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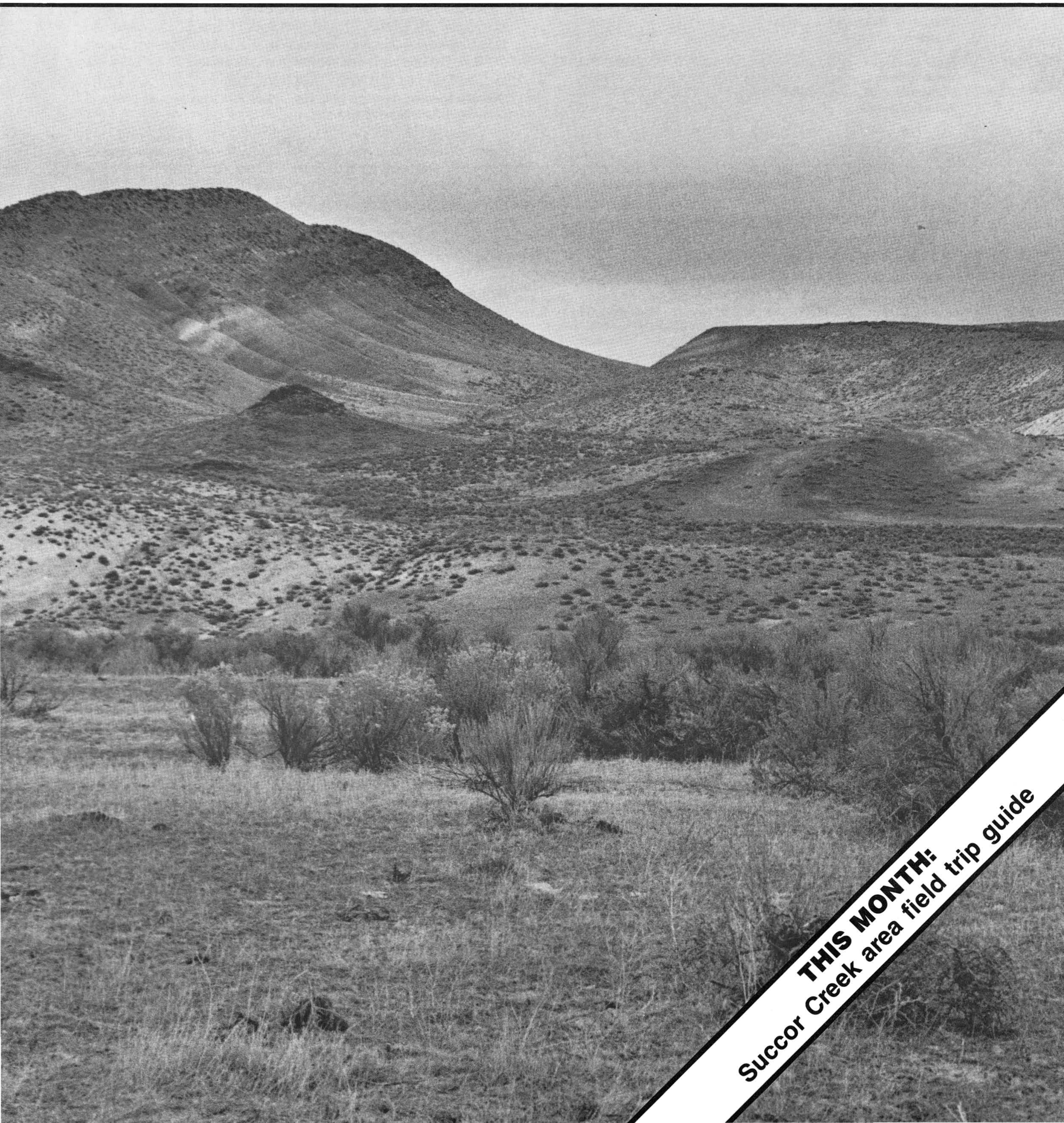

THIS MONTH:
Succor Creek area field trip guide

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Information for contributors

Oregon Geology is designed to reach a wide spectrum of readers interested in the geology and mineral industry of Oregon. Manuscript contributions are invited on both technical and general-interest subjects relating to Oregon geology. Two copies of the manuscript should be submitted, typed double-spaced throughout (including references) and on one side of the paper only. If manuscript was prepared on common word-processing equipment, a file copy on 5¼-in. diskette may be submitted in addition to the paper copies. Graphic illustrations should be camera-ready; photographs should be black-and-white glossies. All figures should be clearly marked, and all figure captions should be typed together on a separate sheet of paper.

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 bibligraphic 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

Looking north at boundary of Succor Creek State Park, the south side of Stop 3 of field trip guide beginning on next page. Slope on left exposes top of stratigraphic column of the Sucker Creek Formation with gravels at the top. Knoll left of center is a basalt dike. Area in photo is cut by north-south-trending and northwest-southeast-trending faults.

Map summarizes data on geothermal-resource area at Newberry Crater

A new map published by the Oregon Department of Geology and Mineral Industries (DOGAMI) provides information on geothermal exploration in the Newberry Crater area.

Newberry Crater Geothermal Resource Area, Deschutes County, Oregon, by DOGAMI staff members Dennis L. Olmstead and Dan E. Wermiel, has been released as DOGAMI Open-File Report O-88-3. The blackline ozalid print is approximately 36 by 52 inches large and uses a topographic base at the scale of 1:24,000. It covers the area in and around Newberry Crater, the locations of past and future geothermal drilling activity.

The map contains detailed information, such as location, total depth, date, name of operator, and status, for all geothermal wells drilled or proposed as of January 1988. It also outlines the areas that are considered suitable or unsuitable for drilling and those that are closed or restricted with regard to geothermal exploration.

Over the years, Deschutes County and, particularly, Newberry Crater have been the focus of strong interest in geothermal energy. Temperature-gradient wells have been drilled since the 1970's in attempts to determine whether an economical geothermal resource occurs in the area. The new DOGAMI map is intended as a summary of past drilling activity as well as a guide for future planning. It will be updated periodically to reflect new drilling activity or changes in area restrictions.

The new release, DOGAMI Open-File Report O-88-3, is available now at the Oregon Department of Geology and Mineral Industries, 910 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201. The purchase price is $5. Orders under $50 require prepayment. □

MMS to sponsor workshop in Portland

The U.S. Department of the Interior, Minerals Management Service (MMS) is sponsoring a conference/workshop on recommendations for studies in Washington and Oregon relative to offshore oil and gas development. The conference will be held in Portland, Oregon, on May 23-25, 1988. Conference participants will identify and develop recommendations for future studies concerning offshore oil and gas development activities.

Discussion topics will include air quality, physical oceanography/meteorology, fates and effects/chemistry, biology/ecology, sea birds, marine mammals, and socioeconomics.

The meeting will (1) summarize available information on environmental processes of the outer continental shelf (OCS) off Washington and Oregon; (2) identify subject areas in which additional information is required for reasonable understanding and prediction of the environmental effects of oil and gas development activities in this area; (3) develop recommendations for the MMS Environmental Studies Program to deal most effectively with information gaps related to the environmental impacts in this planning area; and (4) improve awareness of the scientific work being conducted in the Washington and Oregon OCS Planning Area.

Inquiries regarding the conference should be directed to Bio/Tech Communications, MMS-OCS Conference Planners, 600 SW 10th Avenue, Suite 418, Portland, OR 97205.

--Bio/Tech news release

Geologic field trip guide to the northern Succor Creek area, Malheur County, Oregon

by David C. Lawrence, Department of Geology and Geophysics, Boise State University, 1910 University Drive, Boise, Idaho 83725

INTRODUCTION

This field trip guide describes interesting and unusual geologic features in Miocene volcanic and sedimentary rocks of the Sucker Creek Formation (Kittleman and others, 1965, p. 6) that are exposed between the town of Adrian, Oregon, and the Succor Creek State Park. The guide, which supplements an earlier guide to the geology of the Owyhee region (Kittleman, 1973), was designed to introduce this interesting area both to geologists and to lay readers and may also be used by earth science teachers and students. Major points of interest include basalt and rhyolite flows, pillow lavas, hyaloclastites, leaf and mammal fossils, and fault breccias.

The area is accessed from Oregon State Highway 201. Nearby towns are Homedale, Idaho, and Adrian, Oregon (Figure 1). Take Highway 201 south from Adrian and turn off at the "Succor Creek State Park" sign onto an all-weather country gravel road leading south. This turnoff is 8.1 mi from Adrian and 7.1 mi west of Homedale. During wet weather, do not leave the gravel road. Much of the area off the gravel is made hazardous by soft clay soil that

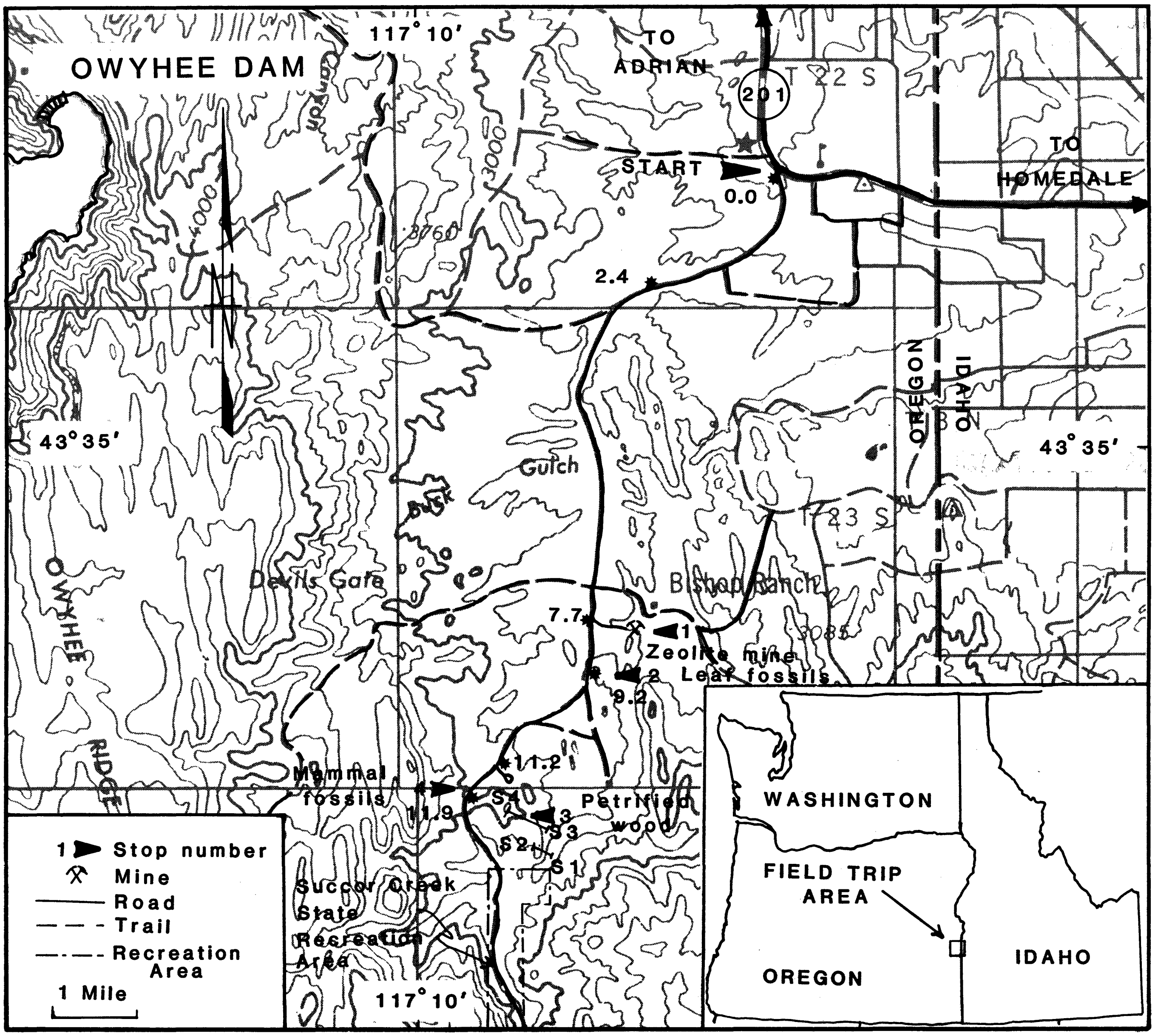

Figure 1. Map along the Oregon-Idaho border, showing field trip route and location of stops described in the text. Asterisks indicate cumulative mileage check points along the trip route. Lines S1-S2 and S3-S4 locate the traverse along which the stratigraphic section of Figure 4 can be observed.

becomes soft and sticky when wet and will immobilize even the hardiest of motor vehicles.

REGIONAL SETTING

Rocks of the Sucker Creek Formation comprise a thick sequence of fluvial and lacustrine sediments predominantly from volcanic source areas. Interbedded are silicic and basaltic intrusive and flow rocks. Outcrops of the formation are distributed in Malheur County, Oregon, and Owyhee County, Idaho (Kittleman and others, 1967; Ekren and others, 1981). The geologic history recorded by these rocks is intriguing because the area lies at the juncture of several major geologic provinces of the northwestern United States. These provinces are the northern Basin and Range, the Columbia Plateau, the Snake River Plain, and the Owyhee Uplands-High Lava Plains.

The geologic characteristics of these provinces were determined primarily by volcanism and tectonic movements during the Miocene epoch. The stratigraphic position of the Sucker Creek Formation with respect to better known geologic units of these provinces is shown in Figure 2. The age of the entire Sucker Creek section is known only approximately, and interpretations of the age may change as the formation is more thoroughly studied. The formation clearly underlies the Owyhee Basalt dated between 13.1 and 15.3 million years (m.y.) (Brown and Petros, 1985). A 3,200-ft-thick section of fluvial and lacustrine sediments similar to the Sucker Creek Formation lies beneath Miocene basalt that may be Columbia River basalt under the Snake River Plain (Wood, 1984, p. 54). The relation of the Sucker Creek Formation to older units of the Columbia River Basalt Group is not well understood, but these sediments appear to occupy a north-south-trending structural trough that was also in existence during the time of earliest eruptions of Columbia River basalt lava flows. Recent studies (Rytuba and others, 1985; Vander Meulen and others, 1987a) have identified a large peralkaline rhyolite caldera complex 17 mi south of the map area. Peralkaline classification refers to igneous rocks with a proportion of alumina that is less than the sodium and potassium oxides combined. Major ash-flow tuff units (tuffs of Leslie Gulch and others) within the Sucker Creek Formation were erupted from this complex 15 to 16 m.y. ago.

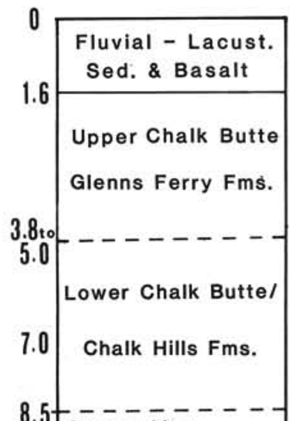

Figure 2. Comparison of generalized Jordan Valley-Owyhee River region showing the Sucker Creek Formation with a tentative age of between 14.0 and 16.5 m.y. Regional stratigraphy is modified after Hart and others (1985) and Armstrong and others (1980). JCR = Jump Creek rhyolite; JMVC = Juniper Mountain volcanic complex; LG = Leslie Gulch ash-flow tuff; OB = Owyhee Basalt; SCR = Silver City rhyolite.

In a regional study of volcanic rocks, Hart and others (1985, p. 6) tentatively placed the Sucker Creek Formation age between 14.0 and 16.5 m.y. The formation is overlain by the Jump Creek Rhyolite dated by Armstrong and others (1980, p. 5) at 11.1±0.1 m.y. Ekren and others (1982, p. 217) show that part of the Sucker Creek Formation in Owyhee County in Idaho overlies an upper rhyolite, rhyolite porphyry flow, dated by Armstrong (1975, p. 9) at about 15.6 m.y., which appears to be the rhyolite of Silver City Range dated by Ekren and others (1981) at 16.0±0.3 m.y. The tuffs of Leslie Gulch, which are thought to be in about the middle of the Sucker Creek Formation, are dated at 15.8±0.6 m.y. (Ekren and others, 1984, p. 10) and 15.5±0.5 m.y. (Vander Meulen and others, 1987a,b). Outcrops of the tuffs of Leslie Gulch, as mapped by Kittleman and others (1967), terminate approximately 2 mi south of the area of this report and have not been specifically related to the geologic section described here. Within the area of this report is the basalt at Bishop's Ranch, which Kittleman and others (1967) placed near the base of the Sucker Creek Formation. This basalt, as mapped by Kittleman and others (1967), is the same basalt as shown in Figure 3. Kittleman and others (1965, p. 6) described this basalt body as a possible equivalent to the one described about 19 mi south of Bishop's Ranch and radiometrically dated at 16.7 m.y. by potassium-argon dating (Evernden and James, 1964, p. 971, sample KA 1285).

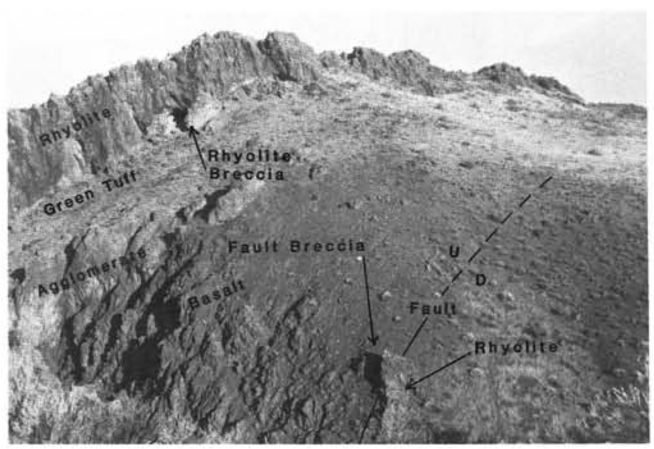

Figure 3. View looking north of zeolite pit. Fault breccia can be seen along the north-south-trending normal fault. West footwall is basalt. The upper zone of the basalt is an agglomerate. Claystone lacustrine sediments overlie basalts. Flow-banded rhyolite overlies the claystones. Volcanic rhyolite breccia and shallow caves are located near the bottom of the rhyolite.

LOCAL STRATIGRAPHY

The oldest strata of the Sucker Creek Formation in the area are bentonitic claystones of a fluvial and lacustrine environment. Conglomerates and gravels interbedded with claystone comprise the upper Sucker Creek Formation within the area of the road log. These coarse sediments indicate that active stream systems coexisted with the lacustrine environment during the later part of time represented by this local section. A system of olivine basalt dikes later invaded this part of the Sucker Creek Formation. Contrary to initial impressions, the low-lying green tuffs of Spring Creek are not the oldest strata in this area. According to current interpretation by James Rytuba, Dean B. Vander Meulen, Thomas L. Vercoutere, and Scott A. Minor of the U.S. Geological Survey (USGS) and unpublished mapping by Mark Ferns of the Baker Field Office of the Oregon Department of Geology and Mineral Industries (DOGAMI), the green tuffs and glassy welded tuffs are caldera-fill material that washed over the older **bentonitic claystones** and have subsequently been downfaulted. Because the green tuff section is faulted against the bentonitic claystone section in this area, stratigraphic relationships have not yet been determined. The tabular basalt unit within the green tuff (Figure 4) has been interpreted as a flow by some geologists and as an intrusive sill by others. In this area of the field trip guide, the Sucker Creek Formation also contains rhyolite and basalt flows and intrusives.

In 1965, Kittleman and others indicated that the type section for the Sucker Creek Formation was 590 ft thick in secs. 28 and 33, T. 24 S., R. 46 E., about 6 mi south of the road log area, and that a section exposed at Owyhee Reservoir may be 1,600 ft thick. Wood (1984, p. 54) indicates the Sucker Creek Formation is about 3,200 ft thick at a well drilled by Chevron-Halbouty in the western Snake River Plain. The mapped section in the area includes at least 780 ft of tuffaceous sedimentary units (Lawrence, 1986, p. 25). As this guide shows, the Sucker Creek Formation contains a variety of volcanic and sedimentary facies. No one type section can be considered typical. No good marker beds have been established. There is clearly a need for detailed mapping to establish lithostratigraphic units of the Sucker Creek Formation and to provide a basis for understanding the basin evolution. It is hoped that this guide will encourage continued detailed studies of the formation.

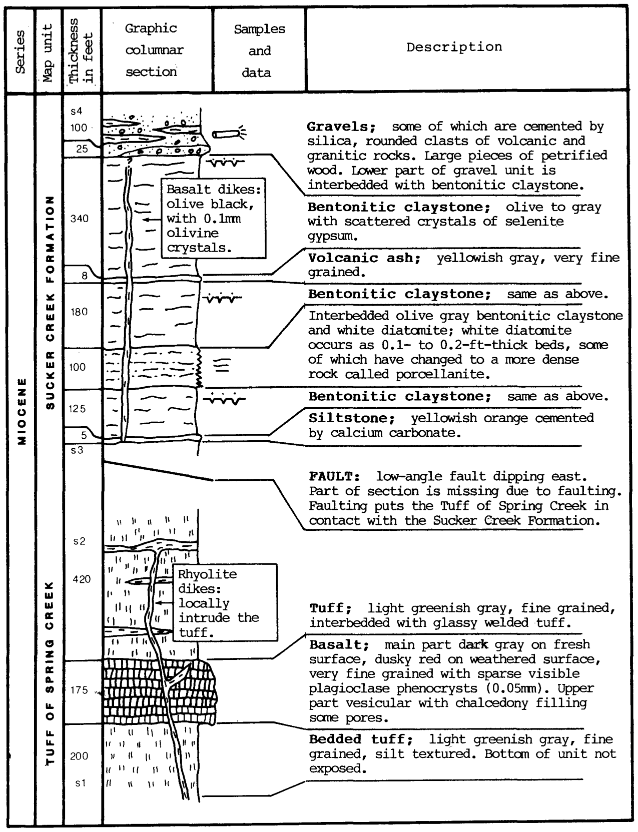

Figure 4. Columnar section for part of the Sucker Creek Formation based on unpublished 1:12,000-scale geologic mapping by Lawrence (1986). This section is located in NW¼ sec. 5 and NE¼, sec. 6, T. 24 S., R. 46 E., Malheur County, Oregon, in the road log area (Figure 1). Although the green bedded tuffs appear topographically low at the bottom of the section, regional mapping by the USGS and DOGAMI suggests that the tuffs are younger than the topographically overlying sedimentary rocks. Interpretation of the relationship of the younger bedded green tuff of Spring Creek to the older sedimentary rocks in the Sucker Creek Formation and the intervening caldera-forming event is from the current geologic mapping and interpretation by Dean B. Vander Meulen, James J. Rytuba, Thomas L. Vercoutere, and Scott A. Minor of the USGS and Mark Ferns of DOGAMI. Gravels and conglomerates locally cap the section of the Sucker Creek Formation in the area of the road log.

ROAD LOG

0.0 *Begin at State Highway 201 and the sign "Succor Creek State Park" showing the turnoff to a gravel road leading to the field trip area (Figure 1). Mileage of the road log starts at the Succor Creek State Park sign and is cumulative throughout the field trip. Travel south on the public gravel road, which is normally well maintained for hauling bentonitic clays from the Teague Mineral Company pits.*

2.4 Owyhee Ridge is on the skyline directly southwest. Owyhee Ridge was described by Kittleman (1973) as being composed of Owyhee Basalt. Kittleman recorded the Owyhee Basalt as a thick, multiple-flow unit of olivine-poor basalt that overlies the Sucker Creek Formation near Owyhee Dam. The basalt seen on the skyline clearly overlies the Sucker Creek Formation and is probably Owyhee Basalt as described by Kittleman and others (1965). Current mapping by Mark Ferns (personal communication, 1987) suggests it may also be an unnamed sequence in the uppermost Sucker Creek Formation.

7.7 STOP ONE. Zeolite mine 0.3 mi to the east. A short side road leads to an open-pit zeolite mine. Glen Teague, of Teague Mineral Products located 2 mi south of Adrian, operates the mine and should be contacted for permission to visit the mine prior to entering the area. Parking is available on the northwest side of the mine.

Just south of the parking area, basalt lava flows overlie the zeolite deposit (Figure 5a). At this locality, the basal part of the basalt sequence is composed of pillow lavas. Glassy skins enclose the pillows (Figures 5b and 5c), indicating sudden chilling of molten basalt as it flowed underwater. Around the pillows is fine-grained yellow-brown material formed by decrepitation of the lava surfaces into water, producing a material called hyaloclastite. The yellowish-brown color in the hyaloclastite is from glassy basalt shards that have been altered to palagonite. Palagonite is an isotropic mineraloid formed by hydration and devitrification of basaltic glass.

North of the parking area and across Camp Kettle Creek Canyon are prominent cliff-forming rhyolites (Figure 3). To observe features of the rhyolite flow, make a 20-minute descent and ascent across the canyon. Walk from the parking area east to a fence and follow the fence to the bottom of the canyon. Caution should be taken on the steep rocky hillside. You cross a north-south-trending fault shown in Figure 3 as you head west up the bottom of the creek toward the rhyolite. The fault plane dips 67° to the east. Geologic mapping by Squires (1985) indicates this is a normal fault with the downthrown block toward the east. Fault breccia contains fragments of wall rock crushed by repeated movements in late Cenozoic time. The footwall block, which is west of the fault, is basalt. The fault zone contains an enigmatic layer of rhyolite approximately 8 ft thick that is inclined at the angle of the fault plane. Basaltic footwall fragments occurring within the rhyolite were probably incorporated into it during its emplacement into the fault zone. This coherent mass of rhyolite could be either a sliver of sheared rhyolite in the fault zone or a viscous rhyolite dike intruded into the fault zone.

Basalt of the footwall block is very fine grained and massive. This massive basalt exposed in the canyon is at least 50 ft thick and probably much thicker. The upper 15 ft is a basalt agglomerate. The massive basalt grades almost imperceptibly upward into the agglomerate. The agglomerate becomes more fragmental upwards, and

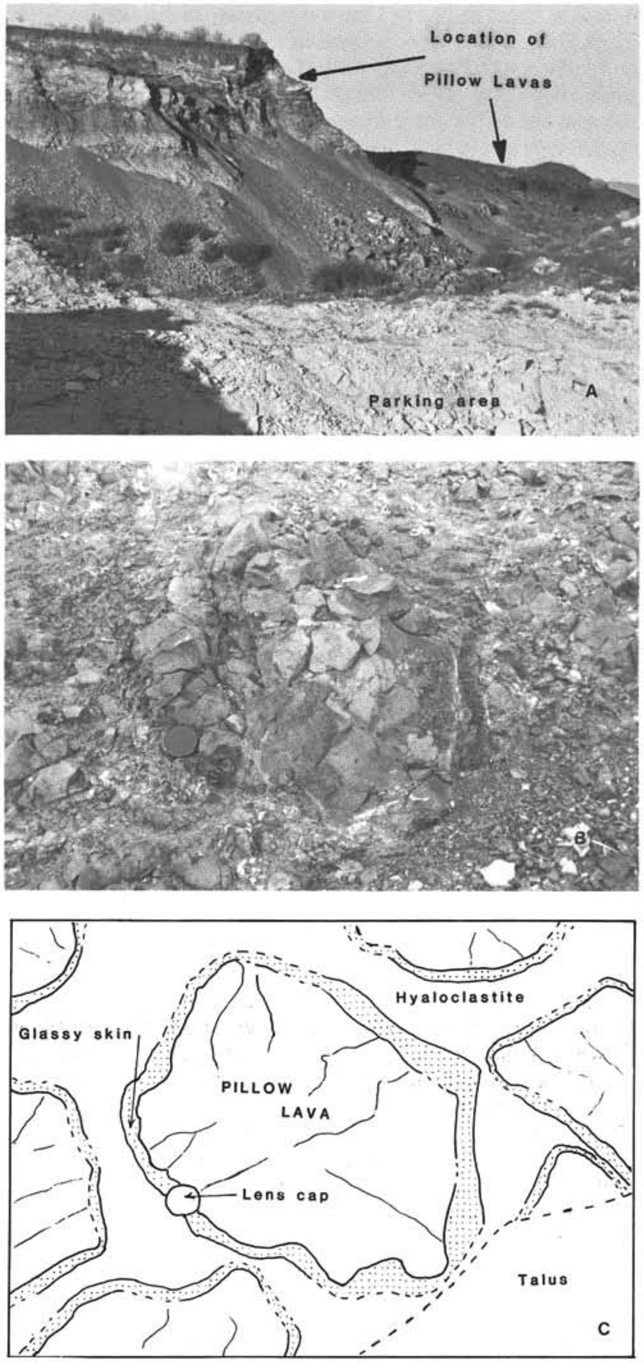

Figure 5. Pillow lavas at the zeolite mine. A. Looking south from the parking area, where pillow lavas are overlying the zeolite bed in the foreground. Zeolite shows bedding of the original volcanic-ash beds (white laminae) that underlie the basalt. B. Photo of a basalt pillow taken on the west face of the outcrop shown in Figure 5A. C. Interpretive sketch of Figure 5B showing cross section of pillows embedded in the hyaloclastite. Sudden chilling formed glassy skins, and spalled debris formed the hyaloclastite. Radial joints are crudely columnar.

the upper 8 ft is clearly a breccia with a fine matrix. This uppermost zone of the breccia has a dusky yellow matrix with inclusions of basalt and water-altered lake sediments.

The sequence of basalt grading upward to a breccia with included siltstones suggests that lavas were erupted over lacustrine sediments, flowing out and then burrowing down into the sediments. Also, the absence of red oxidation colors indicates an oxygen-poor environment, suggesting that some of the lava eruption may have occurred beneath an existing lake.

Overlying the basalt unit is a yellowish-gray to pale yellowish-brown volcaniclastic siltstone grading upward into a green tuff, which is then overlain by the cliff-forming rhyolite. Celadonite, a soft earthy-green to gray-green mineral, gives the tuffaceous unit its green color (Odom, 1984, p. 545). Celadonite is a very fine-grained mineral of the mica group and appears to replace fine glass fragments and pumice.

Walk about 230 to 260 ft up the hill to the north along the bottom contact of the rhyolite. Flow-banding is common in the lower zones of the rhyolite where the lava swirled and flowed over an uneven surface. Volcanic breccias and shallow caves occur near the bottom of the rhyolite. These features can be seen by following the cliff-forming unit north. Figure 6 shows a volcanic breccia with clasts of preexisting country rock (tuff) and clasts of the rhyolite flow rock. Siliceous deposits formed by precipitates of presumably warm ground water can be observed in the joints of the rhyolite along the cliff.

Figure 6. Rhyolite volcanic breccia shown in Figure 3. Preexisting country rock (tuff) and tuff clasts are included in the rhyolitic breccia.

Return to the zeolite mine parking area. The zeolite bed in the pit contains interbedded hard siliceous jasperoid zones near the upper part. The presence of jasperoids with zeolites suggests a low-temperature (50° to 100° C) hydrothermal alteration. The jasperoid breaks with a subconchoidal fracture, and some gem-quality "picture jasper" has been collected from here by rockhounds.

The zeolite in the quarry is apparently an authigenic (formed in place) silicate mineral. Sheppard and Gude (1983, 1987) indicate shards of silicic glass deposited as a volcanic ash layer in a freshwater lake environment that is highly saline and alkaline typically alter to the zeolite mineral clinoptilolite $(Na_4K_4)(Al_8Si_{40}O_{96})\cdot 24H_2O$ (Mumpton, 1977, p. 5). The glass was probably altered by flowing or percolating ground water to form the zeolite mineral.

Leppert (1986, p. 496) indicates that clinoptilolite mined here can be used commercially to absorb many organic and inorganic compounds. In this way, zeolites are used to control pollutants in air and water. They appear to provide cost-effective solutions to some environmental problems associated with hazardous waste.

Return to the main gravel road and turn left heading south to Stop Two.

9.2 STOP TWO. Leaf fossils in the Sucker Creek Formation. Leaf fossils are common in white siltstone of the Sucker Creek Formation. Park along the side of the road and walk down the draw to the southeast (S. 70° E.) to a leaf fossil area. To the east of the road, where the vehicle is parked, are two dry stream beds with a low ridge between them. Near the confluence of the streambeds, about 600 yd southeast of the main gravel road, is the fossil area. Fossils are not plentiful, but a diligent search should produce two or three good specimens of leaf fossils similar to the one in Figure 7 in hard siltstone slabs. These sediments must have accumulated rapidly, so that delicate leaves were protected from circulating water and organisms that would have consumed or decayed them.

Figure 7. Fossils such as this deciduous-tree leaf fossil can be found at Stop Two and at many other locations of slabby white siltstone in the Sucker Creek Formation, as indicated in the Succor Creek road log.

Most common leaf fossils in the Sucker Creek Formation are forms of *Cedrela* (South American cedar), *Quercus* (oak), and *Populus* (cottonwood), illustrated in Orr and Orr (1981, p. 33), who also mention (p. 32) that Graham (1965) pointed to the presence of *Cedrela* as indication that the minimum temperatures of the environment where *Cedrela* grew did not dip below freezing, an interesting contrast to the present climate.

Return to the vehicles and head south to Stop Three (Figure 1).

11.2 STOP THREE. Petrified wood in conglomerates. Two short dirt tracks head to the east (Figure 8). If the area is dry and no rainstorms appear threatening, drive east on the second dirt track and follow it 0.2 mi to an area where there is room to turn around (Figure 9); otherwise walk there. This is Stop Three. Walk approximately 1,300 ft to the top of the hill. About 120 ft vertically below the top of the hill is a conglomerate layer bearing the petrified wood shown in Figure 10. This petrified wood is a result of silica replacement of woody material. Silica is deposited from solution and preserves the cell structure of the wood. We ask that visitors not pick at this particular stump. Abundant petrified wood occurs elsewhere in the conglomerate and float in the area.

Gravel and conglomerate cap the hills along this area of Succor Creek. Conglomerate beds are interfingered with uncemented gravels and bentonitic claystones and are a part of the Miocene Sucker Creek Formation. Gravel beds strike to the northwest and southwest and dip 24° to the west. The total thickness of the original deposits cannot be determined because the upper part is eroded away. The mapped thickness of the conglomerates is over 100 ft, with the basal conglomerate resting on bentonitic claystone forming the lower contact in many areas of the road log.

The conglomerates are poorly sorted, but clasts are rounded, with a mixture of sizes ranging from boulders to sand. The coarse fluvial conglomerates and gravels intertongue with lacustrine claystones above the petrified-wood locality shown in Figure 10 at Stop Three. Coarse gravels and conglomerates containing petrified wood are interpreted to be evidence of high-energy stream systems. Claystones interfingering with the gravels and conglomerates indicate that a nearshore lake environment existed here at one time. Fragments of petrified wood contained in younger gravels capping many hills are probably reworked materials from these conglomerates.

Return to the parking area and head toward Stop Four.

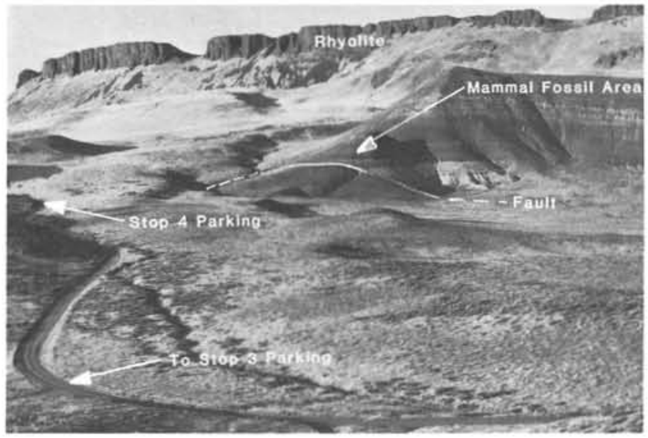

Figure 8. Geologic relationships at Stop Four. View is to the west. Turnoff to Stop Three is at lower left corner of photo. Sucker Creek Formation shows zones of sediments and bentonitic claystones that appear to be capped by an overlying rhyolite. Recent unpublished mapping by Mark Ferns of DOGAMI has shown that these rhyolites are a dome complex locally overlying the section of Sucker Creek deposits discussed in this paper. Sedimentary beds are diatomaceous bentonitic claystones and volcanic ash. Fragments of mammalian vertebrate fossils occur where the arrow points.

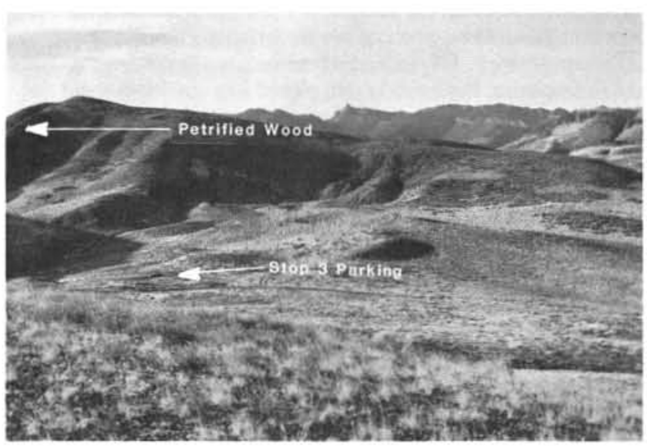

Figure 9. Geologic relationships at petrified-wood area and parking for Stop Three. View is to the south. Gravels and conglomerates that contain petrified wood cap the hill south of the parking area.

Figure 10. Petrified wood in conglomerates. This petrified wood is at the location where the arrow points in Figure 9. Poorly sorted conglomerate beds dip 24° to the west. This petrified wood appears to be a remnant of a horizontally lying tree stump with a root visible below the pen.

11.9 STOP FOUR. Mammal fossil area. The area in which a few fragments of mammal fossils have been found can be reached by parking alongside the road and walking to the mammal fossil area shown in Figure 8.

Pieces of fossilized mammal bones are in bentonitic claystones. Beds of bentonitic claystone weather to popcornlike material. Gypsum crystals ($CaSO_4 \cdot 2H_2O$) associated with the claystone are found scattered over the surface. These claystone beds are interlayered with diatomaceous claystones and volcanic ash. Bentonitic claystones are derived mostly from volcanic glass shards that formed the vast majority of the original sediments in the lakes.

Both bentonitic clay and clinoptilolite zeolite are formed by alteration of rhyolitic volcanic ash. Whether the fine ash particles alter to bentonitic clay or zeolite depends upon both salinity and alkalinity of the water altering the volcanic ash. In extremely alkaline and saline water, the volcanic glass alters to clinoptilolite zeolite (Surdam, 1977, p. 65). In fresher waters, volcanic glass alters to bentonitic clay. The exact chemical conditions and the length of time over which these alterations of glass occur are not completely understood. After deposition of rhyolitic volcanic ash in fresh water, the ash hydrates and releases silica and alkalies during the alteration of glass to clay minerals. Bentonitic clay is primarily montmorillonite clay (Leppert, 1986, p. 496). The montmorillonite clay puffs and swells when it absorbs water. When the clay dries, it forms the popcornlike texture that characterizes the surface. If you dig 1 or 2 ft beneath these popcornlike surfaces, you can see the original compact claystone.

Leppert (1986, p. 497) indicates bentonite is used in drilling fluids and in foundries. Bentonite is also placed as a sealant to water flow beneath hazardous-waste sites. Open-pit mines in the area produce good-quality bentonite that is currently marketed mostly for sealant.

Mammalian vertebrate fossil remains (Figure 11) are not abundant in the Sucker Creek Formation, but some good specimens have been collected. *Oreodonts*, "even-toed" hooved mammals that were about the size of a pig, were recovered about 6 mi south of Stop Four (Walden, 1986, p. 41; identification by Greg MacDonald, Idaho Museum of Natural History). Walden also indicates that a *Merichippus*, a Miocene horse, was found near Succor Creek south of Stop Four, the mammal fossil area. Both of the mammals were grazers, which implies an environment of grasslands near a lake.

The colorful canyon at Succor Creek State Park is about 1 mi south of Stop Four. Tables are located about 5 mi south of the recreation area boundary, and this is a nice place to have lunch. Those wishing a geologic guide farther up Succor Creek Canyon should consult Kittleman (1973).

ATTENTION

Glen Teague should be contacted at Teague Mineral Products, 1925 Highway 201 South, Adrian, OR 97901, phone (503) 339-4385, before the field trip for permission to enter the zeolite mine. Also, the road can become very slick during the wet seasons, so caution should be used.

ACKNOWLEDGMENTS

The author thanks Spencer Wood, Department of Geology and Geophysics, Boise State University, and Edward Squires, student in geology, Boise State University, who contributed valuable information to the preparation of this road log.

Figure 11. Mammalian vertebrate fossils. These bone fragments may be from common grazers, such as Dromomeryx *(cervoid),* Merycodus *(pronghorn), or* Merychippus *(Miocene horse), which roamed the area during the Miocene (Smiley and others, 1975, p. 10).*

REFERENCES CITED

Armstrong, R.L., 1975, The geochronometry of Idaho: Isochron/West, no. 14, 50 p.

Armstrong, R.L., Harakal, J.E., and Neill, W.M., 1980, K-Ar dating of Snake River Plain (Idaho) volcanic rocks--new results: Isochron/West, no. 27, p. 5-10.

Brown, D.E., and Petros, J.R., 1985, Geochemistry, geochronology, and magnetostratigraphy of a measured section of the Owyhee Basalt, Malheur County, Oregon: Oregon Geology, v. 47, no. 2, p. 15-20.

Ekren, E.B., McIntyre, D.H., and Bennett, E.H., 1984, High-temperature, large-volume, lavalike ash-flow tuffs without calderas in southwestern Idaho: U.S. Geological Survey Professional Paper 1272, 76 p.

Ekren, E.B., McIntyre, D.H., Bennett, E.H., and Malde, H.E., 1981, Geologic map of Owyhee County, Idaho, west of longitude 116° W.: U.S. Geological Survey Miscellaneous Investigations Series map I-1256, scale 1:125,000.

Ekren, E.B., McIntyre, D.H., Bennett, E.H., and Marvin, R.F., 1982, Cenozoic stratigraphy of western Owyhee County, Idaho, *in* Bonnichsen, B., and Breckenridge, R.M., eds., Cenozoic geology of Idaho: Idaho Bureau of Mines and Geology Bulletin 26, p. 215-235.

Evernden, J.F., and James, G.T., 1964, Potassium-argon dates and the Tertiary floras of North America: American Journal of Science, v. 262, no. 8, p. 945-974.

Graham, A.K., 1965, The Sucker Creek and Trout Creek Miocene floras of southeastern Oregon: Kent State University Research Series 9 (Bulletin, v. 53, no. 12), 147 p.

Hart, W.K., Mertzman, S.A., and Carlson, R.W., 1985, Late Cenozoic volcanic geology of the Jordan Valley-Owyhee River region, southeastern Oregon: Boise, Idaho, Geological Society of America, Rocky Mountain Section, 38th annual meeting, unpublished composite field trip guide.

Kittleman, L.R., 1973, Guide to the geology of the Owyhee region of Oregon: Eugene, Oreg., University of Oregon Museum of Natural History Bulletin 21, 61 p.

Kittleman, L.R., Green, A.R., Haddock, G.H., Hagood, A.R. , Johnson, A.M., McMurray, J.M., Russell, R.G., and Weeden, D.A., 1967, Geologic map of the Owyhee region, Malheur County, Oregon: Eugene,

Oreg., University of Oregon Museum of Natural History Bulletin 8, scale 1:125,000.
Kittleman, L.R., Green, A.R., Hagood, A.R., Johnson, A.M., McMurray, J.M., Russell, R.G., and Weeden, D.A., 1965, Cenozoic stratigraphy of the Owyhee region, southeastern Oregon: Eugene, Oreg., University of Oregon Museum of Natural History Bulletin 1, 45 p.
Lawrence, D.C., 1986, Geologic report on Miocene volcanics and sediments within the Sucker Creek Formation, Malheur County, Oregon: Unpublished field geology report, 27 p., geologic map, scale 1:12,000. Copy available upon request from Department of Geology and Geophysics, Boise State University, Boise, Idaho 83725.
Leppert, D., 1986, Environmental uses of natural zeolites and bentonites: Proceedings of the 22nd Symposium on Engineering Geology and Soils Engineering, Idaho, Department of Transportation, P.O. Box 7129, Boise, Idaho, p. 496-510.
Mumpton, F.A., 1977, Natural zeolites, *in* Mumpton, F.A., ed., Mineralogy and geology of natural zeolites: Mineralogical Society of America, Short Course Notes, v. 4, p. 1-17.
Odom, E., 1984, Reviews in mineralogy (Micas): Washington, D.C., Mineralogical Society of America, p. 545-572.
Orr, W.N., and Orr, E.L., 1981, Handbook of Oregon plant and animal fossils: Eugene, Oreg., available from the authors, P.O. Box 5286, Eugene, OR 97405, 285 p.
Rytuba, J.J., Vander Meulen, D.B., Plouff, D., and Minor, S.A., 1985, Geology of the Mahogany Mountains caldera, Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 17, no. 4, p. 263.
Sheppard, R.A., and Gude, A.J., 3rd, 1983, Field trip stop 3, Sheaville zeolite deposit, Sheaville, Oregon, *in* Mumpton, F.A., ed., Zeo-Trip '83. An excursion to selected zeolite deposits in eastern Oregon, southwestern Idaho, and northwestern Nevada, and to the Tahoe-Truckee water reclamation plant, Truckee, California, July 7-10, 1983: Brockport, N.Y., International Committee on Natural Zeolites, c/o Department of Earth Sciences, State University College, Brockport, N.Y. 14420, p. 25-31.
———1987, Field trip guide to the Sheaville and Rome zeolite deposits, southeastern Oregon: Oregon Geology, v. 49, no. 1, p. 3-10.
Smiley, C.J., Shah, S.M.I., and Jones, R.W., 1975, Guidebook for the later Tertiary stratigraphy and paleobotany of the Weiser area, Idaho: Idaho Bureau of Mines and Geology Information Circular 28, 13 p.
Squires, E., 1985, A field study of Miocene volcanics and sediments within the Sucker Creek Formation, Malheur County, Oregon: Unpublished field geology report, 24 p., available upon request from Department of Geology and Geophysics, Boise State University, Boise, Idaho 83725.
Surdam, R.C., 1977, Zeolites in closed hydrologic systems, *in* Mumpton, F.A., ed., Mineralogy and geology of natural zeolites: Mineralogical Society of America Short Course Notes, v. 4, p. 65-91.
Vander Meulen, D.B., Rytuba, J.J., King, H.D., Plouff, D., and Scott, D.F., 1987a, Mineral resources of the Honeycombs Wilderness Study Area, Malheur County, Oregon: U.S. Geological Survey Bulletin 1741-A, p. A1-A15.
Vander Meulen, D.B., Rytuba, J.J., Vercoutere, T.L., and Minor, S.A., 1987b, Geologic map of the Rooster Comb quadrangle, Malheur County, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1902, scale 1:24,000.
Walden, K.D., 1986, A stratigraphic and structural study of Coal Mine Basin, Idaho-Oregon: East Lansing, Mich., Michigan State University master's thesis, 70 p.
Wood, S.H., 1984, Review of late Cenozoic tectonics, volcanism, and subsurface geology of the western Snake River Plain, *in* Geology, tectonics, and mineral resources of western and southern Idaho: Dillon, Mont., Tobacco Root Geological Society, P.O. Box 370, p. 48-60. □

Allen publishes *Time Travel Two*

Time Travel Two in Oregon, a Geology Scrapbook, mostly written by John Eliot Allen. Price $10. Available from J.E. Allen, Department of Geology, Portland State University, P.O. Box 751, Portland, OR 97207-0751

John Eliot Allen, Emeritus Professor of Geology at Portland State University, has published a second volume of geologic articles from his "Time Travel" column in the weekly science section of Portland's newspaper *The Oregonian.*

Two years after the first publication of such articles in a separate volume, Allen now has collected 106 more articles that appeared between November 1985 and November 1987. On 153 pages, the spiral-bound book reproduces the newspaper articles as they appeared originally, often with accompanying illustrations. In addition to Allen, 14 other authors contributed to the column. □

DOGAMI moves to new warehouse and expands core repository

by Dan E. Wermiel, Oregon Department of Geology and Mineral Industries

On December 1, 1987, the Oregon Department of Geology and Mineral Industries (DOGAMI) occupied its new warehouse which is located near downtown Portland. The following types of materials are stored in the warehouse, enabling DOGAMI to serve the public better:

1. PROPRIETARY OIL, GAS, AND GEOTHERMAL-WELL SAMPLES

Laws regulating oil and gas exploration were first passed in Oregon in 1923, but it was not until 1953 that statutes were passed authorizing DOGAMI to supervise oil and gas development in the state. As a result, all well cuttings and cores for all wells drilled for oil and gas in Oregon since 1953 are now maintained by DOGAMI and are stored in the warehouse. This repository consists of samples from over 200 wells ranging in depth from less than 1,000 ft to over 13,000 ft.

By State law, the cuttings and cores for oil and gas wells remain confidential for a two-year period after a well is drilled and then are made available to the public for inspection. Arrangements to inspect well samples can be made by contacting Dennis Olmstead or Dan Wermiel at DOGAMI to schedule a time to study the material. A work room is provided, but microscopes and other examination equipment are not supplied by DOGAMI. A complete list of wells and the cuttings and cores stored in the warehouse is provided in a recently released publication (Oil and Gas Investigation 16, *Available Well Records and Samples of Onshore and Offshore Oil and Gas Exploration Wells in Oregon).*

In addition, when an analysis in which slides are produced is done on well samples, the slides are permanently stored in the warehouse. If well samples are treated for a particular analysis, such as a paleontological study, the samples are also stored and are

Chuck Radasch, warehouse curator, checks oil and gas samples stored in new warehouse.

available for public inspection.

Similarly, geothermal well cores and cuttings are also stored in the warehouse and are available to the public for inspection after a four-year confidentiality period. Arrangements to study a geothermal well should be handled in the same manner as for oil and gas wells.

2. NONPROPRIETARY DRILL-HOLE SAMPLES

The warehouse will now also serve as a storage facility for samples from selected nonproprietary, geologically significant holes drilled in the state. There is no confidentiality period for any of this material. For example, the cores obtained from the recent super-collider studies in Oregon are now stored in the DOGAMI warehouse.

All well samples should be marked with the name of the operator and the location from which the samples are obtained and any pertinent information or data derived from the samples. A recommended time of duration to store the samples should be determined when the samples are delivered to DOGAMI. The samples may be skeletonized if there is an excessive volume. DOGAMI will consider accepting skeletonized cores from appropriate new or existing wells in the state. Anyone wishing to submit drill-hole samples for consideration should contact DOGAMI.

3. OUTCROP HAND SAMPLES

When a DOGAMI field project in which outcrop samples are taken is in progress, they are stored in the warehouse for use on the specific project. When the project is completed, the outcrop rocks are discarded. However, if a significant analysis has been made, such as age determination, the samples may be retained. Also, slides made from the samples are stored indefinitely.

4. LABORATORY MATERIAL

Lab samples are stored in the warehouse for use until the discard date of the material is reached. This is generally five years from the date of the last use of the material. Lab pulp from assays is stored indefinitely in the warehouse.

5. DOGAMI PUBLICATIONS

The warehouse is also used for storage of the numerous publications, including maps and written documents covering a wide range of geologic subjects, that are available from DOGAMI. A list of publications can be obtained and publications may be purchased from DOGAMI's Portland, Baker, and Grants Pass offices. An abbreviated list of available publications appears on the back cover of each issue of *Oregon Geology.* □

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 AND PETROLEUM POTENTIAL OF THE HAY CREEK ANTICLINE, NORTH-CENTRAL OREGON, by Stephen I. Wareham (M.S., Loma Linda University, 1986)

For many years, it has been reported that the core of the Hay Creek Anticline exposes metamorphic rocks of Paleozoic or Mesozoic age. On closer study, it was found that these rocks consist of only slightly metamorphosed black to dark-gray siltstones and sandstones with less abundant chert pebble conglomerate and recrystallized limestone. The sequence is here informally named "Hay Creek Formation." Calcareous nannofossils recovered and identified from the limestone yielded an age of early to middle Eocene.

The depositional environment of the "Hay Creek Formation" is interpreted to be a submarine turbidite fan. Siltstones were deposited as pelagic rain and turbidite fallout. Sandstones were deposited in turbidite flows as evidenced by flute casts. The Hay Creek Anticline formed as a result of multiple compressional forces, with periods of deposition and erosion between orogenic events.

The petroleum potential of the "Hay Creek Formation" is good. The total organic carbon in the siltstones, the kerogens, and the maturity indicators suggest that oil and/or gas have been produced from these rocks. Shallow exploration drilling in the area has revealed that petroleum is present.

THE GEOLOGY AND ALTERATION OF THE BEAR CREEK BUTTE AREA, CROOK COUNTY, CENTRAL OREGON, by Richard Matthew Wilkening, (M.S., Portland State University, 1986)

The Eocene Clarno Formation, the Oligocene John Day Formation, and basalts of the High Lava Plains are exposed in the Bear Creek Butte area in central Oregon. In this area, the Clarno Formation can be divided into a lower sequence composed of intermediate lava flows with intercalated mudflows and volcaniclastic sediments and an upper sequence of rhyolite and basalt flows and felsic tuffs. Separating the two units is a well-developed saprolite. The change from intermediate to rhyolite-basalt volcanism reflects a change in the tectonic environment of the Cascade volcanic arc from compression to relaxation, as subduction of the Farallon plate by the North American plate slowed, allowing extension of the continental plate margin to occur.

Hydrothermal alteration has affected rocks of the Clarno and John Day Formations in the Bear Creek Butte area. The Oronogo and Platner Mines and the Admunsen prospect, currently being worked, are hosted in the Clarno Formation. Alteration is most intense at the Platner Mine, where hydrothermal alteration forms an ellipse along north-northwest-trending faults. Hydrothermal breccias are associated with silicified and kaolinitized felsic tuffs and a mafic intrusion at this mine. At the Admunsen claim, located south of the Platner Mine, a mafic intrusion is argillized and cut by fine quartz veinlets, and felsic tuffs have been silicified. At the Oronogo Mine, the northernmost property, alteration zones are confined to fractured basaltic andesite along a northwest-trending fault. Alteration consists of silicification with minor argillization of plagioclase phenocrysts in the basaltic andesite.

The Platner Mine contains the highest concentrations of As and Sb. Trace-element geochemistry indicates Sb concentrations (maximum 102 ppm, average 44 ppm) are highest in the area of the Platner Mine and decrease northward along the controlling structure more gradually than to the south of the mine. Arsenic concentrations increase northward along the controlling structure from the Platner Mine (maximum 45 ppm, average 12 ppm). Hg is irregularly distributed along the structure and has its highest concentration south of the Platner Mine. Trace concentrations of U occur along the fault zones in the areas of alteration.

Altered rocks of the John Day Formation, which unconformably overlies the Clarno Formation, host uranium mineralization. The alteration zones are located along northwest- to west-northwest-trending faults. The alteration assemblages are similar to that at the mercury prospects: clays, predominately kaolinite, and fine-grained quartz. Trace-element geochemistry indicates anomalous U (maximum 59 ppm, average 24 ppm) and Mo concentrations.

The presence of cinnabar + hematite ± pyrite indicates that the hydrothermal system that operated at the mercury prospects was an oxidizing system. Deposition of U and Mo required a reducing environment. The differences in the environment of deposition for mercury and uranium indicate that two different systems were active in the study area.

Although alteration is extensive and hydrothermal breccias are present in the Bear Creek area, significant base- and precious-metal anomalies have not been detected along controlling structures. □

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