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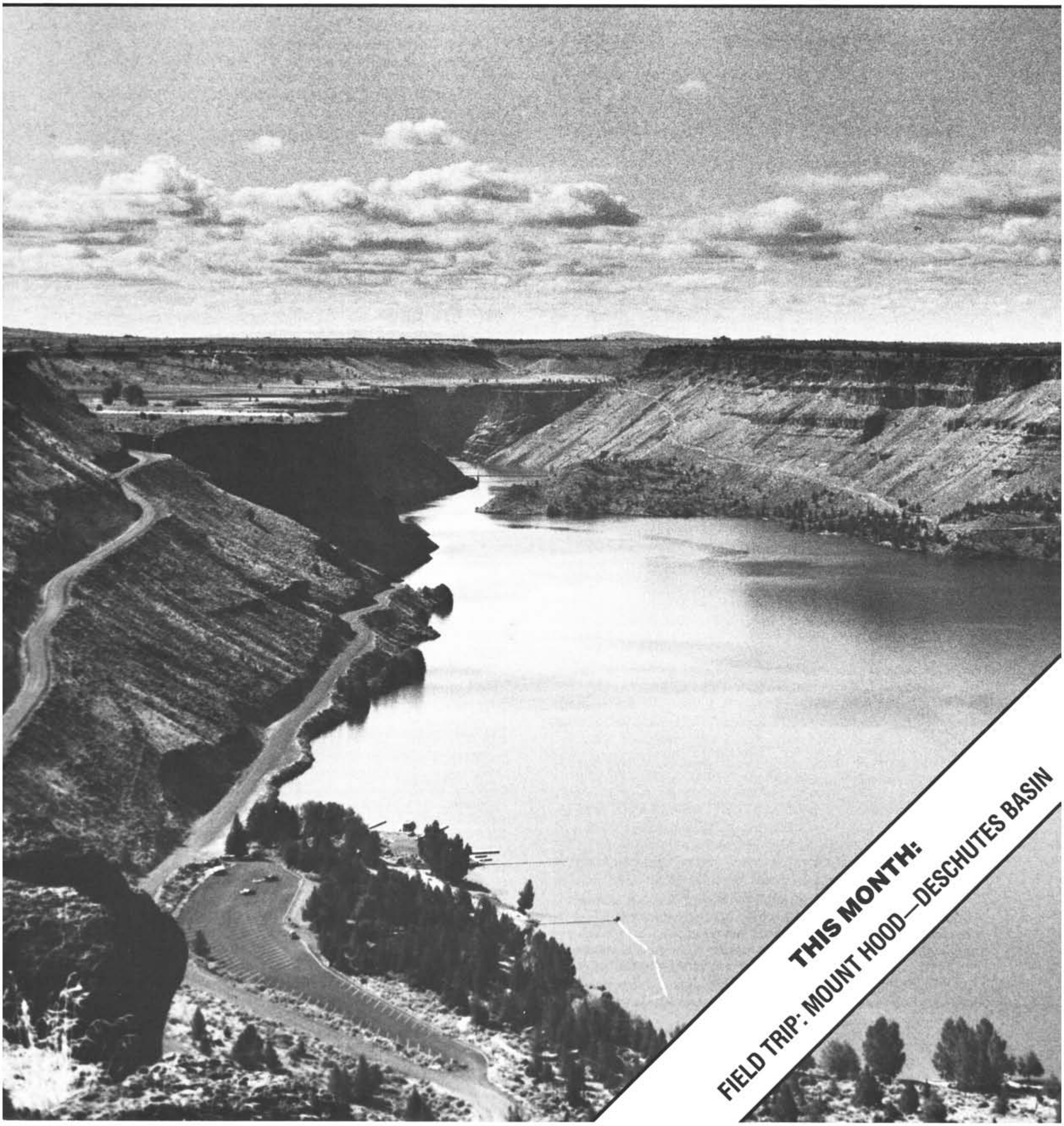

THIS MONTH:
FIELD TRIP: MOUNT HOOD—DESCHUTES BASIN

OREGON GEOLOGY

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COVER PHOTO

Crooked River arm of Lake Billy Chinook looking south from above the marina at the Cove Palisades State Park. Pleistocene intracanyon basalt flows form the prominent terrace within the canyon in the background. Other exposures on the canyon walls are volcanic and volcaniclastic rocks of the Neogene Deschutes Formation. See article beginning on next page.

OIL AND GAS NEWS

Clackamas County

RH Exploration Anderson 1, permit 241, located in sec. 29, T. 5 S., R. 1 E., was plugged and abandoned October 3, 1983.

RH Exploration Rose 1, permit 240, located in sec. 20, T. 5 S., R. 1 E., was spudded October 6, 1983, and is presently drilling.

Columbia County

Reichhold Energy Corporation Investment Management 21-20, permit 243, located in sec. 20, T. 6 N., R. 4 W., was plugged and abandoned September 21, 1983, at a total depth of 2,505 ft.

Reichhold Energy Corporation Wilson 11-5, revised from Wilson 12-5 and located in sec. 5, T. 6 N., R. 5 W., was spudded October 4, 1983, and is presently drilling.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
244	Hutchins & Marrs Lord's Will 1 019-00018	SW¼ sec. 3 T. 27 S., R. 7 W. Douglas County	Application; 4,000
245	Hutchins & Marrs Lord's Will 2 019-00019	SE¼ sec. 34 T. 26 S., R. 7 W. Douglas County	Application; 4,000
246	Hutchins & Marrs Lord's Will 3 019-00020	NE¼ sec. 3 T. 27 S., R. 7 W. Douglas County	Application; 4,000
247	Hutchins & Marrs Glory Hole 1 019-00021	NW¼ sec. 10 T. 27 S., R. 7 W. Douglas County	Application; 4,000
248	Reichhold Energy Corp. Crown Zellerbach 33-26 009-00118	SE¼ sec. 26 T. 6 N., R. 4 W. Columbia County	Location; 4,000
249	Reichhold Energy Corp. Busch 14-15 009-00119	SW¼ sec. 15 T. 6 N., R. 5 W. Columbia County	Location; 2,800
250	Reichhold Energy Corp. Longview Fibre 33-36 009-00120	SE¼ sec. 36 T. 6 N., R. 5 W. Columbia County	Location; 4,000
251	Reichhold Energy Corp. Grimsbo 11-16 009-00121	NW¼ sec. 16 T. 6 N., R. 5 W. Columbia County	Location 2,600
252	Hutchins & Marrs Great Discovery 1 019-00022	SE¼ sec. 3 T. 27 S., R. 7 W. Douglas County	Application; 4,500

1983 oil and gas drilling activity to date

Operator	Applications	Permits issued	Wells drilled
Diamond Shamrock Corp.	5	5	2
Reichhold Energy Corp.	12	8	3
RH Exploration	3	2	2
Petroleum & Mineral Analysis	1	1	—
Leavitt Exploration	1	1	—
Hutchins & Marrs	5	—	—

□

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A field trip guide to the central Oregon Cascades

This field trip to the central Oregon Cascades was offered as part of the annual meeting of the Geothermal Resources Council on October 24-27, 1983, in Portland, Oregon. The trip began in Portland on October 28 and ended back in Portland on October 29, after an overnight stay in Bend, Oregon.

As presented here, the trip is guided by mileage count and comments, on the first day, from Government Camp at Mount Hood to Bend and, on the second day, from Bend to the final stop at Breitenbush Hot Springs. The trip route is indicated by the trip stops in Figure 1. The first day's trip is printed here, the second day's trip and the references will be in the next issue.

The main purpose of the trip was to examine the structure of the central Oregon Cascades, particularly the evidence for a central High Cascade graben.

We thank the Geothermal Resources Council for the permission to reprint the field trip guide here.

First day: Mount Hood—Deschutes basin

by Gary A. Smith, Department of Geology, Oregon State University, Corvallis, Oregon 97331, and George R. Priest, Oregon Department of Geology and Mineral Industries

INTRODUCTION

Although the road log for this trip begins at Mount Hood, the first day of the field trip is primarily concerned with the geology of the Deschutes basin and the Green Ridge area. Green Ridge itself is not conveniently accessible, but discussions of its significance with respect to down-to-the-west faulting on the east side of the High Cascades are included. The trip starts in Government Camp at Mount Hood and ends in Bend after the geologic sections exposed in canyons of the Deschutes River drainage (Figure 1) have been examined.

General geology of Mount Hood

The Mount Hood volcano is composed of chiefly andesitic lavas and pyroclastic rocks which were erupted within the last 700,000 years. The youngest eruptions occurred from the vicinity of Crater Rock where, about 200 years ago, andesite domes exploded forming hot debris flows which spread out into the headwaters of the Sandy River. Crater Rock is a hypersthene-hornblende andesite dome with twenty active fumaroles ranging in temperature from 122° to 194° F on its east and northeast sides. Minor eruptions of dacite pumice in 1859 and 1865 A.D. were the last phase of this activity (see Crandell, 1980, for the details of Mount Hood eruptive activity).

The volcano sits on a platform of andesites and dacites of middle Miocene to Pliocene age. These rocks are underlain by the Yakima Basalt of the Columbia River Basalt Group which flowed into the area during the interval from about 15.3 to about 12 m.y. B.P. (million years before the present) (Anderson, 1980; Lux, 1982).

According to Williams and others (1982), geophysical data indicate that Mount Hood sits on a graben bounded by the Hood River fault system on the east and unmapped faults on the north, south, and west sides. A northwest-trending, down-to-the-east fault identified by Priest and others (1982) may be one of the graben-bounding faults.

Geothermal exploration at Mount Hood

Many shallow (500 ft) to intermediate-depth (2,000 ft) temperature-gradient holes have been drilled around Mount Hood by the Oregon Department of Geology and Mineral Industries (DOGAMI), Northwest Natural Gas Company (NWNG), and the U.S. Geological Survey (USGS). Only three deep wells have been drilled. Two deep wells were drilled by NWNG and DOGAMI at Old Maid Flat near the west flank of the volcano to depths of approximately 4,000 and 6,000 ft. These wells are aimed at discovering low- to moderate-temperature water for district heating in the suburbs of Portland. Both were dry holes, although the deeper well had temperatures up to 246° F. The third deep well was drilled near Timberline Lodge by the USGS. It reached a depth of 4,000 ft and temperatures as high as 169° F. The well encountered significant thermal fluids between 3,600 and 4,000 ft but caved in after flow testing.

Heat-flow analysis of the Mount Hood temperature-gradient data reveals that the volcano is associated with a local heat-flow anomaly which, at distances of 3 to 5 mi from the apex, reaches values of 130 to 150 mW/m^2 (Blackwell and others, 1982). No drill holes are closer than 3 mi to the apex, but heat flow must be quite high near the Crater Rock vent where fumaroles indicate that feeder dikes are still cooling. The reader is referred to DOGAMI Special Paper 14 (Priest and Vogt, 1982) for a more comprehensive review of the Mount Hood data.

Overview geology of the Deschutes basin

The Deschutes basin of central Oregon is defined by the exposed extent of the Deschutes Formation, an upper Miocene-lower Pliocene assemblage of volcanic and nonmarine epiclastic rocks. The basin extends from the Mutton Mountains on the north to the High Lava Plains on the south, and from the Ochoco Mountains on the east to the High Cascade Range on the west.

The pre-Deschutes Formation history of the region (Figure 2) is well known back only to the late Eocene. Eocene calc-alkaline volcanism of the Clarno Formation is represented by exposure of andesites and tuffs along the northern and eastern margins of the basin. The John Day Formation, lower Oligocene to lower Miocene rhyolite domes and ignimbrites with interbedded tuffaceous sediment, is widely distributed in the Mutton and Ochoco Mountains. Several of the dome complexes also occur within the basin where they protrude through younger cover. During the middle Miocene, two flows of the Columbia River Basalt Group were emplaced in the eastern half of the basin. These basalts are of the Prineville chemical type (Uppuluri, 1974; Swanson, personal communication, 1983) and are interbedded with, and overlain by, middle Miocene volcaniclastic rocks informally referred to as the Simtustus formation.

The Deschutes Formation represents a major period of aggradation within the basin between 7.6 and 4.5 m.y. B.P. (Smith and Snee, in press). During this time, explosive volcanism along the site of the present High Cascades produced dozens of ash-flow tuffs with volumes sufficient to cover large areas of the Deschutes basin. A large volume of epiclastic debris was carried into the

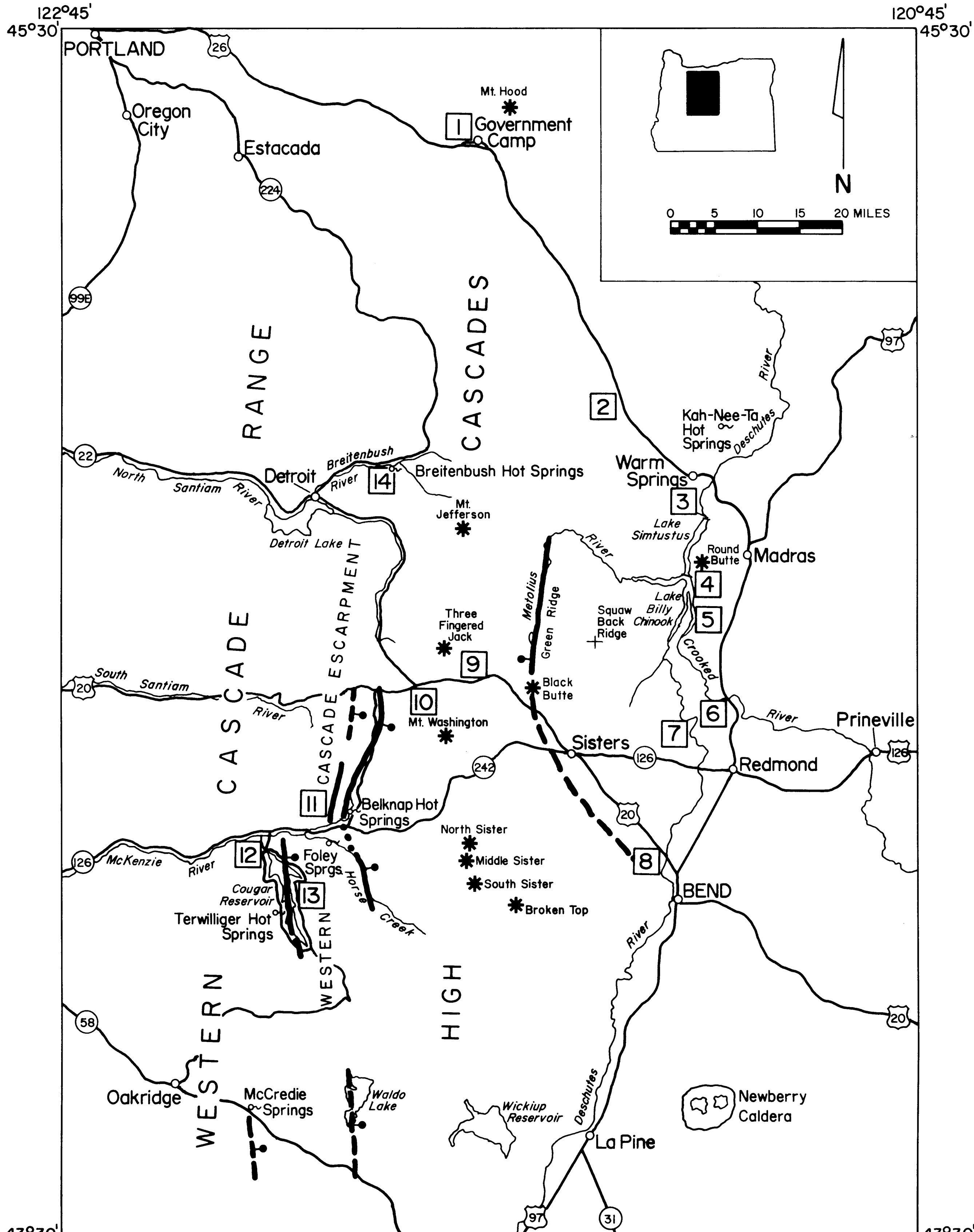

Figure 1. Location map for the central Oregon Cascade field trip. Numbers surrounded by squares are the field trip stops.

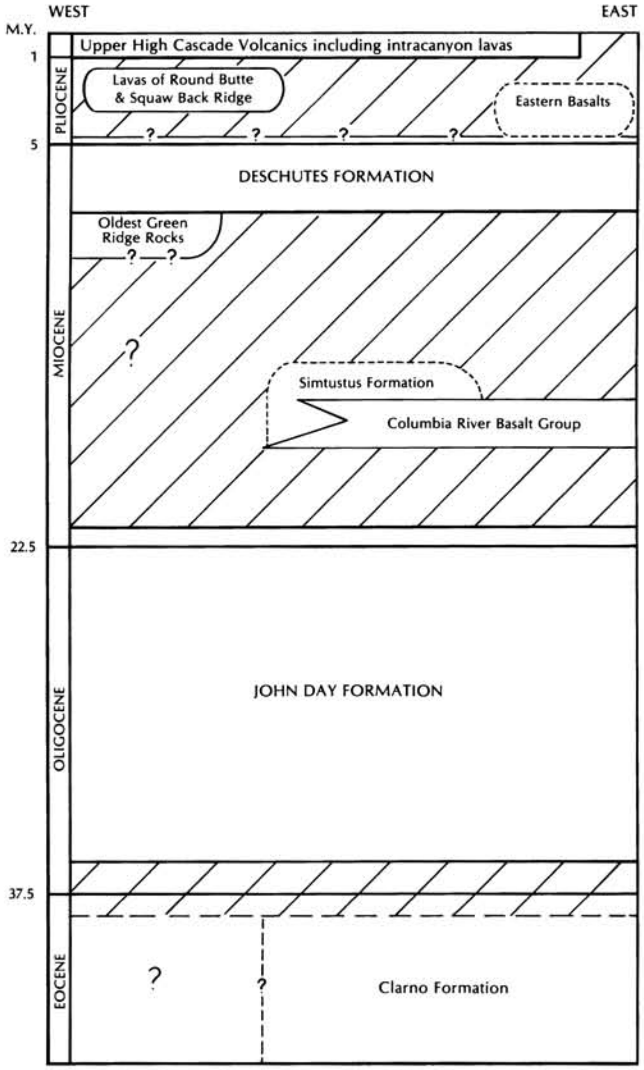

Figure 2. Cenozoic stratigraphy of the Deschutes basin and vicinity.

basin, largely during floods, burying many pyroclastic units before extensive erosional modification. Lava flows of basalt and basaltic andesite composition are also abundant in the basin and were derived from vents within and east of the basin as well as from the Cascades on the west.

Study of the structure and petrology of Deschutes Formation volcanic rocks indicates that this volcanic episode occurred during a period of extension within the High Cascade arc. This extension culminated in the formation of a discontinuous axial graben which is represented along the central western margin of the Deschutes basin by the Green Ridge fault escarpment. This 2,000-ft-high, west-facing scarp is composed of silicic to mafic lavas and ash-flow tuffs of the Deschutes Formation overlying the eroded remnants of slightly older upper Miocene volcanic vents. The Deschutes Formation volcanic rocks on Green Ridge were clearly derived from the west, where the oldest exposed rocks are only 2.5 m.y. old. Thus the Deschutes source volcanoes, an ancestral High Cascades Range, have subsided along faults, such as the faults at Green Ridge, and were subsequently buried by a younger platform of predominantly mafic character. The modern High Cascade stratovolcanoes and shield volcanoes were developed on this "mafic platform" starting in the early Pleistocene (Taylor, 1981; Smith and Taylor, in press).

Following the formation of the central Oregon High Cascade graben at about 4.5 m.y. B.P. (Taylor, 1981) and the general shift to less explosive mafic volcanism, aggradation in the basin ended. As the Deschutes River and its tributaries began cutting through the Deschutes Formation pile, small shield volcanoes of middle Pliocene age, such as Squaw Back Ridge and Round Butte, developed in the basin. Younger Pliocene and Pleistocene lavas from the High Cascades, Newberry volcano, and other shield volcanoes east and southeast of the basin flowed into well-developed canyons producing spectacular intracanyon basalt benches such as those at the Cove Palisades State Park. Also, during the early Pleistocene, an isolated highland of silicic volcanism extending eastward from the Three Sisters area was the source for at least five andesite to rhyodacite ash-flow tuffs which are now exposed over a large area between Sisters and Bend.

Acknowledgments

The mapping and analytical work which have led to the understanding of the Deschutes Formation as presented in this guide are far from being one person's efforts. Considerable credit for the information presented here must go to Donald E. Stensland, Southwestern Oregon Community College, and to Edward M. Taylor, Oregon State University, and his recent graduate students, Debra Cannon, Richard Conrey, Thomas Dill, Glenn Hayman, Brittain Hill, Jere Jay, Angela McDannel, David Wendland, and Gene Yogodzinski, for their contributions to the regional geologic picture. Author Smith's field expenses have been supported by the Sohio Field Research Fund at Oregon State University, a fellowship from Shell Oil Company, and the Penrose Foundation, Geological Society of America.

ROAD LOG

(See Figure 1 for locations of stops. To indicate viewing directions, the "o'clock" system is used, with the word "o'clock" omitted. Thus, for example, "12:00" means straight ahead.)

Miles	Comments
0	Ratskeller Restaurant, Government Camp, Mount Hood. *Proceed east on U.S. Highway 26.*
1.0	Holocene eruptive debris from Mount Hood in roadcut on left.
1.7	Pleistocene platy andesite from Mount Hood on left.
2.7	Junction, Oregon Highway 35. *Continue on U.S. 26.*
6.9	Two-pyroxene andesite of late Miocene age (Keith and others, 1982) erupted from a volcanic center on Barlow Ridge to the east (Wise, 1969). These lavas are similar in age to andesites overlying the Rhododendron Formation on Zigzag Mountain west of Mount Hood.
7.5	Wapanitia Pass.
8.8	Blue Box Pass.
11.4	Junction, Skyline Road. *Continue straight on U.S. 26.*
15.8	Entering Warm Springs Indian Reservation.
16.5	Junction, Oregon Highway 216. *Continue straight on U.S. 26.*
22.7	Quarry on right in upper High Cascade platy andesite.
27.7	Exposure on right is diktytaxitic glomeroporphyritic olivine basalt. This lithology forms a thick rimrock on the east half of the Reservation but is overlain here by 60 ft of sand and gravel.

29.1 The forested hill just southeast of the highway is Hehe Butte, a rhyolite dome of probable John Day age, projecting through younger cover. Peaks visible on the Cascade crest are Mount Jefferson (10,497 ft) and Olallie Butte (7,215 ft).

29.7 Junction, road to the left leads to Simnasho and Kah-Nee-Ta. *Continue straight on U.S. 26.*

30.1 Warm Springs River.

31.5 Roadcuts in "post-rimrock" sand and gravel continue for the next several miles.

32.5 The ridge crossed by power lines to the southwest is Sidwalter Buttes, three coalescing silicic domes of probable John Day age.

33.1 Mutton Mountains, composed of gently folded Clarno and John Day Formation rocks, form the skyline at 9:00. The Ochoco Mountains dominate the skyline from 10:00 to 12:00. The two most prominent peaks ahead are Grizzly Mountain (5,635 ft), a John Day dome complex, on the left and Gray Butte (5,108 ft), uplifted rocks of the Clarno and John Day Formations, on the right.

37.5 **STOP 1.** Mill Creek Canyon. This 220-ft-deep canyon exposes five units of diktytaxitic olivine basalt which are over 400 ft thick in this area. These flows are the "northern Deschutes basin rimrock basalts" of Smith and Taylor (in press) and were erupted from unknown vents on the east flank of the High Cascades onto an erosion surface developed on the Deschutes Formation. There are no reliable dates on these rocks, and they may be equivalent to the oldest "mafic platform" rocks upon which the High Cascade shield and composite volcanoes have been constructed (Smith and Taylor, in press). As noted by Hughes and Taylor (in press) for "mafic platform" basalts, the lavas exposed in Mill Creek Canyon have a major-element composition atypical of calc-alkaline chemistry (e.g., TiO_2=1.36-1.48 percent) and are more similar to basalts associated with extensional tectonic regimes.

39.4 Ridge at 10:00 with the lookout tower is Eagle Butte, a John Day eruptive center.

40.7 Panorama of Cascades at 3:00. Moving left from Mount Jefferson, the first prominent forested peak is Bald Peter (6,574 ft), a basaltic andesite shield volcano 2.1$\pm$0.2 m.y. old (Armstrong and others, 1975). Bald Peter is located west of Green Ridge which is visible to the left of the glaciated spires of Three Fingered Jack (7,841 ft), a Pleistocene basaltic andesite eruptive center. This view of Green Ridge is perpendicular to its strike.

44.4 Warm Springs grade. Roadcuts on left side of road are in Deschutes Formation and expose two ash-flow tuffs, numerous air-fall pumice lapilli beds, and interbedded sediment. Pediment surfaces along Shitike Creek, on the right, are developed on the John Day Formation.

45.5 From here to the Deschutes River, roadcuts expose tuffaceous sandstones and mudstones of member I of the John Day Formation. The unit dips about 5° to the south and southwest in this area. More extreme dips are the results of landslides. Gravel observed in many roadcuts is Pleistocene in age. Member I is the youngest unit in the John Day Formation, and plagioclase separated from tuff 2 mi northeast of Warm Springs yielded dates of 22.7$\pm$2.7 and 23.4$\pm$3.3 m.y. B.P. (data of E.H. McKee reported in Dingus, 1979).

47.3 Angular unconformity visible at 12:00, across the Deschutes River (difficult to see in morning sunlight), is between Columbia River Basalt Group, below, and Deschutes Formation, above (Figure 3). The lava flow with the spectacular colonnade is the Seekseequa basalt flow which can be traced for a distance of 20 mi where it fills the channel of an ancestral Deschutes River.

Figure 3. View eastward from near Warm Springs of an angular unconformity in the Deschutes River canyon. Cliff-forming unit dipping to the south (right) is Columbia River Basalt Group overlying slope-forming John Day Formation. Flat-lying lava flows and epiclastics above unconformity are in Deschutes Formation.

47.9 Junction, road leads to Warm Springs on the right and to Kah-Nee-Ta on the left. *Continue straight on U.S. 26.*

50.0 Crossing the Deschutes River, leaving the Warm Springs Indian Reservation. Cuts visible uphill on left side of highway for the next several miles are along the abandoned Oregon Trunk railroad grade, constructed around 1910. Exposures in these cuts are mostly John Day Formation. Above Rainbow Market, just east of the Deschutes River, Pleistocene terrace deposits are exposed in cuts at a railroad tunnel and an adjacent power-line service road. Within these terrace deposits is an ash flow of rhyodacite composition (SiO_2=72 percent, K_2O=2.21 percent), probably derived from Pleistocene activity at Mount Jefferson (Yogodzinski and others, in press). This eruptive event is older than that reported by Beget (1981).

51.2 The cliff on the left is the scarp of a large prehistoric landslide and provides excellent exposure of Deschutes Formation volcaniclastic rocks. The prominent light-colored unit near the base of the exposure is the Chinook tuff member (named by D.E. Stensland at Cove Palisades State Park), a silicic ash-flow tuff which provides a distinctive marker horizon in the northern Deschutes basin.

52.5 Junction, Pelton Dam Road. *Turn right.*

54.1 Roadcuts on both sides of road are in the Simtustus formation.

54.6 Roadcut on left is in the upper of two basalt flows in this vicinity that are of the Prineville chemical type.

55.3 **STOP 2.** Pelton Dam. Roadcut exposure here is of lower Simtustus formation which occurs as an interbed between two flows of Columbia River basalt. These Prineville chemical type basalts are characterized by high P_2O_5 content (greater than 1 weight percent) which is portrayed in the rock by abundant groundmass and intracrystal apatite. These two flows both have normal magnetic polarity and are probably equivalent to the base of the section described by Uppuluri (1974) at Prineville Dam. The Simtustus formation interbed shows sedimentary structures suggestive of low-gradient, possibly meandering, fluvial deposition within a channel and on an adjacent flood plain. An approximately 8-in.-thick accretionary lapilli bed near the top of the exposure is the only unreworked pyroclastic material present here. About 1,000 ft south of the dam, two high-angle faults (trend N. 20° W.) displace the basalts and Simtustus formation a few feet but do not affect the overlying Deschutes Formation. The prominent basalt bench about halfway up the canyon wall on both sides of the river is the Pelton basalt member of the Deschutes Formation. The Pelton basalt is 7.6 ± 0.3 m.y. old (Smith and Snee, in press) and rests on conglomerate exposed in old railroad cuts on the east canyon wall. Current work by author Smith indicates that this conglomerate is the base of the Deschutes Formation, and the age of the Pelton basalt member therefore closely represents the age of the base of the formation.

Turn around and return to U.S. 26. (Optional trip: Continue south on Pelton Dam Road and rejoin field trip at mile 75.0. This route leads across Willow Creek. Air-fall pumice along the road after crossing Willow Creek is from a Pleistocene eruption of Mount Jefferson reported by Beget [1981]. From the top of the grade south of Willow Creek, a view of the north canyon wall shows a Deschutes Formation ash-flow tuff filling a channel.)

58.2 Junction, U.S. 26. *Turn right.*

59.2 Bedded air-fall pumice lapilli deposit on left side of road is compositionally and mineralogically identical to the Pleistocene ash-flow tuff above Rainbow Market mentioned at mile 50.0.

60.3 Roadcut on left is in mudflow breccia that has yielded Hemphillian leaf fossils (Chaney, 1938). Vertical flutes are upright tree molds. Plagioclase collected from this locality has yielded ages of 4.3 and 5.3 m.y. (uncorrected from Evernden and James, 1964).

60.5 Roadcut in the spectacular colonnade of the Agency Plains basalt flow of the Deschutes Formation. This basalt, which forms the rimrock over an area of at least 70 mi^2 on the east side of the Deschutes River, flowed northward from a vent which has not yet been positively located. Here, the Agency Plains basalt is over 150 ft thick where it filled and overflowed an ancestral Deschutes River channel.

61.2 Road turns southeastward across Agency Plains toward Madras. This rich, irrigated farm area was first homesteaded around 1900 but not irrigated until the 1920's and 1930's. Mutton Mountains at 9:00.

61.9 Panorama of the eastern margin of the Deschutes basin. Hills from 9:00 to 12:00 are faulted John Day Formation ignimbrites and interbedded sedimentary rocks. Grizzly Mountain is at 12:00, Gray Butte at 1:00. Round Butte, a late Pliocene basalt shield volcano, is at 2:00.

66.9 Descending into the city of Madras.

67.3 Deschutes Formation sedimentary rocks in roadcuts on right. Distinctive red cobbles and boulders are John Day ignimbrite clasts.

67.8 Junction, U.S. 97. *Continue straight on U.S. 26 East/U.S. 97 South.*

68.9 Junction, J Street. *Turn right.*

69.3 Pelton basalt member on the left at road level.

69.4 Stop sign. *Jog left and continue west on Belmont Lane.*

70.3 Railroad crossing; road is on the Agency Plains basalt flow. Note the cinder cone capping the Round Butte shield volcano at 11:00.

71.7 Road descends into Dry Canyon. Rimrock on the west side of the canyon is Round Butte basalt. Thin Agency Plains basalt is present on left and right sides of the road ahead but does not appear in roadcuts.

73.0 Roadcuts in diktytaxitic olivine basalt from Round Butte.

75.3 Panorama to northwest across the Warm Springs Indian Reservation.

76.1 *Turn left on SW Mountain View Drive.* Quarry on right, after turn, is in intracanyon basalt to be described at the next stop.

77.8 Road to right to Round Butte Dam viewpoint. *Continue straight.*

78.7 Intersection. *Bear right toward Lake Chinook Village.*

80.8 **STOP 3.** Deschutes basin overview. *Turn right to overlook of Cove Palisades State Park and Lake Billy Chinook.* Here at the confluence of the Crooked (foreground) and Deschutes Rivers are typical exposures of Deschutes Formation volcanic and sedimentary rocks. The light-colored unit visible downstream at water level, near the mouth of the Metolius River, is the Chinook tuff member (see mile 51.2). Prominent ledges are intraformational basalts and basaltic andesites. The spectacular 450-ft-high cliff of basalt between the Deschutes and Crooked Rivers, called The Island, and benches of similar appearance visible downstream are Pleistocene intracanyon basalt flows. These diktytaxitic olivine basalt flows have reversed magnetic polarity and can be traced southward until they disappear beneath normal-polarity flows of similar composition which fan out from the north flank of Newberry volcano, about 50 mi away. The intracanyon flows continued downstream only 3 miles farther before coming to rest. Basalt was quarried (see mile 76.1) for the construction of Round Butte Dam from the distal end of this flow. Younger, normal-polarity flows proceeded down the Deschutes River to a point about 4 mi south of here and will be seen at stop 6. On the skyline, the Cascades from Bachelor Butte on the south to Mount Adams on the north are visible on a clear day. Mount Jefferson is due west and the Three Sisters are visible at 10:00. The broad ridge about 12 mi distant at 11:00 is Squaw Back Ridge, a basaltic andesite shield volcano 2.9±0.2 m.y. old (Armstrong and others, 1975). The conical summit of Black Butte (6,436 ft), an early Pleistocene basaltic andesite volcano, is visible over the left flank of Squaw Back Ridge. Black Butte is located at the south end of Green Ridge, which extends northward behind Squaw Back Ridge to a point in front of Mount Jefferson where the Metolius River canyon extends around the northern end of the ridge. The west side of Green Ridge is a steep, 2,000-ft-high fault scarp facing the late Pliocene-Pleistocene High Cascade Range. Rocks exposed on Green Ridge are of late Miocene to early Pliocene age and are largely part of the Deschutes Formation. The oldest rocks along the northern third of the ridge are as old as 9.4±0.6 m.y. (Armstrong and others, 1975, recalculated by Fiebelkorn and others, 1982) and are associated with volcanic centers which became extinct shortly before deposition of the Deschutes Formation in the basin. The Green Ridge fault is the local expression of the central Oregon High Cascade graben. Subsidence there occurred about 4.5 m.y. ago (Taylor, 1981; Smith and Taylor, in press) and isolated the Deschutes basin from its ancestral High Cascade source volcanoes which were subsequently buried by younger, predominantly mafic volcanics. *Return to the road and turn right.*

81.6 Hills at 11:00 are faulted and folded John Day Formation ignimbrites. Juniper Butte, a John Day rhyolite dome complex, is the dominant hill at 12:00.

83.0 Intersection. *Turn right, enter Cove Palisades State Park.*

83.2 Campground on the left is located on a bench of intracanyon basalt. The intracanyon bench can be seen extending several miles up the Crooked River canyon.

83.9 **STOP 4.** Cove Palisades State Park. *Pull off on left side of road.* Roadcut exposures here illustrate the lithologic variety of the Deschutes Formation. Note the poor sorting of the sediments which is attributed to rapid deposition from high-sediment-load floods (Figure 4). Two plagioclase-rich, silicic ash-flow tuffs are exposed here. The white tuff, the Cove Palisades tuff member, is widespread in the area of the park and is prominent on the point called The Ship (Figure 5), across the Crooked River and south of The Island. The orange tuff has been recognized only in this

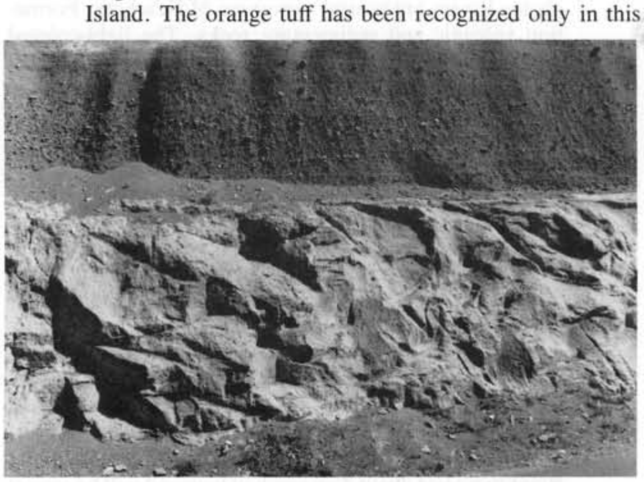

Figure 4. Deschutes Formation ash-flow tuff overlain by poorly sorted flood-deposited sediment. Exposed portion of the tuff is about 12 ft thick. Roadcut on east side of Cove Palisades State Park.

Figure 5. Deschutes Formation ash-flow tuffs and sediments, capped by basalt, form The Ship, a prominent feature in the Cove Palisades State Park. Conical butte in the background is Black Butte, behind and to the left of the Squaw Back Ridge shield volcano.

roadcut. Clasts of orange welded tuff with black pumice are common in the sediment here and are derived from the McKenzie Canyon tuff member which will be seen at stop 6. The top and bottom of the section exposed in the Deschutes canyon 1 mi west of here was dated by Armstrong and others (1975) as 5.0±0.5 and 5.9±1.0 m.y., respective (recalculated by Fiebelkorn and others, 1982). Although the standard errors on these K-Ar ages are large, paleomagnetic stratigraphy also implies that the entire exposed section was deposited in 1 to 1.5 m.y. *Turn around and proceed eastward from the Cove Palisades State Park.*

85.0 Stop sign. *Turn right on SW Frazier Drive.*

85.5 *Sharp curve left onto SW Fisch Road.*

86.0 Stop sign. *Turn right on SW Feather Drive.*

87.0 Intersection. *Turn left on SW Huber Road.*

87.3 *Enter Culver.*

87.9 Stop sign. *Turn right on 1st Street.*

88.2 *Bear left on paved road.*

90.5 Junction, U.S. 97. *Turn right.*

91.5 Basal member H rhyolite ignimbrite of the John Day Formation in the roadcuts on the left (Robinson and Stensland, 1979), Juniper Butte on the right.

91.6 Prominent hill at 12:00 and about 15 mi distant is Cline Buttes, a silicic dome complex of probable John Day age projecting through the Deschutes Formation.

93.1 Newberry volcano visible on southern skyline. Numerous cinder cones on the northwest flank of the shield are also visible.

95.5 Smith Rock, a massive, tan tuff of either John Day or Clarno age, is visible at 10:00.

96.9 *Cross Crooked River, turn right into Ogden Scenic Wayside.*

97.0 **STOP 5.** Ogden Scenic Wayside. The Crooked River has sliced a 300-ft-deep canyon through Newberry intracanyon lavas. The cliff-forming lava flow on the north side of the canyon and east of the highway bridge is a Deschutes Formation basaltic andesite. The thickness of this flow suggests that it filled a river channel that existed here about 4 to 4.5 m.y. ago. *Return to U.S. 97; turn right.*

99.4 Intersection. *Turn right on Lower Bridge Way.*

100.0 Low cinder cones at 9:00 are the Tetherow Buttes. Ejecta from these cinder cones have a composition very similar to the Agency Plains basalt and may have been the source for that extensive lava flow.

101.0 Small ridges along the road are pressure ridges on a normal-polarity, diktytaxitic olivine basalt flow probably erupted from the Newberry volcano complex.

101.5 Intersection, 43rd Street. *Continue straight.*

104.8 Roadcut on right exposes Newberry basalt overlying white diatomite. Spoil piles across the Deschutes River indicate the site of former efforts at mining this diatomite horizon. Diatoms collected here are probably of Pleistocene age (J.P. Bradbury, USGS, written communication, 1983) and are not part of the Deschutes Formation. The lake represented by this diatomite probably formed from the disruption of local drainage by Newberry lavas, one of which later flowed over the lake deposits.

104.9 Lower Bridge tuff member on right.

105.1 **STOP 6.** Lower Bridge. *Pull off on gravel on left and walk across bridge to exposure on right side of road.* Here are the two most extensive exposed ash-flow tuffs in the Deschutes Formation. The lower, pink-gray tuff is the Lower Bridge tuff member, and the upper white to red-orange tuff is the McKenzie Canyon tuff member, which is stratigraphically nearly equivalent to, but slightly younger than, the Cove Palisades tuff member at stop 4. Textural variation within the two tuffs exposed here and paleotopography suggest a source to the southwest, probably from volcanoes now buried beneath the early Pleistocene "silicic highland" of Taylor (1978) which extends eastward from the Three Sisters. Exposure does not permit accurate estimation of the volume of these ash-flows, but if a source under the present highland is assumed, the minimum dispersal distance is about 50 percent greater than for Mount Mazama ash-flows east of Crater Lake (Smith and Taylor, in press). Large calderas were probably formed during each eruptive event. Chemical analyses by Debra Cannon (Oregon State University) indicate that the Lower Bridge tuff represents a rhyolite magma (SiO_2=70 percent, K_2O=5 percent) and that the McKenzie Canyon tuff was erupted from a heterogenous magma chamber. The base of the McKenzie Canyon tuff is dominated by rhyolite pumice (SiO_2=70 percent, K_2O=4.5-6 percent), and black andesitic pumice (SiO_2=61 percent) becomes more abundant upward. Mixed pumice is very common (Figure 6). The andesitic component is not of calc-alkaline parentage but has a major-element composition similar to icelandite (TiO_2= 1.5-1.6 percent; FeO*/MgO=2.5). Basaltic andesite and andesite lava flows with high TiO_2 content and high FeO*/MgO ratio are widespread, though not dominant, in the Deschutes Formation. These compositions suggest petrogenetic processes more like those in extensional tectonic regions than in a subduction-related arc and are undoubtedly related to the formation of the central Oregon High Cascade graben. *Turn around and return to U.S. 97.*

* Total Fe recalculated as volatile-free FeO.

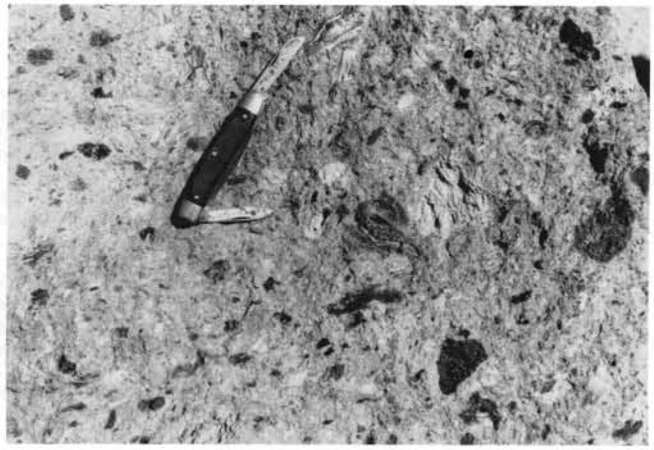

Figure 6. Close-up of McKenzie Canyon tuff at Lower Bridge. Note different types of pumice—white (rhyolite), black (andesite), and mixed (e.g. at upper knife point). Body of knife is 3.5 in long.

111.0 Junction, U.S. 97. *Turn right.*

111.5 Entering the community of Terrebonne. The town is built on diktytaxitic olivine basalt that is younger than the Tetherow Buttes. This basalt was probably erupted from Pliocene shield volcanoes near Prineville, about 15 mi to the east.

112.2 Tetherow Buttes cinder cones ahead and on right.

114.8 Highland at 10:00 is Powell Buttes, a John Day dome complex which was the target of a geothermal-gradient drilling program in 1979-1980 (Brown and others, 1980a).

116.9 Entering the city of Redmond which is located on the same, or a similar, basalt flow as Terrebonne.

117.9 Junction, Oregon Highway 126. *Continue straight on U.S. 97.*

120.0 Low scarp on left is erosional edge of the diktytaxitic olivine basalt on which most of Redmond is built. Banked against this scarp is a normal-polarity diktytaxitic olivine basalt flow from Newberry volcano. Pressure ridges on this Pleistocene flow will be visible along the road most of the way to Bend.

130.2 Pilot Butte, at 11:00, is a Holocene cinder cone on the eastern outskirts of Bend. Newberry volcano on the horizon.

131.5 Junction, U.S. 20. *Turn left and follow U.S. 20 west toward Sisters.*

135.0 Deschutes River.

135.4 Intersection. *Turn left.*

136.5 Intersection. *Turn right.*

136.8 Exposure of the Desert Spring tuff, an early Pleistocene ash-flow tuff, on the right.

137.0 **STOP 7.** Pleistocene pyroclastic rocks. Five ash-flow tuffs and one air-fall lapilli tuff of Pleistocene age are exposed in the Bend-Sisters area. From oldest to youngest these are the Desert Spring tuff, Bend pumice, Tumalo tuff, Lava Island tuff, Century Drive tuff, and Shevlin Park tuff (Taylor, 1980). These pyroclastic rocks appear to be derived from sources in the "silicic highland" of Taylor (1978) and are now buried by late Pleistocene-Holocene volcanic rocks. The inactive borrow pit here exposes the rhyodacitic Tumalo tuff overlying consanguineous, air-fall Bend pumice (Figure 7). The dacitic Desert Spring tuff is exposed across and below the road. About 0.1 mi down the road, a fault can be seen offsetting this sequence, including interbedded epiclastics, by several feet. This northwest-trending fault is one of many en-echelon normal faults spread over a zone 15 mi wide that extends from the north flank of Newberry volcano to the south end of Green Ridge. The dacitic Lava Island tuff and andesitic Century Drive and Shevlin Park tuffs are absent here but are exposed to the south and west (see Taylor, 1981). Early Pleistocene volcanism in the central Oregon Cascades was dominantly mafic (i.e., basalt and basaltic andesite) in character. The silicic volcanism represented by these pyroclastic units and contemporary domes to the west (e.g., Three Creek Butte and Melvin Butte) is anomalous (Taylor, 1978). This "silicic highland" may obscure graben-forming faults analogous to Green Ridge (Taylor, 1978) and almost completely obscures a similar highland that existed during Deschutes time (Smith and Taylor, in press). *Return to U.S. 20.*

Figure 7. Tumalo tuff overlying Bend pumice in a borrow pit south of Tumalo. White band, 2 ft thick, in center of the photo is ground-surge deposit at base of the Tumalo tuff. Note hammer for scale just below center of photo.

End of first-day road log.

NEXT MONTH:
Second day: Santiam Pass—Belknap Hot Springs—Breitenbush Hot Springs.

OSU, PSU schedule guest speakers

Oregon State University:

The guest speakers series of the Department of Geology, Oregon State University (OSU), is being dedicated this year to Professor William H. Taubeneck, who is retiring on December 31, 1983, after 32 years of distinguished service to OSU and the general geologic community. In keeping with Professor Taubeneck's knowledge of igneous petrology and the rocks of Oregon and western Idaho, the topic of the series will be granite petrology, with a focus on the Idaho batholith. Seminars will be held on Tuesday and Thursday at 12:30 p.m. in Room 108, Wilkinson Hall, OSU, in Corvallis, beginning November 15, 1983. The speakers and tentative topics are listed below.

Nov. 15: Lawrence Snee, OSU, *Introductory Remarks on the Series Topic and the Invited Speakers.*

Nov. 17: Karen Lund, OSU, *Structural Setting of Mesozoic- and Cenozoic-Age Igneous Complexes of Central Idaho.*

Nov. 22: Paul Bateman, U.S. Geological Survey (USGS), *The Sierra Nevada Batholith, California, with a Comparison to the Idaho Batholith.*

Nov. 29: E-an Zen, USGS, *Epidote-Bearing Plutons and Their Implications on the Tectonic Development of the North American Cordillera.*

Dec. 1: Robert Fleck, USGS, *Strontium Isotope Constraints on the Origin of Rocks along the Western Margin of the Idaho Batholith.*

Dec. 6: William Kelly, University of Michigan, *The Tin-Tungsten Deposit of Panasqueira, Portugal, as a Basis for Research on Ore Deposits Related to Granite Plutons.*

Dec. 8: Thor Kiilsgaard, USGS, *Plutons and Ore Deposits of the South-Central Part of the Idaho Batholith.*

Dec. 13: Karl Evans, USGS, *Pre-Cambrian Granites of Central Idaho and Their Use in Understanding the Structural History of the Idaho Batholith.*

Dec. 15: Lawrence Snee, OSU, *Summary and Conclusion.*

For additional information and confirmation of the schedule and topics, please contact Lawrence Snee, (503) 754-2284, or the OSU Department of Geology, (503) 754-2484.

Portland State University

The fall seminar series for the Department of Geology at Portland State University (PSU) has begun, and Sam Johnson of Washington State University, Terry Keith of the USGS, and Jack Kepper of PSU have already presented talks. Upcoming seminars are scheduled for the following dates and will be held at 3:00 p.m. in Room 258, Cramer Hall, PSU, in Portland.

Nov. 9: Erwin Suess, OSU, *Coastal Upwelling and a History of Organic-Rich Mudstone Deposition: Stable Isotope and Geochemical Evidence.*

Nov. 14: Dick Couch, OSU, *Structures of the Cascade Range in Oregon.*

Nov. 16: Richard Fifarek, OSU, *Geology and Mineralization of the Red Ledge Volcanogenic Massive Sulfide Deposit, Idaho.*

Nov. 30: William Orr and Paul Miller, University of Oregon, *Depositional Environments of Sediments of Late Oligocene Age in the Central Western Cascades, Oregon.*

Dec. 7: Michael Alger, Reichhold Energy, Portland, *Development of a Petroleum Prospect: From Raw Dirt to Pay Dirt(?).*

For additional information on the seminars, please contact Mike Cummings, (503) 229-3029, or the PSU Department of Geology, (503) 229-3022. □

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