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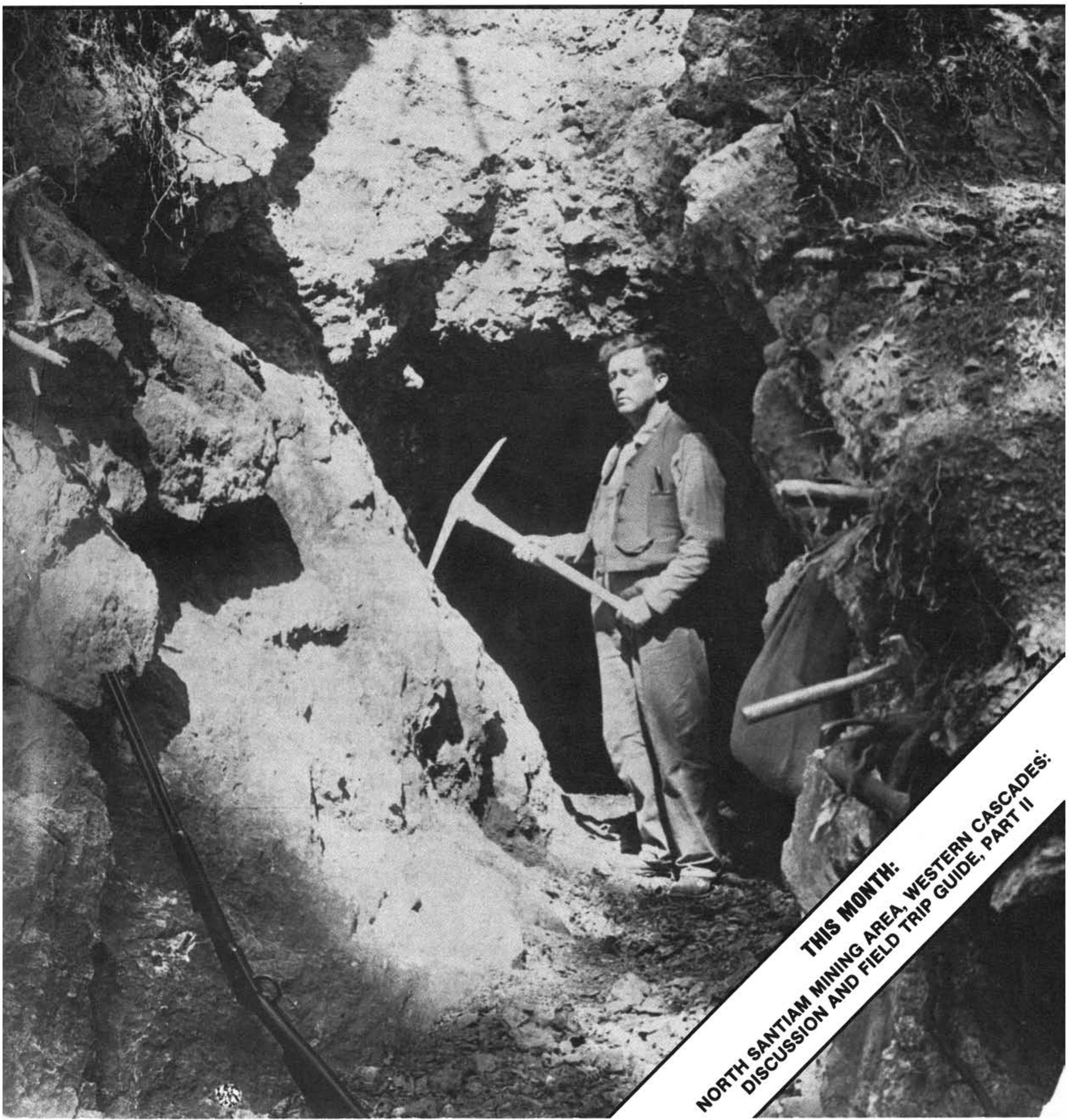

THIS MONTH:

NORTH SANTIAM MINING AREA, WESTERN CASCADES: DISCUSSION AND FIELD TRIP GUIDE, PART II

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The style to be followed is generally that of U.S. Geological Survey publications (see the USGS manual *Suggestions to Authors*, 6th ed., 1978). The bibliography should be limited to "References Cited." Authors are responsible for the accuracy of the bibliographic references. Names of reviewers should be included in the "Acknowledgments."

Authors will receive 20 complimentary copies of the issue containing their contribution. Manuscripts, news, notices, and meeting announcements should be sent to Beverly F. Vogt, Publications Manager, at the Portland office of DOGAMI.

COVER PHOTO

Typical early-day mine adit and miner. Photo was taken in the Blue River mining district in the Western Cascades, south of the North Santiam area, which is the subject of field trip guide beginning on next page. Photo courtesy Oregon Historical Society.

OIL AND GAS NEWS

Columbia County — Mist Gas Field

ARCO Columbia County 22-27, located in NW¼ sec. 27, T. 6 N., R. 5 W., in the vicinity of five recent gas completions, was spudded November 17, 1985, drilled to a total depth of 2,500 ft, and plugged and abandoned November 25, 1985.

ARCO Columbia County 32-32, located in NE¼ sec. 32, T. 6 N., R. 5 W., in the extreme west central part of the field, and 1¾ mi southwest of the nearest production, was completed November 13, 1985, as the 21st producing well in the field and ARCO's second success there this year. The well was drilled to a total depth of 2,711 ft.

ARCO Crown Zellerbach 23-15, located near Pittsburg in the extreme southeast part of the field in SW¼ sec. 15, T. 5 N., R. 4 W., was spudded November 26, 1985, and is drilling toward a permitted total depth of 3,500 ft. This well is just southeast of ARCO Crown Zellerbach 31-16, the most southeasterly producing well in the field.

ARCO Crown Zellerbach 41-2, located in NE¼ sec. 2, T. 5 N., R. 5 W., was spudded November 5, 1985, drilled to a total depth of 2,109 ft, and plugged and abandoned November 12, 1985.

ARCO Longview Fibre 23-25, located in SW¼ sec. 25, T. 6 N., R. 5 W., was spudded December 1, 1985, and is drilling toward a permitted total depth of 2,100 ft.

Columbia County — Wildcat

Exxon GPE Federal Com. 1, located in sec. 3, T. 4 N., R. 3 W., 2 mi north of Chapman in south-central Columbia County, was spudded September 2, 1985, and plugged and abandoned November 8, 1985. Permitted total depth was 12,000 ft. Total depth reached has not been released by the operator.

Lincoln County

Damon Petroleum Longview Fibre 3, located in NW¼ sec. 21, T. 9 S., R. 11 W., was spudded September 27, 1985, drilled to a total depth of 3,040 ft, and plugged and abandoned November 16, 1985. This is the third well drilled in this immediate vicinity since 1980. None have found production.

Production: Mist Gas Field

Cumulative: (1979-1984): 19,219,335 Mcf
1985 Production (Mcf):

January	271,717	June	372,148
February	242,077	July	385,157
March	301,885	August	386,511
April	300,775	September	405,563
May	364,072		

Cumulative (1985): 3,029,905
Cumulative (1979-Sept. 1985): 22,249,240 Mcf

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
341	ARCO Longview Fibre 41-35 009-00182	NE¼ sec. 35 T. 6 N., R. 5 W. Columbia County	Location; 1,900.
342	ARCO Columbia County 31-27 009-00183	NE¼ sec. 27 T. 6 N., R. 5 W. Columbia County	Location; 2,115.
343	ARCO Longview Fibre 34-25 009-00184	SE¼ sec. 25 T. 6 N., R. 5 W. Columbia County	Location; 2,020.

□

North Santiam mining area, Western Cascades — relations between alteration and volcanic stratigraphy: Discussion and field trip guide

by J. Michael Pollock and Michael L. Cummings, Department of Geology, Portland State University, P.O. Box 751, Portland, Oregon 97207

Part II. Field trip guide*

ROAD AND TRAIL LOG

The route of the trip is shown in Figure 1. Mileage is indicated in this log by italicized numbers. The first set of numbers is cumulative throughout the field trip; the numbers in parentheses indicate the mileage between points. The portion of the trip that goes through the Shiny Rock Mining Company claims is to be traveled on foot and is 4.7 mi each way. For your safety, avoid open mine adits. Most are not maintained and are unstable and very dangerous.

0.0 mi (0.0 mi) Proceed east on Oregon Highway 22 from its intersection with Interstate I-5 (exit 253) on the southeast edge of Salem. The highway climbs out of the Willamette Valley into the Waldo Hills. These hills, the Salem Hills to the southwest, and the Eola Hills west of Salem are underlain by flows of the Columbia River Basalt Group (CRBG).

Thayer (1939) originally named these basalts the Stayton lavas, indicated that the rocks were similar to the CRBG, and tentatively correlated them with the CRBG. M. Beeson (oral communication, 1984) confirmed that the Stayton lavas are actually flows of the CRBG.

Tolan and others (1984), in their studies of the Neogene history of the Columbia River, indicated that the oldest identified channel of the Columbia River passed near Stayton, through the Salem Hills, and possibly west to the Pacific Ocean. This channel developed during "Vantage time," a period of time lasting for several hundred thousand years or longer between the last eruptions of CRBG flows of the Grande Ronde Basalt (15.5 m.y. ago) and the first eruptions of the Frenchman Springs Member of the Wanapum Basalt. The first flow of the Frenchman Springs Member to reach this area, the Ginkgo flow, followed this ancestral channel. Hoffman (1981) reported the thickness of the Ginkgo flow in the southeastern Salem Hills as 180 m.

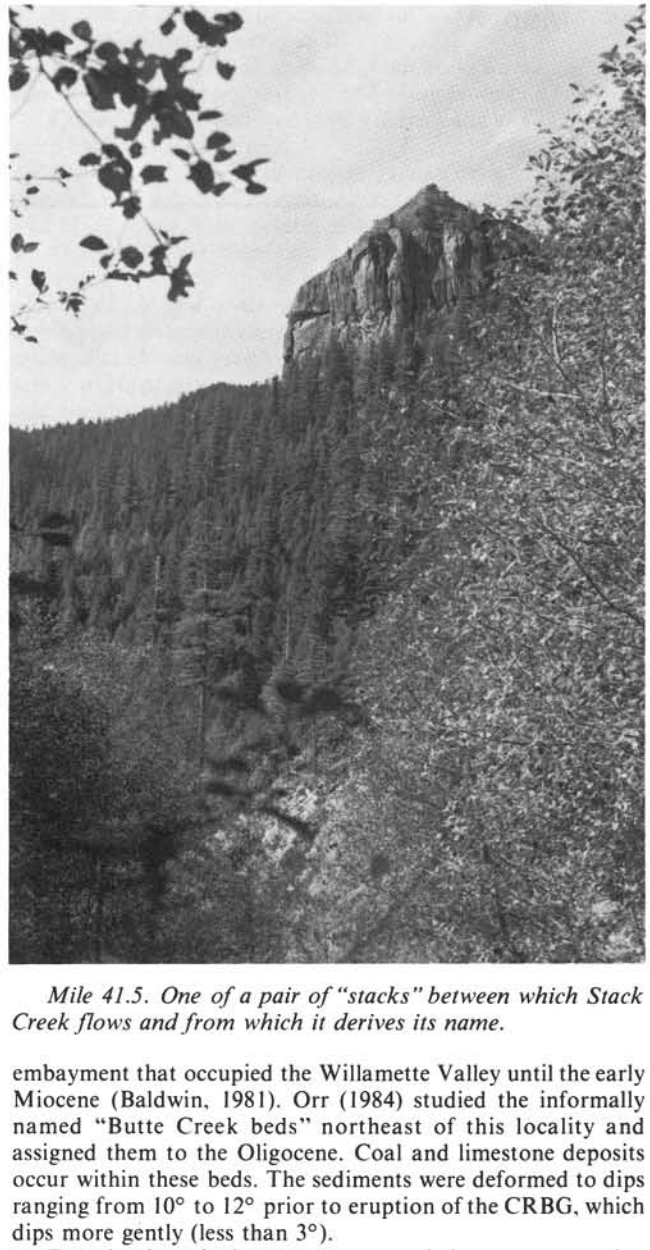
As the road climbs the hills, note the red-colored laterite soils developed on these basalts. In the Salem Hills, ferruginous bauxite deposits have developed from the Frenchman Springs Member (Hoffman, 1981). These bauxite deposits are iron-rich and, in the Salem Hills, contain 13.4 million dry long tons of ore at 36.02 percent Al_2O_3; 4.17 percent SiO_2; and 32.49 percent Fe_2O_3 (Hook, 1976).

4.0 mi (4.0 mi) View to the east from the crest of the Waldo Hills toward the Cascade Range. The snow-covered peak in the distance is Mount Jefferson, one of the composite volcanos of the late High Cascade group of Priest and others (1984). Most of the hills in the intermediate distance are composed of rocks of the Western Cascade group of Priest and others (1984).

12.3 mi (8.3 mi) Sediments exposed in small outcrops are of the Illahe formation as defined by Thayer (1939). These sediments, which underlie the CRBG, are well-bedded, tuffaceous marine sandstones that were deposited in a marine embayment that occupied the Willamette Valley until the early Miocene (Baldwin, 1981). Orr (1984) studied the informally named "Butte Creek beds" northeast of this locality and assigned them to the Oligocene. Coal and limestone deposits occur within these beds. The sediments were deformed to dips ranging from 10° to 12° prior to eruption of the CRBG, which dips more gently (less than 3°).

Examination of this outcrop reveals distinct reverse grading (finer particles near the base and increasing in size toward the tops of individual beds) resulting from the tendency of pumice to float. Also present are abundant carbonized and uncarbonized plant materials.

14.5 mi (2.2 mi) Flows of the CRBG are exposed to the right and left of the highway as the road descends a small hill north of the town of Stayton. The road to the right enters Stayton, and in a quarry along the road, andesitic volcanic rocks that may be the



Mile 41.5. One of a pair of "stacks" between which Stack Creek flows and from which it derives its name.

*Part I, discussion, and references for both parts appeared in last month's issue (December 1985).

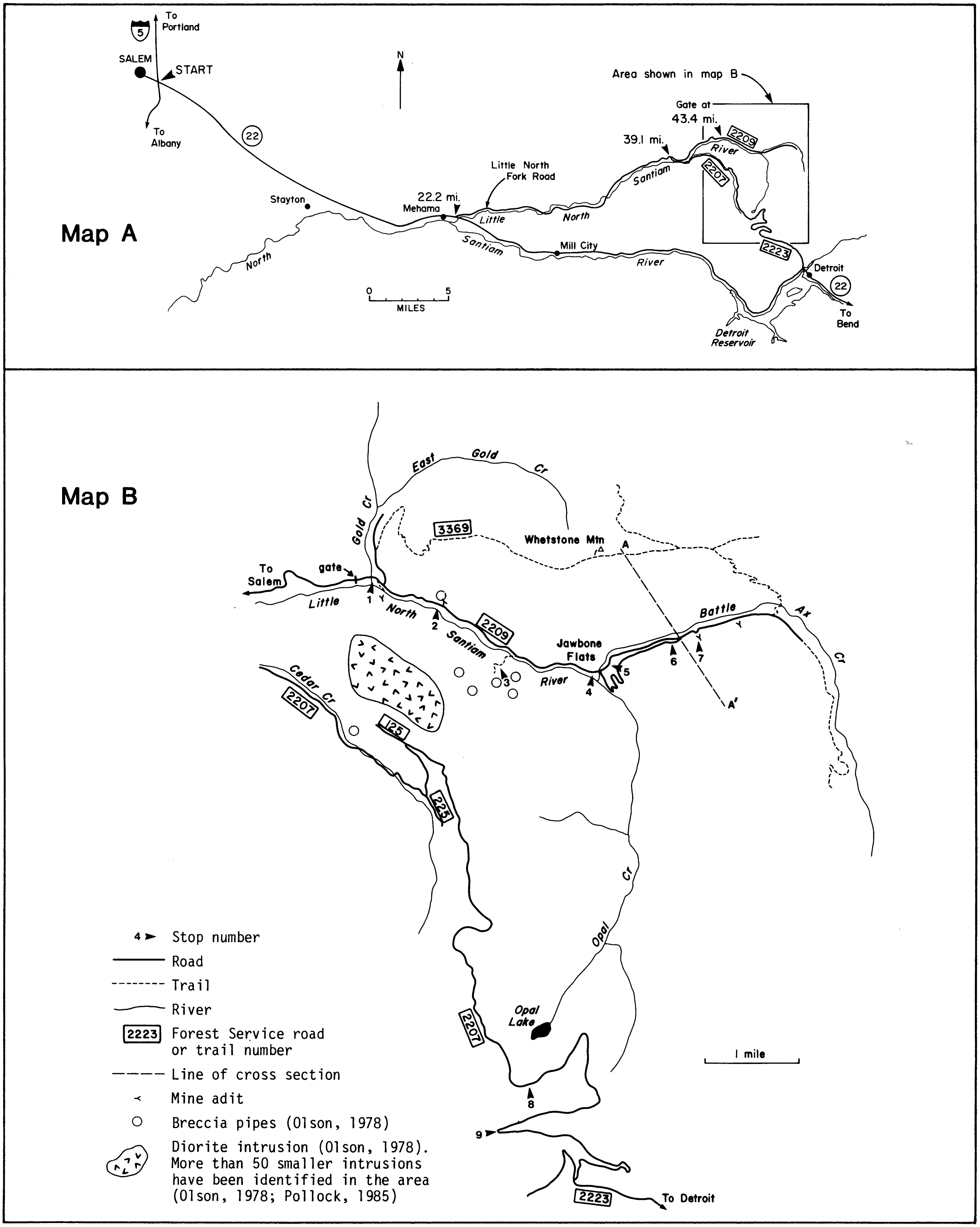


Figure 1. Map A. Route of field trip to North Santiam mining area, Oregon. Map B. Locations of key geologic features and field trip stops.

Mehama volcanics of Thayer (1936, 1939) are exposed.

21.4 mi (6.9 mi) Mehama-Lyons junction. *Continue on Highway 22 for 0.8 mi.*

22.2 mi (0.8 mi) Intersection with Little North Fork Road to the Little North Santiam Recreation Area along the Little North Santiam River. *Turn left (northeast).* The Little North Santiam River joins the North Santiam River immediately south of this intersection. Upper slopes of hills in this area are flows of the CRBG.

25.2 mi (3.0 mi) Exposures of a basalt intracanyon flow are located to the left on the north side of the road. The source of the basalt is not known. It is not basalt of the CRBG (M. Beeson, oral communication, 1984) but may be a flow from a High Cascade basalt shield volcano. The intracanyon flow can be observed at several localities along the road up the valley, suggesting that the ancestral Little North Santiam River was located in approximately its present location at the time the flow was erupted.

27.2 mi (2.0 mi) The irregularity in the road surface is due to active landslides. Deeply weathered volcaniclastic sediments in the cliff are involved in a particularly troublesome landslide. In the woods north of the road is the basalt intracanyon flow. Steep contacts between diverse volcanic units are commonly associated with slope failures.

28.3 mi (1.1 mi) BEWARE — the road takes a very tricky turn onto the bridge over the Little North Santiam River.

29.0 mi (0.7 mi) The basalt intracanyon flow is exposed in the quarry along the south side of the road. The jointing pattern is typical of the jointing developed in intracanyon flows.

33.6 mi (4.6 mi) Bridge over the Little North Santiam River. Rocks of the Mehama volcanics (Thayer, 1936, 1939) crop out along the river valley.

36.3 mi (2.7 mi) Entrance to Salmon Falls State Park.

37.3 mi (1.0 mi) Intersection with Evans Mountain Road. *Continue straight ahead on USFS Road 2209.* Evans Mountain is named for a mysterious prospector known as "Old Man Evans" who was found tortured and murdered on his claims. Local legend has it that Evans was finding sufficient gold to support an elegant life style. As in all such mining legends, the location of his "mother lode" has not been found. This legend and others of the area are recounted by Roberts (date unknown) in her book, *Elkhorn and Mehama: True Stories of Oregonians of the North Santiam*, which is usually available in the general store in Mehama.

38.4 mi (1.1 mi) Bridge over Henline Creek. North of USFS Road 2209 are abandoned workings on the Capital claim. The claim was patented as early as 1893. Most of the workings were caved by the 1930's. Veins have an average strike of N. 50° W. and dip of 75° to 80° SW. The veins are composed of a breccia of silicified andesite containing sericite and mesitite, an iron-magnesium carbonate. The breccia is cemented with stringers and veinlets of quartz with sulfides, chiefly sphalerite. There is minor galena and chalcopyrite (Callaghan and Buddington, 1938).

The Crown Mine, located to the south on the north flank of Elkhorn Mountain, was developed around 1927. Several veins were crossed in altered andesite, tuff, and volcanic breccia. A rhyolite is encountered near the contact of an intusive quartz diorite at the south end of the main crosscut. The Blind, Salem, Thirteen-Foot, and Winze Veins are along brecciated zones in which minor chalcopyrite, pyrite, and minor sphalerite are located within wall rocks mapped as tourmaline hornfels. These weakly mineralized veins strike from N. 55° W. to N. 60° W. (Callaghan and Buddington, 1938).

39.1 mi (0.7 mi) Intersection of USFS Roads 2207 and 2209. *Stay on USFS Road 2209 straight ahead at this intersection.* The road continues to follow the glaciated valley of the Little North Santiam River.

39.5 mi (0.4 mi) The area between this outcrop and the Ruth Mine was mapped by Olson (1978), who concentrated on the mineralization and alteration associated with breccia pipes in the area. Olson informally divided these rocks into upper and lower members of the Sardine Formation, and the lower member crops out along the road. The rocks in the major road cuts are andesite tuffs and contain accretionary lapilli, abundant lithic fragments, possible pumice fragments, and crystal clasts.

Epidote-lined fractures are present in the outcrop, and the common occurence of epidote in the tuffs is indicated by their yellow-green color.

39.7 mi (0.2 mi) The lithic-crystal tuff exposed in these road cuts contains accretionary lapilli.

41.5 mi (1.8 mi) Road crosses Stack Creek. To the north is a scenic view of the twin stacks on Henline Mountain.

42.8 mi (1.3 mi) The road is very narrow and on the edge of a steep cliff into Horn Creek.

42.9 mi (0.1 mi) Road crosses Horn Creek after passing through a large pile of unconsolidated debris of glacial origin. The Black Eagle Mine is located at this point.

43.4 mi (0.5 mi) Gate at the west edge of the claim block controlled by the Shiny Rock Mining Company. *At this point park your car and proceed on foot. The Shiny Rock Mining Company is attempting to preserve the historic mining artifacts of the district, and your cooperation is appreciated. For your safety, avoid open mine adits, many of which are not maintained and are unstable.*

43.8 mi (0.4 mi) Bridge over Gold Creek.

43.9 mi (0.1 mi) **Stop 1.** A short side road leads to the adit of the Santiam 1 Mine on the Little North Santiam River. This

Stop 1. The adit of Santiam 1 Mine is one of hundreds of mine adits and prospects in the North Santiam mining area.

mine has also been known as the Minnie E. and the Lotz-Larsen at various times in its history. Most of the development work was done in 1915-1917, with some ore shipped in 1924. The vein strikes N. 43° W. and dips 50° to 80° NE. and has been mined on both sides of the river. Ore minerals are distributed along the vein, but there are four distinct narrow ore shoots. Chalcopyrite is the principal ore mineral; pyrite and sphalerite are subordinate. Ore grades ranged from 1.25 to 4.47 percent copper and 0.1 to 1.22 oz of gold per ton. Locally the vein was up to 35 cm wide and composed primarily of chalcopyrite (Callaghan and Buddington, 1938).

The waterfall developed where the altered rocks of the vein were less resistant than the surrounding rocks. When the water level is low, the vein can be seen on the downstream end of the plunge pool. Waterfalls are common throughout the district and serve as one means of locating veins.

Stop 1. The Minnie E. Vein on which the Santiam 1 Mine adit is located crosses the Little North Santiam River and has been mined on both sides. Waterfalls such as the one in this photo commonly form where streams are able to downcut easily into the altered rock of the veins.

44.0 mi (0.1 mi) Whetstone Mountain trailhead. The trail, which is not included as part of this log, proceeds north along Gold Creek and then east along the ridge to the top of Whetstone Mountain. This well-maintained trail makes a scenic side trip, but it is over 5 mi to the top and moderately steep, with no water. The top of Whetstone Mountain can also be reached from the Clackamas River drainage. Maps are available from the Ripplebrook Ranger Station.

44.3 mi (0.3 mi) **Stop 2.** Half bridge along the north bank of the Little North Santiam River. An intrusion of porphyritic diorite forms a prominent cliff. Phenocrysts up to 8 mm long of blocky- to prismatic-shaped plagioclase comprises 15 percent of the rock. The dike has vesicles that have been filled by quartz. Plagioclase is altered to epidote, and hornblende is replaced by chlorite. The dike intrudes a lithic-crystal tuff, and xenoliths are common along its margins.

44.4 mi (0.1 mi) The Golden Bear mine workings are in a vein of the Santiam group of claims. This adit is located in what Olson (1978) mapped as a tourmaline-bearing breccia pipe. The rocks are brecciated, silicified, and sericitized. An adit has been driven into the alteration for nearly 270 ft along a bearing of N. 35° W. (Oregon Department of Geology and Mineral Industries, 1951).

44.7 mi (0.3 mi) This porphyritic diorite intrusion was mapped by Olson (1978) as an intrusion genetically related to the large intrusion located in the center of the mining area and dated at 13.4 m.y. B.P. (Power and others, 1981a). This intrusion follows a N. 30° W. trend along its eastern margin but is strongly sheared on a N. 10° W. trend on its western margin. This same relationship occurs for the porphyritic diorite dike near the Level 5 portal of the Ruth Mine.

45.4 mi (0.7 mi) The collapsed buildings to the south of the road are part of the Merten sawmill built in 1943. Two steam-driven capstans believed to have been salvaged from the battleship *Oregon* were used in this mill and remain on the site (Cox, 1985). One of the storage sheds is still standing near the east end of the mill site.

45.6 mi (0.2 mi) **Stop 3.** *Take the side road that crosses the Little North Santiam River on an old bridge to the south of the main road.* This road leads to the site of holes drilled by Amoco Minerals under lease agreement with Shiny Rock Mining Company. These holes are located in a cluster of tourmaline breccia pipes mapped by Olson (1978). The pipes, which are intensely altered and circular to elliptical in plan, range from 10 to over 100 m in length. Olson (1978) defined two types of breccia pipes: (1) shatter breccias of highly fractured rocks partially or completely altered to an assemblage of tourmaline, quartz, and sericite; and (2) "characterized by highly-altered angular to subrounded clasts cemented by quartz, sericite, tourmaline, oxides, sulfides, and rarely carbonate." In the first type of breccia pipe, there was little or no movement of fragments; in the second, the clasts have been displaced within the breccia. Zones of hydrothermal alteration extend 50 to 100

Stop 2. Half bridge, so called because the road is supported on one side by timbers and the other by the side of the valley, was required where the highly resistant rock of a large intrusion was encountered by the early miners in the North Santiam mining area.

m beyond the margins of the pipes. The last event in formation of the pipes was the filling of open-space veins with quartz.

Tourmaline occurs at this location as black rosettes, some of which surround chalcopyrite and are associated with secondary malachite. The best samples are found along the road and in small stream bed to the east. *Return to the main road.*

45.7 mi (0.1 mi) Lure No. 3 adit is developed beneath the level of the road. The rocks are brecciated and silicified. Rosettes of tourmaline occur in the silicified materials, and pyrite and chalcopyrite occur in the alteration zone.

46.6 mi (0.9 mi) **Stop 4.** Jawbone Flats, Oregon. This historic mining camp was built in the early 1930's and still serves as the operational headquarters for the mining activities in the district. *Please stay out of the buildings and away from equipment, and respect the historic artifacts that are present. On the east end of Jawbone Flats, a bridge crosses Battle Ax Creek about 0.25 mi north of where it joins Opal Creek to form the Little North Santiam River. Just across the bridge, a side road leads a short distance to the ore mill currently used by Shiny Rock Mining Company for processing ore from the Ruth Mine. Return to the main road.*

Stop 4. Jawbone Flats was constructed in 1932 as a mining camp and still serves as the operational headquarters for mining activity in the eastern portion of the North Santiam mining area. Of the 30 or so original buildings, about half are still in use.

46.8 mi (0.2 mi) **Stop 5.** At this site are the ruins of the original ore mill constructed by the Amalgamated Mining Company in 1932. This mill collapsed under heavy snows in 1949 (George, 1985). The original steam generator and other equipment are still visible. On the right side of the road was the old ore stockpile, and samples of ore from several of the veins in this part of the district can be found in this pile.

47.1 mi (0.3 mi) An unmarked trail leads to the left. This was an old tram road used to haul ore from the Ruth Mine to the mill. *Stay on the main road.*

47.5 mi (0.4 mi) A side road joins the main road at a sharp angle. In the stream bed of Battle Ax Creek below this point are several veins and adits of the Bueche Group of claims. The ruins of an old building are located on the north side of the road. *Stay on the main road.*

47.9 mi (0.4 mi) **Stop 6.** The road crosses a small tributary of Battle Ax Creek. Exposed in the road cut to the west of the creek is an outcrop of a quartz-feldspar porphyry intrusion. The rocks are nearly white in color, with an abundance of quartz and feldspar phenocrysts. To the east of the creek, an intrusion of equigranular diorite intrudes a tuff of Unit A. The creek is located on a fault, and alteration along this fault is visible in both intrusions. At the level of the tram road visible below, float from a collapsed adit suggests that this vein contains more

Stop 4. This operating ore mill located just south of Jawbone flats was constructed in part from equipment salvaged from earlier mills in the mining area.

chalcopyrite than is common in veins this far east in the district.

48.0 mi (0.1 mi) Road intersection. The road to the right leads to the adit of Level 4 of the Ruth Mine. *Stay to the left.*

48.1 mi (0.1 mi) Road intersection. **Stop 7.** The road that turns sharply to the left leads down to Level 5 of the Ruth Mine while the main road continues a short distance to a small creek. *Follow main road to small creek.* This creek, which is commonly called Ruth Creek, is downcut on the Ruth Vein. Adits have been driven on five levels of this vein. The open adit visible above the road is the fourth level and is collapsed where it encounters the vein. It was a primary producer of ore in the 1930's. Ore was removed by ore cart and dumped into a loading chute that is now collapsed at the road level. Ore samples from this adit can be collected in the stream.

Return to the road intersection. Take the steep lower road down to Level 5 of the Ruth Mine. A small roadcut along this road is located in a porphyritic diorite intrusion that is strongly sheared on its west margin. *When you reach the level of the tram road, STOP.* To the right is Level 5 of the Ruth Mine. This adit is being actively mined at present. *BEWARE of mining activities, and stay out.* Below the adit in the creek bed, an intrusion of quartz-feldspar porphyry cuts a coarse block breccia of Unit A. Just downstream, a dike of porphyritic diorite is visible as a resistant unit.

This concludes the trail log. Return to the main road and to your car by the same route. You may then return to Salem by the same route or take the optional route over French Creek Ridge.

OPTIONAL TRIP BEGINS AT INTERSECTION OF USFS ROADS 2207 AND 2209

At road log mile 39.1, take USFS Road 2207 to the southeast. Note: USFS Road 2207 is a logging road and not regularly maintained. It may be impassable in bad weather.

3.3 mi (3.3 mi) Bridge over the Little North Santiam River. On private land north of the road, Amoco Minerals Company has discovered a mineralized breccia pipe. The pipe is exposed in small outcrops on the north bank of Cedar Creek. Although discovery and drilling on the prospect were underway in 1981, no public announcement has been made, and no published information on the pipe is available.

5.1 mi (1.8 mi) Road crosses Cedar Creek.

5.5 mi (0.4 mi) Intersection of USFS Roads 225 and 2207. *Remain on USFS Road 2207 to the left.*

6.0 mi (0.5 mi) Intersection of USFS Roads 125 and 2207. *Stay on USFS Road 2207 to the right.*

9.2 mi (3.2 mi) Epidote-lined fractures are seen to cut rocks of the Sardine Formation in the roadcuts. The North Santiam mining area is approximately 3 mi to the north. Signs of hydrothermal alteration are common in the area, and epidote-lined fractures and propylitic alteration are typically noted.

10.2 mi (1.0 mi) A large dike crops out near where the road swings to follow the cirque wall to the east.

10.4 mi (0.2 mi) **Stop 8.** Overlook of Opal Lake, the headwaters for Opal Creek, which joins Battle Ax Creek at Jawbone Flats to form the Little North Santiam River. Opal Lake occupies a cirque, and Opal Creek plunges over a series of three falls for a total drop in elevation of nearly 170 m. The upper falls is less than 0.25 mi northeast of the lake. The outcrops at this stop are bedded pyroclastic rocks that are probably rhyodacitic in composition. On the basis of White's (1980b) lithologic descriptions, similar stratigraphic position, and elevation, it appears that these rocks are part of the Elk Lake formation. The outcrops are well-layered, coarse heterolithic fragmental units of weathered, light-colored units interlayered with dark-colored, fragmental units of uniform clast types. The rocks are cut by a zeolite-coated fracture set that trends N. 40° W. and dips 70° SW. The fracture orientation is a common orientation encountered in the North Santiam mining area. The volcaniclastic rocks are intruded by subvolcanic intrusions that cut the bedding at various angles.

11.6 mi (1.2 mi) White (1980b) mapped the crest of French Creek Ridge as the Elk Lake formation unconformably overlying rocks of the Sardine Formation. The thickness of the Elk Lake formation is 150 m at this locality. White defined two members of the formation: the lower consists of rhyodacitic flows and pyroclastic rocks, the upper of one or more thick flows of hornblende andesite. The pyroclastic units of the lower member are white or pale-pink crystal-lithic tuff; flows are light gray and generally are flow banded. These lavas were probably erupted from a vent complex at the southwestern end of French Creek Ridge. This vent complex is the knob immediately southeast of the road at the crest of French Creek Ridge. White indicates that a small dome can be seen to intrude and to overlie the Sardine lavas at this point. A spine that is 10 m high occurs near the center of the dome. The upper member of the Elk Lake formation overlies the rhyodacitic rocks in the prominent knobs northeast of the pass at Martin Buttes and Byers Peak. These prominences are underlain by a single andesitic flow that is 60 m thick and that displays a prominent colonnade. The andesites contain abundant phenocrysts of plagioclase and less abundant but common phenocrysts of augite. Hypersthene and remnants of probable amphibole crystals are sparsely present as phenocrysts. The Elk Lake formation overlies both the Sardine and Breitenbush Formations with strong angular unconformity. Two K-Ar whole-rock ages for rocks of the Elk Lake formation are 9.8±0.46 m.y. and 11.8±0.4 m.y. (White, 1980b).

13.3 mi (1.7 mi) **Stop 9.** At this switchback, medium- to coarse-grained quartz diorite dikes intrude fine-grained ash beds of the Sardine Formation. Hydrothermal alteration around the dikes has produced zeolitic alteration of the tuffs. Near the contact, the replacement is extensive but decreases in intensity away from the contact where the development of zeolites becomes confined to fracture fillings and breccia cement. Analysis by X-ray diffraction indicates that laumontite is the main zeolite present. The contacts of the dikes are chilled against the wall, and xenoliths of tuff are incorporated into the dike. Abundant fine-grained xenoliths occur in the dike but, except for those near the contacts, are not derived from the immediate wall rocks. The contact strikes N. 10° W. and dips 75° NE. Feldspar phenocrysts are strongly fractured, suggesting shattering such as might occur during hydrofracturing. These intrusions were emplaced at shallow depths.

14.2 mi (0.9 mi) Overview of Sardine Mountain, the type locality of the Sardine series as defined by Thayer (1939). Sardine Mountain is an eroded vent complex. Thin flows, bedded cinders, and radial dikes are considered to be a typical vent-facies assemblage exposed on the northern and western sides of the mountain (White, 1980b). On Hall Ridge immediately south of Sardine Mountain, flows are generally porphyritic, containing abundant plagioclase phenocrysts and lesser amounts of mafic phenocrysts. Most of the andesites have hypersthene and augite as phenocrysts. Lava flows compose from 50 to 70 percent of the formation in areas away from the vent complex. The rest of the formation is composed of lahars and lapilli tuff.

18.4 mi (4.2 mi) Intersection with USFS Road 2223. *Continue straight ahead.* The sharp turn to the right would take you up Sardine Mountain to Tumble Lake.

18.6 mi (0.2 mi) Intersection with Oregon Highway 22. *Turn right to return to Salem or left to go to the towns of Detroit, Breitenbush Hot Springs, or Bend.* □

BOOK REVIEW

by Daniel M. Johnson, Associate Professor of Geography, Geography Department, Portland State University, Portland, Oregon 97207

The Legacy of Ancient Lake Modoc: A Historical Geography of the Klamath Lakes Basin, by Sam and Emily Dicken, published by the authors, available from the University of Oregon Bookstore, 895 E. 13th, Eugene, OR 97403, or Shaw Stationery Company, 792 Main St., Klamath Falls, OR 97601. Price $10.

For nearly 40 years, geographers Sam and Emily Dicken have been exploring and studying their adopted state of Oregon. They have shared the results of these efforts with the public through a series of books and journal articles, beginning with the first edition of *Oregon Geography* published in 1950. In recent years we have been treated to *Two Centuries of Oregon Geography: Vol 1., The Making of Oregon* (1979) and *Vol. 2, A Regional Geography* (1982). Their work on the historical geography of Oregon has now been continued in a newly published book entitled *The Legacy of Ancient Lake Modoc: A Historical Geography of the Klamath Lakes Basin* (copyright 1985 by the authors). This book represents a delightful blend of the two disciplines, but it differs from the Dickens' earlier work in that it focuses on one region of the state, the Klamath Lakes basin of south-central Oregon. It amounts to a chronological description of both natural and human features, beginning with the period of exploration in the early 19th century and continuing to 1985. Throughout, the authors have given careful attention to the perceptions of the region by those who explored and settled it.

In the first chapter, the Dickens present an overview by the interesting technique of escorting the reader on an imaginary airplane flight. Only from this lofty perspective can the unity of the Klamath Lakes region be appreciated. As they point out, the "unifying feature is the lake plain, the bed of Old Lake Modoc," a Pleistocene lake whose shoreline was drawn for the first time by Sam Dicken in an article in the November 1980 issue of *Oregon Geology*. Modern lakes of the region, including Oregon's largest (Upper Klamath Lake), are remnants of this larger Lake Modoc. *(Continued on page 10, **Book Review**)*

ABSTRACTS

The Department maintains a collection of theses and dissertations on Oregon geology. From time to time, we print abstracts of new acquisitions that we feel are of general interest to our readers.

GEOLOGY OF THE GREEN MOUNTAIN-YOUNGS RIVER AREA, CLATSOP COUNTY, NORTHWEST OREGON, by Carolyn Pugh Peterson (M.S., Oregon State University, 1984 [thesis compl. 1983])

The upper Eocene to lower Oligocene Oswald West mudstone is the oldest formation (informal) in the Green Mountain-Young's River area. This 1,663-m-thick hemipelagic sequence was deposited in a low-energy lower to upper slope environment in the Coast Range forearc basin. The formation ranges from the late Narizian to the early Zemorrian (?) in age and consists of thick-bedded bioturbated foraminiferal claystone and tuffaceous siltstone. Rare glauconitic sandstone beds also occur. In the eastern part of the study area, the upper part of the Oswald West mudstone is interbedded with the upper Refugian Klaskanine siltstone tongue. This informal unit consists of thick bioturbated sandy siltstone and silty sandstone that is a lateral deep-marine correlative of the deltaic to shallow-marine Pittsburg Bluff Formation in the northeastern Coast Range.

Discontinuous underthrusting of the Juan de Fuca oceanic plate at the base of the continental slope of the North American plate caused extensive uplift and subsidence along the Oregon continental margin throughout the Cenozoic (Snavely and others, 1980). Initiation of Oregon Coast Range uplift and accompanying erosion in the early Miocene, coupled with a global low stand of sea level (Vail and Mitchum, 1979), stripped most of the Oligocene (Zemorrian) Oswald West strata and in places much of the uppermost Eocene (upper Refugian) Oswald West strata in the field area, creating an unconformity. Deformation accompanying uplift included a system of east-west-trending, oblique-slip faults.

The Pillarian to Newportian-age Astoria Formation unconformably overlies the Oswald West mudstone and reflects deposition offshore from an open, storm-dominated coast during an early to middle Miocene transgression. Deposition of the Big Creek sandstone and Silver Point mudstone members of the Astoria Formation was controlled in part by submarine paleotopography that developed as a result of early Miocene deformation of the Oswald West strata. The up-to-200-m-thick Big Creek member varies from storm-deposited laminated sandstone to bioturbated mollusk-bearing silty sandstone that accumulated during fair-weather conditions on the inner to middle shelf. Overlying and perhaps in part laterally equivalent to the Big Creek member is the up-to-200-m-thick, deeper marine Silver Point member which consists of two lithologies: (1) interbedded, micaceous, turbidite sandstones and laminated mudstone; and (2) laminated bathyal mudstone that intertongues with and caps the turbidite sequences. The turbidite lithology is composed of two facies: (1) an underlying sand-rich facies, transitional between the shallow-marine Big Creek member and bathyal Silver Point strata, that was deposited on the outer shelf by storm-induced turbidity currents; and (2) an overlying sand-poor facies that was deposited at bathyal depths. The turbidite facies channelized and at some places removed the underlying Big Creek member and was deposited directly over Oswald West mudstone. The Astoria depositional sequence ranges from inner to outer neritic to bathyal facies and reflects continued deepening and anoxic depositional conditions of the Astoria basin through the middle Miocene. Big Creek and Silver Point sandstone petrology reflects volcanic sources from an ancestral western Cascades volcanic arc and metamorphic and granitic basement rocks farther east via an ancestral Columbia River drainage system. Diagenetic effects include: (a) formation of local calcite concretionary cements; and (b) formation of pore-filling smectite from alteration of volcanic rock fragments.

At least six middle Miocene Columbia River Basalt Group intrusive episodes affected the Green Mountain-Youngs River area soon after deposition of the Astoria Formation. These basalt sills and dikes include normally polarized and reversely polarized low MgO-high TiO_2, low MgO-low TiO_2, and high MgO Grande Ronde basalt chemical subtypes and two porphyritic Frenchman Springs Member basalts (Ginkgo and Kelly Hollow(?) petrologic types). These basalt intrusions are virtually indistinguishable, based on chemistry, from subaerial flows of the plateau-derived Columbia River Basalt Group subtypes at nearby Nicolai Mountain and Porter Ridge. This correlation supports the Beeson and others (1979) hypothesis that the intrusions are not of local origin but formed by the invasion of the flows into the Miocene shoreline sediments to form "invasive" sills and dikes. Many dikes were emplaced along northeast- and northwest-trending faults, and some (*i.e.*, Ginkgo) cut older sills (Grande Ronde). A laterally extensive Frenchman Springs sill occurs under an older widespread Grande Ronde sill. From this older over younger intrusive relationship, a mechanism of "invasion" of sediment from overlying lava flows is difficult to envision.

A pulse of rapid subduction starting in the middle Miocene (Snavely and others, 1980) was accompanied by renewed uplift, intensive block faulting, and continued development of the earlier formed Coast Range uplift. Left-oblique northeast-trending faults and conjugate northwest-trending right-oblique faults offset Grande Ronde and Frenchman Springs dikes and sills. This conjugate fault pattern may reflect oblique east-west convergence between the North American and Juan de Fuca plates.

The Silver Point mudstones and Oswald West mudstones have high total organic carbon contents, up to 5.5 percent, but are thermally immature and may act only as a source for biogenic gas(?) in the subsurface. Suitable reservoir rocks, such as the gas-producing upper Eocene Cowlitz Formation Clark and Wilson sandstone, may pinch out before reaching the Green Mountain-Youngs River area and are yet to be penetrated by exploration drilling. Post-middle Miocene fault traps abound in the area, although these faults might also breach subsurface natural gas reservoirs in the Green Mountain-Youngs River area.

LANDSLIDE HAZARDS IN THE DALLES, WASCO COUNTY, OREGON, by Michael Hugh Sholin (M.S., Oregon State University, 1982)

Human activity has led to the reactivation of portions of a Pleistocene landslide complex in The Dalles, Oregon. Slope movements are in rocks of the Chenoweth Formation: agglomerate, conglomerate, tuff breccia, sandstone, and siltstone. Slope movements occur in at least two distinct areas in The Dalles. At one, the shear surface is defined by the contact between the Chenoweth Formation and the underlying Columbia River basalt. Data from inclinometer readings at the other area fail to reveal a well-defined shear surface. Slope movements in The Dalles cause tens of thousands of dollars worth of damage annually and may present a threat to human safety. So far, there has been little organized response to this hazard. ☐

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