Plagioclase Anorthite content (mole percent An)	Orthopyroxene Mode (percent)	Orthopyroxene Size (millimeter)	Clinopyroxene Mode (percent)	Clinopyroxene Size (millimeter)
						Ridge-capping basalt (unit Trb)						
Trd	S82-02	48.03	Suboph	-----	-----	seriate to 0.5 mm		67	0	-----	0	-----
Do	S81-23	48.89	Intergr(pilo)	10	0.8-2.0	4	0.8-2.0	-----	0	0	-----	-----
Do	S81-08	50.10	Intergr/por	5	1-3	3	0.4-0.8	71	0	-----	0	-----
Do	S81-18	50.72	Intergr(pilo)	11	1-2	1	0.2-1.0	60	0	-----	1	0.8-1.2
Do	S81-10	50.81	Intergr/por	6	0.50-1.5	no phenos.		73-69	0	-----	0	-----
Do	S82-05	53.72	Intergr	1	0.2	seriate to 1 mm		-----	0	-----	0	-----
Do	S81-125	53.85	Intergr/por	2	0.3-0.6	<<1	0.3	-----	tr.	<03	0	-----
Do	S82-04	54.32	Intergr(pilo)	1	0.5	2	1	57	3	0.5	0	-----
Do	S82-27	57.00	Intergr/por	1	0.3-3.0	19	0.3-2.0	-----	3.5	0.3-1.0	2	0.3-1.5
Do	S82-03	57.64	Intergr(pilo)/por	one grain		5	<1	-----	gm	0.2	0.5	-----
				Basalt member (unit Twb) of basalt and andesite of the Western Cascades								
Twb	S82-18	48.55	Suboph	5	1-2	-----	-----	-----	0	-----	0	-----
Do	S81-123	50.56	Intergr/por	8	0.3-2.0	18	0.3-2.0	76	0	-----	0	-----
Do	S82-17	50.65	Intergr/por	8	0.5-1.0	13	0.5-1.0	68	0	-----	0	-----
Do	S82-20	51.07	Intergr(pilo)/por	1	1	gm	-----	66	0	-----	0	-----
Do	S82-41	51.98	Intergr/por	7	0.5-1.5	3	0.5-1.0	59-45	tr	-----	0	-----
Do	S82-22	52.06	Intergr/por	-----	1	gm	-----	73	0	-----	1	-----
Do	S82-23	53.64	Intergr/por	3	0.15-0.30	1	0.3-0.6	65	0	-----	0	-----
Do	S82-42	53.71	Intergr/por	3	0.5-1.5	gm	-----	57-44	gm	0.5	0	-----
Do	S82-19	54.04	Intergr/por	1	1	gm	-----	66	4	0.2	0	-----
Do	S81-17	54.68	Intergr/por	2	0.3-1.0	seriate to 1.3 mm		65	gm	-----	0	-----
Do	S82-58	55.07	Intergr/por	3	0.3-0.6	1	2-3	68	gm	-----	0	-----
Do	S80-30	55.90	Intergr/por	3	0.3-0.6	4	0.3-1.5	63	tr	0.1	6	0.3-2.0
Do	S82-30	58.43	Intergr(pilo)	tr	0.15-0.3	tr	1	62-42	gm	0.2	0	-----