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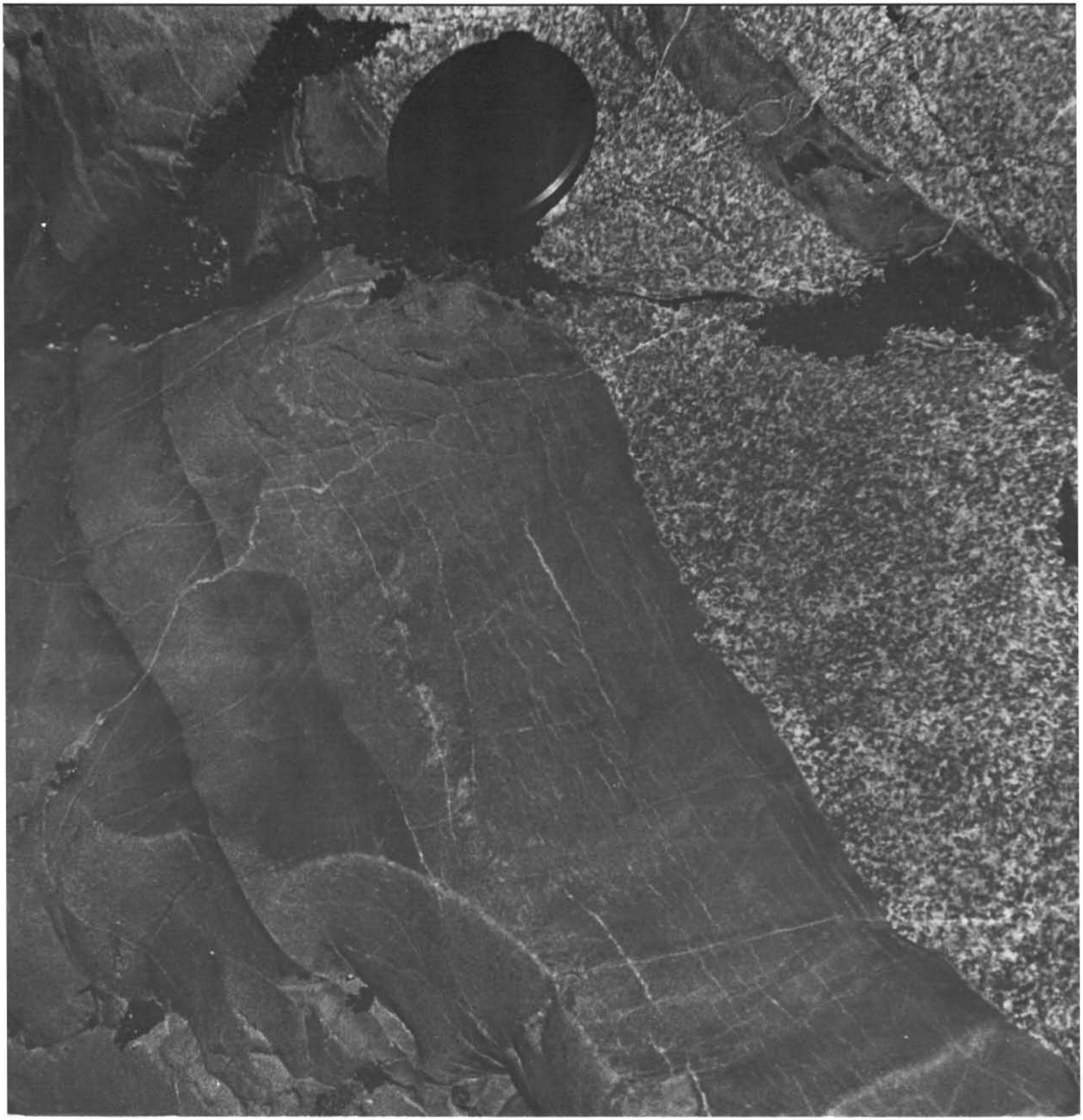

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COVER PHOTO

One margin of meter-wide gabbro screen near base of sheeted-dike complex of Josephine ophiolite, southwestern Oregon and northwestern California. Article beginning on next page discusses depositional contact between Galice Formation and Josephine ophiolite.

Geology and geothermal resources of central Cascades summarized in new report

A summary of five years of research into the geology and geothermal resources of the central Cascade Range has been placed on open file by the Oregon Department of Geology and Mineral Industries (DOGAMI). The report, DOGAMI Open-File Report 0-82-7, is entitled *Geology and Geothermal Resources of the Cascades, Oregon.*

The 205-page report presents a geologic overview of the entire area, including recommendations for geothermal exploration, describes the geology of four smaller areas of particular interest in Marion and Lane Counties, and discusses the heat flow of the entire Cascade Range. Past and present volcanic-stratigraphy studies are summarized, and tectonic models of the Cascades and exploration models for geothermal resources are presented.

New information in the report includes numerous radiometric age determinations, chemical analyses of rocks and thermal waters, and temperature and heat-flow data from drilling projects.

The text is accompanied by five map sheets containing four new geologic maps, a heat-flow map with data points for the entire Oregon Cascades, and an index to geologic mapping of the area.

Because this paper is only a first draft of a more complete report that will be released as Special Paper 15 in the fall of 1983, only a limited number of copies were produced, primarily for purposes of review. It is thus possible that very few, if any, copies will be available at the time of this printing. Copies are, however, available for inspection at the DOGAMI library in Portland and at the State Library in Salem.

Purchase price of Open-File Report 0-82-7 is $20. Check with the DOGAMI office, 1005 State Office Building, Portland, OR 97201, for availability before ordering. Orders under $50 require prepayment. □

Mineral payments increased to states

The Bureau of Land Management (BLM) has made record payments to the states of Oregon and Washington as their share of mineral revenues from federal lands in the two states.

For the fiscal year ending September 30, 1982, Oregon gained $4,415,626, while Washington gained $582,035. These sums are half of all mineral leasing fees collected within the states.

Payments were made to 23 mineral-producing states for a total of $548,161,648, a 44-percent increase over the previous record year. In the Pacific Northwest, increases were even more—for Oregon, the total was more than 400 percent over the previous year, and in Washington it was 1,100 percent.

—*BLM News: Oregon and Washington*

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A depositional contact between the Galice Formation and a Late Jurassic ophiolite in northwestern California and southwestern Oregon

by Gregory D. Harper, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112

INTRODUCTION

The Late Jurassic Galice Formation was originally named and described by Diller (1907) for slaty shale, sandstone, and rare conglomerate exposed on Galice Creek near the hamlet of Galice in southwestern Oregon (Figure 1). Wells and others (1949) subsequently recognized volcanic members within the Galice, and Wells and Walker (1953) named the Rogue Formation for a thick sequence of mafic to silicic, largely fragmental volcanic rocks which lie beneath the Galice Formation in its type area. The Galice Formation was also mapped southward into the Gasquet quadrangle of northern California by Cater and Wells (1953), who recognized a lower volcanic member considered by them to be correlative with the Rogue Formation and an upper metasedimentary member similar to the type Galice of Diller (1907). Irwin (1960) later mapped the Galice Formation in reconnaissance south along the entire length of the Klamath Mountains province and named this belt the western Jurassic belt (Figure 1). Davis (1969) noted the similarity of rocks of the western Jurassic belt and the foothills metamorphic belt of the Sierra Nevada region and considered them to be correlative.

Two recent studies in northwestern California and extreme southwestern Oregon have documented the presence of a well-preserved, complete ophiolite (Josephine ophiolite, Figure 2) within the western Jurassic belt (Vail, 1977; Harper, 1980a), resulting in a major revision of the stratigraphy in this

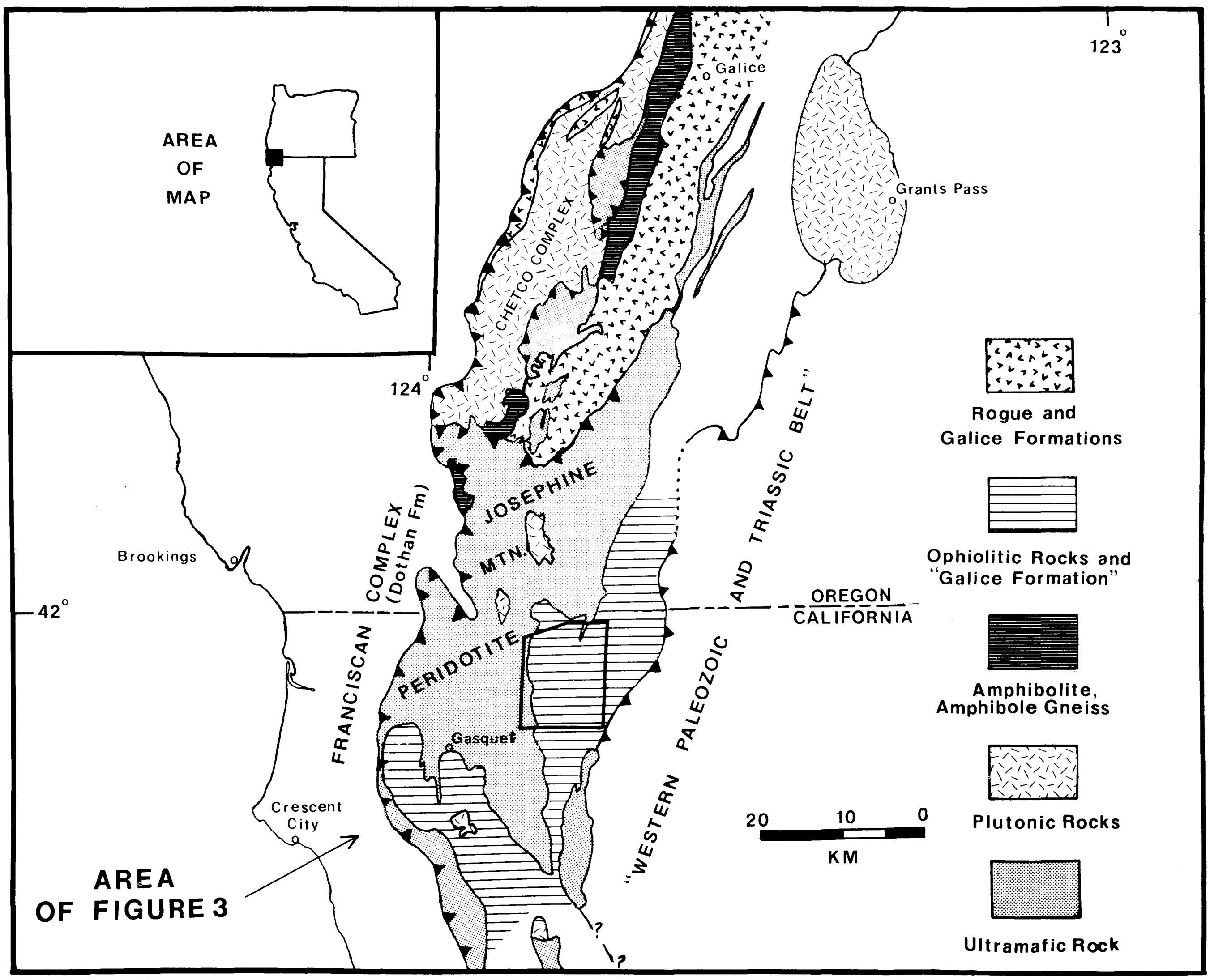

Figure 1. Generalized geology of Irwin's (1960) western Jurassic belt, modified from Hotz (1971b) and including mapping by Ramp (1975), Dick (1976), Snoke (1977), Vail (1977), and Harper (1980a).

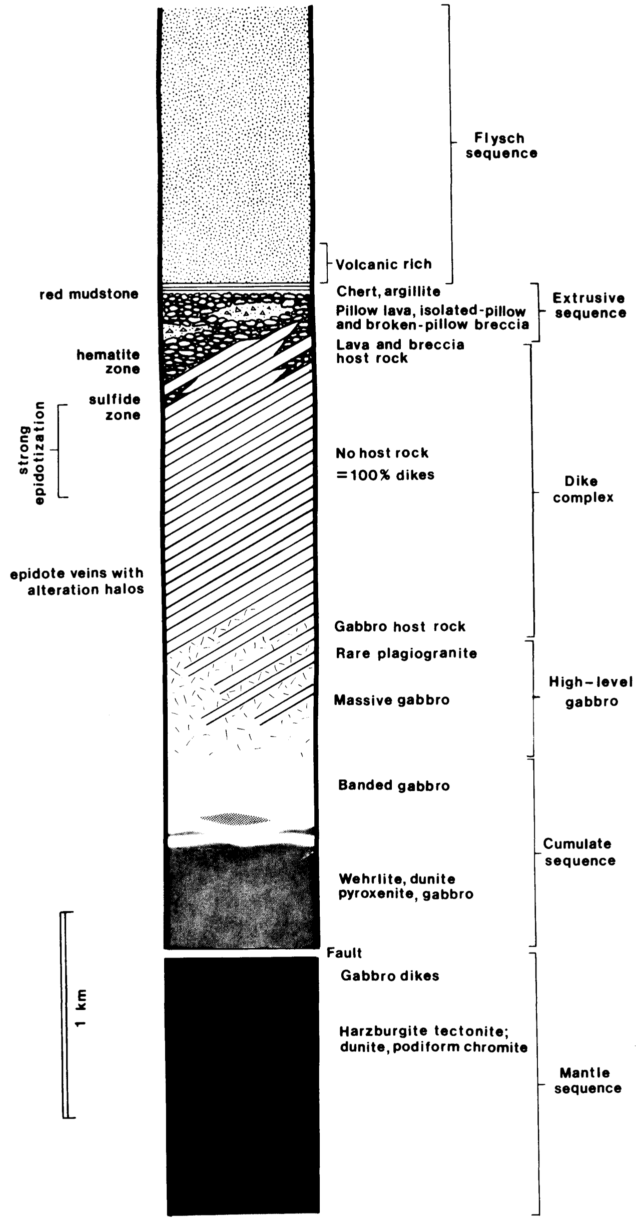

Figure 2. Reconstruction of the Josephine ophiolite, northwestern California.

area. In particular, the lower volcanic member of the Galice Formation described by Cater and Wells (1953) is now recognized as the upper part of the Josephine ophiolite, namely sheeted dikes and pillow lavas. The lower portions of the ophiolite consisting of gabbro and peridotite were mapped by Cater and Wells (1953) as younger intrusive rocks. The purpose of this paper is to report a perfectly preserved depositional contact between the Josephine ophiolite and the Galice Formation.

It is important to note that the type Galice Formation near Galice, Oregon, is not underlain by an ophiolite but rather is underlain by a thick sequence of mafic to silicic, chiefly fragmental metavolcanic rocks of the Rogue Formation (Wells and Walker, 1953; Garcia, 1979; my own field work). Nevertheless, data presented below show that the "Galice Formation" overlying the Josephine ophiolite is very similar in petrography and age to the type Galice Formation.

It should be noted that an earlier interpretation by Harper (1978) that the Josephine Mountain peridotite (the basal unit of the ophiolite) was thrust over the Galice Formation has been shown by later work to be incorrect. Although the Josephine Mountain peridotite is in many places faulted against the Galice, it is now recognized as part of the Josephine ophiolite which forms the basement for the Galice Formation. This interpretation is strongly supported by aeromagnetic data which indicate peridotite underlies at shallow depth exposed mafic rocks of the ophiolite (A. Griscom, personal communication, 1979).

THE JOSEPHINE OPHIOLITE

Ophiolites are distinctive sequences of ultramafic and mafic rocks generally regarded as the remains of ancient oceanic crust and upper mantle. The Josephine ophiolite is one of the best preserved, complete ophiolites in North America. Although the area in which the ophiolite has been mapped is heavily vegetated, excellent water-polished exposures are found in the forks of the Smith River and its major tributaries. In addition, mapping of the ophiolite was greatly facilitated by good access and exposures created by numerous logging roads.

The lowermost unit of the ophiolite is the Josephine Mountain peridotite (Figures 1, 2 and 3), a harzburgite tectonite with minor dunite covering more than 800 km^2. The peridotite is an "alpine-type" peridotite which typically occurs at the base of ophiolites and which represents depleted upper mantle (Loney and Himmelberg, 1976; Dick, 1976, 1977; Harper, 1980a). The harzburgite tectonite unit is overlain by olivine- and clinopyroxene-rich ultramafic rocks having cumulate textures; however, the base of the ultramafic cumulates is not preserved within the area mapped, and the contact with underlying harzburgite is always marked by sheared serpentinite. The ultramafic cumulates are overlain and intercalated with layered gabbro, which in turn grades upward into nonlayered gabbro and less common diorite. The "high-level" gabbro is characterized by complex intrusive breccias, abundant diabase dikes, and rare plagiogranite dikes and pods.

The high-level gabbro grades upward into a sheeted dike complex (Figure 4) consisting of 100 percent mafic dikes that are nearly all subparallel. The lower contact is gradational, and fine-grained diabase dikes increase in abundance upward through the high-level gabbro until no gabbro host rock is present. The upper contact of the sheeted dike complex is similarly gradational, with first the appearance of screens of pillow lava or breccia between dikes, followed by an upward decrease in the proportion of dikes. The "inclined" nature of the sheeted dikes (Figure 2) is interpreted as the result of rotations (probably by faulting) at the spreading center when the ophiolite formed (Harper, 1982a).

Volcanic rocks of the ophiolite are as much as 400 m thick (not including screens in sheeted dikes) and consist of pillow lavas (Figure 5) with lesser massive lava and isolated- and broken-pillow breccias. Many of the pillow lavas are highly vesicular, a feature which has been interpreted to indicate the lavas had high primary volatile contents (Harper, 1982b). Excellent exposures of pillows, breccias, and massive lava are found at the mouth of Little Jones Creek (Locality 1, Figures 3 and 5). Interpillow green chert and hyaloclastites are common in the upper part of the lavas.

THE GALICE FORMATION

A depositional contact between the Galice Formation and pillow lavas of the Josephine ophiolite is exposed at several localities (Localities 1, 2, and 4, Figure 3). The best exposed and most easily accessible locality (Locality 1, Figure 3) is located on the Middle Fork Smith River near the mouth of Little Jones Creek (Figure 6) and is within easy walking distance

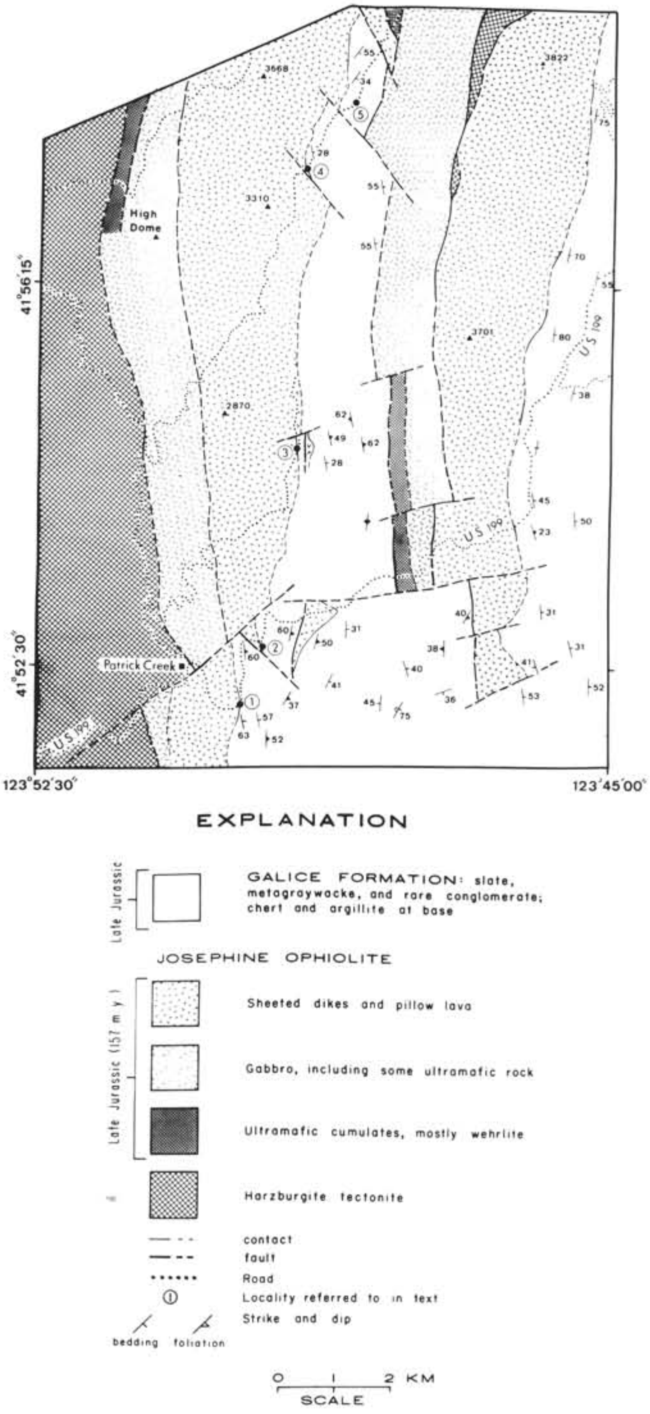

Figure 3. Generalized geologic map of part of the northeastern quarter of the Gasquet quadrangle, northwestern California. Northeastern part of map is modified from Cater and Wells (1953), and the remainder was mapped by Harper between 1976 and 1981.

of U.S. Highway 199. Vail (1977, p. 20) also reports a clearly exposed contact between the ophiolite and slaty shale of the Galice Formation on several road cuts below Lone Mountain, near O'Brien, Oregon.

In the area shown in Figure 3, the basal Galice Formation consists of a pelagic sequence up to 35 m thick of gray-green radiolarian chert interbedded with black slaty argillite. At several localities (Localities 2 and 4, Figure 3), metalliferous

Figure 4. Sheeted dikes dipping steeply to the right (southeast), Josephine ophiolite.

sedimentary rocks occur within the pelagic sequence and have locally been found intercalated with pillow lavas. These unusual rocks are red to black, thin-bedded to massive, and rich in iron and/or manganese. They probably formed by precipitation from hydrothermal fluids near vents on the ancient sea floor.

The thin basal pelagic sequence is overlain by metagraywackes, slate, and rare conglomerate. This contact varies from a sharp depositional contact (Locality 1, Figure 3) to one where metagraywacke is interbedded with the upper portion of the pelagic sequence (Localities 3 and 4, Figure 3). The metagraywackes commonly have well-preserved sedimentary structures indicating deposition by turbidity currents and related flow mechanisms; these include load casts, flame structures, ripple cross-stratification, graded bedding, rip-up mud chips, and rare sole markings. Trace fossils collected in slates include *Chondrites*, *Spirophycus*, and *Cosmoraphe*, which are indicative of deposition in very deep water (A.A. Ekdale, personal communication, 1980).

The metagraywackes are all feldspathic lithic wackes containing volcanic rock fragments, siliceous argillite, chert, plagioclase, and lesser monocrystalline quartz and metamorphic rock fragments. Heavy minerals identified both in thin sections and heavy mineral separates include zircon (rounded and euhedral), tourmaline, apatite, and muscovite with less common chromian spinel, biotite, garnet, sphene, and blue

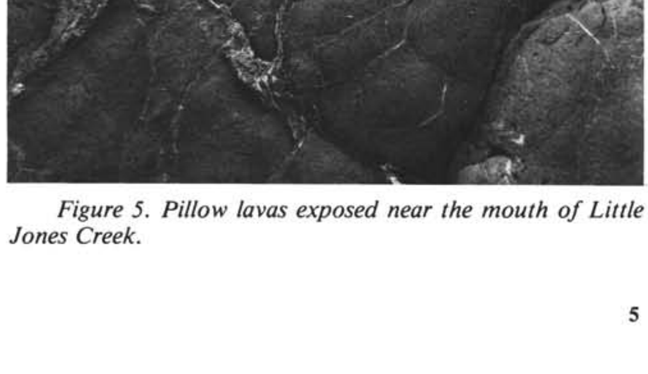

Figure 5. Pillow lavas exposed near the mouth of Little Jones Creek.

Figure 6. Depositional contact between pillow lavas (right) and bedded chert and slaty argillite of the Galice Formation. Ruler is 6 in. long and lies on the contact which dips steeply to the left (east). Locality 1 of Figure 3.

amphibole. In addition, graywackes rich in volcanic rock fragments typically contain abundant clinopyroxene and less common hornblende. Snoke (1977) reported Galice graywackes with very similar petrography just east of the area shown in Figure 3 but also observed staurolite as a detrital mineral. The petrography of graywackes varies with stratigraphic position; the lower few hundred meters of the Galice Formation contain graywackes rich in volcanic rock fragments and plagioclase, whereas the rest of the formation contains graywackes consisting predominantly of chert and siliceous argillite fragments (Harper, 1980a).

The stratigraphy of the Galice Formation is quite different in the vicinity of Buck Mountain, 25 km south-southeast of Gasquet. In this area, the basal Galice is a polymictite interpreted as a submarine slide deposit and consists of boulders up to 15 m in diameter in a matrix which varies from pebbly mudstone to green metatuff. Most of the larger boulders were apparently derived from the Josephine ophiolite and overlying pelagic sequence and include chert, greenstone, gabbro, and rare serpentinite. The pebbly mudstone contains clasts of argillite, chert, mica schist, marble, sandstone, and locally pumice. The polymictite is overlain by a thick sequence of metagraywackes (channel fill?) which are in turn overlain by metagraywacke and slate.

SUMMARY OF AGE DATA

The timing of ophiolite genesis, deposition of the overlying Galice Formation, and subsequent deformation is well constrained by radiometric and fossil ages (Saleeby and others, 1982). Two plagiogranites from the ophiolite have been dated, and both yielded concordant U-Pb ages of 157 ± 2 million years (m.y.) on zircon. Cherts from the pelagic sequence (Locality 3, Figure 3) have yielded Late Jurassic radiolaria (D.L. Jones, personal communication, 1981). J.S. Diller collected *Buchia concentrica* (Sowerby), which has a known range of Late Oxfordian to Lower Kimmeridgian (Imlay, 1959), from several localities in upper Shelly and Monkey Creeks. I was able to find one of these localities from Diller's descriptions; it is located near the mouth of the west fork of Shelly Creek ("Station Creek") just south of Baker Flat (Locality 5, Figure 3). The fossils occur in a "grit" bed (pebble conglomerate) near the base of the Galice Formation, approximately 150 m above the top of the ophiolite.

The ophiolite and overlying Galice Formation are intruded by numerous meta-andesite and metadacite dikes and sills. Two of these dikes and sills have been dated with zircon at 151 ± 2 and 150 ± 2 m.y. B.P. (concordant U-Pb ages, Saleeby and others, 1982). Following emplacement of the dikes and sills, the Josephine ophiolite and overlying Galice Formation were deformed and regionally metamorphosed under conditions of prehnite-pumpellyite to lower greenschist facies (Nevadan orogeny). Regional metamorphism of Galice metagraywackes has been dated in the southern Klamath Mountains at approximately 150 m.y. B.P. (Lanphere and others, 1978).

The type Galice Formation has also yielded *Buchia concentrica* (D.L. Jones, personal communication, 1979) and is thus the same age as the "Galice Formation" which overlies the Josephine ophiolite. The Rogue Formation which lies beneath the type Galice Formation is probably Middle or Late Jurassic in age. Plutonic rocks of the Chetco complex (Illinois River gabbro) which occur within the northern part of the western Jurassic belt (Figure 1) have yielded K-Ar ages of 150-157 m.y. except for a single age of 140 m.y. (Hotz, 1971; Dick, 1976). The Chetco complex probably represents the plutonic roots for the volcanic rocks of the Rogue and Galice Formations (Dick, 1976).

THE GALICE PROBLEM

The type Galice Formation overlies and is intercalated with mafic to silicic, largely fragmental volcanic rocks, whereas the "Galice Formation" in northwestern California and extreme southwestern Oregon is clearly depositional on the Josephine ophiolite. Nevertheless, both sequences have yielded *Buchia concentrica* and are lithologically similar. In addition, point counts have shown that metagraywackes from the two sequences are essentially identical in composition (Figure 7), although data from the type Galice are sparse. Heavy mineral assemblages from type Galice metagraywackes are also very similar to those from northwestern California (Harper, 1980a); particularly striking is the occurrence of both euhedral and well-rounded detrital zircons in metagraywackes from both sequences.

The differences in the two sequences can readily be explained in terms of deposition in somewhat different tectonic settings. The Rogue Formation, the type Galice Formation, and the Chetco complex have been interpreted as the remains of an ancient island-arc complex (Dick, 1976; Garcia, 1979; Johnson, 1980). In contrast, the Josephine ophiolite and overlying Galice Formation were apparently formed in a back-arc

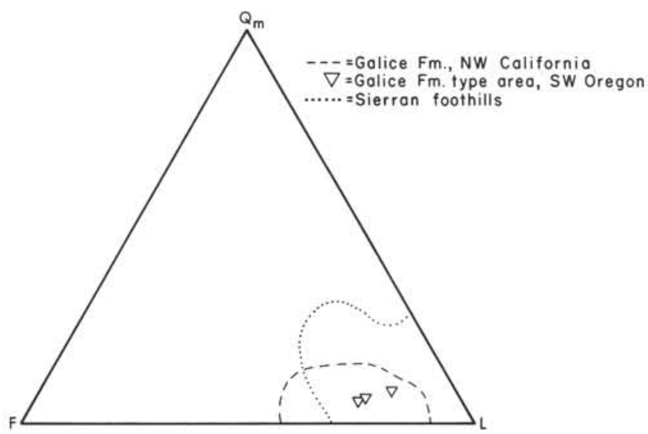

Figure 7. Triangular diagram summarizing point-count data from the Galice Formation (Harper, 1980a) and correlative rocks of the Sierra Nevada foothills (Behrman and Parkison, 1978). Qm = *monocrystalline quartz;* L = *lithics + chert;* F = *feldspar.*

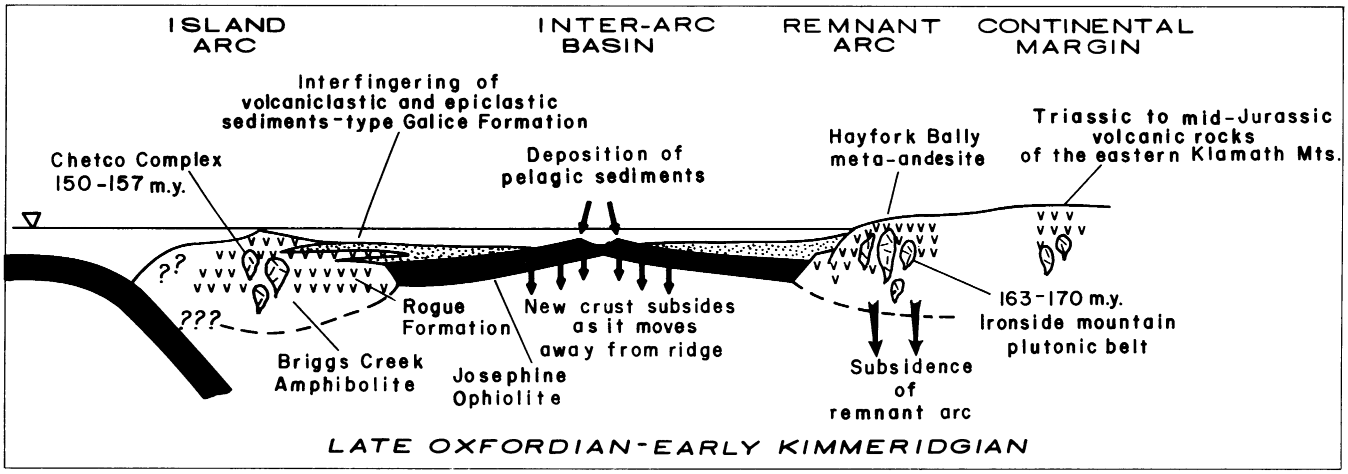

Figure 8. Tectonic model for the Late Jurassic of the Klamath Mountains (Harper, 1980a).

basin behind this island arc (Figure 8; Snoke, 1977; Vail, 1977; Harper, 1980a, b; Saleeby and others, 1982). Graywacke petrography and paleocurrent data indicate the Galice sediments were derived from the continental margin consisting of older Klamath rocks to the east (Snoke, 1977; Harper, 1980a, b).

In light of the above discussion, it is proposed that the western Jurassic belt be divided into two terranes. The northern terrane (Rogue River terrane) consists of the Chetco complex, amphibolites, the Rogue Formation, and the type Galice Formation (Figure 1). The southern terrane (Josephine terrane) consists of the Josephine ophiolite and overlying Galice Formation. The boundary between these two terranes has not been fully determined, but in southwestern Oregon, the Josephine peridotite has been thrust over the Chetco complex and Rogue Formation (Figure 1; Ramp, 1975; Dick, 1976; N. Page, personal communication, 1979). Thus the two terranes appear to comprise two thrust sheets, with the Josephine terrane thrust over the Rogue River terrane. This structural relationship can be envisioned as the result of the collapse of the island-arc and back-arc basin system during the Late Jurassic Nevadan orogeny, only 5-10 m.y. after formation of the Josephine ophiolite.

It is important to note that these two terranes are coeval and are related; in addition, they can be related to slightly older terranes to the east and southeast including the Preston Peak ophiolite (rift-edge facies, Saleeby and others, 1982) and Irwin's (1972) Hayfork Bally meta-andesite (remnant arc, Figure 8). The fact that these terranes can be tied together, combined with the short time interval between their formation and accretion, indicates they are *not* exotic to North America and are not "suspect" as suggested by Coney and others (1980).

ACKNOWLEDGMENTS

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(Depositional contact, *continued on p. 9*)

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.

THE GEOLOGY OF THE WESTERN HALF OF THE LA GRANDE BASIN, NORTHEASTERN OREGON, by George Gehrels (M.S., University of Southern California, 1981)

The La Grande Basin is a 48-km-long by 20-km-wide topographic and structural depression in northeastern Oregon. It has a maximum structural relief of over 1,650 m, with the top of the middle to late Miocene Columbia River Basalt Group downdropped to lower than 200 m above sea level. Late Miocene or early Pliocene and younger alluvial and lacustrine sediments have filled the basin to an elevation of about 825 m.

Downdropping of the basin has formerly been attributed to dip-slip movement on north-northwest-striking faults. The structural relationships mapped in this study, however, suggest that the La Grande Basin is a complex pull-apart structure in a north-northwest-striking, right-lateral fault system. The fundamental kinematic relationships in a pull-apart basin with this orientation include (1) right-lateral faults along the eastern and western margins, (2) northwestern and southeastern corners dominated by normal faulting, and (3) structures along the ends of the basin that record NNW-SSE-directed extension.

Strike-slip faulting is recorded along the western side of the basin by north-northwest-striking vertical faults that have predominantly shallow-plunging slickenside striae. Evidence for a dextral sense of faulting along this margin comes from (1) combinations of stratigraphic offset and trend of shallow-plunging striae on several faults, (2) deflections to the right in the Grande Ronde River where it is crossed by major faults, (3) the juxtaposition of dissimilar stratigraphic sections across a major fault (in Ladd Canyon) that has no vertical offset, (4) the configuration of two left-en echelon fault zones being connected by a zone of northwest-southeast-directed shortening (thrust faults near Hot Lake), and (5) several localities where right-en echelon faults are connected by zones of NNW-SSE-directed extensions (Pyles Canyon and the normal faults north of La Grande).

The eastern margin of the La Grande Basin is formed by sinuous faults that have dip-slip displacements. This apparent lack of right-lateral faulting may be related to the structural complexity of the fault zone along the western margin. In the northern part of the basin, the western margin fault zone is a wide set of right-en echelon faults that are structurally connected by north-northeast-striking normal faults. Striae on one of these normal faults record a northwest-southeast slip-line, which geometrically requires northwest-southeast-directed extension across the fault. Because these are the dominant extensional structures in the basin, very little right-lateral displacement is transferred from the western margin to the faults along the eastern side. The northwestern and southeastern corners of the basin are cut by sinuous faults that have predominantly dip-slip displacements. These faults drop down the gently dipping homoclinal sections of Columbia River basalt that underlie the northern and southern margins.

Structural relationships along the western margin suggest that the total amount of right-lateral displacement across the La Grande Basin is about 2 or 3 km, and the total amount of northwest-southeast-directed extension is somewhat less—probably on the order of 1 km. Although the basin owes its origin to this right-lateral faulting and pull-apart extension, it is geometrically and structurally more complex than other pull-apart basins described in the literature. This complexity is a product of (1) the small amount of overall dextral strain across the La Grande Basin, (2) the region's high fault density, (3) a multiphase movement history on the north-northwest-striking faults, and (4) the wide zone of strike-slip and normal faults along the western margin of the basin.

Neogene faulting in the La Grande area probably began in middle to late Miocene time, but this age has not been reliably determined. Constraints on the age include a 6 or 7 m.y. old dike near the basin margin that may have been emplaced along a fault and Columbia River basalt flows that are younger than 14 m.y. and are everywhere cut by the faults. Structural evidence suggests that the downdropping of the basin occurred during a late stage of movement on these faults, so the basin may be entirely younger than 6 or 7 m.y. Several diatremes and a small body of diorite (near Hot Lake) were emplaced after the basin began to form, but these have not been reliably dated. Evidence for Quaternary faulting is present, although most of the scarps in the area do not show signs of recent movement. Two features that may record Holocene faulting include a 1-km-long scarp in alluvial sediments near Union and a small thrust fault in terrace gravels south of La Grande. Earthquake epicenters in the area suggest that the basin is still tectonically active.

The north-northwest-striking faults in the La Grande area are part of a wide set of right-lateral(?) faults in central and eastern Oregon. Movement on these faults may be due to northwestward extension within the Basin and Range Province relative to the Columbia Plateau or possibly to a wide zone of right-lateral interaction between the Pacific and North American plates.

THE STRUCTURE, EVOLUTION, AND REGIONAL SIGNIFICANCE OF THE BETHEL CREEK-NORTH FORK AREA, COOS AND CURRY COUNTIES, OREGON, by Carl Frederick Gullixson (M.S., Portland State University, 1981)

The Bethel Creek-North Fork area, astride the Coos-Curry County line near the coast in southwestern Oregon, consists of Jurassic Otter Point Formation, a mélange complex, and the lower and middle Eocene Roseburg and Lookingglass Formations, part of a prograding depositional sequence. These units form four north-trending belts through the area. On the basis of differing structural style and lithology, three structural units are distinguished in the area: the Mélange Terrane, comprising western and eastern belts of Otter Point Formation; the fault-bounded North Fork Block, consisting of the Roseburg and Lookingglass Formations; and the fault-bounded Morton Creek Block, consisting of the Roseburg Formation. Rocks of the North Fork Block were deposited in a linear basin between "wedges" of the underlying Otter Point Mélange which formed during continental margin accretion. During the deposition of the Roseburg and Lookingglass Formations, the North Fork Block was deformed into a gently plunging syncline, and the entire block was uplifted along reverse faults developed at the contacts between the North Fork Block and the surrounding Mélange Terrane. The Morton Creek Block may have formed as a "fault slice" of the North Fork Block displaced southward along a left-lateral shear zone. Fold-axis patterns in both the North Fork and Morton Creek Blocks tend to confirm this interpretation. □

Pluvial Lake Chewaucan subject of new book

Geology of Pluvial Lake Chewaucan, Lake County, Oregon, by Ira S. Allison, Professor Emeritus of Geology, Oregon State University. Published as Studies in Geology Number Eleven by Oregon State University Press, Oregon State University, Corvallis, Oregon 97331. Paperback, 80 pages, 43 figures, $6.95.

Ira Allison began studying pluvial Lake Chewaucan in 1939 as part of a group of scientists investigating the prehistory of southeastern Oregon. Over the years, he has returned many times to the area, adding to his knowledge of this fascinating geological region. His numerous articles, monographs, and books clearly establish him as an authority on the geology of the area. This newest book may be purchased at most local bookstores, and a copy is also available for inspection in the library of the Portland office of the Oregon Department of Geology and Mineral Industries. For our readers' convenience, we are reprinting the abstract below.

ABSTRACT

"Pluvial Lake Chewaucan was a late Pleistocene lake, as much as 375 feet deep, covering 480 square miles in the northwestern part of the Great Basin in southern Oregon. The lake basin, now occupied by Summer Lake, Upper and Lower Chewaucan Marshes, and Lake Abert, was formed by downdropped fault blocks bounded by imposing fault scarps, notably Winter Ridge and Abert Rim. Several large landslides occurred along the east side of Winter Ridge.

"Lake Chewaucan shore features include wave-cut cliffs and caves, beaches, terraces, bay bars, spits (as at The Narrows), and a huge alluvial fan built by Chewaucan River at Paisley. Later, at lower lake stages, part of the fan deposit of sand and gravel was distributed across four-mile-wide Paisley Flat, which subsequently became a divide between Winter Lake in the Summer Lake basin and ZX Lake (new name) in the Chewaucan Marshes-Lake Abert part of the Lake Chewaucan basin. Overflow from ZX Lake later cut a shallow channel across the divide enroute to Winter Lake.

"The bottom sediments of Lake Chewaucan are exposed mainly in the bluffs of Ana River, the main source of Summer Lake water. The stratigraphic section there is about 54 feet thick and composed mainly of silt, with numerous seams of sand, oolites, occasional pebbles, and many layers of volcanic ash, especially near the top.

"Fossils found in the area include (1) mammals and birds obtained from man-occupied caves near Paisley, (2) ostracods, diatoms, and small mollusks in the Ana River section, (3) similar tiny snail shells in a gravel pit north of the Ana Springs Reservoir, and (4) additional shells from the 4425-foot level near Ten Mile Butte east of Summer Lake. The snail shells have radiocarbon ages of >25,900, 22,000, and 17,500 years—all within the span of the Tioga-Pinedale glacial stage of the Sierra Nevada and the Rocky Mountains. The top 4520-foot shoreline, the 4485-foot beach and Paisley Caves, and the bulk of the Paisley fan may possibly be Tahoe in age, but the wave erosion of the Paisley fan, development of Paisley Flat, overflow from ZX Lake, and later formation of ZX Red House beach are assigned to Tioga-Pinedale time.

"The history of Lake Chewaucan is thought to be analogous to those of Lake Bonneville, Lake Lahontan, and Searles Lake, and correlative with climatic changes recorded in marine deposits.

"The post-Lake Chewaucan history of the basin includes Anathermal, Altithermal, and Medithermal climatic changes, as shown by a pollen profile in Upper Chewaucan Marsh. Mount Mazama pumice sand fell in the area about 6,600,-6,700 years ago. Dessication and wind work were strong in Altithermal time. In the Neopluvial (new term), corresponding to Neoglaciation in the mountains (perhaps 4,000-2,000 years ago), new lakes many tens of feet deep developed in the Summer Lake and Chewaucan Marshes-Lake Abert basins. Later, Summer Lake and Lake Abert were reduced to the very shallow, alkaline bodies of water of the present day." □

Newberry Volcano soil-mercury survey completed

A soil-mercury survey of Newberry Volcano was recently completed by the Geothermal Group of the Oregon Department of Geology and Mineral Industries (DOGAMI) during a geothermal resource assessment sponsored by the Bonneville Power Administration. A limited number of copies of a preliminary report on the results of the survey, including a 1:62,500-scale contour map of the 1,641 mercury determinations, have been produced and are available from the Portland office of DOGAMI, 1005 State Office Building, Portland, OR 97201 at a cost of $5. Orders under $50 require prepayment.

This preliminary report will be available for a limited time only. A complete, finalized report will be released in March or April of 1983. □

AEG 26th Annual Meeting set for San Diego

The twenty-sixth annual meeting of the Association of Engineering Geologists (AEG) will be held October 3-8, 1983, at the Sheraton Harbor Island Hotel, San Diego, California. Featured will be symposia, short courses, field trips, and harbor cruises. For further information on submitting abstracts or registering for the meeting, contact Dennis Hannan, c/o Leighton and Associates, 7290 Engineer Road, Suite H, San Diego, CA 92111, phone (619) 292-8030. □

(Depositional contact, *continued from p. 7***)**

America Abstracts with Programs, v. 12, no. 3, p. 113 (insert).

Lanphere, M.A., Blake, M.C., Jr., and Irwin, W.P., 1978, Early Cretaceous metamorphic age of the South Fork Mountain Schist in the northern Coast Ranges of California: American Journal of Science, v. 278, p. 798-815.

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Ramp, L., 1975, Geology and mineral resources of the Upper Chetco drainage area, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 88, 47 p.

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Wells, F.G., and Walker, G.W., 1953, Geology of the Galice quadrangle, Oregon: U.S. Geological Survey Geologic Quadrangle Map GQ-25, scale 1:62,500. □

OIL AND GAS NEWS

Columbia County:

Reichhold Energy Corporation has changed the name of its recently permitted well, permit 225, from Adams 13-34 to Columbia County 13-34. The company will spud this well in mid-December. The well is programmed for 2,800 ft in search of a new pool. The location is 1 mi north and east of producing wells and is at the northern edge of the field.

Mist Gas Field production:

Gas production at the Mist Gas Field in 1982 has increased from 8 million cubic feet per day (MMcfd) in January to about 10 MMcfd in October. There have been fluctuations from month to month, but the trend has been an increase.

This increase has been made possible by the completion of three new wells during the year. Reichhold Energy Corporation, operator of all the producing wells, completed a redrill of Columbia County 13-1 in May of this year, after redrilling to a depth of 3,027 ft. The well was originally drilled in 1981. In July, the company redrilled Columbia County 4 to 2,894 ft for a completed well. This well was originally drilled during 1979. A third producer, Paul 34-32, was also drilled during 1982. This well, drilled to a total depth of 2,698 ft, extended the field farther west than any previous well. Reichhold plans further development and exploratory drilling in 1983.

Permit activity:

The following table will bring you up to date on permit expirations for the year.

Permit no.	Operator and well name	Location	Status, depth
134	Reichhold Energy Longview Fibre 33-12	SE¼ sec. 12 T. 6 N., R. 5 W. Columbia County	Permit expired and canceled.
148	Reichhold Energy Columbia County 32-5	NE¼ sec. 5 T. 6 N., R. 5 W. Columbia County	Permit expired and canceled.
169	Reichhold Energy Columbia County 14-34	SW¼ sec. 34 T. 7 N., R. 5 W. Columbia County	Permit expired and canceled.
176	American Quasar Franbea 36-34	SE¼ sec. 36 T. 7 N., R. 5 W. Columbia County	Permit expired and canceled.
183	Reichhold Energy Hemeon 14-14	SW¼ sec. 14 T. 6 N., R. 5 W. Columbia County	Permit expired and canceled.
187	Reichhold Energy Ellis 23-26	SW¼ sec. 26 T. 5 N., R. 4 W. Columbia County	Permit expired and canceled.
188	American Quasar Chipman 4-14	SW¼ sec. 4 T. 12 S., R. 2 W. Linn County	Permit expired and canceled.
190	Reichhold Energy Lee 32-32	NE¼ sec. 32 T. 7 N., R. 5 W. Columbia County	Permit expired and canceled.
198	Reichhold Energy Columbia County 44-2	SE¼ sec. 2 T. 6 N., R. 5 W. Columbia County	Permit expired and canceled.
225	Reichhold Energy Columbia County 13-34	SW¼ sec. 34 T. 7 N., R. 5 W. Columbia County	Location.

BLM automates oil and gas filing

The December 1982 *BLM News* reported that the Bureau of Land Management (BLM) has automated its system for receiving simultaneous applications for oil and gas leases on federal lands. Machines now can be used to read the application forms. The Cheyenne, Wyoming, office of the BLM will now handle applications for all western states. This automated system will be used only for previously leased parcels of land where the leases have expired or were relinquished, canceled, or terminated. Competitive oil and gas leases and over-the-counter filings will be handled as in the past.

In the states of Oregon and Washington, the BLM has about 10.5 million acres under oil and gas leases. □

Association of Engineering Geologists elects 1982-1983 officers

The newly elected officers of the Association of Engineering Geologists (AEG) took office at the meeting of the Board of Directors held during the Annual AEG Meeting in Montreal, Canada.

Elected as President is Richard W. Galster, Chief of the Geology Section, U.S. Army Corps of Engineers, Seattle District. Vice President is Robert M. Valentine, Senior Associate and Chief of Geosciences Division, Woodward-Clyde Consultants, Houston, Texas. Secretary is Norman R. Tilford, Consulting Geologist, Ebasco Services, Greensboro, North Carolina. Treasurer is Allen W. Hatheway, Professor of Geological Engineering, University of Missouri, Rolla, Missouri.

AEG represents over 3,000 members in 44 countries and is a member society of the American Geological Institute. The AEG is dedicated to promoting public safety, welfare, and the understanding of the profession. □

Available publications

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36. Papers on Tertiary foraminifera: Cushman, Stewart, and Stewart, 1949: v. 2	3.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	3.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	3.00		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	3.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
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62. Andesite Conference guidebook, 1968: Dole	3.50		
65. Proceedings of the Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
77. Geologic field trips in northern Oregon and southern Washington, 1973	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
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COVER PHOTO

Oblique aerial photograph of Jordan Craters vent and pit craters. Article beginning on next page discusses ages and chemistry of these and other volcanic rocks in the Jordan Valley area, southeastern Oregon.

OIL AND GAS NEWS

Columbia County

Reichhold Energy Corporation spudded its Columbia County 13-34 well on December 9, 1982, and drilled to a total depth of 2,822 ft, completing the well for gas production on December 23, 1982. This is the second gas completion in as many months for the operator and the eleventh for the field. The well tested at about 500,000 cubic feet per day and is located in sec. 34, T. 7 N., R. 5 W., about 1 mi from the nearest production.

Clatsop County

Diamond Shamrock Corporation has applied for a permit to drill in Clatsop County. To be located 10 mi west of gas production at the Mist Gas Field, the well will also be 1 mi north of a Quintana Petroleum Corporation well drilled two years ago. This well, Watzek 30-1, was drilled to 7,068 ft and abandoned as a dry hole. Details of Diamond Shamrock's well are found in the table below.

Oregon Division of State Lands lease sale

The Division of State Lands has listed over 43,000 acres in Clatsop County to be auctioned at the next lease sale. Parcels range in size from 1.61 acres to 651.62 acres. The townships with the most acreage are T. 4 N., R. 6 W., and T. 4 N., R. 7 W., with 8,213 acres and 8,379 acres available respectively. No date has been set for the auction. More information is available from the Division of State Lands by calling (503) 378-3805.

Recent permits

Permit no.	Operator, well, API number	Location	Status, Depth (ft)
226	Diamond Shamrock Corporation Hummel 22-19 007-00012	NW¼ sec. 19 T. 6 N., R. 6 W. Clatsop County	Application

□

Fireball sighted in December

James B. Marckette, U.S. Geological Survey, sighted a fireball at 11:15 p.m. PST , on December 30, 1982. Marckette, who was looking west from about 2 mi west of Alder Creek on U.S. Highway 26 in northern Oregon, first sighted the fireball at about 30° above the horizon. The fireball, which was visible for about 2 seconds, traveled from north to west, came down at an angle of about 15°, and was last seen about 10° above the horizon to the west. It was about one-sixth the size of the full moon and bright white in color, had a short yellow tail, and cast a shadow.

This sighting has been reported to the Scientific Event Alert Network, Smithsonian Institution. Anyone with any additional information about this or other meteor sightings should contact Dick Pugh, Cleveland High School, 3400 SE 26th Ave., Portland, OR 97202, phone (503) 233-6441. □

CONTENTS

Late Cenozoic volcanic stratigraphy of the Jordan Valley area, southeastern Oregon

by William K. Hart, Department of Geological Sciences, Case Western Reserve University, Cleveland, OH 44106; and Stanley A. Mertzman, Department of Geology, Franklin and Marshall College, Lancaster, PA 17604*

ABSTRACT

Miocene to Recent volcanism in extreme southeastern Oregon has produced thick sequences of basaltic and silicic material. Basalts ranging in composition from low-K, high-alumina olivine tholeiite (HAOT) to alkaline olivine basalt (AOB) and in age from 0 to 10 million years (m.y.) are observed. Thin layers of unconsolidated silicic tuffaceous material are often found as interbeds within the basalt sequence, whereas thick rhyolite flows and ash-flow tuffs predate the basaltic volcanism.

Excellent exposures throughout this area, especially along the Owyhee River and Jordan Creek, allow detailed stratigraphic, geochronologic, and geochemical studies. These investigations reveal a complex suite of basalts which overlap in both space and time. The observed occurrence of coevally erupted, depleted oceanic-type tholeiite (HAOT) and enriched AOB in close geographic proximity is important for regional stratigraphic correlations and petrogenetic models. These AOB's are the youngest reported in this portion of the Great Basin and are volumetrically less significant than the associated tholeiites. The complex volcanic assemblages encountered in the Jordan Valley area probably reflect variations in local and regional tectonic characteristics and upper-mantle processes which together have acted to control the eruptive histories of these lavas.

INTRODUCTION

The geology of the northwestern United States is characterized by extensive outpourings of Cenozoic volcanic material. On the basis of age, tectonic setting, and composition of erupted magmas, four major late Cenozoic volcano-tectonic provinces have been defined. These include the Cascade, Columbia Plateau, Snake River Plain and Basin and Range provinces.

Cascade volcanism is dominated by porphyritic two-pyroxene andesites erupted from large stratovolcanos along a general north-south belt extending from southern British Columbia to northern California. In contrast, volcanism in the other three provinces has been dominated by fissure-erupted, quartz-normative tholeiites (Columbia Plateau), olivine tholeiites and subalkaline rhyolites (western Snake River Plain), and alkaline olivine basalts and sub- to peralkaline rhyolites (Basin and Range).

An additional subprovince, located in the extreme northwestern Basin and Range, was originally defined by Waters (1962) as the Oregon-Modoc Plateau. More recently (e.g., Christiansen and McKee, 1978; Hart, 1982a; Hart and others, 1982), this region has been investigated because its tectonic, geochronologic, and magmatic features overlap with those of the Cascade, Columbia Plateau, Snake River, and southern Basin and Range provinces. The most striking feature of this region is the widespread occurrence of a distinctive low-K, high-alumina olivine tholeiite magma type with many petrographic and chemical features which strongly resemble those of mid-ocean ridge and back-arc basin basalts. Of particular interest is the area between the Owyhee River and Jordan Valley in southeastern Oregon (Figure 1). This area lies adjacent to the western Snake River Plain and provides a unique opportunity to investigate a complex and varied suite of basaltic and rhyolitic volcanic material (Hart and Mertzman, 1980, 1981). The remainder of this paper is devoted to a detailed stratigraphic, K-Ar geochronologic, and chemical discussion of this volcanic sequence.

JORDAN VALLEY AREA

Introduction

Dominating the pre-Miocene to Miocene record are mineralized, silicic volcanic and plutonic rocks of the Owyhee Mountains (Pansze, 1975; Bennett, 1976). Miocene to Pliocene alkaline basalts and rhyolite ash-flow tuffs and flows typical of the Basin and Range basalt-rhyolite association are also observed. The late Miocene to Recent record is dominated by interbedded basalts, silicic tuffs, breccias and flows, and lacustrine sediments historically considered as part of the Snake River volcanic province (see Armstrong and others, 1975, for summary and references) as well as very young alkaline olivine basalts of the Jordan Valley area. The dominant rock type in this area is basalt, often locally interbedded with silicic tuffs and sediments, reaching thicknesses of approximately 300 m and ranging in age from 0 to 10 m.y. Underlying the basaltic sequence is a sequence of nonmineralized silicic flows and welded vitric tuffs originally defined by Malde and Powers (1962) as the Idavada Volcanics.

Petrography and chemistry

Forty petrographic and chemical analyses of volcanic rocks from the Jordan Valley area indicate the presence of three distinct basalt types: low-K, high-alumina olivine tholei-

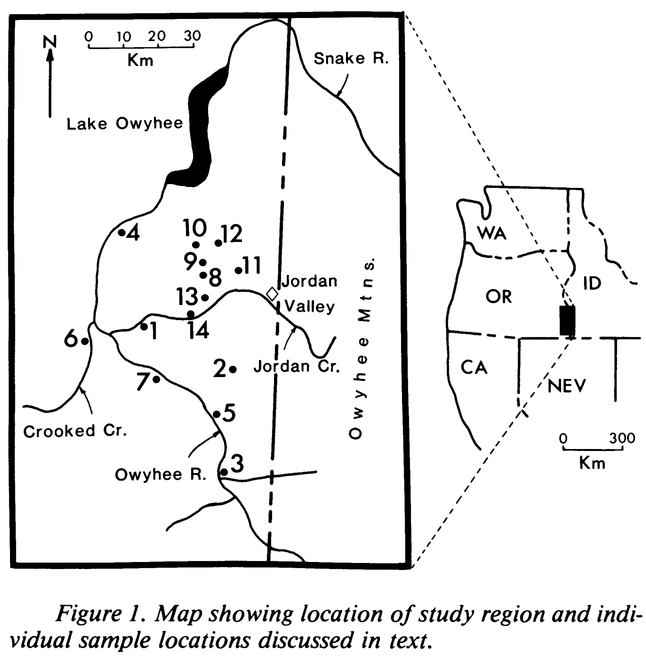

Figure 1. Map showing location of study region and individual sample locations discussed in text.

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Table 1. *Chemistry of major units*[a]

	HAOT	TB	AOB JC	AOB RBI	AOB RBII	AOB CB	AOB TMH	ST	SF
SiO_2	47.52	47.40	47.45	48.07	47.65	48.68	46.97	68.87	74.23
TiO_2	1.21	1.84	2.38	2.42	2.10	2.10	1.92	0.72	0.40
Al_2O_3	16.61	16.02	16.15	16.14	16.08	17.01	15.89	13.87	12.42
FeO	10.27	11.36	10.45	10.96	10.78	10.06	11.65	4.08	2.50
MnO	0.17	0.18	0.17	0.17	0.17	0.16	0.17	0.07	0.03
MgO	9.04	8.03	9.09	6.50	7.73	6.48	7.88	1.32	0.15
CaO	11.32	10.93	9.77	9.89	9.31	8.38	10.51	2.55	1.09
Na_2O	2.54	2.57	3.07	3.04	3.21	3.47	2.63	2.83	3.49
K_2O	0.25	0.40	0.69	1.35	1.07	1.88	0.72	4.12	5.00
P_2O_5	0.13	0.28	0.27	0.45	0.35	0.52	0.34	0.13	0.07
Rb	3	5	11	28	16	43	8	143	161
Sr	233	243	659	516	508	478	299	258	115
Ni	165	125	155	72	121	73	116	22	<DL
Ba	107	291	202	405	325	583	334	1024	1482
Zr	108	152	202	270	226	255	183	299	502
V	231	243	211	263	224	195	261	58	20
Y	18	24	<DL	21	19	18	35	56	77
MgO/FeO*	0.88	0.71	0.87	0.59	0.72	0.64	0.68	0.32	0.06
Rb/Sr	0.0013	0.021	0.017	0.054	0.032	0.090	0.027	0.554	1.40

a. HAOT=avg. of 7 low-K, high-alumina olivine tholeiites. TB=avg. of 17 transitional basalts. AOB=avgs. of individual alkaline basalt units: JC=Jordan Craters (1), RBI=Rocky Butte Type I (3), RBII=Rocky Butte Type II (6), CB=Clarke's Butte (1), TMH=Three Mile Hill (1). ST=avg. of 3 unconsolidated tuffaceous silicic units. SF=avg. of 4 rhyolite-flow/ash-flow units. FeO*=total Fe as FeO. All major elements in weight percent, trace elements in parts per million. <DL=less than detection limit.

ite (HAOT); alkaline olivine basalt (AOB); and tholeiites (TB) with characteristics transitional to those of HAOT and AOB. Also occurring in the area are two distinct silicic varieties: Low-SiO_2, unconsolidated tuffaceous units (ST); and high-SiO_2, welded ash-flow and rhyolite-flow units (SF of Table 1).

Petrographically, the HAOT's are characterized by distinctive holocrystalline, equigranular, diktytaxitic, nonporphyritic textures; subophitic to ophitic intergrowths of Ca-plagioclase (An_{60-75}) and augite; and abundant (up to 25 modal percent) intergranular olivine. The AOB's display varied textures, ranging from holocrystalline and diktytaxitic to intersertal, porphyritic, and glomeroporphyritic. These basalts often display a subophitic to intergranular relationship between plagioclase (An_{55-68}) and highly pleochroic titanaugite. In many cases, titanaugite is observed as a phenocryst phase in the AOB's, a feature not observed in HAOT. Modally, in AOB's olivine is less abundant (<20 percent) and clinopyroxene more abundant (>20 percent) than in HAOT's. The transitional basalts (TB's) have characteristics intermediate to and overlapping with both HAOT and AOB. This transition is also seen in the chemical data of Table 1, especially in the concentrations of the incompatible elements K_2O, TiO_2, P_2O_5, Rb, and Ba, which serve to distinguish between these three varieties of basalt. An important point to note is the depleted incompatible element signature of HAOT along with its characteristically high concentrations of CaO, MgO, and Ni and high MgO/FeO*. These characteristics set this basalt apart from other basalts of the northwestern United States (e.g., Columbia River, Steens Mountain, and Snake River).

As previously stated, the silicic material studied can be divided into two groups: tuffaceous units and flow units. The tuffaceous deposits generally occur as thin interbeds between basalt and/or basalt and rhyolite flows and are best categorized as crystal or vitric tuffs. These tuffs display matrices of banded glass, glass shards, flattened vesicles, mafic rock fragments, and deformed pumice balls. Mineralogically, the tuffaceous units are characterized by phenocrystic K-feldspar (anorthoclase and orthoclase) and Na-plagioclase (oligoclase to andesine) as well as scattered crystals of clinopyroxene, hornblende, and quartz. In contrast, the silicic flow units exhibit banded-glass and/or felsitic cryptocrystalline matrices with phenocrysts of Na-plagioclase (andesine to oligoclase), K-feldspar (sanidine and orthoclase), plus one or more of the following phases: clinopyroxene (diopsidic augite to subcalcic augite), orthopyroxene, quartz, magnetite, and zircon. In many cases, quartz and sanidine occur as large phenocrysts, up to 2 mm and 4 mm in length, respectively. Glomeroporphyritic clumps of pyroxene, feldspar, and oxide are common, as are needles of apatite as inclusions in feldspar. Further distinctions between these two silicic groups are obvious when the chemical data of Table 2 are examined. The rhyolite-flow/ash-flow units (SF of Table 1) illustrate chemical characteristics comparable to previously reported analyses of Idavada rhyolite from the western Snake River Plain region (Leeman and Manton, 1971).

* FeO = total Fe as FeO.

Table 2. *K–Ar age data*

Sample #	Map #	Type	K_2O (wt.%)	$\%^{40}Ar^*$	Age[b.] (Ma)
H-8-28C	1	TB	0.39_8	21.24	8.14±0.65
H-8-28D	1	TB	0.25_2	5.11	4.96±0.93
H-8-28E	1	HAOT/TB	0.37_2	18.72	7.05±0.61
H-8-29	2	HAOT/TB	0.35_2	10.89	9.87±1.10
H-8-34	3	TB	0.31_5	13.00	8.21±0.85
H-8-36	3	HAOT/TB	0.29_1	19.70	7.58±0.70
H-8-42	4	TB	0.44_6	16.78	4.49±0.38
H-8-45	4	HAOT	0.32_1	23.49	4.09±0.34
H-8-47	4	HAOT	0.33_2	13.36	4.06±0.41
H-8-69D(1)				16.74	9.95±1.02
H-8-69D(2)	5	TB	0.25_4	18.73	9.81±0.97
H-8-69D(3)				21.20	10.06±0.95
H-8-69G	5	TB	0.42_6	16.28	8.42±0.74
H-9-36A	6	HAOT	0.16_8	2.44	0.91±0.36
H-9-36C	6	HAOT	0.37_8	3.85	1.25±0.28
H-9-37A	7	TB	0.48_0	21.99	7.75±0.58
H-9-37C	7	TB	0.55_1	33.44	9.57±0.60
H-9-37D	7	TB	0.42_9	9.28	1.49±0.18
H-8-57	8	AOB	1.26	-	0.03(max)
H-8-70	9	AOB	1.88_2	4.18	0.25±0.05
JC-4	10	AOB	0.69_2	0.57	0.15(max)
H-9-42	11	HAOT	0.26_2	3.04	0.44±0.16
H-9-44	12	TB	0.40_9	6.20	3.84±0.57
H-9-49	13	TB	0.74_2	9.98	1.86±0.19
SM-75-9	14	AOB	0.99_0	-	0.09(max)
SM-75-12A	14	HAOT	0.35_0	9.46	8.51±1.02

a. $\lambda_\varepsilon=0.581\text{x}10^{-10}\text{yr}^{-1}$ $\lambda_\beta=4.962\text{x}10^{-10}\text{yr}^{-1}$ $^{40}K/K=1.167\text{x}10^{-4}\ \frac{\text{mol}}{\text{mol}}$

b. Uncertainty in calculated ages estimated by assuming uncertainties of 0.3% in measured isotopic compositions of sample and atmospheric argon, 1.0% in the volume of ^{38}Ar spike, 2.0% in sample heterogeneity and an absolute uncertainty in the measurement of K_2O.

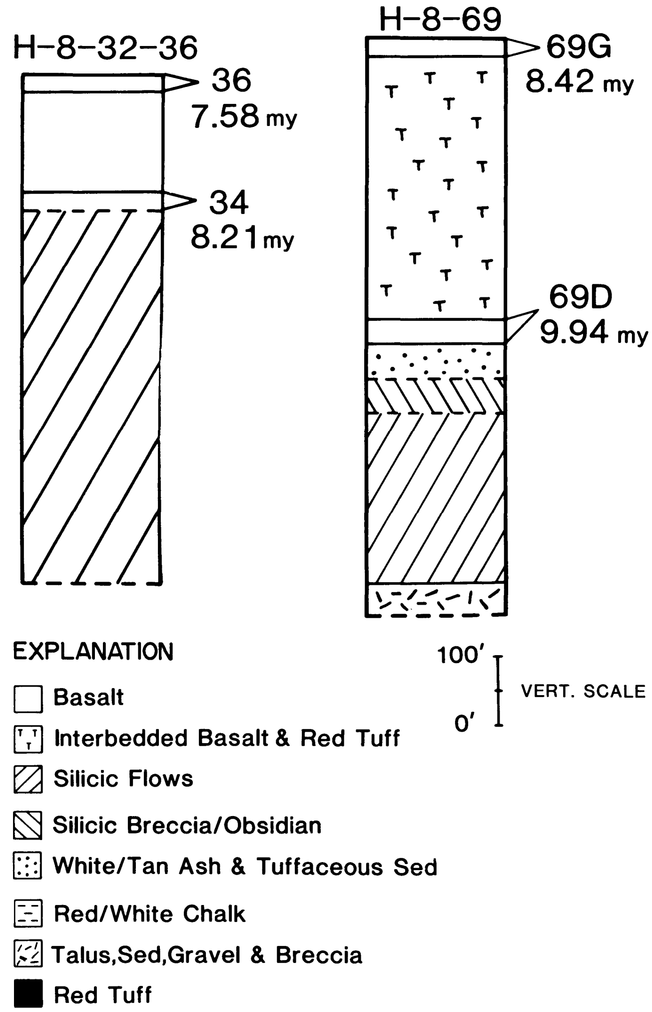

Figure 2. Stratigraphic relationships at map locations 3 (left column) and 5 (right column) of Figure 1.

Stratigraphy and geochronology

Twenty-four basalt samples from fifteen locations throughout the region depicted in Figure 1 have been dated by the K-Ar method (see Hart, 1982a, for experimental techniques). These results are reported in Table 2. Most of the dated samples are from various locations along the Owyhee River where excellent exposures allow construction of detailed stratigraphic sections. The remainder of the sampling was concentrated in the region north of Jordan Creek where a complex assemblage of volcanic material is observed.

Figure 2 illustrates the stratigraphic relationships at map locations 3 and 5. Basalts from these two locations range in age from 7.6 to 9.9 m.y. In both cases, these basalts are of the transitional variety and are underlain by rhyolitic-flow/ash-flow material (SF). Location 5 (sample H-8-69), at the mouth of Soldier Creek, exhibits a thick sequence (approximately 100 m) of interbedded basalt and red silicic tuffaceous material (ST) ranging in age from 8.4 to 9.9 m.y. Basalts of similar age and composition (e.g., sample H-8-29, Table 2) can be traced northeastward from locations 3 and 5 to the foothills of the Owyhee Mountains.

Farther north along the Owyhee River and Crooked Creek, various assemblages of basalt, silicic tuff, and lacustrine sediments occur. The stratigraphic relationships at three places (locations 4, 6, and 7) are illustrated in Figure 3. Location 4 (samples H-8-42-47) is dominated by a thick sequence (approximately 300 m) of white/tan ash and tuffaceous sediment, red/white chalk, and gravel, with basalt flows on top, in the middle, and at the base. These basalt flows are HAOT/TB and display a narrow range in age from 4.1 to 4.5 m.y. The age and lithologies of this exposure correspond to the descriptions and age relationships of the Glenns Ferry-Upper Chalk Butte Formations of the western Snake River Plain (Malde and Powers, 1962). The data and observations suggest that between at least 4 and 4.5 m.y. ago (probably from 2.6 to 6 m.y.) significant lacustrine sedimentation, accompanied by basaltic volcanism of varying compositions, was taking place in portions of the Owyhee River-western Snake River Plain region. Since this time period corresponds to that of active extensional tectonism in this region, the possibility exists that large lakes were formed in grabens created by major episodes of normal faulting. A similar sequence of ash and tuffaceous sediment is seen unconformably underlying a 1.3-m.y.-old HAOT flow at location 6 (sample H-9-36). Capping this sequence is another flow of HAOT dated at 0.9 m.y. Both of these flows appear to have originated from a source, or sources, to the northwest, and neither of the flows is exposed along the eastern side of Crooked Creek. Location 7 (sample H-9-37) yields a sequence of interbedded transitional tholeiite and red silicic tuff similar to that observed at location 5. An age range of 1.5 to >9.6 m.y. is observed for this exposure. It is important to note that the basal TB flow (sample H-9-37A of Table 2) at this location was dated at 7.8 m.y., whereas a TB flow (sample H-9-37C of Table 2) approximately 30 m upsection yielded an age of 9.6 m.y. It is believed that the 7.8-m.y. age of sample H-9-37A is inaccurate due to the presence of abundant altered glass and secondary clay.

The eastern Jordan Creek-Jordan Valley area is of great interest because of the diversity of volcanic material found in close geographic and geochronologic association. Exposure throughout this region is excellent, and good flow-on-flow stratigraphy is revealed in the walls cut by Jordan Creek.

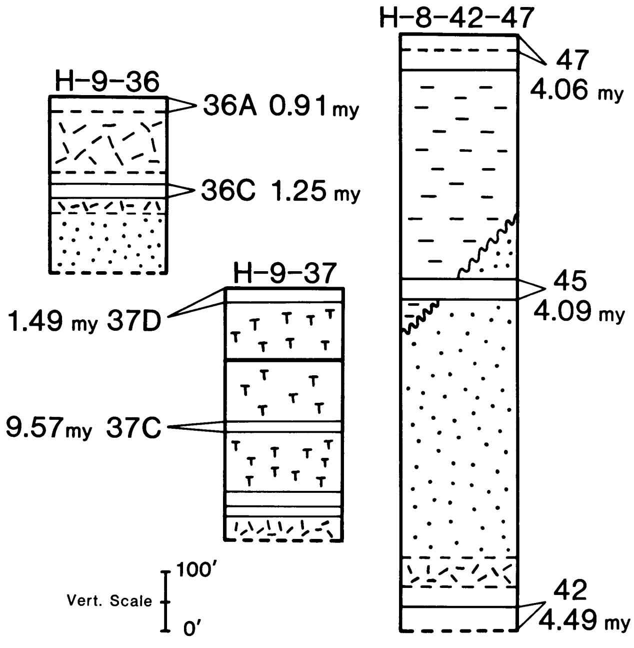

Figure 3. Stratigraphic relationships at map locations 4 (right column), 6 (left column), and 7 (center column) of Figure 1. Symbols as in Figure 2.

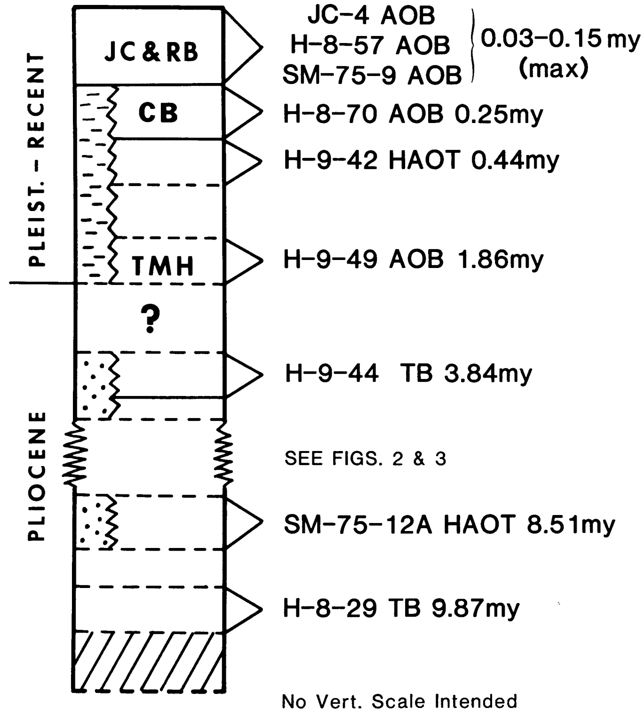

Figure 4. Generalized stratigraphic column for the eastern Jordan Creek-Jordan Valley area. Symbols as in Figure 2 plus JC = *Jordan Craters,* RB = *Rocky Butte,* CB = *Clarks Butte, and* TMH = *Three Mile Hill.*

Basalts ranging chemically from HAOT to AOB, as well as chalk, tuffaceous sediment, ash, and silicic flows, have been identified. Lacustrine sediments are present predominantly in the western portion of this area and appear to pinch out in an eastward direction. In the light of the previous discussion, this occurrence may be considered to mark the eastern edge of an ancient lacustrine system. A generalized stratigraphic column for this area is presented in Figure 4 and a geologic map in Figure 5.

The late Miocene-Pliocene section in this region is characterized by flows of HAOT and transitional basalt (TB) ranging in age from 9.9 to 3.8 m.y. and by basal Idavada rhyolite and interbeds of ash and tuffaceous sediment. Pleistocene to Recent volcanism is concentrated in the area northwest of Jordan Valley and is dominated by eruptions of alkaline olivine basalts. These AOB's have been erupted from a series of N. 10° to 15° W.-trending vents extending from Three Mile Hill to Jordan Craters. Scattered vents farther to the west and east are also observed. These AOB's cover an area of nearly 750 km² and flow up against and over older HAOT, TB, and silicic flows. The southernmost and oldest (1.9 m.y.) of these main vents is Three Mile Hill, a small, partially eroded shield volcano. Clarks Butte, lying approximately 10 km north of Three Mile Hill, has been dated at 0.25 m.y. Flows from this small, collapsed, eroded shield spread out in all directions and exhibit erosional features similar to the older AOB flows. Overlying the flows from both Three Mile Hill and Clarks Butte are younger AOB's (0.03-0.09 m.y. maximum) from Rocky Butte and a source east of Rocky Butte (Skinner Hill). These flows exhibit primary volcanic features such as tumuli, pahoehoe surfaces, and collapse structures. The most pronounced source area for AOB in this region is Jordan Craters, a name which comprises both the main crater and series of northwest-trending spatter cones. The main crater is a large collapse feature nearly 200 m by 100 m and up to 75 m deep. Flows emanate from the south side, and high walls of pyroclastic material and cinder surround the remainder of the crater. The walls of the crater are composed of interbedded basalt, ash, and volcanic breccia; in the southwest wall is exposed also a layer of reddish silicic material which is chemically identical to the Idavada rhyolite found throughout this region. A sample of massive basalt from the eastern wall yields a maximum age of 0.15 m.y. for the main crater. Extending linearly to the northwest from the main crater is a series of five to six spatter cones which may represent the last stages of activity in this region. The flows associated with Jordan Craters are extremely rugged, with numerous collapse features, tumuli, pahoehoe surfaces, and lava tubes. These lavas flow up against TB (3.8 m.y.) to the east, young HAOT (0.44 m.y.) to the southeast, and older tuffaceous sediment and silicic material to the southwest and overlie AOB from Clarks Butte to the south. An important point to note is the occurrence of AOB and HAOT in close

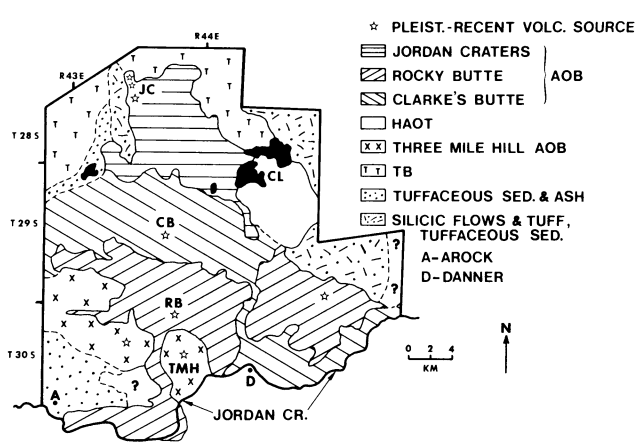

Figure 5. Geologic map of the eastern Jordan Creek-Jordan Valley area. Symbols as in Figure 4 plus CL = *Cow Lakes.*

geographic and geochronologic association. It is also important to note that these volcanic rocks are the youngest AOB's found in the northwestern Great Basin, and with the exception of one flow of Miocene AOB ("Lower Basalt" of Pansze, 1975) in the Owyhee Mountains, the only AOB's recognized in the Jordan Valley area.

DISCUSSION

The complexity of the sedimentary-volcanic sequences in the Jordan Valley area is obvious. Many of the stratigraphic and geochronologic relationships in this region can be grossly correlated with those occurring in portions of the western Snake River Plain. Care must be taken in making these regional correlations because many, if not most, of the sedimentary and volcanic units are local in extent and are often bounded by unconformities. The basalts, which dominate the volcanic sequence, follow the topography onto which they were extruded, giving rise to such features as local basin and channel-fill deposits. In addition, a wide range in basalt compositions is observed, indicating that further care must be taken in attempts at regional correlations.

The close geographic and geochronologic association of a variety of basaltic and rhyolitic composition materials in the Jordan Valley area necessitates calling on complex upper-mantle and/or crustal melting models, possibly coupled with crystal fractionation and magma or source mixing. Such processes have been suggested to account for the elemental characteristics of the observed TB's (Hart and Mertzman, 1981) as well as the elemental and isotopic characteristics of the HAOT's, TB's, and AOB's (Hart, 1982a, b). These petrologic and geochemical models imply that the volcanic rocks erupted in a given area are closely linked to the present and past tectonic characteristics of that area. One can speculate that in a region such as the Jordan Valley area, where two distinct tectonic provinces merge (Basin and Range and Snake River Plain), the associated volcanism will illustrate characteristics common to both provinces. With this in mind, it is suggested that an understanding of the volcanic geology of the Jordan Valley region of southeastern Oregon may be an important step toward understanding the volcano-tectonic evolution of the entire northwestern Great Basin.

SUMMARY

The late Cenozoic geology of the Jordan Valley area is characterized by complex assemblages of interbedded basalts, rhyolites, and lacustrine sediments. The basalts range in composition from low-K, high-alumina olivine tholeiite to alkaline olivine basalt and in age from 0 to 10 m.y. Interbedded with these basalts are silicic volcanic tuffs and lacustrine sediments. Flows and ash flows of unmineralized Idavada rhyolite underlie the basalt-sedimentary sequences throughout this region. The complexities of this area are most likely related to complex and varied petrogenetic processes which are in turn related to the regional tectonic characteristics.

ACKNOWLEDGMENTS

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Oregon Council of Rock and Mineral Clubs gives display case

On December 10, 1982, a display case located in the Capitol Building in Salem and featuring museum-quality specimens of Oregon rocks and minerals along with finished cabochons or slabs was given to the State of Oregon by the Oregon Council of Rock and Mineral Clubs.

Oregon Council representatives assisting in the dedication ceremony were Ted Jackson, President; Keith Wooldridge, Treasurer; and Ted and Mary Arrowood, Carol Lundin, Harold Dunn, Otto DeShon, Vivian Johnson, Jessie Jackson, and Lyle and Florence Riggs.

The current display includes 40 items or groups of specimens loaned by seventeen people representing fifteen Oregon rock clubs. The case, located at the west end of the corridor leading from the Information Desk on the main floor of the Capitol, measures 11 ft long by 3 ft high by 1 ft deep, is constructed of tempered glass and aluminum with adjustable glass shelving, and features diffused lighting.

The Capitol display case was made possible through contributions of member clubs of the Oregon Council and other interested clubs. The first display was installed on November 12, 1982, and will remain for about three months, after which it will be replaced by materials from one of the clubs of the Oregon Council. □

Geochemical evidence for changing provenance of Tertiary formations in northwestern Oregon

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INTRODUCTION

The Cowlitz, Keasey, Pittsburg Bluff, and Astoria Formations exposed near Mist, Columbia County, northwestern Oregon (Figure 1), display geochemical variations that are a reflection of different provenances (Kadri, 1982). These variations and the lithology of clasts within these upper Eocene to middle Miocene marine sedimentary units are used in this paper to infer "continental" and volcanic sources. The Mist area rocks are important because they are the host for the only producing natural gas field in the Pacific Northwest (Bruer, 1980).

STRATIGRAPHY

The Cowlitz Formation is the oldest exposed unit of the thick marine sedimentary sequence that overlies Eocene volcanic rocks and interbedded sedimentary rocks of the Tillamook highlands south of Mist. The Cowlitz Formation consists of fine-grained, well-sorted, micaceous, arkosic sandstone, siltstone, and mudstone.

The Keasey Formation unconformably overlies the Cowlitz Formation (Bruer, 1980) and consists of tuffaceous, concretionary mudstone, siltstone, and minor volcaniclastic sandstone. The Keasey Formation rocks contain abundant volcanic-derived constituents and were deposited in bathyal to outer neritic depth (McDougall, 1980) on a broad, unstable shelf.

The deltaic deposits of the Pittsburg Bluff Formation unconformably overlie the Keasey Formation. Bioturbated arkosic to lithic arkosic sandstone, siltstone, and finely laminated mudstone are the dominant rocks of the Pittsburg Bluff Formation.

The middle Miocene Astoria Formation, which unconformably overlies the Pittsburg Bluff and Keasey Formations, consists of basalt clast conglomerate, sandstone, and siltstone. Lithic arkosic to quartzose sandstone displays ripple lamination and cross-bedding. Flows of the Columbia River Basalt Group cap the stratigraphic section and belong to the Grande Ronde Basalt (low-MgO geochemical type) and the Wanapum Basalt (Frenchman Springs Member). The Columbia River basalt and coevally deposited Astoria Formation lap onto the older rocks.

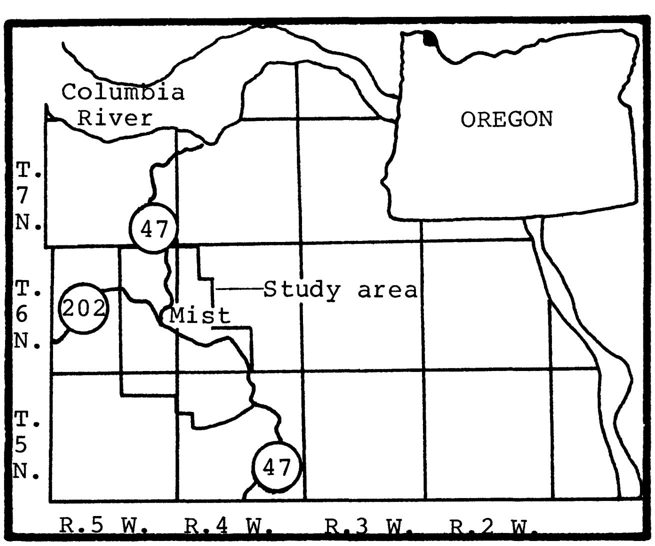

Figure 1. Location map of the Mist area.

GEOCHEMISTRY

In this study, instrumental neutron activation analysis was used to determine concentrations of sodium (Na), potassium (K), iron (Fe), and a number of trace elements in 53 sedimentary rock samples. These samples were analyzed to examine geochemical variations within the Tertiary rocks and to determine the possibility of using geochemical parameters to characterize formations and to identify their provenances.

The sedimentary rocks were disaggregated, and approximately one gram of sample was analyzed. Among the elements detected, Na, K, lanthanum (La), samarium (Sm), scandium (Sc), and thorium (Th) were important in characterizing the formations. Relative concentrations of these elements appear to establish significant groupings.

The Cowlitz Formation has a higher concentration of K and a higher La/Sm ratio than does the overlying Keasey Formation (Figure 2). Th is a "continental" element (Moore, 1972) in that it occurs in greater abundance in typical continental igneous and metamorphic terranes than it does in volcanic rocks of arc complexes or oceanic areas. In the Cowlitz sedimentary rock samples, Th averages 12 parts per million (ppm) (Figure 3), which is closer to the continental average of 9.6 ppm (Taylor, 1964); by contrast, in the Keasey samples, Th averages only 3 ppm, well within the 0.18- to 5.5-ppm range of volcanic rocks of volcanic arcs (Condie, 1976).

The Pittsburg Bluff Formation has higher K and Na concentrations compared to the Keasey Formation (Figure 4), but there is an overlap in the concentrations of Sc and in the La/Sm ratio. Concentration of Th in the Pittsburg Bluff Formation is intermediate to that of the Cowlitz and Keasey Formations (Figure 3).

Rocks of the Columbia River Basalt Group have much higher concentrations of Sc than do the sedimentary rocks. Among the sedimentary rocks analyzed, only those of the

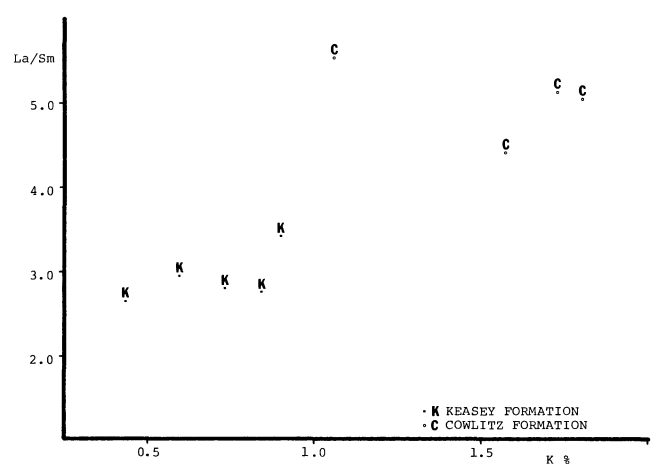

Figure 2. Plot of La/Sm ratio versus K.

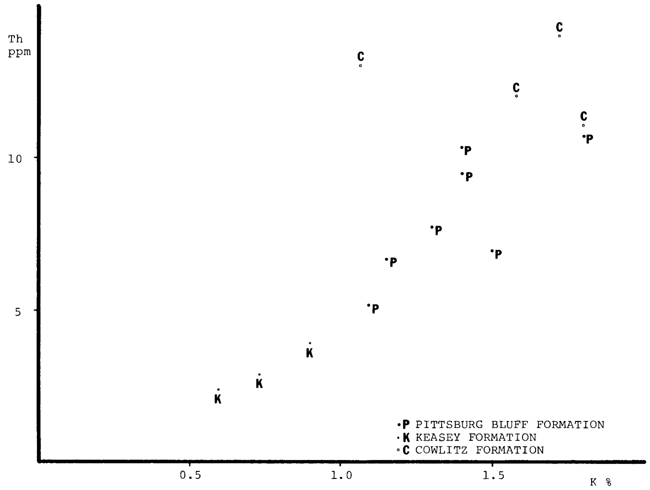

Figure 3. Plot of Th versus K.

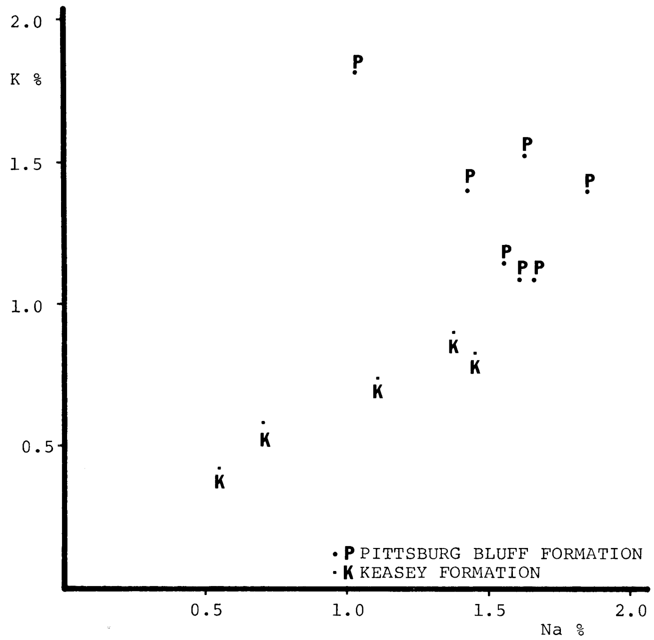

Figure 4. Plot of K versus Na.

Astoria Formation have consistently high Sc concentrations (Figure 5). The Astoria Formation samples that have highest Sc concentrations are pebbly sandstones that contain basalt pebbles with high Sc content.

DISCUSSION

Geochemistry of the sedimentary rocks, together with petrographic evidence, delineates important differences in provenance of the Tertiary rocks of the Nehalem River basin. Relative concentration of elements varies in a consistent manner between the lithostratigraphic units.

The Cowlitz Formation has a higher amount of potassium feldspar and mica (Van Atta, 1971) than any other formation in the Nehalem River basin. Higher K and Th concentrations and higher La/Sm ratios in the Cowlitz rocks further substantiate Van Atta's (1971) conclusion for a granitic and metamorphic provenance for the Cowlitz Formation.

The Keasey rocks contain abundant ash and lapilli as well as basaltic and andesitic rock fragments (Van Atta, 1971).

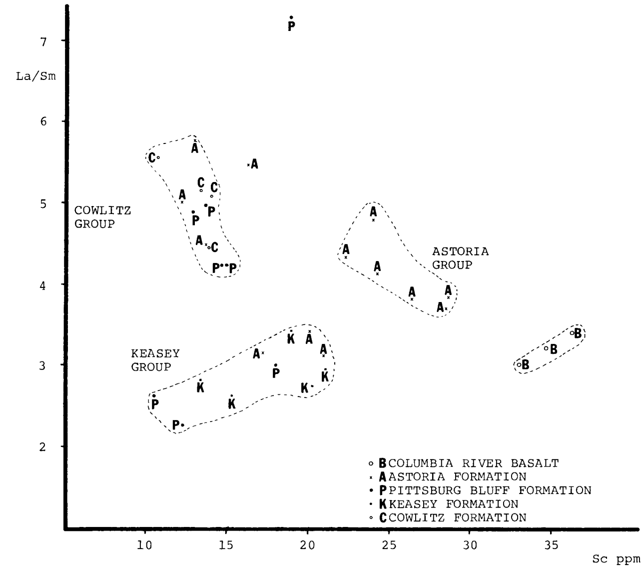

Figure 5. Plot of La/Sm ratio versus Sc.

Geochemically, rocks of the Keasey Formation have relatively low K and Th concentrations and low La/Sm ratios. These geochemical and lithologic data suggest a much greater influence of a volcanic component in the provenance of the Keasey Formation as compared to the Cowlitz Formation. Therefore, a major change from a granitic-metamorphic-dominated provenance to a volcanic-dominated provenance occurs between the Cowlitz and Keasey Formations. Concentration of Th, a "continental" element, is much lower in the Keasey than in the Cowlitz.

Another major change in provenance is recorded by the rocks of the Astoria Formation. Higher Sc concentrations in some of the Astoria Formation samples may be due to the presence of the Columbia River basalt in the provenance.

Geochemical evidence of these three major provenances is shown graphically in Figure 5, a plot of La/Sm versus Sc. The

Table 1. Concentration of elements in analyzed samples.

Sample No.	Na %		K %		La ppm		Sm ppm		Sc ppm		Th ppm	
	COWLITZ FORMATION											
22-4-5	2.22	±0.01	1.06	±0.18	50.30	±1.40	9.08	±0.19	11.20	±0.40	13.0	±2.0
6-3-5	1.26	0.01	1.80	0.20	45.90	1.30	9.05	1.18	13.90	0.60	11.0	4.0
32-3-5	0.85	0.0	1.57	0.16	35.80	1.0	8.09	0.14	13.70	0.50	12.0	2.0
TCW3092	1.95	0.01	1.72	0.21	47.00	1.30	9.16	0.18	13.20	0.40	14.0	2.4
	KEASEY FORMATION											
25-6-5	0.71	0.0	0.59	0.08	130.0	3.0	44.0	0.60	20.90	0.50	2.3	0.1
20-6-4	1.11	0.01	0.73	0.10	10.10	0.50	3.60	0.10	13.30	0.50	2.8	0.1
2-5-5	0.56	0.0	0.43	0.06	103.0	2.0	39.0	0.50	15.30	0.40	n.d.	
23-6-5	1.39	0.01	0.90	0.13	16.50	0.70	4.83	0.12	18.90	0.50	3.9	0.1
33-6-5	1.46	0.01	0.84	0.12	15.70	0.60	5.66	0.13	20.30	0.50	n.d.	
	PITTSBURG BLUFF FORMATION											
23-5-4	1.85	0.01	1.40	0.18	36.10	1.10	7.31	0.15	13.50	0.50	9.4	0.2
23-5-4b	1.81	0.01	1.30	0.18	14.70	0.30	6.45	0.15	12.10	0.50	7.7	0.2
28-6-4	1.43	0.01	1.40	0.17	26.60	0.90	10.20	0.16	10.40	0.40	10.3	2.3
12-6-5	1.55	0.01	1.15	0.14	27.60	0.90	6.55	0.15	14.60	0.50	6.6	0.2
12-6-5b	1.64	0.01	1.52	0.18	25.30	0.80	5.17	0.13	12.80	0.50	6.9	0.1
12-6-5d	1.66	0.01	1.09	0.16	36.90	1.10	5.07	0.13	18.80	0.50	5.1	0.1
11-6-5	1.60	0.01	1.09	0.16	36.90	1.10	12.20	0.19	17.90	0.50	n.d.	
4-5-4	1.03	0.01	1.82	0.20	30.00	0.90	7.13	0.14	14.80	0.40	10.7	2.0
	ASTORIA FORMATION											
12-6-5e	0.89	0.01	1.03	0.14	103.0	3.0	33.0	0.50	20.90	0.50	7.2	0.2
12-6-5g	0.53	0.0	0.91	0.10	23.90	0.70	5.51	0.11	22.20	0.50	n.d.	
12-6-5h	0.06	0.0	0.06	0.02	17.89	0.60	4.60	0.09	28.50	0.50	6.3	2.1
6-6-4	2.81	0.02	n.d.		19.0	0.80	6.01	0.14	17.10	0.50	n.d.	
3-6-5	0.23	0.0	0.62	0.07	33.90	1.00	9.93	0.16	20.00	0.40	n.d.	
2-6-5	0.22	0.0	0.63	0.07	32.10	0.90	6.67	0.12	23.90	0.40	10.7	3.3
2-6-5b	0.14	0.0	0.70	0.07	20.30	0.60	4.91	0.09	24.10	0.40	8.8	1.4
25-6-5b	0.15	0.0	1.19	0.13	26.70	0.80	4.89	0.10	16.0	0.40	10.0	3.0
25-6-5d	0.14	0.0	1.27	0.14	23.50	0.70	4.09	0.09	12.90	0.30	10.7	3.1
30-6-4	0.69	0.0	0.98	0.11	37.6	1.0	9.76	0.16	26.3	0.50	8.9	2.1
30-6-4b	0.65	0.0	0.93	0.10	55.6	1.40	14.90	0.20	28.40	0.50	10.0	2.7
2-5-5a	1.17	0.01	1.60	0.18	26.80	0.90	5.96	0.13	13.60	0.50	n.d.	
2-5-5c	0.98	0.01	1.50	0.17	22.40	0.80	4.48	0.13	12.10	0.50	8.9	3.4
	COLUMBIA RIVER BASALT											
6-5-4	1.62	0.01	0.65	0.11	21.6	0.70	7.10	0.14	32.90	0.60	n.d.	
6-5-4a	2.37	0.01	1.08	0.19	23.50	0.90	7.30	0.17	34.70	0.60	n.d.	
6-6-4a	2.84	0.02	1.02	0.20	30.0	1.0	8.78	0.17	36.20	0.70	n.d.	

sedimentary rocks plot into three groups: one group consists exclusively of samples from the Astoria Formation, whereas the remaining two groups consist of samples from the Keasey and Cowlitz Formations respectively, and *each* includes samples from the Pittsburg Bluff and Astoria Formations. The samples that plot in the Cowlitz group contain or are geochemically inferred to contain granitic-metamorphic detritus, whereas the samples that plot with the Keasey group have a dominant volcanic component. Thus, the Cowlitz rocks are probably derived from distant granitic-metamorphic terranes and the Keasey rocks from nearby volcanic arcs (western Cascades).

In conclusion, the Cowlitz and Keasey Formations appear to record a change in geologic setting. Deposition of predominantly continental detritus during Cowlitz time was terminated by the onslaught of widespread volcanism in the western Cascades. The concentration of Th in the Pittsburg Bluff Formation is intermediate to that in the Keasey and Cowlitz Formations, and the mixed provenance in the Pittsburg Bluff Formation indicates both "continental" and volcanic sources. The voluminous outpouring of the Columbia River basalt in the middle Miocene embayment contributed detritus to the sediments of the Astoria Formation.

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The Oregon Academy of Science (OAS) Annual Meeting will be held February 26, 1983, at Willamette University, Salem, OR. This year's theme is Marine Fisheries. For additional information, contact Neal Bandick, Western Oregon State College, Monmouth, Oregon, phone (503) 838-1220.

Geologic and tectonic evaluation of The Dalles quadrangle released

The Oregon Department of Geology and Mineral Industries (DOGAMI) has just released the results of a geologic and neotectonic study of The Dalles 1° × 2° quadrangle, conducted in cooperation with the U.S. Nuclear Regulatory Commission. The release is map GMS-27 in DOGAMI's Geological Map Series.

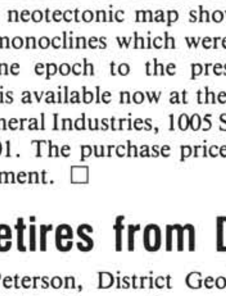
Geologic and Neotectonic Evaluation of North-Central Oregon: The Dalles 1° × 2° Quadrangle was compiled by James L. Bela. The map set consists of a multicolor geologic compilation map and a detailed two-color neotectonic map, both at a scale of 1:250,000. The area covered by The Dalles quadrangle extends along the Columbia River and spans the tectonic boundary between the geologic provinces of the Cascade Range and the Columbia Plateau.

The geologic map identifies and describes 25 different surficial and bedrock geologic units, shows the general structure of the region, and includes the locations and ages of 23 dated rock samples. The neotectonic map shows, in greater detail, folds, faults, and monoclines which were formed from about the middle Miocene epoch to the present.

Map GMS-27 is available now at the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR 97201. The purchase price is $6. Orders under $50 require prepayment. □

Peterson retires from Department

Norman V. Peterson, District Geologist at the Grants Pass Field Office of the Oregon Department of Geology and Mineral Industries for the last 25 years, retired from the Department in December 1982. During his years with the Department he participated in geologic studies covering most of Oregon and authored or coauthored over 50 articles, papers, and books on both technical and general-interest subjects. He conducted commodity studies of uranium, limestone, diatomite, pumice, perlite, volcanic cinders, and geothermal resources; worked on numerous county studies including Lake, Klamath, Deschutes, Josephine, and Douglas Counties; assisted with geologic mapping of the Crescent and Jordan Valley 1° by 2° quadrangles; participated in the wilderness mineral evaluation in Harney and Malheur Counties; and helped author nuclear power plant siting and volcanic hazards



Norman V. Peterson

studies. He introduced many of our readers to the volcanic wonders of Oregon by his articles and field trip guides about such places as Hole-in-the-Ground, Diamond Craters, Cove Palisades State Park, Fort Rock, Newberry Volcano, and Crack-in-the-Ground. He and Ed Groh edited one of the Department's most popular guidebooks, the *Lunar Geological Field Conference Guidebook*, which focused on the volcanic features found in Oregon.

Following his retirement, he intends to remain active in his profession and in his hobbies which include coin collecting, bee keeping, ski touring, and traveling. □

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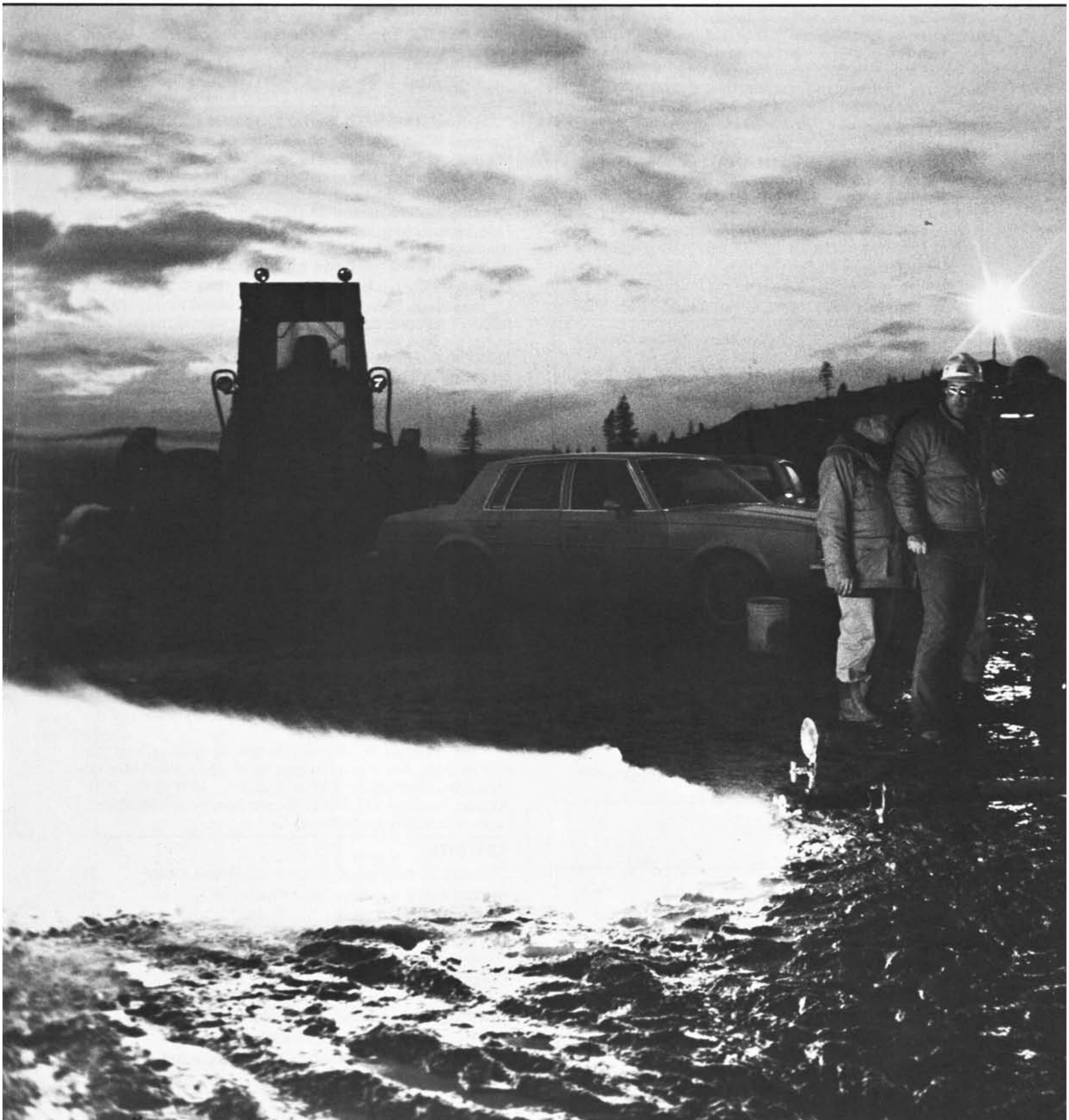

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COVER PHOTO

Reichhold Energy Corporation testing Columbia County 13-34 at the Mist Gas Field. Flame is flared gas released during the test to determine the potential of the well, the fourth well completed to production by the operator during the year. Article beginning on next page summarizes oil and gas activity in Oregon during 1982.

OIL AND GAS NEWS

Clatsop County:

Diamond Shamrock Corporation has applied for the following permits:

Permit no.	Operator, well name, API no.	Location	Status, depth (ft)
226	Diamond Shamrock Corp. Watzek 22-19 007-00012	NW¼ sec. 19 T. 6 N., R. 6 W. 1,945 ft S. of N. line 2,151 ft E. of W. line	Location, 5,000.
227	Diamond Shamrock Corp. State of Oregon 23-33 007-00013	NE¼ sec. 33 T. 6 N., R. 7 W. 1,753 ft N. of S. line 1,636 ft E. of W. line	Location, 7,000.

Diamond Shamrock Watzek 22-19 is located 1 mi north of Quintana Watzek 30-1, which was dry and abandoned in 1981 at a total depth of 7,068 ft. The State of Oregon 23-33, the first well to be permitted on state lands in the State of Oregon, is located 4 mi southwest of Quintana Watzek 30-1.

Oregon Natural Gas Development Corporation Patton 32-9, located in sec. 9, T. 7 N., R. 8 W., 4 mi east of Olney, was suspended November 4, 1982. The company plans to re-enter the well and redrill to a proposed total depth of 4,000 ft.

Columbia County—Mist Gas Field

Reichhold Energy Corporation Columbia County 13-34, located 1 mi north and east of producing wells at the northern end of the field, was completed as a gas well flowing at the rate of 473,000 cubic feet of gas per day. This brings the total of producing wells in the field to 11. Currently, nine wells are on line, of which six are producing and three are shut-in. Two wells, Reichhold Paul 34-32 and Reichhold Columbia County 13-34, are awaiting pipeline connection. □

Department publishes thesis bibliography

The Oregon Department of Geology and Mineral Industries (DOGAMI) has made available a comprehensive list of theses and dissertations on the geology of Oregon. The new publication, DOGAMI Special Paper 11, is entitled *Theses and Dissertations on the Geology of Oregon: Bibliography and Index, 1899-1982*. It was designed to provide valuable bibliographic information to anyone doing research on geology in the state of Oregon.

Special Paper 11 contains a compilation of over 660 titles of master's theses and doctoral dissertations. Accompanying the text is a 25- by 36-inch black-and-white map of Oregon (scale 1:1,000,000) showing the locations of study areas of the theses and dissertations.

The bibliography is available now by mail or over the counter from the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, 1400 S.W. Fifth Avenue, Portland, OR 97201. The purchase price is $6. Orders under $50 require prepayment. □

CONTENTS

Oil and gas exploration and development in Oregon, 1982

by Dennis L. Olmstead, Petroleum Engineer, Oregon Department of Geology and Mineral Industries

ABSTRACT

During 1982, the oil and gas industry in Oregon experienced the same slump that was occurring nationwide. Leasing was up due to issuance of leases applied for in 1981, but drilling footage was down 31 percent from the previous year.

There were five active operators in the state, including three new ones, drilling a total of 13 wells and five redrills. The bright spot for the year was the completion of four new gas producers in the Mist Gas Field by Reichhold Energy Corporation. Field production for the year was 3.4 billion cubic feet.

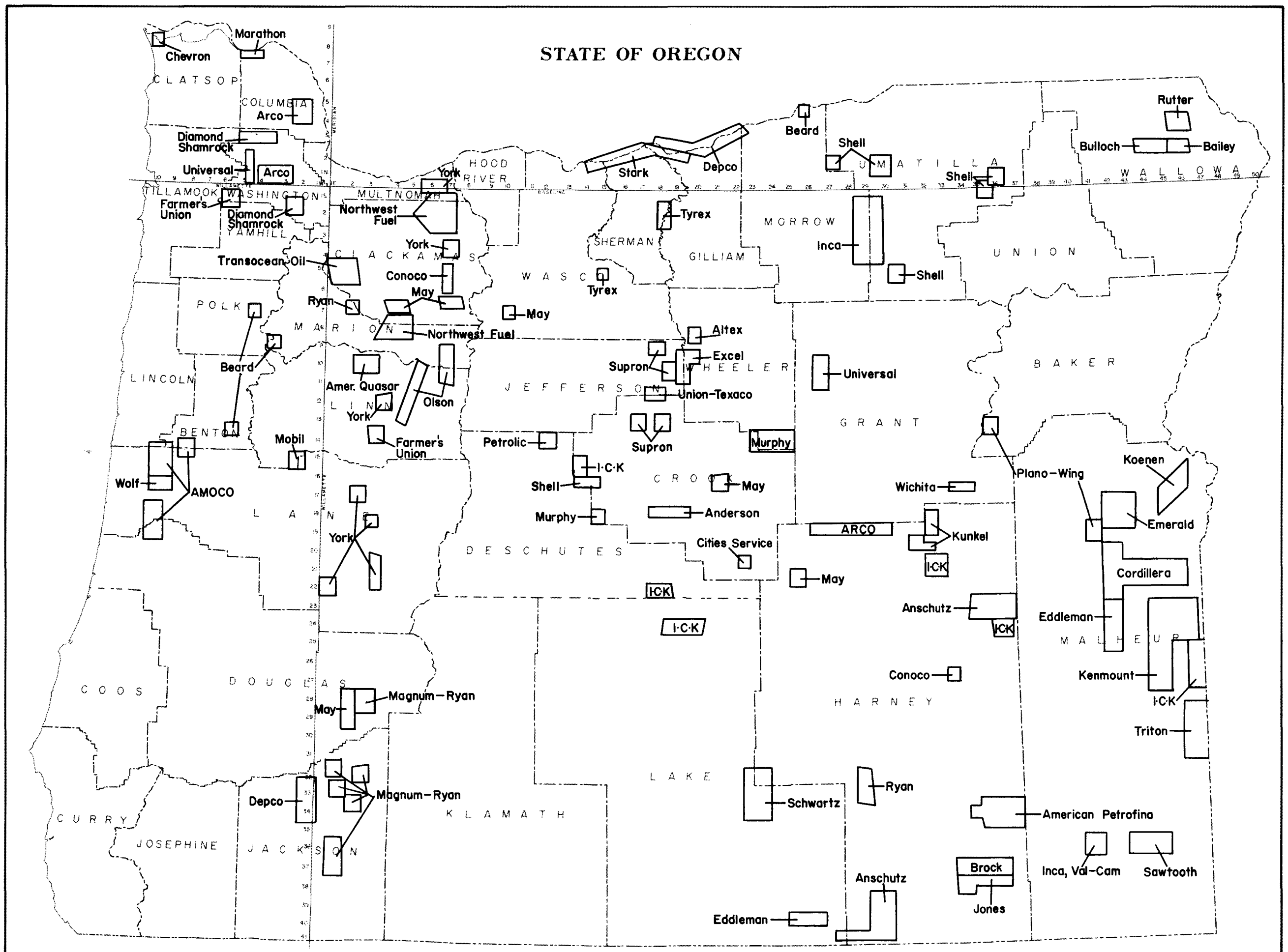
LEASING ACTIVITY

The leasing of oil and gas rights in 1982 was influenced most heavily by federal lands leased through the Bureau of Land Management (BLM). This has been the case for the past several years due to the boom in the oil industry and the subsequent rush to lease available land by industry, land brokers, and speculators. During 1981, a large backlog of lease applications accumulated with the BLM, which led to a directive late in the year to reduce the backlog by issuing these leases. This resulted in an increase in leases issued during 1982, while new applications decreased.

The BLM received lease applications for 433 parcels of land during 1982, totaling over 1.5 million acres. Interest again centered in central and eastern Oregon where most of the federal land is located. The Bureau issued leases on 2,249 parcels covering a total of 6.9 million acres during the year, bringing the total for federal leased lands to nearly 9.2 million acres in the state by year's end. This again tripled the federal acreage under lease, just as the 1981 activity had done.

Counties with the largest federal acreages leased included Harney with over 2 million acres, Malheur with about 1.6 million, and Crook and Lake Counties with about 950,000 acres each. Other counties in eastern Oregon with high lease totals were Grant, Jefferson, and Wasco. West of the Cascades, large amounts of federal acreage were leased in Clackamas, Coos, Douglas, Jackson, Lane, and Lincoln Counties, with over 100,000 acres each.

While this surge of leasing occurred, partially as a result of 1981 applications, a softening of oil prices and the inability of some speculators to sell their leases resulted in the withdrawal or termination of over two million acres of leased land. The leasing of federal land is a good indicator of industry interest in a state. Drilling usually lags by several years, however,



Major areas of oil and gas lease activity in Oregon, 1982. Map shows acreage applied for, issued, and assigned. Withdrawals not shown. Lease data courtesy Dolores Yates, LANDATA Reporting and Services.

tors included Florida Exploration Company, Nahama and Weagant Energy Company, and Z and S Construction Company. Most of the wells (nine new wells and five redrills) were drilled by Reichhold Energy, operator of the producing wells in the Mist Gas Field. Table 1 lists the wells drilled and also other permits issued during the year. Permits that were canceled during the year were listed in the December 1982 issue of *Oregon Geology*.

The total footage drilled during the year was 67,479 ft, down 31 percent from the 1981 total of 97,989 ft.* These footage totals include redrill footages from the kickoff point to the redrill depth. The average depth of wells in 1982 was 3,940 ft, a decrease from the 1981 average of 4,700 ft. This is due to a higher percentage of wells being drilled in the Mist Gas Field, where the target sand is at a depth of about 2,500 ft. Thirteen of the eighteen original holes and redrills were field wells during the year.

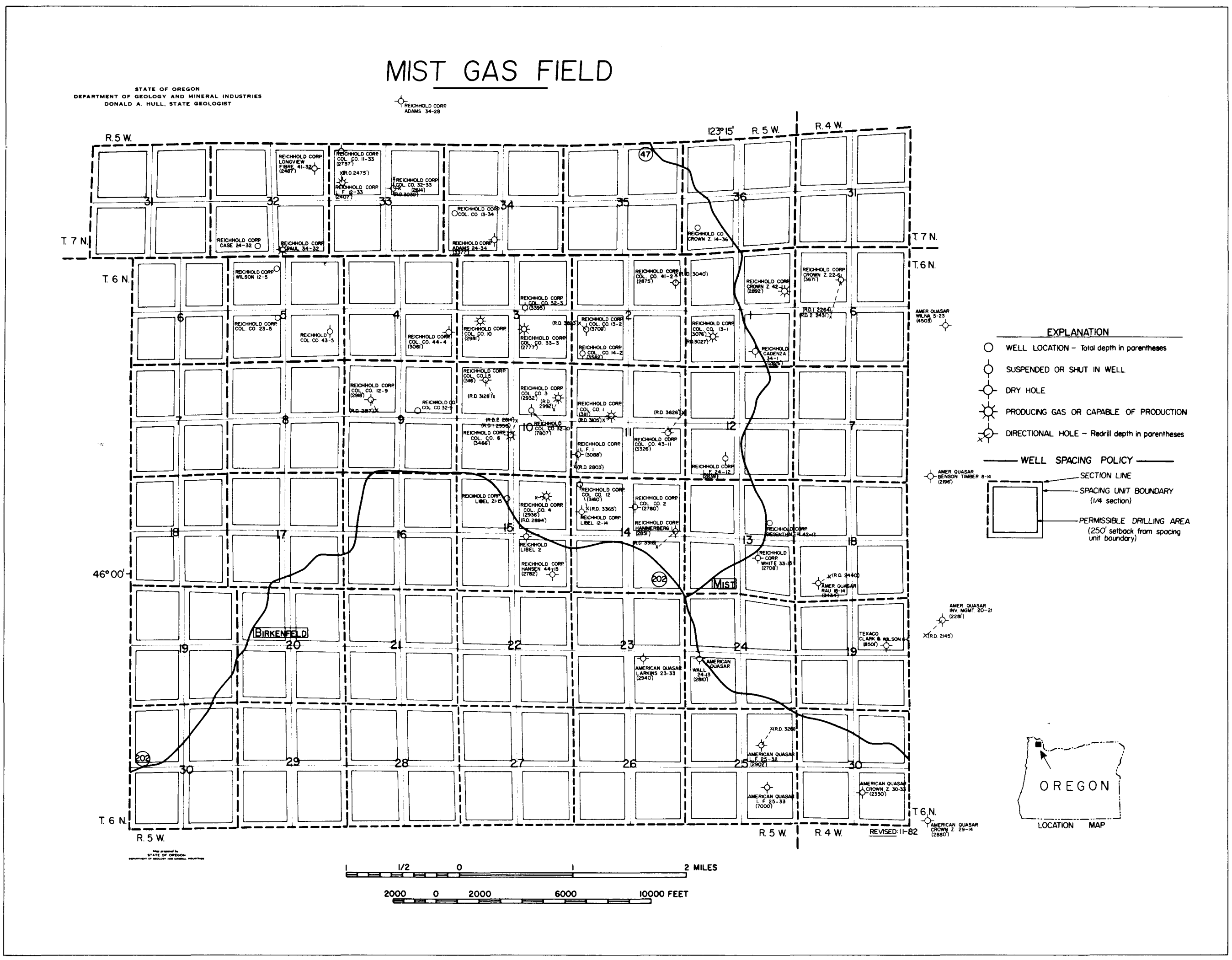
The reduction in high-risk wildcat drilling parallels the trend of the entire industry, which was characterized in 1982 by a drastic reduction in drilling nationwide. The active rig count for the nation reached an all-time high at the end of 1981 but fell through most of 1982, ending the year more than 35 percent below the high mark. Oregon's rig count during the year fluctuated between one and four.

Reichhold Energy Corporation of St. Helens, Oregon, was again the most active operator. All but two of the company's wells were in the Mist Gas Field, and four of the wells were completed as producers. Two of the new gas wells were redrills of previously completed wells which had developed water trouble. These wells were Columbia County 4 in sec. 15, T. 6 N., R. 5 W., and Columbia County 13-1 in sec. 1, T. 6 N., R. 5 W. Initial flow tests indicated potentials of 2.2 and 1.9 MMcfd, respectively.

The other two completions occurred at year's end on two new wells: Paul 34-32 in sec. 32, T. 7 N., R. 5 W., and Columbia County 13-34 in sec. 34, T. 7 N., R. 5 W. These wells had initial flow tests of 1.4 and 0.5 MMcfd, respectively.

GAS PRODUCTION

During 1982, the number of completed gas wells at the Mist Gas Field increased from eight to 11, while the number of wells actually on production fluctuated between seven and nine. This is accounted for by two wells that were shut in during the year due to water production. The producers at the Mist Gas Field, which comprise all of Oregon's production, are operated by Reichhold Energy. In partnership with Reichhold are Northwest Natural Gas and Diamond Shamrock. From January to December, production rate increased from eight to ten million cfd. This will likely increase in early 1983 when Paul 34-32 and Columbia County 13-34 are put on line. The number of known pools at Mist now stands at eight, and several of these are one-well pools at present.



Mist Gas Field, Columbia County.

The federally controlled price of gas from the Mist Field has increased from $3 per million Btu in January 1982, to $3.27 per million Btu in December, according to the Federal Energy Regulatory Commission price schedule. At the average heating value of about 920 Btu per cubic foot, the gas value ranged from $2.76 per Mcf to $3 per Mcf during the year. The value of the 3.4 billion cubic feet of gas recovered during the year was $10 million.

Table 1. *Oil and gas permits and drilling activity in Oregon, 1982*

Permit no.	Operator, well name, API no.	Location	Status and depth TD = total depth (ft) RD = redrill (ft)
86	Reichhold Energy Corp. Columbia County 4 009-00011-01	NE¼ sec. 15 T. 6 N., R. 5 W. Columbia County	Completed, gas; RD: 2,894.
147	Reichhold Energy Corp. Columbia County 12-9 009-00063-01	NW¼ sec. 9 T. 6 N., R. 5 W. Columbia County	Abandoned, dry hole; RD: 2,917.
182	Reichhold Energy Corp. Columbia County 13-1 009-00084-01	SW¼ sec. 1 T. 6 N., R. 5 W. Columbia County	Completed, gas; RD: 3,027.
191	Reichhold Energy Corp. Paul 34-32 009-00089	SE¼ sec. 32 T. 7 N., R. 5 W. Columbia County	Completed, gas; TD: 2,698.
199	Oregon Natural Gas Development Patton 32-9 007-00011	NE¼ sec. 9 T. 7 N., R. 8 W. Clatsop County	Suspended; TD: 10,159.
202	Florida Exploration Co. Florida Exploration 1-4 019-00014	NE¼ sec. 4 T. 21 S., R. 6 W. Douglas County	Abandoned, dry hole; TD: confidential.
203	Reichhold Energy Corp. Columbia County 41-2 009-00095	NE¼ sec. 2 T. 6 N., R. 5 W. Columbia County	Abandoned, dry hole; TD: 2,875 RD: 3,040.
205	Reichhold Energy Corp. Columbia County 32-33 009-00097	NE¼ sec. 33 T. 7 N., R. 5 W. Columbia County	Abandoned, dry hole; TD: 2,614 RD: 3,030.
206	Reichhold Energy Corp. Adams 34-28 009-00098	SE¼ sec. 28 T. 7 N., R. 5 W. Columbia County	Abandoned, dry hole; TD: 2,572.
209	Reichhold Energy Corp. Columbia County 43-5 009-00100	SE¼ sec. 5 T. 6 N., R. 5 W. Columbia County	Suspended; TD: 3,099.
210	Reichhold Energy Corp. Crown Zellerbach 34-26 009-00101	SE¼ sec. 26 T. 5 N., R. 4 W. Columbia County	Permit issued.
211	Reichhold Energy Corp. Crown Zellerbach 32-26 009-00102	NE¼ sec. 26 T. 5 N., R. 4 W. Columbia County	Abandoned, dry hole; TD: 6,501.
212	Z and S Construction Co. Recla 1 045-00023	SE¼ sec. 9 T. 19 S., R. 44 E. Malheur County	Abandoned, dry hole; TD: 4,745.
213	Florida Exploration Co. USA 1-25 019-00015	NW¼ sec. 25 T. 24 S., R. 8 W. Douglas County	Permit issued.
214	Florida Exploration Co. USA 1-22 019-00016	SE¼ sec. 22 T. 26 S., R. 8 W. Douglas County	Permit issued.
215	Florida Exploration Co. Eagle's View Mgmt. 1-26 019-00017	NW¼ sec. 26 T. 20 S., R. 6 W. Douglas County	Permit issued.
216	Nahama and Weagant Energy Co. Klohs 1 071-00003	NE¼ sec. 6 T. 3 S., R. 2 W. Yamhill County	Abandoned, dry hole; TD: 5,870.
217	Reichhold Energy Corp. Libel 21-15 009-00103	NW¼ sec. 15 T. 6 N., R. 5 W. Columbia County	Permit issued.
218	Reichhold Energy Corp. Columbia County 32-9 009-00104	NE¼ sec. 9 T. 6 N., R. 5 W. Columbia County	Permit issued.
219	Reichhold Energy Corp. Werner 14-21 047-00013	SW¼ sec. 21 T. 5 S., R. 2 W. Marion County	Abandoned, dry hole; TD: 3,354.
220	Reichhold Energy Corp. Crown Zellerbach 31-33 009-00105	NE¼ sec. 33 T. 6 N., R. 4 W. Columbia County	Permit issued.
221	Reichhold Energy Corp. Crown Zellerbach 44-23 009-00106	SE¼ sec. 23 T. 5 N., R. 4 W. Columbia County	Permit issued.
222	Reichhold Energy Corp. Siegenthaler 42-13 009-00107	NE¼ sec. 13 T. 6 N., R. 5 W. Columbia County	Permit issued.
223	Reichhold Energy Corp. Crown Zellerbach 14-36 009-00108	SW¼ sec. 36 T. 7 N., R. 5 W. Columbia County	Permit issued.
224	Reichhold Energy Corp. Libel 12-14 009-00109	NW¼ sec. 14 T. 6 N., R. 5 W. Columbia County	Abandoned, dry hole; TD: 2,681.
225	Reichhold Energy Corp. Columbia County 13-34 009-00110	SW¼ sec. 34 T. 7 N., R. 5 W. Columbia County	Completed; gas; TD: 2,822.

CXC Company of Houston developing seismic data by vibroseis method in Columbia County during June 1982. Truck generates energy that vibrates the earth for reflection seismology.

OTHER DEVELOPMENTS

During the year, a new trade organization, the Northwest Association of Petroleum Landmen, was founded in the Pacific Northwest. An organizational meeting and two business meetings were held, and membership numbered over 100 by year's end. The purpose of the group is to provide public relations for the profession in the Northwest and to present educational opportunities for members. The need for such an organization is a sign of expansion of the industry in the state.

The 1981 session of the Oregon legislature passed two bills dealing with oil and gas exploration and production. As a result, in 1982 the DOGAMI staff revised the Oregon Administrative Rules dealing with these activities. After accepting comments through the hearing process, rule changes became effective June 25 and August 16, 1982. Rules that generated the most discussion and controversy were (1) a rule opening up the possibility of a longer period of confidentiality for well data than the standard two years and (2) a compulsory integration rule to compensate operators for the risk of wildcat drilling by allowing the integration of the mineral rights owners in a drilling unit where there is unleased acreage. Other rule changes regarded definition changes, inclination surveys on wells, notification of mineral owners adjacent to deviated wells, and wording changes for better clarity. □

Surface mined land reclamation in Oregon, 1982

by Paul F. Lawson, Supervisor, Mined Land Reclamation Program, Albany Field Office, Oregon Department of Geology and Mineral Industries

Mined land reclamation in Oregon made good progress in 1982, although indications are that the year was worse than any of the recent past for Oregon's mining industry. Although the staff level fluctuated and administration had increased responsibilities, the program completed 682 field inspections in 1982, compared to 912 in 1981 and 681 in 1980.

The first annual award honoring the most outstanding reclamation project and its operator was given this year. The unanimous choice of the selection committee was Cascade Pumice Company of Bend, managed by Charles (Chuck) Clark. Deserving runners-up included North Santiam Sand and Gravel Company of Stayton and the Coos County Highway Department at Coquille. Details were published in the December 1982 issue of *Oregon Geology*.

The Oregon Department of Geology and Mineral Industries had to initiate court proceedings in one case, alleging a violation of law in that an operator continued mining operations after a closure order had been issued for mining without the required security. After delays were exhausted, an out-of-court settlement was reached and a plea-bargained fine accepted.

One mining site in southwest Oregon was reclaimed by the Department, after the operation was found abandoned and the operator had declared bankruptcy. Reclamation was successfully completed by a local contractor; however, the incident further emphasized the need for a realistic bonding (security) ceiling. The Department will continue to seek legislation authorizing a bonding ceiling which will enable it, as charged by law, to complete reclamation of mined lands (of "aggregate minerals") in instances of operator default. Acreage not otherwise exempted and affected by surface mining after July 1, 1972, or, under another provision, January 1, 1981, is required to be reclaimed. Security to guarantee reclamation or to provide funds for the State to reclaim, in the event of operator default, is required for already affected acreage plus that acreage forecast to be affected during the 12 months following the permit anniversary. To achieve the goals of the program and to minimize costs to operators, the Department strongly encourages concurrent reclamation and reduces bonding levels in proportion to the reclamation completed. A recently completed study of 119 "aggregate" sites for which the Department has figures indicates an average of slightly less than 18 percent of their permitted land bonded, or 1,666 acres of 9,483 acres.

In July 1982, the Department presented testimony at a public hearing conducted by the Office of Surface Mining, U.S. Department of the Interior, on proposed permanent rules for Oregon concerning the regulation of surface coal mining. These rules are now in effect.

The Oregon Administrative Rules for Surface Mining (OAR 632) were amended in support of the 1981 revisions of the Oregon Revised Statutes (ORS 715.750 ff.). In line with the legislature's designation of "non-aggregate" mining operations, i.e. for coal and metal-bearing ores, OAR 632 was amended to contain two divisions, OAR 632, Div. 30, for aggregate mining and OAR 632, Div. 35, for non-aggregate mining. These amendments became effective in October 1982. Each new operator will now receive a copy of only those rules which actually pertain to his operation. This is intended to minimize confusion and has worked well.

ORS 715.780 authorizes county or city administration of all or parts of the Mined Land Reclamation Program under certain (various) provisions. A program for systematic review of the performance of local governments in exercising this authority has been initiated and will be continued.

Status of the Mined Land Reclamation Program

Total acreage reclaimed

1972 through Dec. 1980: 443
1972 through Dec. 1981: 805.75*
1972 through Dec. 1982: 961.65
(1982: 155.9)

* Includes voluntary reclamation not previously reported.

Total acreage under security to guarantee reclamation

December 31, 1980: 2,173
December 31, 1981: 2,606
December 31, 1982: 3,105

Uses to which acreage was reclaimed

	Agriculture	*Forestry*	*Housing*	*Other***
1972 through 1980	*251*	*6.5*	*37*	*148*
During 1981	*168*	*7*	*21*	*167.5*
During 1982	*105*	*14.5*	*0*	*36*
Total	524	28	58	351.5

** "Other" includes a wide variety of uses but contains a high percentage of various kinds of water impoundments, sites for wildlife management, industrial-commercial construction, and permanent stockpiles.

Changes: New and closed sites, 1980-1982
(Permits issued for new sites, records closed, sites reclaimed, or activity legally terminated)

	Surface mining permit[1]		Limited exemption[2]		Total exemption[3]	
Year	New	Closed	New	Closed	New	Closed
1980	46	19	34	4	46	3
1981	84	32	50	7	51	26
1982[4]	35	34	24	14	106	28

[1] Sites requiring a fee, reclamation, and security.
[2] Sites requiring a fee, but legally exempt from reclamation and security until horizontal expansion occurs—after July 1, 1972, or January 1, 1981 (different provisions). Expansion requires conversion to surface mining permit; expansion area **only** is then subject to reclamation and bonding.
[3] Sites legally exempt from fee, reclamation, and bonding—for various specific reasons, most commonly "access roads," size, and inactivity. (Surface mining permit sites **cannot** go to total exemption status if the surface mining permit has been utilized.)
[4] During 1982 there were 87 other changes in status from one category to another.

Total number of sites under permit

As of	Surface mining permit	Limited exemption	Total exemption
December 31, 1980	348	333	571
December 31, 1981	399	338	587
December 31, 1982	400	287	648 □

BOOK REVIEW

by Ralph S. Mason, former State Geologist

Oregon Divided, *by Samuel N. and Emily F. Dicken.* Oregon Historical Society, 1982, 176 p., paperback $10.95, cloth $17.95.

This is not only a continuation of the author-team's earlier book, *The Making of Oregon: A Study in Historical Geography*, but a sincere and serviceable documentation of two centuries of Oregon history as it developed within the strictures imposed by the unique geographic features which form part of the western margin of the North American continent.

The authors have mercifully sidestepped the many maudlin mudholes of historical sentimentality and have crafted a clean-cut, no-nonsense analysis of the culture, economy, and politics that have been shaped by the geography which the pioneers discovered and with which their descendants have coped ever since.

Geography is often best appreciated from high in the sky, and the text is liberally sprinkled with aerial photos of views typical of the locale being discussed. Augmenting these pictures are nearly sixty maps and photos of plastic relief models which further impress the reader with man's response to his geographic surroundings. Each major geographic region is discussed from a variety of standpoints, including a running commentary of an airplane flight over each of the countrysides. In every region, the geographical imprint on the history of the area is carefully described.

Geography, as presented by the authors, is a far cry from the usual textbook offerings. Here a very much alive geography provides the scene for the unfolding of history, the settling of a wilderness, the harnessing of rivers, and the growth of industry and agriculture. All of the seven geographic divisions of the state have some hills, a few of them have little else. "Mountain men are always free," but their mountainous fortress-prisons impose an inflexibility of opportunity. This is clearly revealed in the discussion of the southwestern Oregon basically one-crop economy, where logging and wood processing are the dominant factors. In the Deschutes-Umatilla plateau, where dry-land wheat is the only significant cash crop, the region is hemmed in by steep-sided canyons, the Cascade and Blue Mountains, and the Columbia River.

The philosopher Will Durant once said, "Civilization exists by geological consent, subject to change without notice." Fortunately geography, even though it is the end product of geologic forces, is considerably more stable. Apparently the authors have an unshaken faith in the stability of natural things and in their last chapter have ventured to make some predictions about Oregon for the rest of the century. If there are any shortcomings in this otherwise excellent book, they are to be found here. The authors see increasingly severe problems as the population grows: Transportation poses some questions as the need for mass transit looms, and timber production faces difficult times with annual cut exceeding growth. On the other hand, the outlook for agriculture is excellent, with improving markets and a good supply of water. Population growth has been accelerating (it took nearly 100 years to reach one million, but only fifteen to get to two million), but the overall density is still very low, and the populace is tending to gravitate to urban and away from rural areas. If the state reaches a projected population of 3,228,000 by the year 2000, it will, even then, have a density of only thirty-three people per square mile.

Unfortunately, projections of future population and tomorrow's economic levels often stumble on the ubiquitous unknowns of fads, federal policies, and foreign and domestic economic developments. The authors correctly assess the strengths and weaknesses of the present Oregon scene, but their predictions for the year 2000 are flawed by the rapidly shifting currents of social and economic change. The art of prediction is something like trying to write your name on a waterfall. The Swedes say it better: "It's difficult to prophesy, especially about the future."

The book closes with a plea for better education of the public in its awareness of the potentials and problems facing a population- and energy-shy state which, due to the quirks of geography, is divided into often widely disparate economic, political, and social enclaves. □

New Landsat mosaic map of Oregon available

The Environmental Remote Sensing Applications Laboratory (ERSAL) of Oregon State University announces the completion of a two-year project—a satellite map of the state of Oregon produced with 40-m resolution data at a scale of 1:500,000, the same scale as the data-acquisition scale.

The latest satellite mosaic represents the state of the art in that it is composited from the most detailed satellite imagery of Oregon available through 1982, Landsat-3 RBV (return beam vidicon). The original imagery from which the mosaic was made is similar to black-and-white panchromatic photographs; however, it was acquired from 570 mi above Oregon with a resolution (detail) of better than 40 m. The exceptional resolution, cartographic qualities, and timeliness of the satellite photographs used in the construction of the Oregon Landsat Mosaic make it the most detailed up-to-date view of the state available today. The mosaic is also unique in that it is the first of its kind produced of any state in the United States.

From the launch of the first of the Landsat series in 1972, ERSAL has realized the importance of a satellite mosaic of the entire state of Oregon and has taken the responsibility of producing satellite mosaics of the state. The first satellite map was generated utilizing black and white satellite imagery from Landsat-1 (originally ERTS) in 1973. This was followed by the production of a false-color mosaic made from both Landsat-1 and -2 data in 1974.

As in the past, ERSAL is making the new satellite mosaic available to interested parties, both public and private. The mosaic has been published in two versions—a three-color and a one-color printing (ERSAL Publications 82-1 and 82-2, respectively). In the three-color printing, the satellite imagery is printed in brown, and overlying data from the 1:500,000 U.S. Geological Survey state map of Oregon are printed in blue (hydrology) and black (cultural features, such as roads, cities, and county boundaries). On the single-color printing, the satellite imagery is printed in black with lines of latitude and longitude at one-degree increments printed over the satellite imagery. Both versions come with a 1,000-word text on the side margin that briefly describes the mosaic and identifies some characteristic features on the mosaic (satellite map). On the side margin, two small insert maps of Oregon identify (a) county names and (b) the satellite images used in the mosaic.

The three-color mosaic is available from the Portland office of the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR 97201, for a cost of $8 over the counter or $11 by mail. Orders under $50 must be prepaid. □

Meteors sighted

On November 24, 1982, between 2:15 and 2:30 a.m., a fireball was sighted by Bill Crews and Randy Williams in the vicinity of Walker Rim, Klamath County. The fireball came down out of the northwest going to the southeast at an angle of about 45 degrees. The fireball, which was visible for about 3 seconds, was blue-green in color, with a yellow-green tail that was about four times the size of the fireball. The fireball was between a half or full moon in size. The fireball, which was very bright, lit up the area like daylight. It left a glowing ionization trail for a few seconds after it had passed across the sky. As it went below the horizon, it appeared to have flames behind it. After it disappeared, there was a bright flash from below the horizon.

Another fireball was sighted in southwest Oregon at 9:24 p.m., January 29, 1983. Three of the reports were from the Coos Bay-Bandon area, Coos County. There the fireball came from the zenith, going to the east and descending at almost 90 degrees for from one to three seconds. The fireball was reported to be from a quarter to a full moon in size. Its color varied with the reports, but most observers said it was blue white. It had a long tail, ranging from yellow to orange and red to blue. It lit up the area as in broad daylight, left a glowing trail, and exploded at the end of its path. An additional report of the same fireball came from a Grants Pass, Josephine County, observer who said the fireball came down at 35 degrees, had a very long tail, and disrupted below the horizon. There the sighting was accompanied and followed by a low rumbling sound.

An unusually large fireball was seen the morning of February 4, 1983, from several locations along the Pacific coast from British Columbia to Newport, Oregon. South of Astoria, Clatsop County, it was seen by the tender of the Youngs Bay Bridge at 7:02 a.m. The fireball traveled in a horizontal path over the Pacific from north to south. It was about the size of a full moon, red and green in color, and had a red tail that was 15 to 20 times the size of a full moon. The fireball was visible for from 2 to 4 seconds, made no sounds, and did not break up. The same fireball was observed at the same time in Seaside, also in Clatsop County, starting at 45 degrees above the horizon in the west-northwest and traveling to the west-southwest, where it was last seen about 10 degrees above the horizon. The Seaside observer reported that the fireball was three-fourths the size of a full moon, blue white in color, and had a very long blue-white tail that was ten times the size of the fireball. Again there were no sounds and no breakup.

These sightings have been reported to the Scientific Event Alert Network, Smithsonian Institution. Anyone with any additional information about these or other meteorite sightings should contact Dick Pugh, Cleveland High School, 3400 SE 26th Ave., Portland, OR 97202, phone (503) 233-6441. □

GSOC luncheon meetings announced

The Geological Society of the Oregon Country (GSOC) holds noon meetings in the Standard Plaza Building, 1100 SW Sixth Avenue, Portland, in Room A adjacent to the third floor cafeteria. Topics of upcoming meetings and speakers include:

March 18—*Roadside Geology of Oregon*, by Donald Barr, naturalist and GSOC President, 1968.

April 1—*History of DOGAMI and All Those Rocks*, by Ralph Mason, State Geologist, retired.

April 15—*England—Geology and Architecture*, by Hugh Owen, retired architect.

For additional information, contact Viola L. Oberson, Luncheon Program Chairwoman, phone (503) 282-3685. □

DOGAMI and BLM announce release of preliminary data from eastern Oregon geochemical survey

During the 1982 field season, the Oregon Department of Geology and Mineral Industries (DOGAMI) collected 1,491 geochemical samples (stream sediment, rock chips, and soil) from Bureau of Land Management (BLM)-managed lands in southeastern Oregon. Data from this survey are currently being evaluated, and the final report from this study will be released later this spring as DOGAMI Open-File Report 0-83-2, *Geology, Mineral Resources, and Mineral Potential of 18 BLM Wilderness Study Areas in Harney and Malheur Counties, Oregon*. Since several anomalous zones for gold and other metals were identified, on February 22, 1983, DOGAMI and the BLM released raw data on microfiche in a report entitled *Preliminary Geochemical Data, Mineral Assessment of Bureau of Land Management Wilderness Study Areas, Southeastern Oregon*. The report may be purchased for $3 from the Portland office of the Oregon Department of Geology and Mineral Industries. Orders under $50 must be prepaid. The release of Open-File Report 0-83-2 will be announced in a later issue of *Oregon Geology*. □

New release lists landslide studies for Oregon

A special bibliography on landslides, landslide deposits, and landslide hazards in Oregon has been made available by the Oregon Department of Geology and Mineral Industries (DOGAMI).

The new report is entitled *Bibliography of Landslide Deposits for the State of Oregon* and has been released as DOGAMI Open-File Report 0-82-6. It was produced by DOGAMI for the U.S. Geological Survey (USGS) and will be included in the USGS computerized data base on landslides in Oregon.

Approximately 300 titles were compiled from thorough searches of numerous bibliographies and published and unpublished articles, reports, and theses dealing with the geologic, engineering, and forestry-related aspects of landslides in Oregon. A separate listing identifies those studies that were published by DOGAMI. The bibliography will serve as a research tool for later work in this field.

The report is now available at the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, 1400 S.W. Fifth Avenue, Portland, OR 97201, and may be purchased for $6. Orders under $50 require prepayment. □

SOSC gets $1,000 grant

Southern Oregon State College's (SOSC) geology department recently received $1,000 from the Freeport Exploration Co., a division of Freeport Minerals Company.

Chuck Verro, a senior geologist with Freeport, said the gift was made to SOSC because Freeport hires many of the college's graduates and finds them to be "well-trained, conscientious and diligent workers."

Verro said it was company policy to offer support to college and university geology departments. SOSC is the first college without a graduate program to receive a gift from Freeport.

Bill Purdom, a professor of geology, is chairman of the department.

—Grants Pass Courier

Geothermal Resources Council schedules symposium for May 1983

The Geothermal Resources Council is sponsoring a symposium on the role of heat in the development of energy and mineral resources in the northern Basin and Range province. The symposium, which will be held May 16-18, 1983, at the Pioneer Theatre, Reno, Nevada, is designed to provide discussion on a range of topics pertinent to geothermal energy, hydrocarbon resources, and ore deposits. It will include papers on regional tectonics, magmatism, structure and stratigraphy, active and fossil hydrothermal systems, and the geological, geophysical, and hydrological expressions of energy and ore resources of this important area of the western United States.

The presentations by leading researchers and explorationists from government, academia, and industry will attempt to promote a comprehensive approach to the problems of metallogenesis, petroleum formation and accumulation, and geothermal energy in the context of the continuing evolution of this portion of the western Cordillera.

To provide a look at some of the situations and locations discussed in the symposium, optional field trips have been scheduled before and after the meeting to Ely-Railroad Valley-Tonopah, Dixie Valley, Steamboat Springs, Virginia City, Brady/Desert Peak-Humboldt House-Golconda-Getchell, and Candelaria-Tonopah-Round Mountain.

For additional information, contact the Geothermal Resources Council, P.O. Box 1350, Davis, CA 95617, phone (916) 758-2360. □

Nature hides her secret because of her essential loftiness, but not by means of ruse.

—Albert Einstein

User guide to AGI bibliography and index published

Earth science students, researchers, and librarians can simplify literature searching by using the new *User Guide to the Bibliography and Index of Geology*, which is published by the American Geological Institute (AGI).

The guide tells users how to scan monthly issues of the *Bibliography and Index of Geology* for current research, how to plan systematic searches, and how to use the index.

The *User Guide to the Bibligraphy and Index of Geology*, edited by John Mulvihill, is 160 pages long and is available for $8.95 from AGI's Customer Service Department, One Skyline Place, 5205 Leesburg Pike, Falls Church, VA 22041. For information on a discount available for bulk orders, call toll-free 1-800-336-4764. One copy of the *User Guide* will be mailed free of charge to each 1983 subscriber to the *Bibliography and Index of Geology*. □

DOGAMI updates list of open-file reports

The Oregon Department of Geology and Mineral Industries (DOGAMI) frequently releases information in open-file reports, which may be purchased by mail or over the counter from the Portland office. Names of available DOGAMI open-file reports and their prices are included on a recently updated open-file report list which is available free of charge from the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR 97201, phone (503) 229-5580. □

New Code of Stratigraphic Nomenclature to become effective in August

At its 37th Annual Meeting held in New Orleans on October 19, 1982, the North American Commission on Stratigraphic Nomenclature (NACSN) formally adopted a new stratigraphic code. The new rules of procedure will be known as the *1983 North American Code of Stratigraphic Nomenclature*.

The *1983 Code* is substantially revised from the 1961 and 1970 American Stratigraphic Codes presently in general use. New classifications are provided for lithodemic (crystalline rock), magnetopolarity, allostratigraphic (discontinuity-bounded), polarity-chrono-stratigraphic, polarity-chronologic, diachronic, and geochronometric units. Geologic-climate units are deleted.

The *1983 Code* will be published in the American Association of Petroleum Geologists (AAPG) *Bulletin* and will become effective on the date of its publication, which is expected to be August 1983. Upon publication of the *1983 Code*, all previous NACSN codes will be vacated.

All geologic entities active in North America will be urged to formally adopt the *1983 Code* when it becomes effective. NACSN will wish to be advised of any such adoptions. □

New USGS publication correlates Tertiary rocks off southern Oregon coast

The U.S. Geological Survey (USGS) announces the publication of Miscellaneous Field Studies Map MF-1482, *Sections Showing Correlation of Tertiary Rocks Penetrated in Wells Drilled on the Southern Oregon Continental Margin*, by P.D. Snavely, Jr., H.C. Wagner, and W.W. Rau. The publication, which costs $1.25, is available by mail from the Western Distribution Branch, USGS, Box 25286, Federal Center, Denver, CO 80225. □

What is a ''geoligust''?

"A geoligust is something that grubs around in the woods looking for little rocks and stones. When he finds them he smiles as he beats them brutally with a little hammer. Sometimes if he is really mad he uses a great big hammer. When he don't find the rock he wants he walks around all day like he is lost. A geoligust has one big eye and one little eye like popeye. He usually looks through a magniflying glas, which incidently always hangs around his nek, with his little eye so he can tell if he has found a for sure rock or stone. He usually walks bent over all the time which is why he always looks so stooped. What you can see of his face looks like old leather, the rest is usually covered with snarled and bushy hair. He cusses terribul. He always has a back ake from carrying around bags of rocks to beat on. He hasn't figured out yet that there are rocks everywhere he goes. He keeps saying he is going back to school at the end of the summer, maybe they will teach him about that if he gets there. Every time he picks up a rock he wrights about it in a little book like it was a important thing to remembur, and if he ever luzes his little book he looks like nobody fed him for a week. His pants are always tore from rocks and sticks, and his shoes look like they was made of mud. People stare at him, forest kritters chase him, and he always looks wore out. I don't know why anyone wants to be a geoligust."

—Rex Orgill, helleecopter pilot
Timberline Aviation
Pinedale, Wyoming

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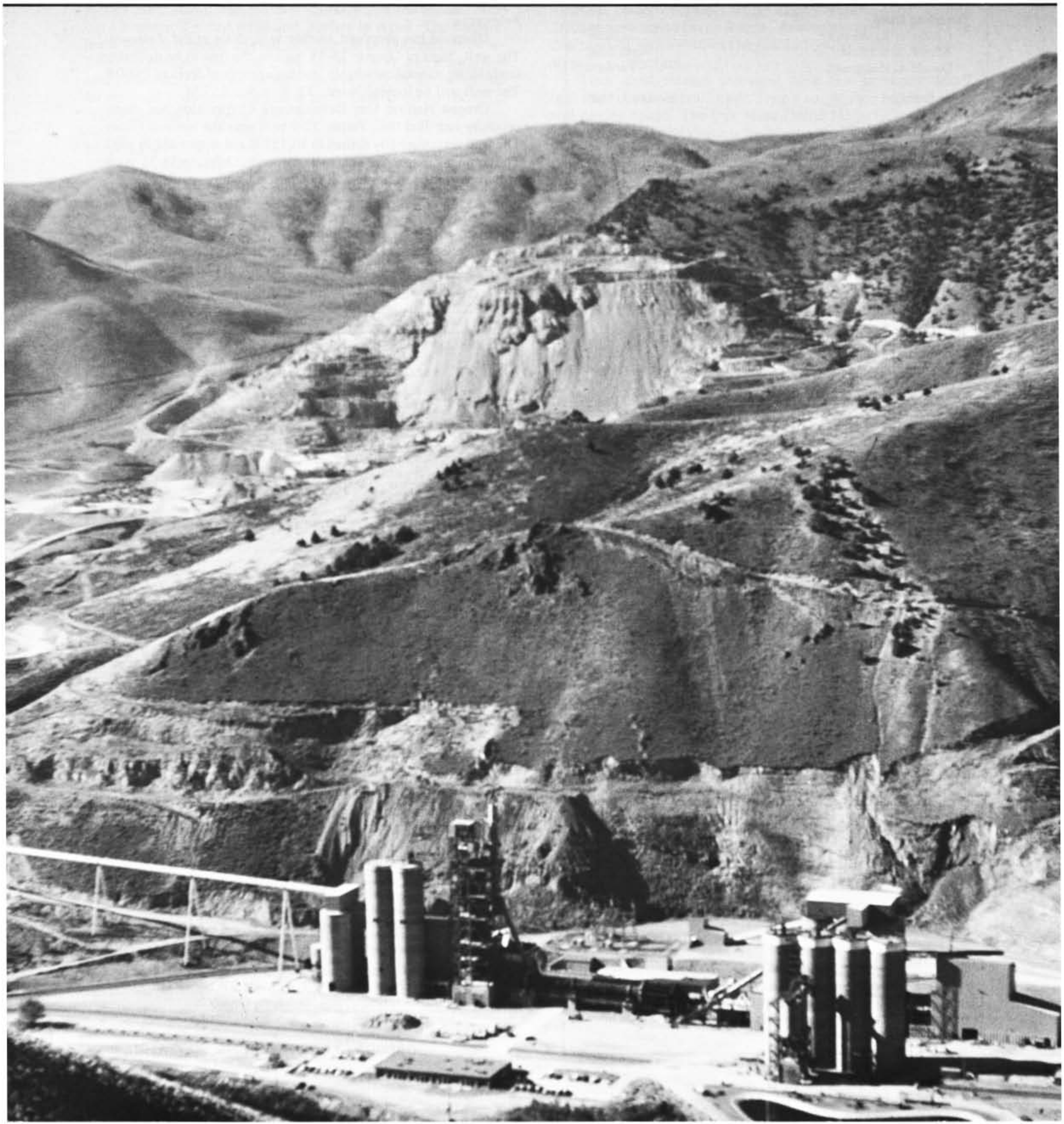

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CONTENTS

COVER PHOTO

Oregon Portland Cement Company plant near Durkee, Baker County. Company's limestone quarry is in background. Article beginning on next page summarizes industrial activity in Oregon in 1982.

OIL AND GAS NEWS

Clatsop County

Diamond Shamrock Corporation has changed the name of its Hummel 22-19 well to Watzek 22-19. The proposed depth for the well was 5,000 ft, looking for Clark and Wilson sand, the same sand which produces gas in the Mist field 10 mi to the east. Brinker-Signal was the contractor. The well was drilled and abandoned in February.

Diamond has proposed another well, 5 mi to the southwest. The well, State of Oregon 23-33, will be the first to be drilled on land of State mineral ownership and has a proposed depth of 7,000 ft. The well will be located in sec. 33, T. 6 N., R. 7 W.

Oregon Natural Gas Development Corporation has unsuccessfully redrilled their Patton 32-9 well near the town of Olney. The well was originally drilled to 10,159 ft and suspended in 1982. The company may move next to its suspended Johnson 33-33 or one of two permitted locations, all in Clatsop County.

Mist Gas Field: New pool names

State Geologist Donald Hull has named two new pools at the Mist Gas Field. Reichhold Energy, operator of two new completed wells, suggested the pool names:

Well	Location	Pool name
Columbia County 13-34	SW¼ sec. 34, T. 7 N., R. 5 W.	Adams
Paul 34-32	SE¼ sec. 32, T. 7 N., R. 5 W.	Paul

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
199	Oregon Natural Gas Dev. Patton 32-9 007-00011-01	NE¼ sec. 9 T. 7 N., R. 8 W. Clatsop County	Abandoned.
204	Reichhold Energy Case 14-32 009-00096	SW¼ sec. 32 T. 7 N., R. 5 W. Columbia County	Location; name change from Case 24-32.
208	Reichhold Energy Wilson 11-5 009-00099	NW¼ sec. 5 T. 6 N., R. 5 W. Columbia County	Location; name change from Wilson 12-5.
226	Diamond Shamrock Watzek 22-19 007-00012	NW¼ sec. 14 T. 6 N., R. 6 W. Clatsop County	Abandoned; name change from Hummel 22-19.
227	Diamond Shamrock State of Oregon 23-33 007-00013	NE¼ sec. 33 T. 6 N., R. 7 W. Clatsop County	Location; PTD: 7,000.
228	Reichhold Energy Columbia County 23-28 009-00111	SW¼ sec. 28 T. 7 N., R. 5 W. Columbia County	Application; PTD: 2,600.
229	Reichhold Energy Columbia County 23-35 009-00112	SW¼ sec. 35 T. 7 N., R. 5 W. Columbia County	Location; PTD: 2,800.
230	Reichhold Energy Columbia County 14-33 009-00113	SW¼ sec. 33 T. 7 N., R. 5 W. Columbia County	Location; PTD: 2,800.
231	Reichhold Energy Longview Fibre 23-12 009-00114	SW¼ sec. 12 T. 6 N., R. 5 W. Columbia County	Location; PTD: 3,000.
232	Reichhold Energy Polak 31-12 009-00115	NE¼ sec. 12 T. 6 N., R. 5 W. Columbia County	Application; PTD: 3,000.

□

Mineral industry in Oregon, 1982

by Len Ramp, Resident Geologist, Grants Pass Field Office; Howard C. Brooks, Resident Geologist, Baker Field Office; and Jerry J. Gray, Economic Geologist, Oregon Department of Geology and Mineral Industries

INTRODUCTION

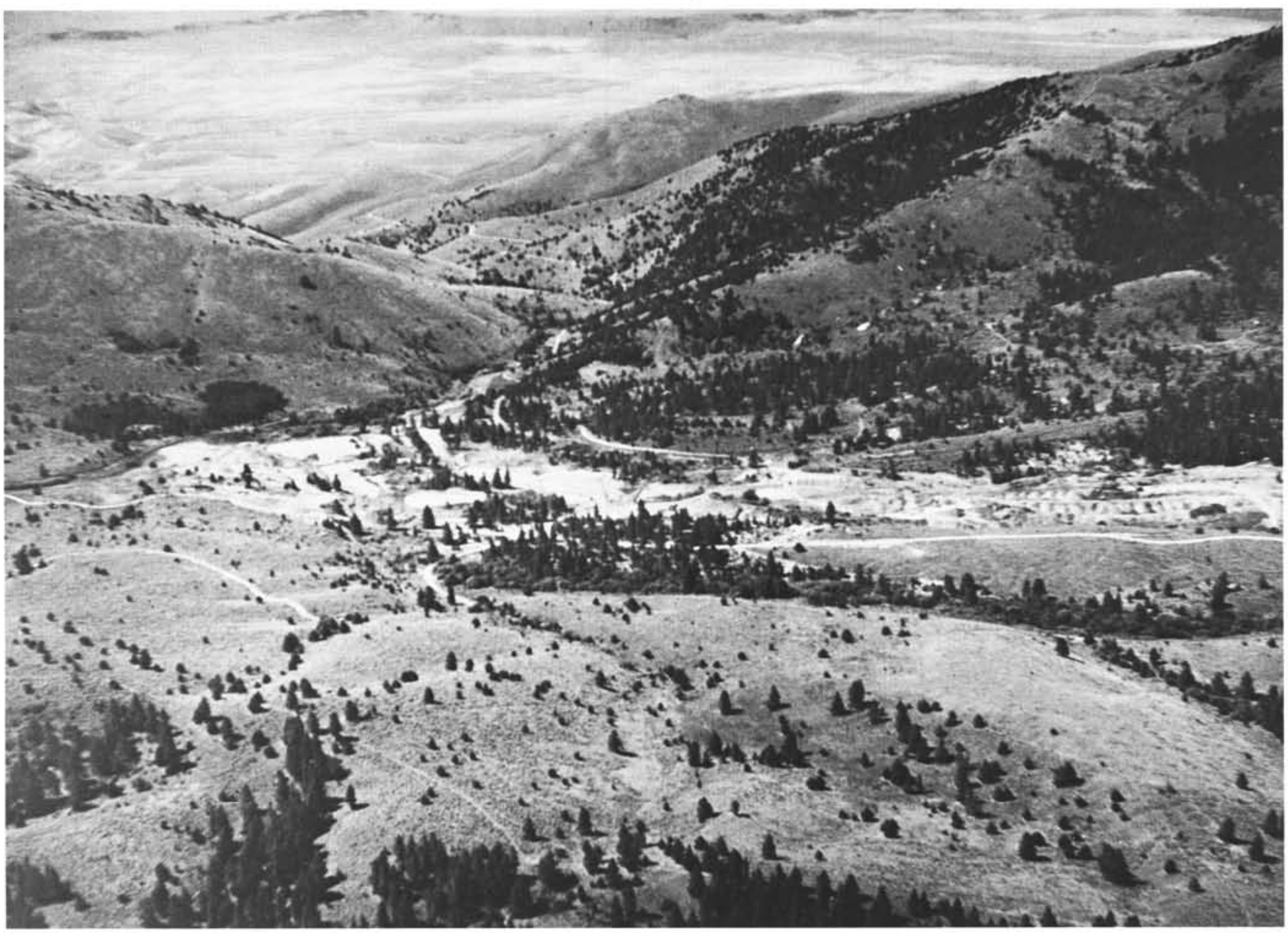
The value of Oregon's 1982 mineral production is down significantly from 1981 due to the serious recession in construction industries and the resulting supply-demand-affected metals price slump that led to a shutdown of the Hanna Mining Company's nickel mine and smelter in April. The Department did not conduct a systematic canvas of 1982 gold production (see *Oregon Geology*, v. 44, no. 4, p. 39), but shutdowns and somewhat reduced activity on the part of a few of the larger gold producers suggest a significant drop in the total production of this metal also.

METALS

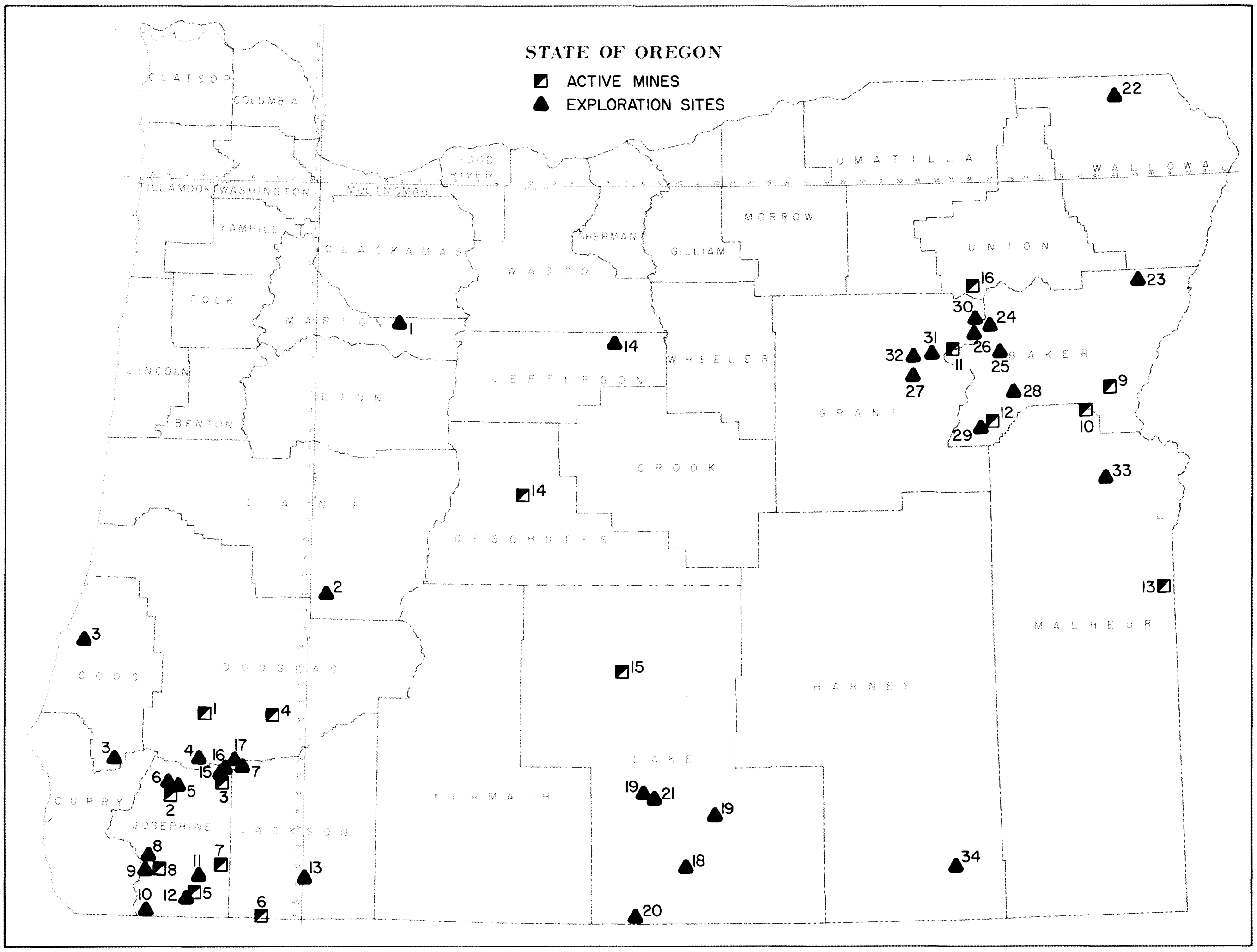
Several placer mines and a few small lode gold mines were in production during the year (see Table 1). The Mormon Basin Placer (Mine 10*), owned by Veta Grande Corporation, operated only sporadically in 1982. The Camp Carson Placer (Mine 16) operated from July through September but reportedly had problems with gold recovery and financing and was shut down through the remainder of the year. Although the Gallagher Placer on Sucker Creek (Mine 5) was shut down and dismantled during the year, several other small placer operations were active farther up on Sucker Creek. Numerous small itinerant placer operators using mostly Venturi-type floating dredges were active in the Rogue, Applegate, and Illinois River drainages of southwestern Oregon and contributed to the overall gold production.

Lode gold mining consisted of a few persistent small operations and several others trying to get into a productive and paying mode. The Pyx Mine (Mine 11) in Grant County was continued in operation by Myron Woodly and partners. Their ore is trucked to a small mill in Sumpter. The Thomason Mine (Mine 12) in Baker County has been operated in the summer months for the past several years by Art Cheatham and partners. Their ore is treated in a 1-ton-per-hour gravity mill near the mine. The old Greenback Mine (Mine 3) in Josephine County was reactivated late in the year by owner Wes Pieren and the newly formed Sunny Valley Mining and Development Company. They have opened up a new vein called the Greenback 2 situated about one-half mile southwest of the old workings. Ore is being processed in a small mill at the mine. Small

* All mine numbers refer to "Active Mines" on location map and in Table 1.



Aerial photograph of placer mine in the Mormon Basin, Malheur County.



EXPLANATION

ACTIVE MINES

1. Nickel Mountain Mine (Ni)
2. Old Channel Placer (Au)
3. Greenback Mine (Au)
4. Coffee Creek placers (Au)
5. Sucker Creek placers (Au)
6. Steatite of Oregon (soapstone)
7. Snowbird Mine (Au)
8. Josephine Creek placers (Au, josephinite)
9. Oregon Portland Cement (limestone)
10. Mormon Basin Placer (Au)
11. Pyx Mine (Au)
12. Thomason Mine (Au)
13. Adrian (bentonite-zeolite)
14. Cascade Pumice, Central Oregon Pumice
15. Christmas Valley Diatomite
16. Camp Carson Placer (Au)

EXPLORATION SITES AND AREAS

1. North Santiam area (Au, Ag, Cu, Zn)
2. Bohemia District (Au, Ag, Cu, Zn)
3. Coos County coal deposits
4. McCullough Creek area (Au, Ag, Cu, Zn)
5. Almeda Mine (Au, Ag, barite)
6. Yankee Silver Mine (Au, Ag)
7. Warner Mine (Au)
8. Fall Creek Copper Prospect (Cu)
9. Lightning Gulch Group (Au, Ag)
10. Turner-Albright Mine (Au, Ag, Cu)
11. Babcock Prospect (Au, Ag, Cu, Co)
12. Rainbow Mine (Au)
13. Ashland Mine (Au)
14. Oregon King Mine (Au, Ag)
15. King Midas Prospect (Au)
16. Fandora, Spotted Fawn Mines (Au)
17. Black Boy Mine (Cr)
18. Salt Creek area (Au)
19. Paisley Hills-Coyote Hills area (Au, Cu)

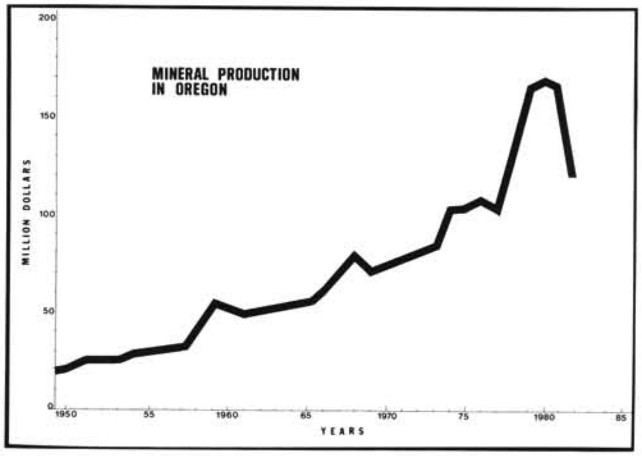
Mining and mineral exploration in Oregon, 1982 (excluding sand and gravel and stone). Active mines are keyed to Table 1; exploration sites are keyed to Table 2.

quantities of ore from the Snowbird Mine (Mine 7) were milled at Dave Vallandigham's mill on Powell Creek near Williams, Oregon. A former important producer of gold, silver, and copper, the Iron Dyke Mine near the Snake River in northeastern Baker County, was idle in 1982.

OREGON'S MINERAL PRODUCTION
MILLIONS OF DOLLARS

	ROCK MATERIALS SAND, GRAVEL, STONE	OTHER MINERALS & METALS CEMENT, NICKEL, PUMICE, ETC.	NATURAL GAS	TOTAL
1982	73	37	10	120
1981	85	65	13	163
1980	95	65	12	172
1979	111	54	+	165
1978	84	44	0	128
1977	74	35	0	109
1976	77	35	0	112
1975	73	33	0	106
1974	75	29	0	104
1973	55	26	0	81
1972	54	22	0	76
1971	56	22	0	78
1970	48	20	0	68

Summary of mineral production in Oregon for the last 13 years.



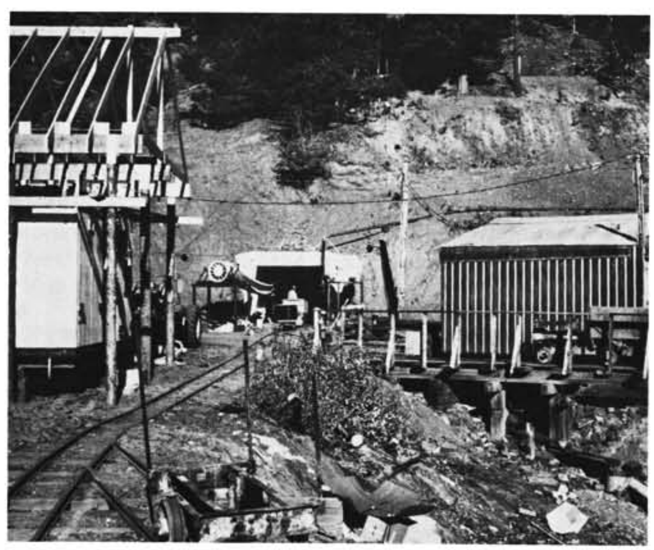
Mineral production in Oregon between 1950 and 1982.

Table 1. *Active mines in Oregon, 1982*

Map no.	Name	Location	Comments
1.	Nickel Mountain Mine	Sec. 17 T. 30 S., R. 6 W. Douglas County	Mine and smelter shut down in April.
2.	Old Channel Placer	Sec. 35 T. 34 S., R. 8 W. Josephine County	Continued production of placer gold from ripped-up bedrock.
3.	Greenback Mine	Secs. 32, 33, 5 Tps. 33, 34 S., R. 5 W. Josephine County	Development and start of production from new vein ½ mi southwest of old workings by Sunny Valley Mining and Development Co.
4.	Coffee Creek placers	Sec. 7 T. 30 S., R. 2 W. Douglas County	Part-time operations. Small production.
5.	Sucker Creek placers	— — — T. 40 S., Rs. 6, 7 W. Josephine County	Several operators.

Table 1. *Active mines in Oregon, 1982—continued*

Map no.	Name	Location	Comments
6.	Steatite of Southern Oregon	Secs. 10, 11 T. 41 S., R. 3 W. Jackson County	Continued production of block soapstone for carving.
7.	Snowbird Mine	Sec. 20 T. 38 S., R. 5 W. Josephine County	Small gold mine reactivated.
8.	Josephine Creek placers	Secs. 30, 36 T. 38 S., Rs. 8, 9 W. Josephine County	Several operators.
9.	Oregon Portland Cement	Sec. 11 T. 12 S., R. 43 E. Baker County	Continued production at reduced rate.
10.	Mormon Basin Placer	Sec. 21 T. 13 S., R. 42 E. Malheur County	Intermittent operation by Veta Grande.
11.	Pyx Mine	Sec. 1 T. 10 S., R. 35 E. Grant County	Myron Woodly and partners continued production. Ore is trucked to small gravity and amalgamation mill in Sumpter.
12.	Thomason Mine	Sec. 6 T. 14 S., R. 37 E. Baker County	Art Cheatham and partners. Small seasonal operation.
13.	Adrian (bentonite-zeolite)	Sec. 29 T. 23 S., R. 46 E. Malheur County	Teague Mineral Products. Continued production. Drying and bagging plant.
14.	Cascade Pumice, Central Oregon Pumice	Bend area Deschutes County	Continued production.
15.	Christmas Valley Diatomite	— — — T. 27 S., R. 17 E. Lake County	Oil-Dri West. Continued production for floor sweep and pet litter.
16.	Camp Carson Placer	Sec. 28 T. 6 S., R. 36 E. Union County	Intermittent production July through September.



Portal of Bald Mountain Mine, Baker and Grant Counties.

Table 2. *Exploration sites and areas in Oregon, 1982*

Map no.	Site or area name	Location	Commodity	Comments
1.	North Santiam area	Sec. 27 T. 8 S., R. 5 E. Marion County	Au, Ag, Cu, Zn	Vicinity of Ruth Mine. AMOCO continued exploration work.
2.	Bohemia District: (a) Champion and Helena Mines	Lane County: Secs. 7, 8, 12, 13 T. 23 S., Rs. 1, 2 E.	Au, Ag, Cu, Zn	Galactic Resources continued work; reopened 900-ft level of Champion Mine.
	(b) President Mine (El Capitain)	Sec. 23 T. 23 S., R. 1 E.	Au, Ag, Cu, Zn	Work continued on construction of mill by local group.
	(c) North Fairview, Lead Crystal, Elephant II, Lizzie Mines	Secs. 2, 11 T. 23 S., R. 1 E.	Au, Ag	Guy Leabo and associates continued constructing small mill.
3.	Coos County coal deposits	Coos Bay and Eden Ridge fields	Coal	Leasing and exploration continued by American Coos Bay Energy (formerly Canasia), and GCO; joint venture with Kennecott Minerals. Principal activity in Coos Bay field.
4.	McCullough Creek (Glendale) area	Secs. 30, 31 T. 32 S., R. 6 W. Douglas County	Au, Ag, Cu, Zn	Exxon continued exploration on leased acreage.
5.	Almeda Mine	Sec. 13 T. 34 S., R. 8 W. Josephine County	Au, Ag, barite	Comanche Petroleum and Blue Diamond Energy Resources ended their exploration program.
6.	Yankee Silver Mine	Secs. 25, 26 T. 34 S., R. 8 W. Josephine County	Au, Ag	Owner George Reynolds continued exploration of siliceous gold ore and had bulk samples mill tested.
7.	Warner Mine	Sec. 4 T. 33 S., R. 4 W. Jackson County	Au	Galactic Resources continued exploration and development of the gold deposits.
8.	Fall Creek Copper Prospect	Sec. 4 T. 38 S., R. 9 W. Josephine County	Cu	Mining Enterprises exposed a zone of massive sulfides in serpentinite.
9.	Lightning Gulch Group	– – – Tps. 38, 39 S., R. 9 W. Josephine County	Au, Ag	FMC continued exploration in the area.
10.	Turner-Albright Mine	Secs. 15, 16 T. 41 S., R. 9 W. Josephine County	Au, Ag, Cu	Noranda continued exploration program initiated by Baretta Mining.
11.	Babcock Prospect	Sec. 5 T. 39 S., R. 6 W. Josephine County	Au, Ag, Cu, Co	Moly Corporation did preliminary mapping and sampling of this volcanogenic massive sulfide deposit.
12.	Rainbow Mine	Sec. 12 T. 40 S., R. 7 W. Josephine County	Au	Siskron Mining completed a 400-ft crosscut adit intersecting vein about 200 ft below old workings and is drifting south on the vein to intersect a projected ore shoot.
13.	Ashland Mine	Sec. 6 T. 39 S., R. 1 E. Jackson County	Au	Touchstone Resources conducted an exploration program of mapping, sampling, and drilling.
14.	Oregon King Mine	Sec. 30 T. 9 S., R. 17 E. Jefferson County	Au, Ag	Conaka Metals drilled mine. It was also looked at by other companies.
15.	King Midas Prospect	Sec. 28 T. 33 S., R. 5 W. Josephine County	Au	Prospected by local group. Bulk samples mill tested.
16.	Fandora and Spotted Fawn Mines	Sec. 22 T. 33 S., R. 5 W. Josephine County	Au	Fortune Mining Company of Eugene opened mines and plan installation of small mill.
17.	Black Boy Mine	Sec. 5 T. 33 S., R. 4 W. Douglas County	Cr	Dick Webb and associates developing massive chromite deposit.
18.	Salt Creek area	Sec. 18 T. 38 S., R. 21 E. Lake County	Au	Freeport Minerals locating claims, mapping, and sampling. Plan to drill.
19.	Paisley Hills-Coyote Hills area	– – – T. 34 S., Rs. 18, 19 E. and T. 35 S., Rs. 22, 23 E. Lake County	Au, Cu	Chevron exploring, mapping, and sampling.

Table 2. *Exploration sites and areas in Oregon, 1982—continued*

Map no.	Site or area name	Location	Commodity	Comments
20.	Dry Creek-Fitzwater Point area	— — — T. 41 S., R. 18 E. Lake County	Au, Hg	U.S. Steel exploring large group of claims.
21.	Tucker Hill area	— — — T. 34 S., R. 19 E. Lake County	Both metallic and nonmetallic	Houston International exploring large group of claims.
22.	Floral coal deposits	Northern Wallowa County	Lignite coal	Utah International still unable to obtain permit from county to explore and sample.
23.	Cornucopia Mine	Secs. 27, 28 T. 6 S., R. 45 E. Baker County	Au, Ag	United Nuclear (mining and milling) continued work through 1982, reopening, rehabilitating, and sampling old workings. A diamond drilling program is planned.
24.	North Pole, E and E, and Columbia Mines	Sec. 32 T. 8 S., R. 37 E. Baker County	Au, Ag	Brooks Minerals and AMAX continued exploration and development until September when AMAX withdrew. Approximately 5,000 ft of old workings rehabilitated and 3,000 ft of new work done.
25.	Sumpter Valley Placer	— — — T. 10 S., Rs. 37, 38 E. Baker County	Au	Noranda completed drilling program on large area of dredged land but has not reported findings.
26.	Bald Mountain and Ibex Mines	Sec. 4 T. 9 S., R. 36 E. Baker and Grant Counties	Au, Ag	Nerco continued exploration and development work, rehabilitating about 3,000 ft of old workings, driving about 2,000 ft of new drifts, and conducting extensive underground diamond drilling.
27.	Dixie Meadows Mine	Sec. 23 T. 11 S., R. 33 E. Grant County	Au, Ag	Western Nuclear conducting underground exploration.
28.	Hereford area	— — — T. 12 S., R. 38 E. Baker County	Au, Ag, Sb, Mo	AMAX and American Selco have acquired land positions and started exploration.
29.	Grouse Spring Prospect	— — — T. 14 S., R. 36 E. Baker County	Cu, Mo	Manville did some drilling and leased the adjoining Record Mine claims.
30.	Cable Cove district	— — — T. 8 S., R. 36 E. Baker and Grant Counties	Au, Ag	AMAX diamond-drilled the Herculean, Red Chief, and Last Chance veins.
31.	Vinegar Hill-Sunrise Butte area	— — — T. 10 S., R. 34 E. Grant County	Mo, Au	American Copper and Nickel is mapping, sampling, and drilling Sunrise Butte pluton.
32.	Susanville district	— — — T. 10 S., R. 33 E. Grant County	Au	American Copper and Nickel continued work in the area, including trenching and drilling.
33.	Northern Malheur County, including Vale area	— — — — — — Malheur County	Au	Freeport, Homestake, and Manville have established land positions and are prospecting for epithermal gold deposits.
34.	Southern Harney County near Fields	— — — — — — Harney County	Au	FMC and Inspiration Development have established land positions and are prospecting for epithermal gold deposits.

NONMETALS

Steatite of Southern Oregon (Mine 6) continued production of block soapstone for carving at about the same rate as 1981. Stone is shipped as far as New York and Alaska. Alaska, where most of the stone is used in the production of genuine Eskimo carvings, is their biggest customer.

Oregon Portland Cement Company operated its plant and quarry at Durkee only eight months in 1982 due to depressed demand for building materials coupled with high cement inventories. The Lake Oswego plant remained closed. In July, the company celebrated production of the first million tons of cement clinker from the modern coal-fired plant at Durkee. The three-year-old computerized installation has an annual capacity of 500,000 tons of cement. Both limestone and shale used in the manufacture of cement are quarried near the plant site.

The Teague Mineral Products drying, grinding, and bagging plant near Adrian (Mine 13) continued production of bentonite and zeolite. The bentonite is mined from pits near the head of Sucker Creek; the zeolite comes from deposits near Rome, Oregon.

EXPLORATION AND DEVELOPMENT ACTIVITY

Coal

Coos County Coal (Site 3**) is still the subject of considerable interest and exploration activity. American Coos Bay Energy, Inc. (formerly Canasia), has tied up large acreages of county and private leases in the Coos Bay area; GCO Minerals, in joint venture with Kennecott Minerals, has also developed a land position and is conducting an exploration program including mapping and drilling in the Coos Bay field.

** All site numbers refer to "Exploration sites and areas" on location map and in Table 2.

Utah International remains interested in the lignite deposits of northern Wallowa County (Site 22) but has been unable to get a permit from the County to mine 233 cubic yards for bulk sample analysis to check the quality of the resource. Other companies are involved in exploring these extensive lignite deposits across the border in southeastern Washington.

Precious and base metals

Exploration activity around the state continued at a fairly good pace in spite of the depressed metals market. The principal areas of interest continue to be northeastern Oregon, with Baker and Grant Counties, and the southwestern part of the state, with Douglas, Josephine, and Jackson Counties. Interest in Tertiary epithermal gold mineralization associated with siliceous volcanic rocks has centered in southern Lake, Harney, and northern Malheur Counties.

Activity in the Cracker Creek District of western Baker County was continued in 1982. Brooks Minerals and AMAX continued exploration and development at the E and E and North Pole Mines (Site 24) at Bourne, 6 mi north of Sumpter, until late September, when AMAX withdrew from the joint venture. Brooks Minerals acquired the property in early 1980 and was joined by AMAX shortly afterward. Approximately 5,000 ft of old workings on the E and E and North Pole Mines have been rehabilitated, and 3,000 ft of new work was done. The Jevne adit has been driven 600 ft to date. This is a projected 3,800-ft crosscut to intersect the North Pole-Columbia lode about 360 ft below existing adit level access. The lode consists of a mineralized fracture zone in argillite, measures 10 to 300 ft in thickness, and is traceable for about 4½ mi. Total combined production from this zone has been about $9 million, mostly prior to 1916.

The Bald Mountain and Ibex Mines (Site 26) on the Baker-Grant County line about 5 mi southwest of Bourne is being explored by NERCO, Inc., who acquired the properties in 1980. Progress by the end of 1982 included rehabilitation of about 3,000 ft of old workings, 2,000 ft of new drifts and crosscuts, and 39,000 ft of diamond drilling. The company plans to continue exploration and development, mainly by diamond drilling. A moderate-size mill is contemplated, if sufficient reserves can be developed. The Bald Mountain-Ibex vein is a mineralized fault zone in argillite and is from 8 to 20 ft thick. Estimated past production is about 9,000 oz of gold and 150,000 oz of silver.

At the Cornucopia Mine (Site 23), 10 mi north of Halfway, Oregon, United Nuclear Corporation (mining and milling) reopened and rehabilitated both the Coulter and Clark level crosscut adits which were the main accessways to the 36 mi of workings of the old mine which had not been operated since October 1941. Prior to 1941, the mine produced about $10 million in gold and silver from two roughly parallel veins, the Union-Companion and Last Chance, which are about 2,500 ft apart, average 4 ft in width, and dip steeply in granodiorite and hornfelsed greenstone. The Coulter Tunnel, a 6,800-ft crosscut to the Union vein, is the lowest adit level of the mine and was the main haulage way during the last phase of mining in 1936-1941. The Clark level adit, 985 ft vertically above the Coulter, gave access for earlier work on both the Union-Companion and Last Chance veins. UNC's plans include reopening an underground shaft and old workings on the Union-Companion vein below the Coulter level where very little mining has been done. UNC stopped work in October 1982, but local representatives are hopeful that exploration efforts will be resumed in the spring of 1983.

(Continued on page 45, **Mineral industry***)*

Significant earthquakes up slightly worldwide in 1982

The number of significant earthquakes in the world in 1982 rose slightly from 1981, but the number of people killed in earthquakes was down by one-third, according to the U.S. Geological Survey (USGS).

Only one of 1982's significant earthquakes occurred in the United States and was centered in the Aleutian Islands. This was the lowest number of significant quakes in the United States since 1974 when none occurred. A significant earthquake is defined as one that registers 6.5 or more on the Richter Scale or one of smaller magnitude that causes casualties or considerable damage.

Worldwide, there were 56 significant earthquakes last year, six more than in 1981 and just about the annual average during the past few years, according to Waverly Person, a USGS geophysicist at the Survey's National Earthquake Information Service in Golden, Colorado.

The 1982 death toll was only about two-thirds of the 5,239 persons reported killed in earthquakes in 1981, most of them in two strong quakes in Iran. The long-term average, however, is about 10,000 earthquake-related deaths per year. No one has been killed in the United States by an earthquake since November 29, 1975, when two persons were killed by a tsunami (seismic sea wave) generated by a 7.2 magnitude earthquake in Hawaii.

Based on data collected by the USGS from about 3,000 seismograph stations around the world, Person said the strongest earthquake in the world in 1982 was a 7.7 magnitude quake December 19 in the Tonga Islands region in the South Pacific Ocean. No damage or casualties were reported in this region, where major earthquakes are common.

The Tonga Islands quake was among ten major earthquakes (those registering 7.0 to 7.9 on the Richter Scale) in the world during 1982. The long-term average is 19 quakes per year with magnitudes of 7.0 or more. For the second consecutive year, no great earthquakes (those with magnitudes of 8.0 or more) occurred in the world. The last great earthquake was a magnitude 8.0 quake July 17, 1980, in the Santa Cruz Islands in the South Pacific.

The strongest 1982 quake in the United States was a 6.5 magnitude tremor January 25 in the Fox Islands in the Aleutians, but there were no reports of any damages or casualties. In the conterminous 48 states the strongest earthquake was a 5.5 magnitude tremor September 24 along the California-Nevada border south of Hawthorne, Nev., and southeast of Mono Lake, Calif. No damages or casualties were reported.

There were 404 earthquakes in the United States last year that were reported to the USGS as being felt by people. This was 33 more "felt" earthquakes than reported in 1981.

As in 1981, Hawaii led all other states with 137 quakes, followed by California with 108 and Alaska with 44.

The total number of "felt" quakes in other states were Arkansas 14; Idaho 11; Nevada 10; Maine 8; New Hampshire 7; Connecticut, New Mexico and Washington 6 each; Vermont 5; Massachusetts and Montana 4 each; Arizona, Colorado, Georgia, Tennessee and Texas 3 each; Alabama, New York, South Carolina, South Dakota and Utah 2 each; and Iowa, Minnesota, Missouri, Mississippi, Nebraska, New Jersey, North Carolina, Oklahoma and Pennsylvania 1 each.

Person said the USGS normally locates between 6,000 and 7,000 earthquakes worldwide each year that range in magnitude from about 3 up to 8 or more on the Richter Scale. Probably several million earthquakes occur each year, he said, but most are so small in magnitude or they occur in such remote areas that they are undetected by even the most sensitive instruments in the worldwide seismograph network.

—USGS news release

PUBLICATIONS RECEIVED

From time to time we print information about new publications that have been recently added to our library. These publications are available, for inspection only, in the Department's library, which is located in Room 901, State Office Building, Portland.

Elements of Soil Mechanics for Civil and Mining Engineers, 5th edition, by G.N. Smith. Published by Granada Publishing Ltd.; available in the U.S. from Renouf USA, Old Post Rd., Brookfield, VT 05036. 493 p., 1982, paper $21.75.

The fifth edition of this well-established book is a published response to the rapidly accelerating development in the field of soil mechanics. It covers the changes that have occurred during the last five years in a concise presentation of the applications of soil mechanics that will satisfy today's teaching and professional requirements.

Mineral and Rock Table, compiled by P. Lof. Published by Elsevier Science Publishing Co. Inc., 52 Vanderbilt Avenue, New York, NY 10017. Chart measuring 28 × 52 inches; available in the following quantities: 10 copies, $78.75; 20 copies, $125.50; 50 copies, $293.50; and 100 copies, $510.50.

This wall chart features all the world's important rock-forming and ore minerals. It includes full-color photomicrographs and optical and physical properties of 74 rock-forming and 53 ore minerals taken in plane- and cross-polarized light. The chart also contains comprehensive diagrams featuring all important rock classifications, full indexing, and a Michel-Lévy chart. □

Oregon AEG plans field trip

The Oregon Association of Engineering Geologists' annual field trip is scheduled for June 11 and 12, 1983. The group will leave at 8:00 a.m. from Portland to tour John Day country and the Columbia River Gorge. Topics to be covered during the two days include geothermal resources of Oregon; geotechnical, water-resources, and planning aspects of Rajneeshpuram; and engineering geology aspects of the Columbia River Gorge.

The registration fee of $65 covers transportation, guide books, snacks, lunches for both days, and a banquet dinner at Rajneeshpuram. For approximately $30, overnight accommodations are available at either Rajneeshpuram or Madras.

Reservations and a $20 deposit are necessary by April 15, 1983. The balance is due at registration. Reservations are limited to the first 40 received. Send registration payable to: Tom Kuper, Century West Engineering Corporation, P.O. Box 1174, Bend, Oregon 97709. For more information, contact Tom at (503) 388-3500 or Marie Marshall at (503) 757-4474. □

Wanted: Mined Land Reclamationist of the Year nominees

All our readers are reminded it is time to identify the potential 1983 Mined Land Reclamationist of the Year.

Criteria to consider include the future value of the site to the owner and the community; the imagination, innovativeness, and effectiveness of the completed reclamation; safety; aesthetics; and general appropriateness to the local environment.

Anyone can nominate a site deserving of recognition by calling 967-2039 or by writing to Mined Land Reclamation Program, 1129 SE Santiam Road, Albany, OR 97321. May 31, 1983, is the deadline. □

Mount St. Helens revisited

The U.S. Geological Survey has published a new account of the Mount St. Helens eruptions of 1980: *Volcanic eruptions of 1980 at Mount St. Helens. The first 100 days*, by B.L. Foxworthy and M. Hill (USGS Professional Paper 1249, 1982). The 125-page report was designed to be of interest to, and understood by, a general audience. It is extensively illustrated with maps, diagrams, and photographs, most of them in color. It was also intended to serve public land managers by demonstrating day-by-day reactions during a natural disaster.

The report uses information obtained from published reports, eyewitness accounts, news releases, and scientific studies as it recounts the events of each single day from March 20 to June 27, 1980. This chronology is complemented by introductory discussions of the Cascade volcanoes, the volcanic history of Mount St. Helens, and early warnings of the hazards and concludes with summaries of conditions, continuing hazards, and the Survey's hazard responsibilities; finally, a glossary explains technical terms, and a bibliography lists titles for further reading.

This publication complements USGS Professional Paper 1250 (1981), which is a detailed account of the scientific aspects of the several eruptions at Mount St. Helens and their aftermath. Both reports are dedicated to David A. Johnston, a 30-year-old USGS volcanologist from Menlo Park, California, who was killed at an observation post on a ridge about six miles north of the volcano's summit when the May 18 eruption occurred.

The new report, Professional Paper 1249, is available from the regional USGS Public Inquiries Office, 678 U.S. Courthouse, West 920 Riverside Ave., Spokane, WA 99201, at a price of $8.50. □

GSOC luncheon meetings announced

The Geological Society of the Oregon Country (GSOC) holds noon meetings in the Standard Plaza Building, 1100 SW Sixth Avenue, Portland, in Room A adjacent to the third floor cafeteria. Topics of upcoming meetings and speakers include:

May 6 – *Cascade Stream and Pond*, by Roger Yerke, education specialist, Washington Park Zoo.

May 20 – *Mayan Culture*, by Betty Ferguson, Audubon representative and naturalist.

For additional information, contact Viola L. Oberson, Luncheon Program Chairwoman, phone (503) 282-3685. □

(**Mineral industry**, *continued from page 44*)

In southwestern Oregon, most of the exploration activity reported for 1981 (*Oregon Geology*, v. 44, no. 4) continued into 1982 (see Table 2). The Turner-Albright Mine (Site 10), explored by Baretta in 1981, was taken over by Noranda in 1982. They did additional drilling, mapping, sampling, and evaluation of all the accumulated data which indicate important bodies of gold-bearing massive sulfides. Work ended late in the year. Noranda has recently dropped its option, and future plans for development are indefinite.

The shutdown of Hanna Mining Company's nickel mine and smelter in Douglas County reflects the status of the nation's steel industry, and this overall picture has resulted in the ending of many years of nickel-laterite exploration in southwestern Oregon. Virtually no activity took place in 1982.

Geologic maps of mineralized areas in Baker and Grant Counties published by the Oregon Department of Geology and Mineral Industries (DOGAMI) in 1982 include GMS-19 (Bourne quadrangle) and GMS-22 (Mt. Ireland quadrangle). Maps of the Granite, Greenhorn, and Bates quadrangles are in progress, and mapping projects of a similar nature have been started by DOGAMI in Josephine County, southwestern Oregon. □

Results of southeastern Oregon geochemical sampling program released

During the 1982 field season, the Oregon Department of Geology and Mineral Industries (DOGAMI) conducted a geochemical sampling program evaluating the mineral potential of 18 Bureau of Land Management (BLM) Wilderness Study Areas in Harney and Malheur Counties, southeastern Oregon. As part of this project, 1,491 stream, rock-chip, and soil samples were collected and analyzed for gold, silver, arsenic, barium, beryllium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, tin, tungsten, uranium, and zinc.

Raw data from this study were released on microfiche in February 1983. DOGAMI now announces the publication of the final results of this study in Open-File Report 0-83-2, *Geology and Mineral Resources of 18 BLM Wilderness Study Areas, Harney and Malheur Counties, Oregon*, by Jerry J. Gray, Norman V. Peterson, Janine Clayton, and Gary Baxter.

Before this study was undertaken, only two of the areas, Steens Mountain and the Pueblo Mountains, were known to be mineralized, mainly for mercury. This study, however, has identified the Owyhee Reservoir and the Pueblo Mountains as areas of gold potential, as well. The study, in fact, showed that all of the wilderness study areas had scattered anomalous gold values, the Pueblo Mountains have high potential for copper and molybdenum, all the areas have geothermal potential, and most have oil and gas potential.

Jerry Gray, principal investigator for this study, taking rock-chip samples for analysis.

Mark Ferns, DOGAMI geologist, taking silt-size stream sediment samples from a dry wash.

Red Butte, BLM Wilderness Study Area 3-56 (Dry Creek Buttes), located on the north shore of the Owyhee Reservoir, Malheur County. This butte, which is formed from silicified and mineralized lake bed sediments, was identified by this study as a gold exploration target. In this photo it is seen from the top of Quartz Mountain, which is out of the study area and which has been staked by a mining company.

Included in the just-released open-file report is a 106-page text containing descriptions of the sampling and analytical techniques, geochemical-data statistical analyses, and discussions of each of the areas including the geology, stratigraphy, structure, mines and prospects, geochemical sampling results, and a summary of mineral potential. Microfiche accompanying the report present raw assay and site data, area summary tables, frequency tables, histograms, scattergrams, and maps showing the location of each of the sample sites.

DOGAMI Open-File Report 0-83-2 is now available at the Portland office of the Oregon Department of Geology and Mineral Industries. Purchase price is $15. Orders under $50 require prepayment. □

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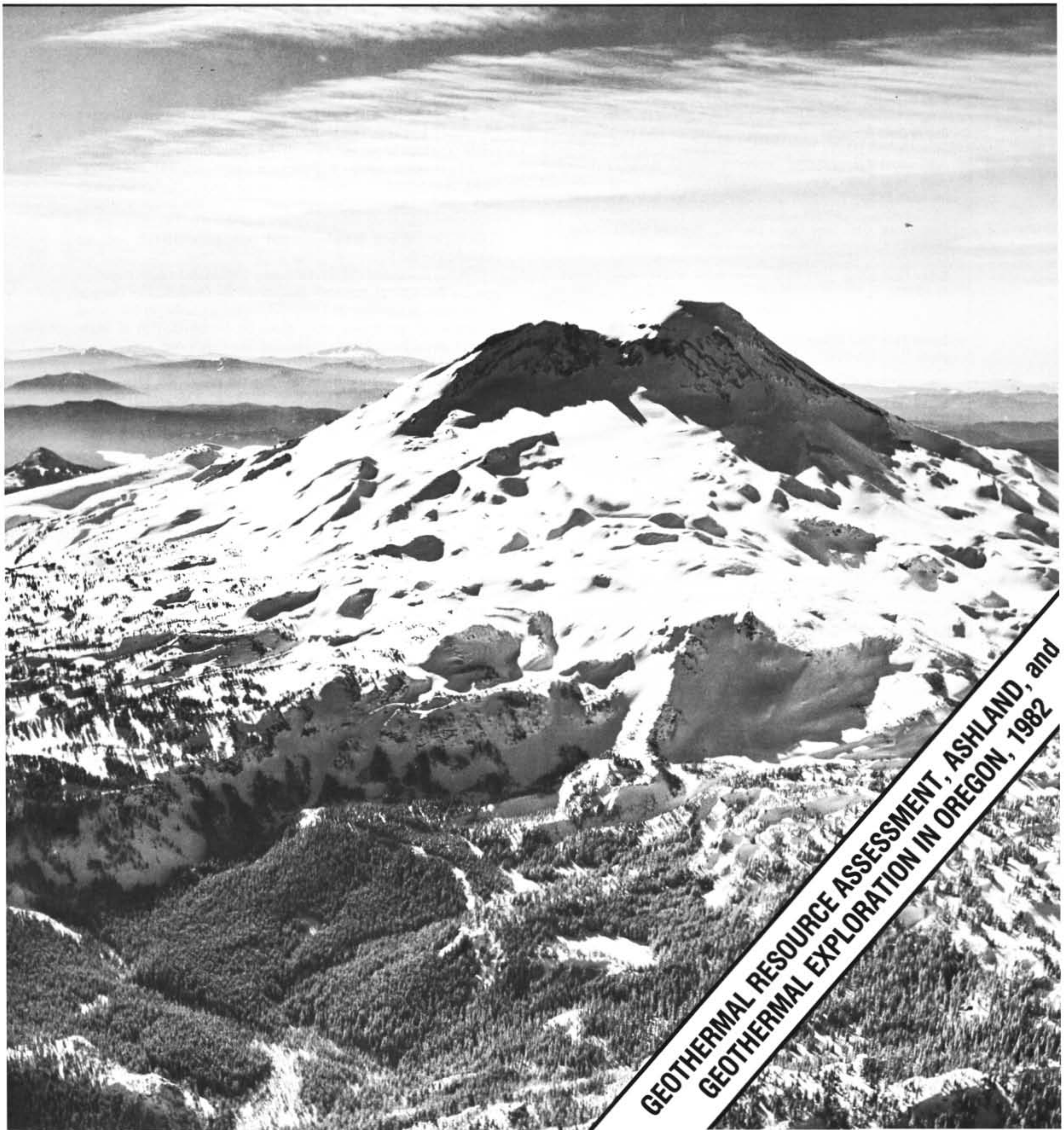

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COVER PHOTO

South Sister, one of the Three Sisters in Oregon's central Cascade Range. Volcanoes such as this suggest the possibility of geothermal potential at depth, and the focus of geothermal exploration has shifted from eastern Oregon to this part of the state. See article beginning on p. 56 for summary of 1982 geothermal activity in Oregon. Photo courtesy Oregon State Highway Commission.

OIL AND GAS NEWS

Clatsop County

Drilling permits continue to be applied for in Clatsop County. Diamond Shamrock has filed for a location in sec. 11, T. 6 N., R. 6 W. (see table below). The well, Clatsop County 33-11, has a proposed total depth of 6,000 ft and will probably be the next well to be drilled by the operator in the state. The tract on which this well is to be drilled was offered by Clatsop County at a sealed bid auction on February 9, 1983. The parcel had originally been nominated for leasing by Diamond Shamrock and went for a bonus bid of $338 per acre.

Gas prices at Mist Gas Field

The U.S. Natural Gas Policy Act (NGPA) became effective December 1, 1978. The Federal Energy Regulatory Commission (FERC), which implements the NGPA, determined several categories of gas wells. These categories are used to establish gas prices. FERC is required to compute and publish maximum lawful prices each month. The monthly equivalent of the annual inflation adjustment allows the price to be increased each month. The prices are in dollars per million British thermal units ($/MMBTU) and are published in the Federal Register.

After passage of the act, each state formulated a determination process for natural gas well categories. In Oregon, the Oregon Department of Geology and Mineral Industries is the jurisdictional agency which processes applications for Determination of Maximum Lawful Price under the Natural Gas Policy Act.

Mist Gas Field gas is priced under NGPA Section 102, New Natural Gas, Category B. Following are prices for Mist gas at various selected times: December 1979, $2.336/MMBTU; December 1980, $2.640/MMBTU; December 1981, $2.971/MMBTU; December 1982, $3.274/MMBTU; and April 1983, $3.367/MMBTU.

Oregon Gas Production 1979-1982

The Mist Gas Field first went on production in December 1979, after completion of four wells and construction of a pipeline. The heating value of the gas measures from 890 to 960 Btu per cubic foot, depending on the individual pool and well.

The following table gives cumulative production figures for the field at the end of each year of production:

Year	Cumulative production at year's end (Mcf)
1979	15,160
1980	4,947,190
1981	9,867,623
1982	13,266,806

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
233	Diamond Shamrock Clatsop County 33-11 007-00014	SE¼ sec. 11 T. 6 N., R. 6 W. Clatsop County	Application
234	Reichhold Energy Werner 34-21 047-00014	SE¼ sec. 21 T. 5 S., R. 2 W. Marion County	Application

□

CONTENTS

Results of a geothermal resource assessment of the Ashland, Oregon, area, Jackson County

by Gerald L. Black, Oregon Department of Geology and Mineral Industries, and Monty Elliott, Jad D'Allura, and Bill Purdom, Southern Oregon State College, Ashland, Oregon

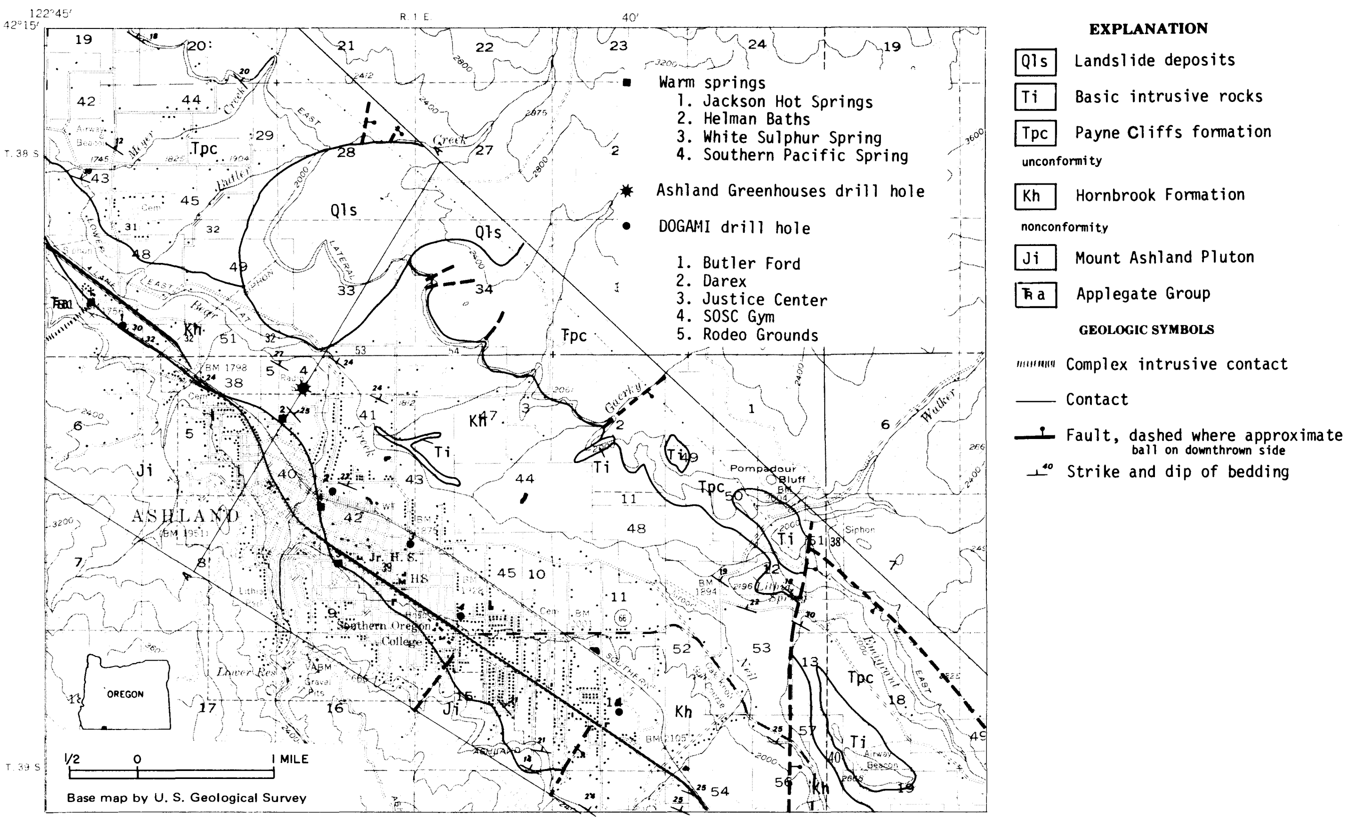

Figure 1. Geologic map of the Ashland, Oregon, area.

INTRODUCTION

As part of its low-temperature geothermal resource assessment program, the Oregon Department of Geology and Mineral Industries (DOGAMI) drilled five temperature-gradient holes in the Ashland, Oregon, area during June of 1982. A sixth hole was drilled in the Cascade Mountains east of Ashland during the same period. This last hole was drilled as part of a continuing evaluation of the geothermal potential of the Cascade Range in Oregon. It was sited to aid in defining the position and/or existence of a transition from lower (~40 milliwatts per square meter [mWm^{-2}]) to higher (>100 mWm^{-2}) heat flow which has been identified in the northern and central Cascade Range in Oregon.

Ashland, a city of 14,975 inhabitants, is located in southwestern Oregon in Jackson County (Figure 1). There are four warm springs located in or near the city (Figure 1). Jackson Hot Springs, the warmest of the four, is located northwest of the city limits (Figure 1). A temperature of 35° C has been reported for Jackson Hot Springs (Berry and others, 1980), but DOGAMI personnel have measured temperatures as high as 43.5° C in the warmest of the approximately ten orifices which occur in the hot springs area. The three other springs lie on a north-northwest-trending line within the city limits (Figure 1). They include Helman Hot Springs (31.5° C), White Sulphur Spring (28.5° C), and the Southern Pacific Spring. A resort located at Jackson Hot Springs represents the only commercial use of geothermal fluids in Ashland.

GEOLOGY

The city of Ashland lies on the boundary between the Klamath Mountains and Western Cascades physiographic provinces. The geology in the immediate vicinity of the city was mapped in 1981 by three of the authors (Elliott, D'Allura, and Purdom) specifically for the low-temperature geothermal resource assessment project. Figure 1 is taken from their map.

Quartz diorites of the Late Jurassic Mount Ashland Pluton dominate the terrain west of the city. The rocks of the pluton were encountered in two of the five temperature-gradient holes drilled for the project (Darex at 93 m [305 ft] and SOSC Gym at 120 m [392 ft]; see Figure 2). In addition, a well drilled at the Ashland Greenhouses (Figure 1) encountered the contact between the pluton and the overlying Hornbrook Formation at a depth of 299 m (982 ft).

Cropping out northwest of the city are rocks of the Late Triassic Applegate Group. These rocks were contact metamorphosed during the emplacement of the Mount Ashland Pluton. The Butler Ford hole encountered Applegate Group rocks at 352 m (115 ft) (Figure 2). The contact between the metamorphic rocks and the pluton is a zone of mixed rocks, where stringers of quartz diorite complexly intrude the Applegate Group. Jackson Hot Springs is located near the contact between the Applegate Group, the Mount Ashland Pluton, and the Hornbrook Formation.

Greenish to gray sandstones and mudstones of the Late Cretaceous Hornbrook Formation nonconformably overlie the Mount Ashland Pluton and the associated metamorphic rocks of the Applegate Group. The Hornbrook Formation, which represents a marine onlap sequence, dips rather uniformly northeastward at about 25° (Figure 1). The four warm springs occurring in the Ashland area are located at the contact of the Hornbrook Formation with the Mount Ashland Pluton, and all five of the temperature-gradient holes drilled in the Ashland area were collared in Hornbrook Formation sediments.

The Hornbrook Formation is in turn unconformably overlain by the Eocene to late Oligocene Payne Cliffs formation which consists of fluvial conglomerates and sandstones. Tertiary intrusions of basaltic composition occur east and southeast of the city, but neither they nor the rocks of the Payne Cliffs formation were encountered in any of the drill holes. Figure 2 shows the lithologies of the five temperature-gradient holes drilled in the Ashland area.

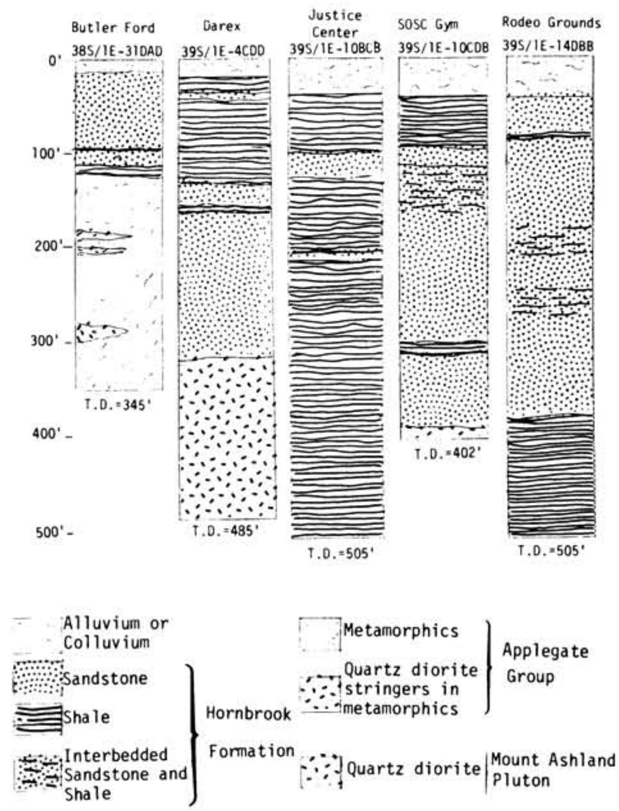

Figure 2. Lithologies of Ashland, Oregon, temperature-gradient holes.

HEAT FLOW

Based on data from a U.S. Geological Survey (USGS) hole drilled as part of a regional heat-flow study of southwestern Oregon and northern California (Mase and others, 1982) and on temperature gradients measured by DOGAMI in unused water wells ("free" holes) during the summer of 1981 (Blackwell and others, 1982), the background heat flow in the Ashland area is approximately 42 mWm^{-2}. Typical background-temperature gradients are 16°-18° C/km in the quartz diorite of the Mount Ashland Pluton and 20°-25° C/km in the sedimentary rocks of the Hornbrook Formation. The USGS hole is located near Winburn Camp, about 6.5 km (4 mi) south of Ashland. The DOGAMI "free" holes are scattered around the outskirts of the town, mostly in the valley to the east-northeast.

The heat-flow data for the six holes drilled as part of the Ashland low-temperature assessment project are summarized in Table 1. Also included in Table 1 are heat-flow data for a 344-m (1,130-ft) well drilled at the Ashland Greenhouses (39S/1E-4BBD) during 1981 and 1982. The temperature-depth curves for the six holes are reproduced in Figure 3. The data for the Ashland Greenhouses hole have been published previously (Blackwell and others, 1982) but are reproduced here because information obtained from the hole was invaluable in understanding the nature of the low-temperature resource at Ashland. It should be noted that the thermal conductivities listed in Table 1 for the Ashland Greenhouses hole were determined on cuttings from the Darex hole, the nearest hole for which cutting samples were available. All thermal-conductivity measurements were performed under the direction of David D. Blackwell at Southern Methodist University, using the divided-bar technique of Sass and others (1971).

The temperature-depth curve of the Butler Ford hole (Figure 3) above 70 m (230 ft) is a good example of fluid upflow within the well bore. During drilling of the well, artesian flow was encountered at about 70 m (230 ft). Normally in temperature-gradient wells the intraborehole movement of fluids is prevented by grouting the hole from bottom to top with cement. Since the quantity of fluid encountered in the Butler Ford hole (~100 gallons per minute [gpm]) represented a potential low-temperature resource, the decision was made not to grout the hole in order to preserve it for possible later use. Instead, the well was sealed with a welded-steel plate. Beneath the artesian zone at 70 m (230 ft), the temperature-depth curve appears conductive. The heat-flow value (118 mWm^{-2}) for the lower portion of the hole is high but reasonable, considering the nearness of the hole to Jackson Hot Springs (Figure 1).

The temperature-depth curve for the Darex hole results from variations in thermal conductivity. There are three linear segments with breaks in slope at 50 m (165 ft) and 100 m (330 ft) (Figure 3). The lithology in the hole consists predominantly of shale to 49 m (160 ft), sandstone from 49 m to 94 m (160 to 310 ft), and quartz diorite from 94 m to 148 m (310 to 486 ft)

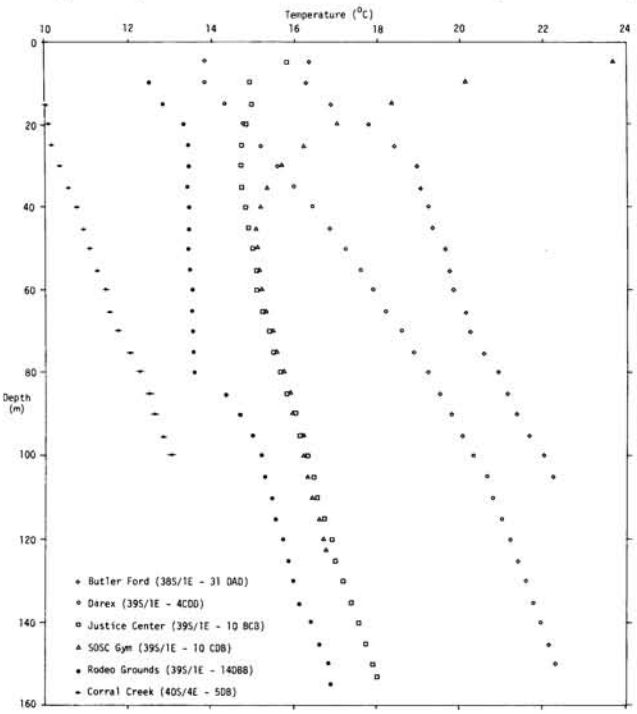

Figure 3. Temperature-depth curves for the Ashland, Oregon, low-temperature assessment program.

(Figure 2). Temperature gradients are typically higher where the thermal conductivities are lower (Table 1). The disparity in heat-flow values between the lower and upper part of the hole (Table 1) most probably reflects the presence of a warm-water aquifer at or near the contact of the Hornbrook Formation with the Mount Ashland Pluton. The difference in heat flow between the upper and lower portions of the Ashland Greenhouses hole is probably due to the same aquifer and will be discussed in more detail in a later section.

The temperature-depth curves for both the Justice Center and SOSC Gym holes are typical of conductive heat flow. The highly convex nature of the curve for the upper part of the SOSC Gym hole (Figure 3) is a microclimatic effect resulting primarily from solar heating. The hole collar is located on the margin of a large parking lot, where evapotranspiration does not effectively moderate the near-surface temperatures. The hole is also adjacent to the Southern Oregon State College steam plant, which may be partly responsible for the high near-surface temperatures. A similar, but smaller, microclimatic effect can be seen in the upper portion of the Justice Center hole (Figure 3) which is located in a large, open, flat field with sparse vegetation.

The temperature-depth profile for the hole at the Rodeo Grounds is typical of intraborehole downflow. The hole was not grouted to prevent intraborehole fluid movement, and as a result it is isothermal to a depth of 80 m (264 ft). Below that depth, the temperature gradient is linear, and the heat flow is conductive.

The hole at Corral Creek, which is located east of the map area of Figure 1, also possesses a linear temperature-depth curve and conductive heat flow.

Based on the above analyses, it appears that the Rodeo Grounds, SOSC Gym, and Justice Center holes all represent "background," or average, heat-flow values for the Ashland area. The heat-flow values for these three holes (50 to 65 mWm^{-2}) are somewhat higher than the background value (42 mWm^{-2}) quoted at the beginning of this section. There are several possible explanations for the discrepancy: (1) The regional heat flow increases from west to east (toward the Cascade Mountains), and the background value of 42 mWm^{-2} was based primarily on a hole located west of the city. It is possible that the regional heat flow in the Ashland area is greater than 42 mWm^{-2}. (2) A warm aquifer located at the Hornbrook Formation-Mount Ashland Pluton contact may underlie the entire Ashland area. The aquifer would not need to be particularly large or particularly warm to produce the required increase in temperature gradient (and hence, heat flow). (3) The lithologies in the upper part of the drill holes consisted mostly of shales and fine siltstones (Figure 2). The in-situ thermal conductivities of shales are nearly always lower than values obtained from laboratory measurements with a divided bar (D.D. Blackwell, personal communication, 1981). The discrepancy is due to the impossibility of preserving the in-situ anisotropic nature of shale in measurements on randomly oriented cuttings fragments. The thermal conductivity values of Table 1 may thus be slightly inflated, resulting in increased heat-flow values. (4) The higher heat flow may be due to thermal refraction at the contact between bodies of higher thermal conductivity (Mount Ashland Pluton) and lower thermal conductivity (Hornbrook Formation), in a manner analogous to many Basin and Range situations (Blackwell and others, 1978). (5) Terrain corrections have not been completed for the holes listed in Table 1.

Since temperature gradients lower than those measured in the SOSC Gym, Rodeo Grounds, and Justice Center holes have been measured in "free" holes east of Ashland, it is doubtful that a regional eastward increase in heat flow is the cause of the anomaly. It is also unlikely that a warm aquifer underlies the entire city, as no such aquifer was identified in the three holes mentioned above. Two of the three holes were slightly artesian, but the artesian zones were located within the Hornbrook Formation rather than at the contact between the Hornbrook Formation and the Mount Ashland Pluton. It is also improbable that thermal refraction can account for much, if any, of the anomaly. The contrast in thermal conductivities between the quartz diorites of the Mount Ashland Pluton and the sedimentary rocks of the Hornbrook Formation is not nearly as great as the conductivity contrast between the unconsolidated sediments of the basins and the bedrock of the ranges in the Basin and Range province. The thermal conductivities in the latter situation often differ by a factor of two or more (Blackwell and others, 1978). It is more likely that the higher

Table 1. *Heat-flow information for the Ashland, Oregon, drill holes.*

Hole name	Location	Lat. (N.)	Long. (W.)	Collar elev. (m)	Depth (m)	Depth interval (m)	Thermal conductivity ($Wm^{-1}°K^{-1}$)	Gradient (°K/km)	Heat flow (mWm^{-2})
Butler Ford	38S/1E-31DAD	42°13.10'	122°44.32'	510	107	70-107	1.90	62.0	118
Ashland Greenhouses	39S/1E-4BBD	42°12.72'	122°42.8'	536	344	180-300 310-330	(1.77) (2.07)	53.5 28.7	95 59
Darex	39S/1E-4CDD	42°12.05'	122°42.52'	502	148	10-50 55-90 100-148	1.77 2.64 2.07	84.8 63.1 41.5	149 167 86
Justice Center	39S/1E-10BCB	42°11.70'	122°41.82'	573	154	65-115 125-154	2.06 1.85	29.8 36.5	61 68
SOSC Gym	39S/1E-10CDB	42°11.25'	122°41.45'	603	123	60-123	1.98	25.1	50
Rodeo Grounds	39S/1E-14DBB	42°10.62'	122°40.07'	635	154	100-150	1.85	33.0	61
Corral Creek	40S/4E-5DB	42°07.08'	122°22.5'	1055	99	65-100	1.31	43.5	57

Table 2. *Silica geothermometers for springs and wells in the Ashland, Oregon, area.*

Name	Type of Source	Location	Measured Surface Temp.	Si Conductive	Si Adiabatic	Si Chal	Si Opal
Jackson Springs North	spring	38S/1E-31DBB	43.5	92.8	94.7	62.2	-21.7
Jackson Springs South	spring	38S/1E-31DBD	42.5	92.8	94.7	62.2	-21.7
Jackson Hot Springs Well	well	38S/1E-31DAB	22.5	50.5	57.4	18.1	-56.5
Butler Ford	well	38S/1E-31DAD	18.4	104.5	104.9	74.8	-11.7
Helman Hot Spring	spring	39S/1E-4CBD	31.5	83.4	86.5	52.2	-29.6
White Sulphur Well	well	39S/1E-9BBA	28.5	73.6	78.0	42.0	-37.8
Darex	well	39S/1E-4CDD	21.1	91.7	93.8	61.0	-22.6
Justice Center	well	39S/1E-10BCB	16.8	67.1	72.2	35.1	-43.1
Lithia Spring	spring	39S/1E-12DAD	12.5	85.9	88.7	54.9	-27.5
Lithia Wells	well	39S/2E-7CCA	18.5	100.9	101.7	70.9	-14.8
Buckhorn Mineral Springs	spring	40S/2E-12ADD	5.5	112.9	112.1	83.9	-4.5
Corral Creek	well	40S/4E-5DB	14.5	110.5	110.0	81.25	-6.6

background heat flow measured in the above three holes results from a combination of the effects of errors in the measurement of thermal conductivities of shales and the lack of terrain corrections. The terrain corrections, when completed, can be expected to lower the temperature gradients and, hence, the heat-flow estimates by approximately 5 to 10 percent (D.D. Blackwell, personal communication, 1982). It is interesting to note that the lowest heat-flow value of 50 mWm^{-2} (Table 1) was obtained from a predominantly sandstone section of the SOSC Gym hole, which should be relatively immune to large errors in the measurement of thermal conductivity. A 10-percent decrease in the heat-flow estimate (resulting from the terrain correction) would result in a heat-flow value of 45 mWm^{-2}, which is very close to the USGS estimate of 42 mWm^{-2} at Winburn Camp.

GEOTHERMOMETRY

By making certain basic assumptions, the chemical compositions of thermal waters can be used to estimate the subsurface temperatures of geothermal reservoirs. The assumptions are as follows: (1) Temperature-dependent reactions occur at depth. (2) All of the chemical constituents involved in the temperature-dependent reactions are sufficiently abundant. (3) Water-rock equilibrium occurs at the reservoir temperature. (4) Re-equilibration does not occur at a lower temperature as the water flows from the reservoir to the surface. (5) The thermal water does not mix with cool, shallow ground water (Fournier and Rowe, 1966). While assumptions (1) and (2) are probably valid for most hot spring systems, assumptions (3), (4), and (5) are less often fulfilled, particularly in low-temperature systems. As a result, the temperatures indicated by the chemical geothermometers tend to be minima.

Table 2 is a tabulation of minimum estimated reservoir temperatures calculated from various silica geothermometers. Included in the table are waters from warm and cold springs in the Ashland area and from the DOGAMI temperature-gradient wells. For the ranges in temperature and flow rate involved, the conductive silica geothermometer probably gives the best estimate of minimum reservoir temperature. The sodium/potassium geothermometers were not included in Table 2, because the amount of potassium in the thermal waters was generally less than the minimum detectable concentration.

As can be seen in Table 2, minimum reservoir temperatures in the Ashland area are on the order of 100° C. The low value of 50.5° C for the Jackson Hot Springs well probably results from the mixing of shallow ground water with the deeper thermal water. The minimum estimated reservoir temperature for the Justice Center hole is also low, probably because the hole is located south of the main geothermal anomalies and thus did not encounter geothermal fluids. It is also possible that geothermal fluids were not encountered because the well did not penetrate the Mount Ashland Pluton-Hornbrook Formation contact, the aquifer which carries the fluids in the geothermal areas to the north. This second possibility is considered unlikely because the heat flow in the hole (Table 1) is significantly lower than that in the holes to the north (Darex, Ashland Greenhouses, and Butler Ford).

INTERPRETATION

Figure 4 is a cross section through northwest Ashland along line A-A' of Figure 1. The cross section passes through Helman Hot Springs and the Ashland Greenhouses well.

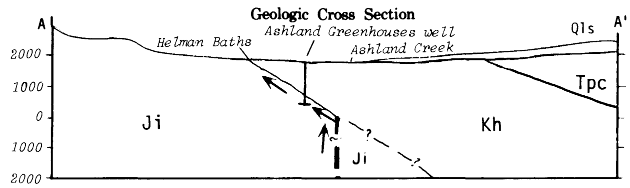

Figure 4. Cross section along line A-A' of Figure 1. Arrows show hypothetical flow of geothermal fluids.

As stated in the introduction, the warm springs in the Ashland area occur on or very close to the mapped contact between the Hornbrook Formation and the underlying Mount Ashland Pluton (Figure 1). It is believed that the positions of the hot springs in the Ashland area are stratigraphically controlled but that the high-temperature geothermal fluids are the result of a forced-convection geothermal system analogous to many known Basin and Range systems.

In a forced-convection system, ground-water recharge in a highland adjacent to a basin penetrates slowly downward to great depths. As the water penetrates downward, it is heated by the natural geothermal gradient. Eventually it reaches a zone of high vertical permeability, such as a fault zone. It then rises rapidly to the surface along the fault zone to emerge at the surface as a spring or series of springs. In effect, the heat is "mined" from beneath the recharge area and is "deposited" in the zone of convective upflow.

In the Ashland area, the geothermal water apparently does not reach the surface along a fault zone. Instead, it appears that as the water moves upward along the postulated fault it encounteres the contact between the Mount Ashland Pluton and the Hornbrook Formation. The water is confined to the contact zone by the impermeable shales of the Hornbrook Formation and is driven up the structural dip by the hydrologic head until it emerges at the surface as a series of warm springs at the contact (Figure 4).

The precise position of the fault zone is unknown, as no surface fault likely to act as a conduit for fluids has been mapped in the area east of the hot-spring line (Figure 1). It must, however, lie between the Ashland Greenhouses well and a "free" well located 3 km (1.8 mi) due east of the Ashland Greenhouses well (Blackwell and others, 1982). This second well is 177 m (581 ft) deep and has a reliable temperature gradient of only 27° C/km. As no warm springs occur in the area east of the Ashland Greenhouses well, it is quite likely that the fault is pre-Hornbrook Formation in age and therefore does not reach the surface.

GEOTHERMAL POTENTIAL

Most of the low-temperature geothermal potential in the Ashland area is confined to the northwestern part of the city. Data from the Rodeo Grounds, SOSC Gym, and Justice Center holes indicate that heat flow is only "background" (50 to 65 mWm^{-2}) in the southeastern area and that fluid temperatures in these areas, even if sufficient fluid volumes could be found, would not much exceed 20° C.

In the northwest part of town, the potential is highest between the existing hot springs and the fault(?) which controls distribution of the fluids. The lateral flow of warm water along the Hornbrook Formation-Mount Ashland Pluton contact makes it possible to find geothermal fluid down the structural dip from the hot-spring line, but the temperature of the water will probably not much exceed the surface temperature of the nearest spring. It is interesting to note that the highest temperature in the Ashland Greenhouses hole was 31.4° C, measured at a depth of 330 m (1,083 ft). The measured surface temperature of Helman Hot Springs, the nearest spring updip from the Greenhouse hole, is 31.5° C (Table 2). In order to encounter fluids at temperatures significantly greater than the temperatures of the springs, drill holes will have to be sited to intersect at depth the faults controlling the distribution of the geothermal fluids. Since neither the precise location nor the dip of the controlling faults is known for certain, the optimum sites for such drill holes are not known. Most probably, however, they lie a short distance east of the Ashland Greenhouse well. In any case, the maximum temperature encountered will not much exceed 100° C and will almost certainly be less.

ACKNOWLEDGMENTS

The authors would like to thank John Fregonese of the City of Ashland Planning Department, Butler Ford, and Darex Industries for their help in obtaining drilling sites. We would also like to thank Jones Well Drilling, the contractor who completed the drilling of the temperature-gradient holes, and John Studebaker of Studebaker Well Drilling, who provided abundant information on local drilling conditions. The project was made possible by funds from the United States Department of Energy (Cooperative Agreement No. DE-FC07-79ID12044).

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Geothermal Resources Council calls for papers for October meeting in Portland

The Geothermal Resources Council will hold its annual meeting October 24-27, 1983, at the Red Lion-Jantzen Beach Hotel in Portland. The three-day meeting will include a technical program consisting of oral and poster presentations, commercial and educational exhibits, photo contest winner display, luncheons, special events, guests' program, and field trips. Special sessions scheduled for the meeting will focus on geothermal resource development in the Cascade Range and on industrial geothermal water heat pumps.

The Council's annual meeting is intended to provide a forum for exchange of new and significant information on all aspects of the development and use of geothermal resources. Papers are solicited in the following areas: exploration (geology, geophysics, and geochemistry), drill technology, reservoir engineering, power generation, direct use, legal/institutional aspects, economics/financing, environmental, and case histories. Papers must be submitted by Friday, June 3, 1983. Authors' packets containing detailed instructions and blue-lined sheets to be used for papers may be obtained from the Geothermal Resources Council, P.O. Box 1350, Davis, CA 95617, phone (916) 758-2360.

The Council is holding its fourth annual photograph contest in conjunction with the annual meeting to recognize artistic merit in recording geothermal development and to augment the Geothermal Resources Council's photo library. For information about the photo contest or any other aspect of the meeting, contact the Geothermal Resources Council at the above address. □

Geothermal exploration in Oregon, 1982

by George R. Priest and Gerald L. Black, Oregon Department of Geology and Mineral Industries

ABSTRACT

The drilling of six shallow wells as part of a low-temperature geothermal resource assessment conducted by the Oregon Department of Geology and Mineral Industries (DOGAMI) in Ashland and the drilling of five 2,000-ft wells by Union Oil of California in the central Cascade Range were the significant geothermal drilling activities in Oregon in 1982. The total area of leased Federal lands increased by 51,916 acres. Most of the geothermal leases relinquished were in areas outside the Cascades, whereas most of the leases newly acquired were in the Cascades, particularly the eastern slope of the High Cascade Range. There appears to be a general shift on the part of developers from eastern Oregon toward the youthful volcanic terrane of the Cascade Range. This comes as a result of both the discovery by the U.S. Geological Survey (USGS) of high-temperature fluids at Newberry Volcano and the measurement of high-temperature gradients in DOGAMI drill holes in the central and northern Cascade Range.

LEVEL OF GEOTHERMAL EXPLORATION

The general level of geothermal exploration activity in Oregon decreased during the last year. This decline is probably the result of numerous factors, but the recent decreases in oil prices have no doubt had a strong impact on both the availability of oil company capital for exploration and the competitiveness of geothermal energy relative to fossil fuels. In addition, in this region there is currently an electrical power surplus, which has kept power prices low. The geothermal picture in Oregon has one very encouraging trend which may portend extensive development of resources capable of electrical generation: As a result of the success of the USGS drilling program at Newberry Volcano and the delineation by the DOGAMI research program of a regional heat-flow anomaly in the Cascades, there is a greater level of activity—both leasing and exploration—in the Oregon Cascade province than in other geothermal provinces of the State. The Newberry 2 drill hole in the summit caldera of Newberry Volcano conclusively proved that substantial temperatures (i.e. 265° C) can be completely masked by shallow ground-water circulation in the young volcanic rocks characteristic of the High Cascade Range (Sammel, 1981; MacLeod and Sammel, 1982). The Newberry well showed that drilling to intermediate depths (2,000 to 3,500 ft) is necessary to explore for geothermal resources in the young volcanic rocks of the High Cascades. As a result, companies such as Union Oil of California have begun to drill intermediate-depth holes into the young High Cascade rocks. In view of the expense of these holes ($100,000 to $300,000 each), this trend reflects substantial confidence on the part of industry in the potential of the High Cascades-Newberry region. This encouraging trend strengthens the hope that large quantities of electrical energy could be generated from Cascade geothermal systems in the near future (see DOGAMI Open-File Report 0-82-7).

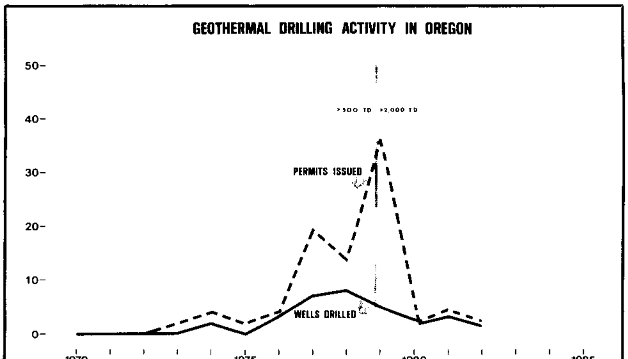

Figure 1. Geothermal well drilling in Oregon. Vertical line indicates time when definition of geothermal well was changed to a depth greater than 2,000 ft.

DRILLING ACTIVITY

In keeping with the general decline in geothermal exploration in 1982, the level of drilling activity was substantially lower than in 1981. No deep wells (greater than 2,000 ft) were drilled, and the number of prospect wells (2,000 ft or less) dropped sharply (Tables 1 and 2).

Table 1. *Permits for geothermal wells (greater than 2,000 ft in depth)*

Permit no.	Operator and well name	Location	Status
85	Sunoco Energy Development Co. Breitenbush 58-28	SE¼ sec. 28 T. 9 S., R. 7 E. Marion County	Abandoned.
86	Union Oil of California Well 47-10	SW¼ sec. 28 T. 19 S., R. 45 E. Malheur County	Suspended.

Table 2. *Permits for geothermal prospect wells (less than 2,000 ft in depth)*

Permit no.	Operator and well name	Location	Issue date and status
91	Renewable Energy, Inc.	Vale Butte, Malheur County	December 1981; drilled one hole to 1,425 ft.
92	Union Oil of California	Western Cascades, Deschutes, Linn, Jefferson, and Klamath Counties	April 1982; drilled five holes to 2,000 ft.
93	DOGAMI	Ashland area, Jackson County	June 1982; drilled six holes to 500 ft.

The only significant drilling activity was in the Ashland, Oregon, area and in the central Cascade Range. Union Oil of California drilled five 2,000-ft wells in the central Cascades. Information on the drillings, including locations, is confidential, however. Utilizing USDOE funds, DOGAMI completed five shallow temperature-gradient wells (depths 325-500 ft) in the Ashland, Oregon, area and a sixth well in the Cascade Mountains east of Ashland. Preliminary results indicate the presence of a low-temperature (30° C) thermal aquifer beneath the northwestern portion of the city. The aquifer appears to occur along the eastward-dipping contact between the Mount Ashland pluton and the overlying Hornbrook Formation.

LEASING

The pattern of geothermal leasing has, like the drilling, shifted toward the Cascade Range. This is reflected in Table 3 by a decrease in U.S. Bureau of Land Managment (USBLM) leases and an increase in U.S. Forest Service (USFS) leases (geothermal resource areas on USFS lands are primarily in the Cascade Range).

In addition to this shift in the pattern of leased Federal lands, there was also an increase in the total acreage of leased lands. The

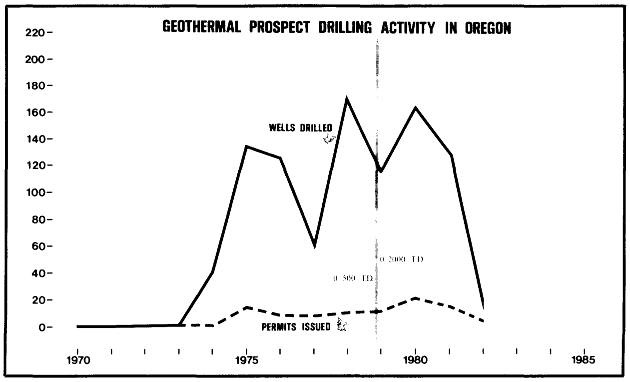

Figure 2. Geothermal prospect-well drilling in Oregon. Vertical line indicates time when definition of prospect well was changed to a depth less than 2,000 ft.

increase in total acreage for 1982 is about the same as in 1981 (51,585 acres in 1981 and 51,916 acres in 1982). This increase was heavily concentrated on the east slope of the High Cascade Range from Green Ridge near Sisters, Oregon, to the Klamath Lake area.

State lands in Klamath and Deschutes Counties will see a particularly sharp rise in total leased acreage in 1983 as a result of this interest in the eastern slope of the High Cascades. 18,369 acres of the 19,649 acres pending on state lands (Table 3) are from this Klamath-Deschutes County area.

The disparity between leasing and drilling activity is probably a reflection of the economy. Whereas developers appear to be optimistic about the geothermal resource potential of the state in general and the Cascade Range in particular, they are not ready to capitalize expensive drilling operations during a period of falling oil prices and electrical energy surpluses. It is clear that, should the utilities offer an economically attractive price for geothermal power, this increasingly large backlog of undrilled leases could result in an explosion of drilling activity.

Table 3. *Geothermal leases in Oregon, 1982*

Types of leases	Numbers	Acres	Relinquished leases Numbers	Relinquished leases Acres
Federal leases (change from 1981)				
Noncompetitive, USBLM	−39	− 50,939	62	85,713
Noncompetitive, USFS	+49	+101,858	13	22,224
KGRA, UŞBLM	− 1	+ 997	No data	No data
KGRA, USFS	0	0	No data	No data
TOTAL	+ 9	+ 51,916	75	107,937
Federal leases pending (total since 1974)				
Noncompetitive, USBLM	11	No new data*		
Noncompetitive, USFS	513	No new data* (est. 1,000,000)		
KGRA, USBLM	No data	No data		
KGRA, USFS	No data	No data		
TOTAL	524			
State (total since 1974)				
Total leases active in 1982	11	7,607		
Total applications pending in 1982	5	19,649		
Private (total since 1974)				
Total leases active (est.)	No data	200,000		

* Last data reported in summary for 1981: *Oregon Geology*, v. 44 (1982), no. 6, p. 67.

KGRA lease sales

Two KGRA lease sales took place in 1982. The first occurred on June 15, 1982, and involved tracts totaling 114,600 acres in the Alvord, Crump Geyser, Klamath Falls, Summer Lake Hot Spring, and Vale Hot Springs KGRA's in Oregon and the Horse Heaven KGRA in Washington. Bids were received on ten tracts totaling 18,718.57 acres in the Alvord, Crump Geyser, Klamath Falls, and Vale Hot Springs KGRA's in Oregon and the Horse Heaven KGRA in Washington. The total bonus was $112,250.06, an average of $6 per acre. The highest bid was $26.05 per acre by Hunt Oil for a tract of 2,605.24 acres in the Alvord KGRA.

The second sale took place on November 16, 1982, and involved two units in the Belknap-Foley Hot Springs KGRA. A total of 4,706.21 acres were involved. Hunt Oil was the only bidder and paid a total bonus of $9,611.23, an average of $2.04 per acre.

Two units totaling 3,658.6 acres in the McCredie Hot Springs KGRA were withdrawn from the November sale due to a lawsuit by the Sierra Club. The suit has since been dropped, and it is assumed that the units will be offered for sale at a later date.

DOGAMI GEOTHERMAL PUBLICATIONS

Several geothermal and geophysical publications were released by DOGAMI in 1982 (Table 4).

Table 4. *DOGAMI geothermal publications, 1982*

Special Papers

14 Geology and geothermal resources of the Mount Hood area, Oregon, ed. by G.R. Priest and B.F. Vogt, 100 p.

Geological Map Series

GMS-20 Map showing geology and geothermal resources of the southern half of the Burns 15′ quadrangle, Oregon, by D.E. Brown, scale 1:24,000.

GMS-21 Map showing geology and geothermal resources of the Vale East 7½′ quadrangle, Oregon, by D.E. Brown, scale 1:24,000.

GMS-26 Residual gravity maps of the northern, central, and southern Cascade Range, Oregon, 121°00′ to 121°30′ W. by 42°00′ to 45°45′ N., by R.W. Couch and others, 3 sheets, scale 1:250,000.

Open-File Reports

0-82-4 Geothermal gradient data (1981), by D.D. Blackwell and others, 430 p.

0-84-5 Oregon low-temperature resource assessment program. Final technical report, by G.R. Priest and others, 53 p.

0-82-7 Geology and geothermal resources of the Cascades, Oregon, ed. by G.R. Priest and B.F. Vogt, 205 p.

0-82-8 Gravity and aeromagnetic maps of the Powell Buttes area, Crook, Deschutes, and Jefferson Counties, Oregon, by Oregon State University Geophysics Group, 4 sheets, scale 1:62,500.

0-82-9 Gravity anomalies in the Cascade Range in Oregon: Structural and thermal implications, by R.W. Couch and others, 66 p.

Released by DOGAMI

Geothermal resources of Oregon, 1982, map by DOGAMI and National Oceanic and Atmospheric Administration, scale 1:500,000.

Articles in Oregon Geology, *v. 44 (1982)*

Thermal springs near Madras, Oregon, by M.S. Ashwill: No. 1, p. 8-9.

An estimate of the geothermal potential of Newberry Volcano, Oregon, by G.L. Black: No. 4, p. 44-46, and no. 5, p. 57.

Newberry Volcano, Oregon: A Cascade Range geothermal prospect, by N.S. MacLeod and E.A. Sammel: No. 11, p. 123-131.

The Open-File Report 0-82-7 was a preliminary version of a Special Paper on the geology and geothermal resources of the central Oregon Cascade Range. The Special Paper will be released in the fall of 1983 and will include a summary of approximately five years of geologic mapping and temperature gradient measurements in the Oregon Cascades. Estimates of the electrical power production potential for the entire province will be included. Publication of this paper will bring to a close the Department's USDOE-funded Cascade geothermal assessment program.

One of the most important products of the Cascade geothermal assessment is a series of gravity and aeromagnetic maps completed by the Oregon State University Geophysics Group (GMS-8, 9, 15, 16, 17, and 26). Gravity data for the entire Oregon Cascade Range are summarized and interpreted in Open-File Report 0-82-8.

The Department's USDOE-sponsored low-temperature geothermal resource assessment project ended in the spring of 1982 with the publication of detailed geologic maps of the Vale quadrangle (GMS-21) and part of the Burns quadrangle (GMS-20) and the completion of a final summary report to USDOE (Open-File Report 0-82-5).

The DOGAMI geothermal group, in cooperation with Andrew Griscom of the USGS and David Blackwell of Southern Methodist University, are preparing a survey of potential geothermal exploration sites at Newberry Volcano under sponsorship of the Bonneville Power Administration (BPA). Preliminary results of a soil-mercury survey completed in 1982 as a part of the Newberry project have been released by DOGAMI under the title *Preliminary Soil-Mercury Survey of Newberry Volcano, Deschutes County, Oregon*.

FUTURE OF THE DOGAMI GEOTHERMAL RESEARCH PROGRAM

The future of the DOGAMI geothermal research program is bleak. The program, since its inception about 15 years ago, has grown to be one of the most active in the United States. A significant portion of the program's support, however, has come from Federal funds. This Federal support for geothermal research (and for other forms of alternative-energy research) has dwindled away. As a result of the loss of Federal support, the ability of the Department to pursue field work and generate new data on the location of geothermal resources in Oregon, using existing contracts, essentially came to an end as of November 1982.

OREGON INSTITUTE OF TECHNOLOGY

The Oregon Institute of Technology (OIT) continues to operate the Geo-Heat Utilization Center to aid geothermal developers. The Center has, however, sharply curtailed its free services, owing to a loss of USDOE support. Their valuable information dissemination service came to a halt in March of 1983, and free consulting to Oregon developers has not been offered since the fall of 1982. They continue to offer consulting services and have aided the cities of Ashland and Klamath Falls on specific contracts. They have also offered some advice and help to the City of La Grande. Aside from time-limited contract work with private developers, such as Wood and Associates in the Lakeview area, this is the extent of their Oregon work. Until additional Federal or State support becomes available, this low level of activity in Oregon will characterize their program.

OREGON DEPARTMENT OF ENERGY

The Renewable Resource Division of the Oregon Department of Energy (ODOE) had two grants with funds for geothermal development during 1982. The first was a USDOE grant of $150,000. This money was earmarked primarily for exploration and, according to David Brown, ODOE's geothermal program manager, has been essentially used up at this time.

The second grant ($750,000) is a BPA grant to the Renewable Resource Division of ODOE and is intended for technical assistance in the development of all forms of alternative energy, including conservation. Of the $750,000, $30,000 is earmarked for geothermal development. With this money, ODOE sponsors OIT, through a letter of agreement, to do district heating studies. Under the terms of this grant, the ODOE geothermal program manager is also allowed to provide some of his time to aid local governments. Most of this aid is in the form of designing exploration programs and overcoming institutional barriers.

Local governments which received aid under the auspices of these grants in 1982 included Malheur, Harney, Deschutes, Lane, Clackamas, Union, Klamath, and Marion Counties, the cities of Vale, Ontario, Nyssa, Little Valley, Burns, Hines, Oakridge, Bend, Klamath Falls, Albany, and Portland, and the Umatilla and Warm Springs Indian Reservations.

ODOE also has available a Small Energy Loan Program (SELP) which provides low-interest loans (up to a maximum of $15 million) for small-scale energy development projects.

USGS—NEW RESULTS FROM NEWBERRY VOLCANO

Although there was no additional field work accomplished in the USGS geothermal program in 1982 because of curtailment of Federal support, the results from their study of Newberry Volcano were published. In 1981, a USGS drill hole encountered a temperature of about 265° C (509° F) at a depth of 3,058 ft in the caldera at Newberry Volcano (Sammel, 1981). The hole produced steam and noncondensible gases from the lower 6.6 ft of the well in a 20-hour flow test (Sammel, 1981). Fluids recovered in this flow test were at first thought to represent injected drilling water (MacLeod and Sammel, 1982), but recent chemical data indicate that they are formation fluids (Sammel, 1983, personal communication).

This discovery well has had a very significant impact on the focus of drilling and leasing activity in Oregon and probably accounts for part of the upsurge in geothermal leasing activity along the eastern side of the High Cascade Range.

Newberry Volcano will probably be the primary focus of exploration for high-temperature geothermal resources in the next several years. The development will be greatly aided by the excellent geologic map for the area recently published by the USGS (MacLeod and others, 1982) and by finalization of the USFS geothermal leasing plan for the Deschutes National Forest.

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MacLeod, N.S., Sherrod, D.R., and Chitwood, L.A., 1982, Geologic map of Newberry Volcano, Deschutes, Klamath, and Lake Counties, Oregon: U.S. Geological Survey Open-File Report 82-847, 27 p., map scale 1:62,500.

Sammel, E.A., 1981, Results of test drilling at Newberry Volcano, Oregon: Geothermal Resources Council Bulletin, v. 10, no. 11, p. 3-8. □

Fireballs sighted in Oregon

Pat Merrill reported a fireball at 9:00 p.m., April 4, 1983, in the Aloha area (lat. 45°27′ N., long. 123°5′30″ W.) going from east to west in the southern sky and descending at an angle of 5°. The duration of the flight was 1.5 seconds. The fireball was one-fifth the size of a full moon and orange-white in color, with a very long white-orange tail. The fireball cast a shadow. No sound was heard, and no breakup was reported.

Cole Gardiner sighted a fireball at 8:58 p.m., April 7, in northeast Portland (lat. 45°37′ N., long. 123°16′30″ W.) going from east to west in the southern sky on a path that was almost parallel to the earth's surface. Duration of the flight was 3.5 seconds; angle of descent was 2°. The fireball was one-third the size of a full moon and blue to blue-white in color, with no tail. No sound, breakup, smoke trail, or shadow accompanied the flight. The fireball dimmed and went out quickly.

John Kellogg sighted the same fireball at 8:58 p.m., April 7, in the Clackamas area (lat. 45°27′ N., long. 123°16′30″ W.) in the southwest sky at about 50° above the horizon. The fireball seemed to hang in the sky for about 1 second. The fireball was about one-eighth the size of a full moon and red-white in color.

These sightings have been reported to the Scientific Event Alert Network, Smithsonian Institution. Anyone with any additional information about these or other meteorite sightings should contact Dick Pugh, Cleveland High School, 3400 SE 26th Ave., Portland, OR 97202, phone (503) 233-6441. □

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VOLUME 45, NUMBER 6 JUNE 1983

THE SALEM METEORITE

Also in this issue:

BLUE MOUNTAINS FIELD TRIP GUIDE—PART I

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COVER PHOTO

The five recovered fragments of the Salem meteorite of May 13, 1981, Oregon's first meteorite to be recovered immediately after it fell. Details of the event are described in article beginning on next page.

OIL AND GAS NEWS

Mist Gas Field

In April, Reichhold Energy Corporation, operator at Mist Gas Field, put two new wells on line. The wells, Paul 34-32 in sec. 32, T. 7 N., R. 5 W., and Columbia County 13-34 in sec. 34, T. 7 N., R. 5 W., were drilled and completed in November and December of last year. Initial tested production was 1,400 Mcf per day and 473 Mcf per day, respectively. The wells were shut in for four months, until a gathering line was completed by Northwest Natural Gas Company.

Reichhold Energy has started its Oregon drilling program for the year. Columbia County 14-33 was drilled and abandoned in sec. 33, T. 7 N., R. 5 W., in April. Total depth was 3,105 ft. Their next drilling will also be in the northwest portion of Mist Gas Field.

Address changes for Mist partners:

Reichhold Energy and Northwest Natural Gas Company, two of the partners at the Mist Gas Field, have both moved to new offices. Effective May 1, 1983, new locations and phones are as follows: Reichhold Energy Corporation, 1410 SW Marlow Ave., Portland, OR 97225, (503) 297-7633; Northwest Natural Gas Company, One Pacific Square, 220 NW Second Ave., Portland, OR 97209, (503) 226-4211.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
235	Diamond Shamrock Watzek Trust 23-4 007-00015	SW¼ sec. 4 T. 6 N., R. 6 W. Clatsop County	Location; 6,000.
236	Diamond Shamrock Watzek Trust 31-4 007-00016	NE¼ sec. 4 T. 6 N., R. 6 W. Clatsop County	Location; 6,000.
237	Reichhold Energy Columbia County 23-22 009-00116	SW¼ sec. 22 T. 6 N., R. 5 W. Columbia County	Application; 5,000.

□

USGS offers new air photos

The U.S. Geological Survey's National Cartographic Information Center—West (NCIC-W) offers photographic coverage of most of Oregon in the new National High Altitude Photography Program. Available are black-and-white and color-infrared photos flown in a north-south direction. There are three black-and-white and five color-infrared exposures per 7½-minute quadrangle, each covering about 130 and 68 square miles, respectively. Paper prints, film positives, and film negatives can be purchased at prices beginning at $5 (9×9 b/w print).

A complete index and detailed information on availability and quality of individual photos can be consulted at the Oregon State Library, State Library Building, Salem, OR 97310. A partial collection is held by the University of Oregon Library in Eugene. □

CONTENTS

The Salem meteorite

by Richard N. Pugh, Science Teacher, Cleveland High School, Portland, Oregon 97202

The fifth meteorite to be found in Oregon fell on a house in Salem on May 13, 1981. The time of the fall was 1:05 a.m., Pacific daylight time (07:05 Greenwich mean time). The location of the fall was lat. 44°58′45″ N., long. 123°58′10″ W. (NW¼NW¼ sec. 8, T. 7 S., R. 2 W., Willamette Meridian, Marion County).

The meteorite struck the house of Marion County Deputy Sheriff James P. Price, who was sitting on the curb in front of his home talking to Deputy Sheriff Vincent Wan, who was in his patrol car. Both officers heard a peculiar fast "fluttering" noise, an impact of something hitting the house, and then the sound of small rocks falling near them. Price examined the area by flashlight and within ten minutes found the first and largest piece of the meteorite in front of his driveway. This specimen, which was warm to the touch, had landed within 10 ft of the officers. Because of his training as a physics major at Linfield College, Price recognized the broken specimen as a meteorite.

The next morning four more pieces of the meteorite were recovered – one on the back side of the garage roof, one in the gutter on the front of the garage, one on the driveway leading to the garage, and one in the street opposite the driveway where the first specimen had been found earlier that morning. The second piece found in the street had been run over by an automobile.

In all, five major pieces and a few very small fragments were recovered. The weights of the five pieces are 22.23 g, 17.65 g, 9.90 g, 8.05 g, and 3.45 g, a total of 61.28 g – just over 2 oz.

Three of the pieces fit together to form about half of the original meteorite. The two remaining pieces fit together but do not fit the first three, indicating that about a third of the meteorite was not recovered.

The original meteorite was in the shape of a flat oval about 6 cm long, 5 cm wide, and about 2.5 cm thick. The fusion crust formed on the leading face of the meteorite as it fell is smooth and about 1 mm thick, while the fusion crust that formed on the trailing side of the meteorite is pitted and measures up to 2.8 mm in thickness. No regmaglypts (indentations resembling thumbprints) were found on the meteorite fragments.

The meteorite interior is concrete gray and shows almost no

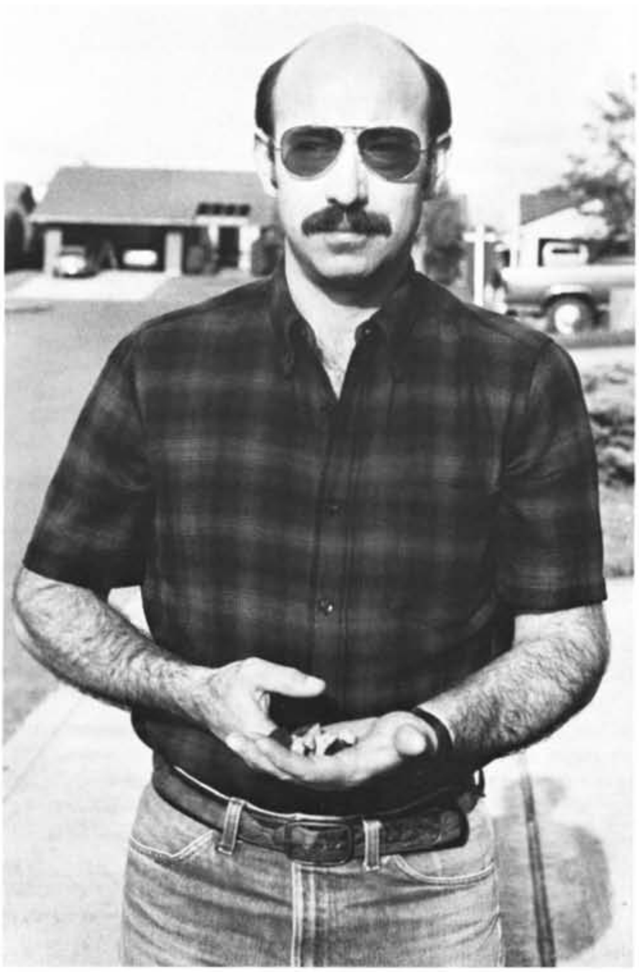
Largest fragment of Salem meteorite, showing fusion crust almost 3 mm thick. This fragment was warm to the touch when it was first picked up.

Five recovered fragments of the Salem meteorite. Note fusion crust.

The James P. Price home, which was hit by the Salem meteorite on May 13, 1981. The meteorite hit the second row of shingles (arrow) from the top of the garage roof directly above the post between the garage doors. The first fragment was found on the street in front of the driveway, another was found in the gutter of the roof, a third was found on the back side of the roof, another in the driveway, and another in the street.

metal. It is only slightly attracted to a magnet.

Price discovered that the meteorite had struck the front center of his garage in the second row of asphalt shingles below the peak of the roof, breaking out a circular piece about 6 cm in diameter in the bottom of one shingle. This indicates that the meteorite came from the southwest at a low angle – barely clearing the peak – before impacting the roof and shattering. Had the meteorite hit the roof at a steeper angle, it probably would have penetrated the roof.

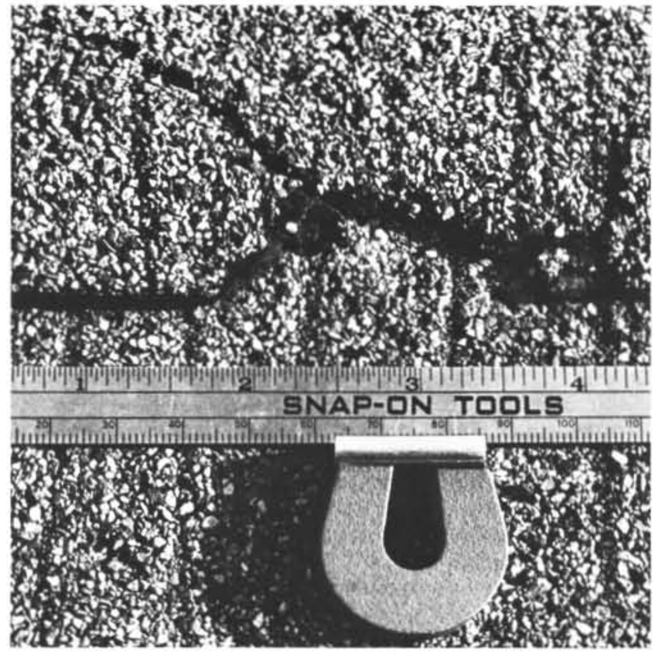


Deputy Sheriff James P. Price holding the Salem meteorite.

No fireball, sonic boom, or electrophonic noises were reported in association with the Salem meteorite fall.

About six weeks after the meteorite fell, Price met Roman Schmitt of the Oregon State University Radiation Center, who suggested that the meteorite be sent to J.C. Evans, Senior Research Scientist, Battelle Pacific Northwest Laboratories in Richland, Washington, for analysis. Using a combination of scanning electron microscopy and energy dispersive X-ray fluorescence, Evans (personal communication, 1982) found the meteorite to be an LL5 chondrite, known also as an amphoterite, a low-iron, low-metal chondrite. The number indicates the petrologic type, with "5" meaning blurred chondrule-matrix boundaries and coarsening of devitrified glass (Todd, 1981). Amphoterites are the rarest type of ordinary chondrites, comprising only 7 percent of all meteorites (Wasson, 1974).

The Salem meteorite is the first meteorite known to fall and then be recovered in Oregon. It also has the distinction of being the first stony meteorite recovered in the state. It is still in the possession of James Price, whose house it hit.



Notch in asphalt shingle where meteorite struck roof.

REFERENCES

Sears, D.W., 1978, Nature and origin of meteorites: New York, Oxford University Press, Monographs on Astronomical Subjects, v. 5, p. 57.

Todd, R.T., 1981, Meteorites: A petrologic-chemical synthesis: New York, Cambridge University Press, p. 23-25.

Wasson, J.T., 1974, Meteorites: Classification and properties: New York, Springer Verlag, p. 20. □

Granite geologic map published

A new geologic map of the Granite quadrangle in Grant County, eastern Oregon, has been released by the Oregon Department of Geology and Mineral Industries (DOGAMI).

Geology and Gold Deposits Map of the Granite Quadrangle, Grant County, Oregon, by H.C. Brooks, M.L. Ferns, and E.D. Mullen, is a multicolor geologic map at a scale of 1:24,000. It shows 17 different bedrock and surficial geologic units, delineates the geologic structure, and locates quartz veins, mines, prospects, and rock sample sites. In addition, the map includes two geologic cross sections, a table listing detailed information on 77 identified mines and prospects, a table showing chemical analyses of 16 rock samples, and a brief discussion of the area's mineral deposits.

Published as Map GMS-25 in DOGAMI's Geological Map Series, the map represents another step in the Department's continuing efforts toward comprehensive geologic coverage of the traditional eastern Oregon gold province. Mainly in cooperation with and supported by funding from the U.S. Forest Service, DOGAMI has so far published geologic maps of the Mineral (GMS-12), Huntington/Olds Ferry (GMS-13), Bourne (GMS-19), Mount Ireland (GMS-22), Bullrun Rock (OFR 0-79-6), and Rastus Mountain (OFR 0-79-7) quadrangles. The mapping will continue with soon-to-be-published maps of the Greenhorn, Bates NE, Bates NW, and Bates SW quadrangles. Together, these maps will cover the old mining districts of Cable Cove, Cracker Creek, Granite, Greenhorn, and Quartzburg and parts of the Rock Creek, Sumpter, Susanville, and Unity mining districts.

The published maps are available at the DOGAMI offices in Portland and Baker. For prices, see the publication list at the end of this issue. Mailed orders under $50 require prepayment. □

Paleozoic and Triassic terranes of the Blue Mountains, northeast Oregon: Discussion and field trip guide*

Part I. A new consideration of old problems

by Ellen D. Mullen, Department of Geology, University of Arkansas, Fayetteville, Arkansas 72701, and Daniel Sarewitz, Department of Geology, Cornell University, Ithaca, New York 14853

INTRODUCTION

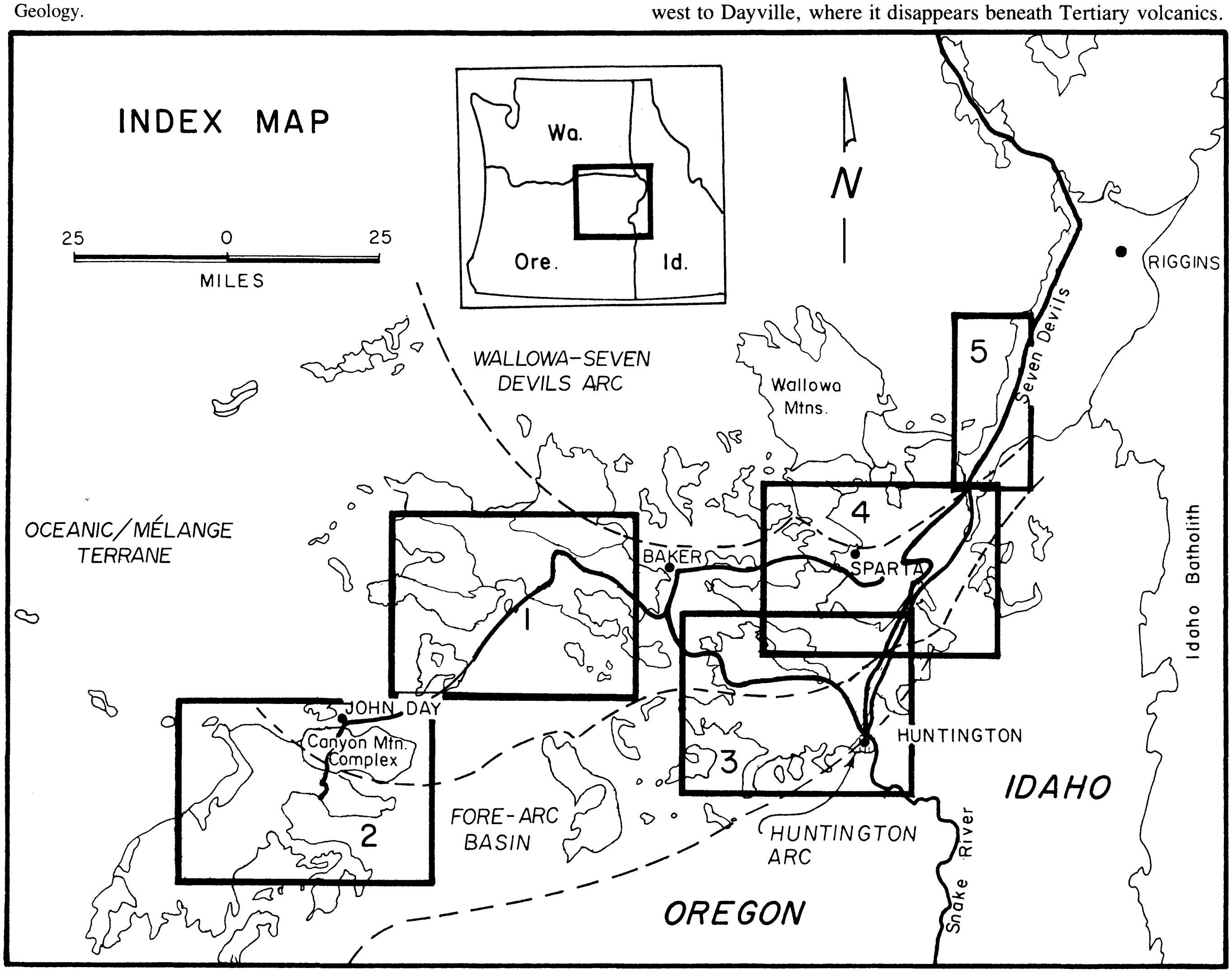
The Blue Mountains of northeast Oregon and western Idaho contain an assemblage of late Paleozoic and Triassic to Jurassic rocks which may represent fragmented oceanic and island-arc crust. These diverse units were probably accreted to the North American Plate during the Late Triassic and Jurassic. Although their origins are not completely understood, these metavolcanic, metasedimentary, and plutonic rocks can be generally described in terms of plate-tectonic environments. (See Brooks, 1979, for a detailed regional discussion.)

* *This is a two-part paper of which only Part I is printed here. Part II, road log and commentary, will be published in the July issue of* Oregon Geology.

Four genetic terranes have been recognized by recent workers (Dickinson and Thayer, 1978; Brooks and Vallier, 1978; Dickinson, 1979). They are (1) the dismembered oceanic crust terrane of Brooks and Vallier (1978) or central mélange terrane of Dickinson and Thayer (1978)—called the oceanic/mélange terrane in the following discussion, (2) the Wallowa-Seven Devils arc, (3) the Huntington arc, and (4) the Triassic to Jurassic forearc terranes. These terranes are shown on the index map.

OCEANIC/MÉLANGE TERRANE

The oceanic/mélange terrane is centrally located and incorporates metasediments and metaigneous rocks mostly of Permian and Triassic age. It extends from western Idaho near the Snake River west to Dayville, where it disappears beneath Tertiary volcanics.



Index map showing terranes of the Blue Mountains as discussed in this paper. Numbered rectangles delineate field trip maps of Part II, to be published in next month's issue of Oregon Geology.

Limited exposures of serpentinite-matrix mélange and pre-Tertiary rocks which may be related occur near Antone and Mitchell. Rare occurrences of limestones southwest of Grizzly Butte near Madras and in Smith Rocks suggest that the terrane may extend far westward toward the Cascades beneath Tertiary cover.

This oceanic/mélange terrane is dominated by fine argillite and chert of the Elkhorn Ridge Argillite which is locally contorted and sheared. Mafic greenstones are interbedded with these sedimentary rocks and form less than 20 percent of the outcrops. Coarser metasediments, including graywacke and fine conglomerates, are included in the Elkhorn Ridge Argillite and are often associated with felsic volcanics. Limestone lenses which vary from less than 3 ft to several hundred feet in length and contain fusulinids and/or conodonts are commonly enclosed within cherts. They seem to retain some stratigraphic coherence with enclosing sediments in the Greenhorn Mountains (Mullen, 1978), on Elkhorn Ridge (Coward, 1982), and near Coyote Butte in south-central Oregon (Wardlaw and others, 1982). Fossils from these limestones were the basis for assigning the Elkhorn Ridge Argillite a Pennsylvanian to Early Triassic age. However, some limestone lenses may be substantially older than the enclosing cherts.

Two fusulinid faunas occur in the limestone blocks—one is Tethyan (Asian), the other is North American. The Tethyan faunas are considered exotic and native to the western Pacific-Tethys region. They have been considered evidence for the origin of these limestones in an area remote from western North America. No mixed Tethyan and North American faunas are known, suggesting that if long-distance transport of limestone with Tethyan fossils did not occur, then at least the fusulinid assemblages developed in effectively separated depositional environments (Nestell, 1980). No apparent difference in conodont assemblages has been recognized between "Tethyan" and "North American" limestones in rare locations where both conodonts and fusulinids occur in the same limestones.

Radiolarians in the Elkhorn Ridge Argillite cherts are pervasively recrystallized. They have yielded Triassic to Early Jurassic dates at two localities: Dog Creek near John Day (Vallier and others, 1977) and Elkhorn Ridge near Sumpter (Coward, 1982).

The Burnt River Schist occurs along the Snake River and westward to Bridgeport and is included in the oceanic terrane. It contains sheared greenstones but is mostly a highly silicic phyllite which is gradational in some locations to cherts and argillites similar to Elkhorn Ridge Argillite. Dates for Burnt River Schist are tenuous. It has been considered contemporaneous with the Elkhorn Ridge Argillite because of lithic similarity. Conodonts collected by Mullen from marble pods along the Burnt River are Triassic (Wardlaw, personal communication, 1980). Poorly preserved conodonts collected by Mullen from the Nelson Marble enclosed in Burnt River Schist near Durkee are Triassic and possibly Early Triassic in age (Wardlaw, personal communication, 1980). These ages suggest that the Burnt River Schist is contemporaneous with or slightly younger than the Elkhorn Ridge Argillite, and the overall record in the limestones and cherts suggests that the oceanic/mélange terrane has a long and possibly continuous depositional history.

Greenstones associated with both the Elkhorn Ridge Argillite and Burnt River Schist are predominantly mafic to intermediate in composition. They are not pervasively spilitized, and many contain relict pyroxene and plagioclase. Pyroxenes have high Ca content and high Al_2O_3/SiO_2 and low TiO_2/SiO_2 ratios, which suggests association with an island arc (Mullen, 1982b). In the Greenhorn Mountains and along the Snake River near Sturgill, pillowed mafic greenstones intercalated with cherts contain relict titanium-rich pyroxene (titanaugite), indicating that the original basalts were alkalic (Mullen, 1979; 1982a). Alkalic basalts are characteristic of seamounts and have also been reported from rift zones and oceanic transform faults. Hence, the greenstones of these two localities may represent accreted seamount volcanics, or they may indicate that extensional tectonics affected the area during Permian or Triassic time.

The leucocratic nature of greenstones, the character of pyroxenes in mafic greenstones, and the detrital nature of sedimentary rocks in the Greenhorn Mountains and elsewhere suggest that the Elkhorn Ridge Argillite and Burnt River Schist may not be only an abyssal assemblage but were in part generated closer to an arc. Coarse Permian sediments previously mapped as Triassic to Jurassic (Brown and Thayer, 1966) occur in the southern Greenhorn Mountains and may extend to the north part of Dixie Butte. These coarse wackes and conglomerates are mixed with cherts and argillites and include interbedded limestones with Early Permian (Wolfcampian to Leonardian) fusulinids and conodonts. The prevalence of large, angular volcanic clasts in these sediments suggests a nearby volcanic source. In the Greenhorn Mountains a boulder conglomerate of very limited extent consists of well-rounded diorite and andesite boulders 2 ft in diameter and may also be derived from an arc. These coarser rocks may represent a tectonically disrupted Permian arc or forearc region (Mullen, 1978). They are not characteristic of pelagic oceanic environments.

Two large, coherent blocks of ultramafic to silicic igneous rocks, the Canyon Mountain Complex and the Sparta complex, have been considered ophiolites (a sequence of rock similar to oceanic crust) and are generally included in the oceanic-mélange terrane. However, both are anomalously silicic for oceanic crust and are probably related to island-arc magmas (Phelps and Avé Lallemant, 1980; Gerlach and others, 1981).

The Canyon Mountain Complex south of John Day is of Permian age (Walker and Mattinson, 1980). It occurs along the southern limit of the oceanic/mélange terrane. The complex includes peridotite (40 percent), layered gabbro (20 percent), and isotropic gabbro (10 percent) which were deformed and altered prior to development of upper-level keratophyre, plagiogranite, diabase, and diorite (30 percent total). Zircon-bearing gabbro of the complex has been dated by U-Pb at 278 m.y. (Walker and Mattinson, 1980); plagiogranites and diorite dated by ^{40}Ar-^{39}Ar are 268 m.y. old (Avé Lallemant and others, 1980). Amphibolite at the western edge of the complex is 258 m.y. old (Avé Lallemant and others, 1980) and is probably related to emplacement. Peridotite of the Canyon Mountain Complex is transitional to mélange on the north and west; Tertiary volcanic rocks and faulting obscure its south and east extensions.

The mineralogy and geochemistry of Canyon Mountain provide conflicting evidence regarding its origin. Major-element chemistry of the Canyon Mountain rocks defines a calc-alkaline trend (Thayer, 1977). However, mineralogical trends of the gabbro and pyroxenites are tholeiitic (Himmelberg and Loney, 1980), and keratophyres and quartz diorites of the complex have a flat, tholeiitic rare-earth-element (REE) pattern (Gerlach and others, 1981) suggestive of ocean-basin or early island-arc rocks. Major-element trends for the leucocratic components suggest the plutonic and volcanic rocks were coeval and from a similar source (Gerlach, 1980). Mineral compositions indicate the harzburgite (peridotite) is refractory material from which gabbros and sheeted dikes were derived (Himmelberg and Loney, 1980). However, field evidence suggests that some gabbros intrude the peridotite, rather than being derived from it. The undeformed keratophyre, plagiogranite, diorite, and diabase were added to the complex after deformation of peridotite and most gabbros. Hence the Canyon Mountain Complex is not a simple, contemporaneous "layer-cake" stack of differentiated magmas.

The Sparta complex near the northern limit of the oceanic/mélange terrane is Triassic, with ages of 218 m.y. according to ^{40}Ar-^{39}Ar (Avé Lallemant and others, 1980) and 219 m.y. based on U-Pb (Walker, 1981). It is more silicic than the Canyon Mountain Complex. Strongly serpentinized ultramafic rocks comprise about

10 percent of the Sparta rocks. Relatively undeformed layered and massive gabbros comprise about half of the complex. They are overlain and intruded by diorite and plagiogranite (Phelps, 1979). Blue-quartz-bearing plutonic plagiogranites grade texturally into hypabyssal and volcanic keratophyre (Brooks, 1979), suggesting simultaneous volcanism and plutonism. The Sparta complex contains rocks with rare-earth element (REE) patterns which indicate a tholeiitic affinity. Increasing light-rare-earth (LREE) enrichment from gabbro through quartz diorite to albite granite and keratophyre suggests a single magma series (Phelps, 1979) that could correlate to the early stages of a Triassic arc.

Much of the oceanic/mélange terrane lacks apparent lithologic coherence and seems to be a truly chaotic mélange. It includes broad zones of serpentinite-matrix mélange, about a mile wide and at least several miles long, generally oriented east-west to northwest-southeast. Clasts within the mélange include all lithologies common to the oceanic terrane plus amphibolites, moderate- to high-pressure schists, and fragments of ophiolite.

The origin and significance of mélanges within the oceanic/mélange terrane are not well understood. Blueschist "knockers" (conspicuous blocks of erosionally resistant rock) near Mitchell dated at 223 m.y. have been linked to a possible Triassic subduction zone (Hotz and others, 1977). Their northeasterly strike is anomalous with regard to the general east-west orientation of most late foliations in the oceanic/mélange terrane.

Other localities of mélange at Mine Ridge, near Hereford, in the Greenhorn Mountains, and near Mount Vernon contain high-pressure schists and amphibolite with minerals characteristic of pressures between 5 and 7 kilobars (Mullen, 1978). These mélanges may represent east-west- or northwest-southeast-trending sutures which bound more competent tectonic slices of arc, forearc, and oceanic terranes (Mullen, 1978, 1980), or they may be discrete, separately generated diapir intrusions. The geometry and relations of mélange localities are difficult to resolve due to extensive Tertiary cover.

WALLOWA-SEVEN DEVILS AND HUNTINGTON ARC TERRANES

A thick (19,000 ft) pile of altered Permian and Triassic volcanic and volcaniclastic rocks is present in the Wallowa Mountains, Snake River Canyon, and Seven Devils Mountains. These rocks constitute the Seven Devils Group and represent the Wallowa-Seven Devils island-arc terrane of Early Permian and Middle to Late Triassic age. Overall, volcaniclastic rocks are more abundant than flow rocks, a feature which is typical of volcanic-arc environments. Flow rocks are generally metamorphosed to lower greenschist facies. They are most commonly intermediate in composition, but metabasalt and silicic volcanic rocks are locally abundant. Trace- and major-element data indicate a calc-alkaline trend for Seven Devils volcanic rocks near Riggins, Idaho (Sarewitz, 1982).

Plutonic rocks which probably represent arc basement occur infrequently in the Seven Devils Group. They include trondjhemite, tonalite, quartz diorite, and gabbro, usually deformed and irregularly distributed within the Snake River Canyon and eastward into Idaho. The ages vary from 256 to 225 m.y., but cluster near 248 m.y. (Walker, 1981). Hence, plutonic remnants of major arc activity in the Seven Devils Group are Triassic.

In the east part of exposures, the Seven Devils Group is unconformably overlain by Middle Triassic platform sediments, including the Hurwal Formation, the equivalent Lucille Formation, and the Martin Bridge Limestone. In the northern Wallowas, limestones are late Carnian to early Norian in age (Nolf, 1966).

Ammonites and brachiopods collected by Mullen (1978) yielded a latest Carnian (Triassic) age for platform limestones in the southeast Wallowas along the Imnaha River. Conodonts found by Sarewitz near the base of the Martin Bridge in western Idaho west of Riggins are early to middle Norian in age.

A belt of deformed greenstones and Triassic plutonic rocks occurs in Hells Canyon near the southern limit of the Wallowa-Seven Devils terrane. This zone, sometimes called the Oxbow-Cuprum shear zone, is about 1,600 ft wide and consists of alternating mylonitic greenstones, keratophyres, and diabases which have undergone multiple flattening deformations (Schmidt, 1980). The dissection and amount of displacement along this zone is uncertain. However, its presence near the southern limits of the Seven Devils Group may be significant.

South of the Seven Devils terrane, along the Snake River near Huntington and eastward to Peck Mountain, Idaho, altered volcanic rocks of the Huntington arc are exposed. These rocks are generally similar in character and age to the Seven Devils Group, although rocks of the Huntington arc are limited to the Upper Triassic. Volcanism in the Seven Devils ended in the late Carnian, whereas Huntington arc volcanic activity continued at least into the middle Norian (Brooks, 1979). Intrusive diorites associated with the Huntington arc have been dated as 210-217 m.y. (Brooks, 1979).

Paleomagnetic data indicate that the Wallowa-Seven Devils and Huntington arcs are part of an exotic block that may have been created far south of its present location (Hillhouse and others, 1982). Jones and others (1977) have correlated the Wallowa-Seven Devils arc with rocks of Wrangellia – an accreted terrane composed largely of Permian and Triassic tholeiitic basalts and cherts overlain by Upper Triassic platform limestones which occur in the Wrangell Range of Alaska, on Vancouver Island, and on the Queen Charlotte Islands, British Columbia. However, the results of paleomagnetic studies are not conclusive. Furthermore, the considerable proportion of intermediate volcaniclastic lithologies and the mature volcanic arc affinity of flow rocks (Sarewitz, 1982) make correlation with the thick tholeiitic basalt section of Wrangellia less than certain. Hence, the Wallowa-Seven Devils arc cannot be treated unequivocally as an exotic orphan.

FOREARC BASIN TERRANE

The last major terrane recognized in this assemblage of oceanic and arc environments is a Triassic to Jurassic forearc basin which extends from the Snake River east to the Aldrich Mountains and covers the contact between the oceanic/mélange and the Huntington arc terranes (Brooks and Vallier, 1978; Dickinson, 1979). It is a monotonous sequence of sandstone and siltstone with minor conglomerate and rare basalts. In the east, the Weatherby Formation of this forearc terrane is juxtaposed with oceanic rocks to the north along the Connor Creek Fault, a high-angle reverse fault which trends southwest-northeast. Westward, from the Unity basin, basalts become increasingly abundant and are often pillowed, and sediments are less metamorphosed and deformed. Forearc sediments contain oceanic and arc-derived clasts and some tectonic slices (Brooks, 1979), which suggests that these rocks were deposited in an environment intermediate to both terranes during uplift and erosion of early arc- and forearc-derived rocks.

SUMMARY

The problems posed by the pre-Tertiary geology of the Blue Mountains include (1) origin of the Elkhorn Ridge Argillite in pelagic or arc environments, (2) allochthonous or in situ development of arc terranes, (3) relations between the Seven Devils and Huntington arcs, and (4) genetic relations of ophiolitic rocks to all major pre-Jurassic terranes. The subduction and/or suture-zone origin of the serpentinite mélanges and the significance of major tectonic features such as the Oxbow-Cuprum zone are key considerations for understanding the emplacement of terranes and regional tectonic history.

Coherent forearc terranes associated with present island arcs such as the Marianas (Karig, 1971; Bloomer, 1981) contain assemblages similar to the rocks found in the "oceanic" terrane, including tectonic slivers of alkalic basalts and cherts from seamounts accreted to the arc, irregularly distributed serpentinite and ultramafics which are tectonically juxtaposed with greenstones, and an assortment of shallow-water limestones. The apparent arc-related nature of the two coherent ophiolites, the widespread occurrence of detrital sediments, and the intermediate to felsic nature of many metavolcanic rocks strongly suggest that the oceanic/mélange terrane may represent a relatively coherent forearc assemblage of Permian to Jurassic age. The time and manner of accretion of these terranes to North America are subjects which require much more thought and investigation before they can be fully resolved.

ACKNOWLEDGMENTS

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NEXT MONTH:
Part II. Road log and commentary.

USGS maps from studies of Oregon Wilderness Areas available

Since 1981, the U.S. Geological Survey (USGS) has been releasing Miscellaneous Field Studies (MF) maps resulting from studies of various Wilderness Areas in Oregon. The maps that are available are listed below:

MF-1240A—*Geologic Map of the Kalmiopsis Wilderness Area, Oregon* (1981), by Page and others
MF-1240B—*Map Showing Distribution of Serpentine Minerals, Density, and Magnetic Susceptibility of Rocks from the Kalmiopsis Wilderness, Southwestern Oregon* (1981), by Barnard and others
MF-1240C—*Geochemical Characteristics of Rock Samples from the Kalmiopsis Wilderness, Southwestern Oregon* (1982), by Carlson and others
MF-1240E—*Mineral Resource Potential, Kalmiopsis Wilderness, Southwestern Oregon* (1982), by Page and others
MF-1303A—*Geologic Map of Deschutes Canyon Further Planning Area, Oregon* (1981), by Walker
MF-1367—*Geology and Mineral Resource Potential, Gearhart Mountain Wilderness and Roadless Area, Oregon* (1982), by Walker and Ridenour
MF-1379A—*Geologic Map of the Mount Hood Wilderness, Oregon* (1982), by Keith and others
MF-1379B—*Geothermal Investigations, Mount Hood Wilderness, Oregon* (1982), by Robison and others
MF-1379C—*Geochemical Map, Mount Hood Wilderness, Oregon* (1982), by Keith and others
MF-1379D—*Aeromagnetic and Bouguer Gravity, Mount Hood Wilderness, Oregon* (1982), by Williams and Keith
MF-1379E—*Mineral and Geothermal Resource Potential of the Mount Hood Wilderness, Oregon* (1982), by Keith and others
MF-1381A—*Geologic Map, Wild Rogue Wilderness, Oregon* (1982), by Gray and others
MF-1381B—*Geochemistry, Wild Rogue Wilderness, Oregon* (1983), by Peterson and Gray
MF-1381C—*Aeromagnetic Map, Wild Rogue Wilderness, Oregon* (1982), by Blakely and Senior.

These maps are available for inspection only in the library of the Portland office of the Oregon Department of Geology and Mineral Industries. They may be purchased by mail from the Western Distribution Branch, USGS, Box 25286, Federal Center, Denver, CO 80225. Price of each of the black-and-white maps is $1.25, including the cost of domestic surface transportation. □

OSU soil study examines unstable landscapes in Coast Range

Clay Mineralogy in Relation to Landscape Instability in the Coast Range of Oregon, by J.D. Istok and M.E. Harward, Department of Soil Science, Oregon State Univeristy, was published in the *Soil Science Society of America Journal*, v. 46, no. 6 (Nov.-Dec. 1982), p. 1326-1331. Because this information may be useful to many readers, we are printing the abstract of the paper below.

ABSTRACT

Field and laboratory data reported in this study indicate that the kind of mass movement and the mineralogy of the materials involved vary with the parent material. The clay fraction of debris avalanches is dominated primarily by nonexpanding layer silicates that have large particle sizes and small water-holding capacities. Dehydrated halloysite, chloritic intergrade, and mica were the common minerals in those areas underlain by sandstones and siltstones of the Tyee Formation as well as the massive basalt flow rock of the Siletz River Volcanic Series. The clay fraction of soils derived from Tertiary sandstones of the Galice and Lookingglass Formations is dominated by chloritic intergrade, chlorite, mica, and kaolinite. Serpentine, chlorite, and mica were the soil clays associated with debris avalanches on serpentinite of the Otter Point Formation. Expandable layer silicates, or those with high charge or water-holding capacity, were not major constituents of debris avalanches, although smectite and vermiculite commonly occurred in a thin layer of soil above the underlying bedrock.

The clay fraction of samples from sites undergoing failure by creep and slump consisted primarily of smectite. Smectite, chloritic intergrade, dehydrated and hydrated halloysite, and mica were the minerals commonly associated with soil creep and slump on slopes underlain by siltstones of the Tyee Formation. Montmorillonite was the major constituent of a large rotational slump at the contact between the Nye Mudstone and the sandstones of the Astoria Formation. Smectite, chlorite, and serpentine were identified in sites underlain by serpentinite of the Otter Point Formation.

The mineralogy of soils involved in earthflow consisted predominantly of hydrated and dehydrated halloysite, amorphous material, and chloritic intergrade. No difference in mineralogy could be detected between sites underlain by siltstones of the Tyee and Nestucca Formations and tuffaceous siltstones and tuff of the Siletz River Volcanic Series. Surface samples were more poorly crystallized than samples taken at lower horizons. Electron micrographs reveal an abundance of amorphous gels and "coatings" on the surface of mineral grains. The abundance of "pores" may account for the fluid behavior of these materials during failure. □

MEETINGS ANNOUNCED

The **Alaska Miners Association** has scheduled its Annual Convention and Trade Show for October 19-22, 1983, at the Hotel Captain Cook in Anchorage, Alaska. For more information, contact Alaska Miners Association, Inc., 509 W. Third Ave., Suite 17, Anchorage, AK 99501, phone (907) 276-0347.

The **Geological Society of the Oregon Country** (GSOC) holds noon meetings in the Standard Plaza Building, 1100 SW Sixth Ave., Portland, OR, in Room A adjacent to the third-floor cafeteria. Upcoming meetings, topics, and speakers:

June 17—*Sketches and Slides of Oregon Wildflowers*, by Julie Kierstead, taxonomic botanist and artist for Berry Botanic Garden.

July 1—*Annual President's Campout at Mount St. Helens*, by Clair F. Stahl, 1983 GSOC President.

July 15—*Description and Locations of Field Trips on President's Campout at Mount St. Helens*, by Clair F. Stahl, 1983 GSOC President.

August 5—*Jaunting Around the Emerald Isle*, by Hazel Newhouse, retired geographer.

For additional information, contact Viola L. Oberson, Luncheon Program Chairwoman, phone (503) 282-3685. □

Send us your announcements

One of our Medford readers has suggested that *Oregon Geology* serve as a clearing house for announcements on geological training sessions, workshops, or seminars for the professional geologist.

We think that is a good idea. So if you send us notices of your meetings and training sessions, we will print them in *Oregon Geology*, space permitting. Allow at least a month and a half—and preferably two months—lead time. □

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.

STRUCTURE OF THE OXBOW AREA, OREGON AND IDAHO, by William J. Schmidt (M.A., Rice University, 1980)

The northeasterly-trending Oxbow-Cuprum shear zone is a zone of intense deformation up to 1 km wide and 8 km long located in northeastern Oregon and western Idaho. The Oxbow-Cuprum shear zone is composed primarily of metamorphosed igneous rocks (quartz diorite, gabbro, diabase, and quartz keratophyre) and their mylonized equivalents.

The rocks of the Oxbow area have experienced four periods of deformation. The first deformational event (F_{1a}) resulted in the formation of a foliation (S_{1a}) and lineation (L_{1a}). S_{1a} strikes northeast and dips steeply. L_{1a} trends northeast and is subhorizontal. Strain associated with this event is irrotational. The effects of the second deformational event (F_{1b}) are not as widespread as those associated with F_{1a}. F_{1b} structures include a subhorizontal northeast-trending intersection lineation (L_{1b}), isoclinal folds, and steep northeast-striking axial plane cleavage (S_{1b}). Strain associated with this event is rotational. During the last two deformational events (F_2 and F_3), S_1-planes were folded into open, asymmetric mesocopic and megascopic folds. Fold axes (L_2) for F_2 plunge at variable angles to the southwest. F_2 axial planes (S_2) have a shallow to moderate dip and northwesterly strike. F_3 fold axes have a moderate to steep plunge. Axial planes (S_3) for F_3 trend either north-south or east-west, dipping steeply.

F_{1a} and F_{1b} are probably the result of northwest-southeast crustal shortening. The ductile nature of F_{1a} and F_{1b}, along with the similar orientation of S_{1a} and S_{1b}, implies that these two events are related to a Triassic metamorphic event which has been dated at 220 m.y. ($^{39}Ar/^{40}Ar$ age determination). F_2 and F_3 appear to be the result of northeast-southwest crustal shortening. These two events may be related to this Triassic event or to some other deformation event (or events) which occurred prior to the Cretaceous.

Paleontological, sedimentological, and structural data indicate that the Seven Devils terrane and portions of the Central Mélange terrane were accreted to the continental margin during the Late Jurassic. The Triassic event is related to crustal shortening which occurred at some distance from the North American continent. The igneous rocks associated with the Oxbow-Cuprum shear zone (i.e. the Oxbow complex) probably represent a portion of the substructure on which the Seven Devils Group was deposited. □

STRATIGRAPHY, LITHOFACIES, AND DEPOSITIONAL ENVIRONMENT OF THE COWLITZ FORMATION, TPS. 4 AND 5 N., R. 5 W., NORTHWEST OREGON, by Dale M. Timmons (M.S., Portland State University, 1981)

The Cowlitz Formation in southern Columbia and Clatsop Counties, northwest Oregon, was studied in order to prepare a geologic map of parts of this formation and to determine the character of its lithofacies and the environments of deposition.

Extensive field and laboratory studies show the sediments of the upper Cowlitz Formation were deposited near shore in a wave-dominated environment in the Narizian. Abundance of carbonized organic remains, boulder conglomerates, and rounded volcanic sandstones exhibiting high-angle planar cross-bedding associated with the Goble Volcanics, morphology and mode of occurrence of trace fossils, especially *Thalassonides*, and presence of thick-shelled pelecypods all indicate energetic, nearshore, shallow-water deposition. Small-scale channeling and discontinuous strata suggest wave-dominated conditions with storm surge deposits. Lack of clay in some sandstones and paleontologic interpretations by other workers verify an open marine environment.

Parts of the Goble Volcanics in the area of study including Green Mountain and Rocky Point were volcanic islands in the late Eocene. Major-oxide chemistry suggests they were erupted in an orogenic (magmatic arc) environment while the Cowlitz Formation was deposited in the associated fore-arc basin.

Volcaniclastic rocks created by autobrecciation and marine fossils within these rocks show the Goble Volcanics are in part subaqueous. The presence of laterites also indicates subaerial eruption of the Goble Volcanics. High-energy conglomerate and volcanic sandstone deposits aproning the volcanic centers further exemplify shallow-water conditions. Overlying subaerial lava flows show that a shoreline is represented by the volcaniclastic and conglomerate member of the Cowlitz Formation.

K-Ar dates ranging from 32.0 ± 0.3 m.y. to 45.0 ± 1.4 m.y., occurrences of Goble-like rocks with Keasey-age rocks, and highly variable geochemistry show the Goble Volcanics occupy a long geologic time span and should be subdivided. □

STRATIGRAPHY, STRUCTURE, AND PETROLOGY OF THE LOOKINGGLASS AND ROSEBURG FORMATIONS, AGNESS-ILLAHE AREA, SOUTHWESTERN OREGON, by Raisuddin Ahmad (M.S., University of Oregon, 1981)

The early-middle Eocene Roseburg and Lookingglas Formations, named by Baldwin (1974) for exposures near Roseburg, Oregon, are also present in the Agness-Illahe area, southwestern Oregon. Only the upper part of the Roseburg Formation is exposed in this area, where it is composed principally of lithic sandstones and siltstones. The basal Bushnell Rock Member and the middle Tenmile Member of the Lookingglass Formation crop out in the Agness-Illahe area, but the Olalla Creek Member is absent. The Bushnell Rock Member is composed of two lower units of petromict conglomerate overlain by lithic sandstones and siltstones. The Tenmile Member is composed entirely of lithic sandstones, siltstones, and minor shale.

Petrographic study of the formations indicates that the Roseburg and Lookingglass sandstones and siltstones were derived from a mixed provenance of Klamath Mountain mélange terrane and Cascade Mountain volcanic arc, and the Bushnell Rock conglomerates were derived largely from the Klamath Mountains.

Petrographic data together with some regional paleotectonic information provided by previous workers suggest that the Roseburg and Lookingglass sandstones and siltstones were deposited by turbidity currents in forearc basins. Based on descriptive physical and biological features and the overall stratigraphic context, two depositional models are indicated for the Bushnell Rock conglomerates: a fluvio-neritic model for the lower unit, and a trench-slope model for the upper unit.

REFERENCE CITED

Baldwin, E.M., 1974, Eocene stratigraphy of southwestern Oregon: Oregon Department of Geology and Mineral Industries Bulletin 83, 40 p. □

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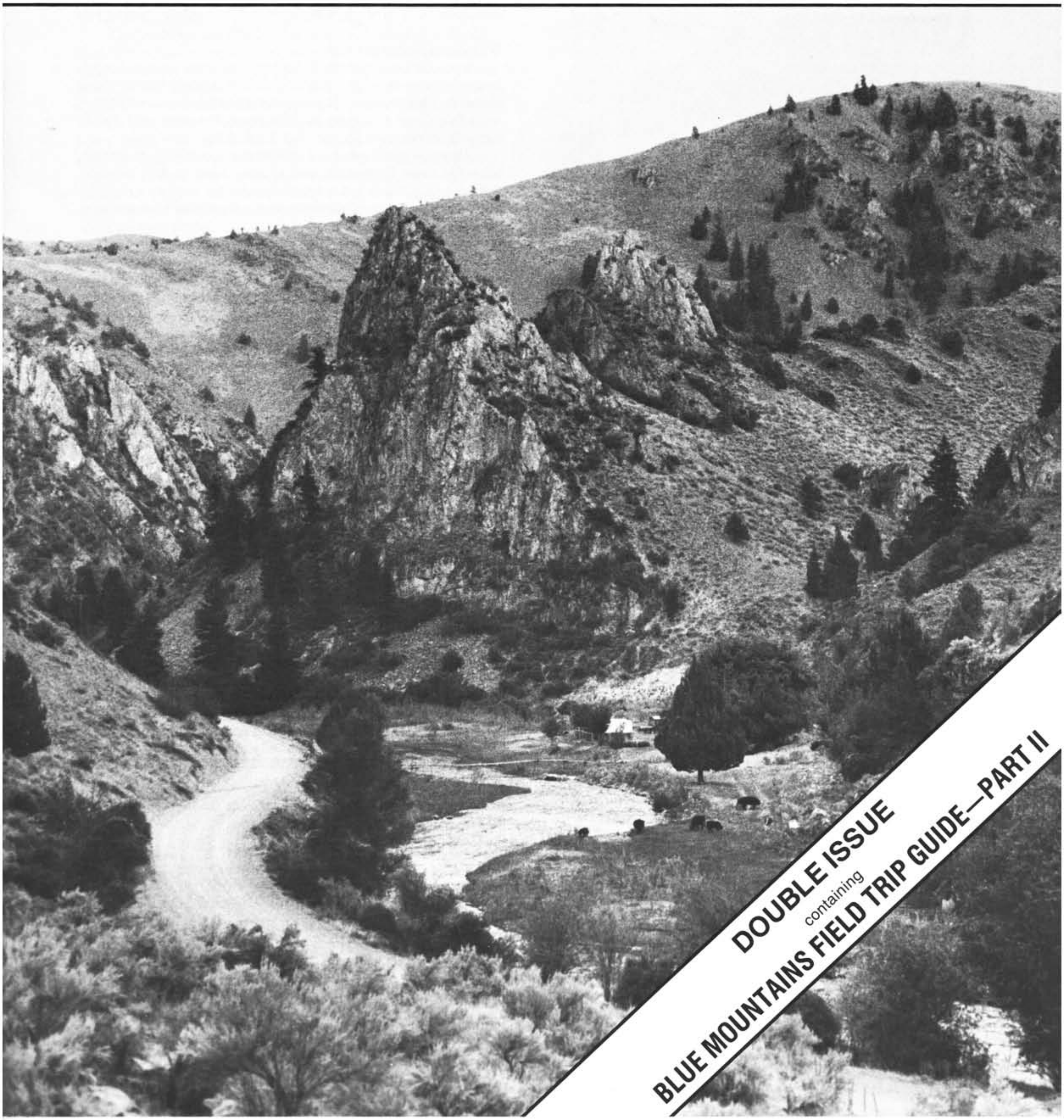

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COVER PHOTO

Burnt River Canyon, southeast Baker County, exposing Triassic limestone pods in Burnt River Schist phyllite. Field trip guide leading through this area begins on page 75.

OIL AND GAS NEWS

Clatsop County

Diamond Shamrock has drilled Clatsop County 33-11 in sec. 11, T. 6 N., R. 6 W. The well was spudded May 22, drilled to a total depth of 4,223 ft, and abandoned as a dry hole on June 4. The company still has permits to drill three more wells in Clatsop County, and the next location to be drilled may be one of the two sites in sec. 4, T. 6 N., R. 6 W.

Willamette Valley permits

Renewed interest in the Willamette Valley has appeared in the form of several new applications to drill. Reichhold Energy has a permit for a location near St. Louis in Marion County, to offset two wells drilled by the company in recent years. The proposed 3,500-ft well will be located in sec. 21, T. 5 S., R. 2 W.

Two new operations have also obtained permits to drill (table below). Leavitt Exploration and Drilling plans to drill Maurice Brooks 1 to 3,000 ft in Lane County near the town of Creswell. Little drilling has been done in this area; only two wells exist within ten miles.

Elswhere in the valley, Petroleum and Mineral Analysis plans to drill Keech 1 to 3,600 ft southeast of Turner in Marion County. Several wells in the area have had gas shows, and the American Quasar Hickey 9-12 to the south produced gas for several months during 1981.

Correction of Mist gas production figures

In the May issue we published production figures for the Mist Gas Field. We have discovered reporting errors which make the published numbers incorrect. Correct figures are as follows:

Year	Cumulative production at year's end (Mcf)
1979	1,516
1980	4,933,546
1981	9,868,991
1982	13,268,148

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
238	Leavitt Exploration Maurice Brooks 1 039-00005	NE¼ sec. 34 T. 19 S., R. 3 W. Lane County	Location; 3,000
239	Petrol. & Min. Analysis Keech 1 047-00015	NE¼ sec. 15 T. 9 S., R. 2 W. Marion County	Location; 3,600

□

CONTENTS

Paleozoic and Triassic terranes of the Blue Mountains, northeast Oregon: Discussion and field trip guide*

Part II. Road log and commentary

by Ellen D. Mullen, Department of Geology, University of Arkansas, Fayetteville, Arkansas 72701

INTRODUCTION

The field trips described in this road log are three separate day-long loops through northeast and eastern Oregon. Each focuses on a separate terrane and associated problems. Loop A (Maps 1, 1A, and 2), from Baker to John Day via the Greenhorn Mountains, examines Paleozoic oceanic and ophiolitic rocks. Loop B (Maps 3 and 4), from Baker to Huntington and then north along the Snake River, deals with relations between oceanic terrane, Huntington arc, and Jurassic flysch (Flysch: An extensive marine sedimentary sequence of shale, marl, and graywacke resulting from rapid erosion of an adjacent rising land mass). It also examines the gradational contact between Burnt River Schist and Elkhorn Ridge Argillite north of the Connor Creek Fault. Loop C (Maps 4 and 5) begins at Oxbow Dam, tours the Seven Devils arc in the Snake River Canyon, and returns to Baker via the Oxbow-Cuprum shear zone and the Sparta ophiolite.

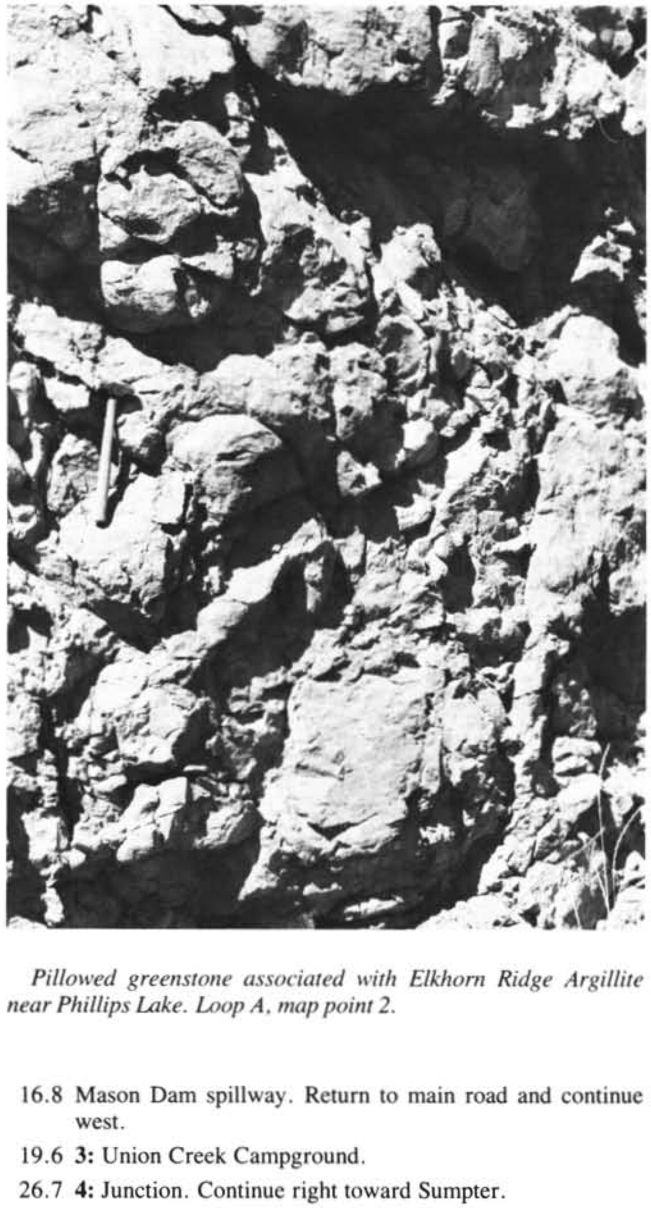
Most outcrops are easily located and adjacent to the road. A few important exposures are not included in the guide due to their relative inaccessibility. However, the outcrops examined in this field guide are a representative introduction to the complex Paleozoic and Triassic geology of northeast Oregon.

This field trip road log was developed to be used as part of an Oregon State University graduate course in tectonics of the Western Cordillera. H.C. Brooks led Loop B, and the writer is indebted to him, to T.L. Vallier, and to W.H. Taubeneck for locating and describing many of the outcrops included here.

CAUTION: SOME OF THE ROADS IN THIS GUIDE ARE SUITABLE FOR FOUR-WHEEL-DRIVE VEHICLES ONLY AND MAY BE VIRTUALLY IMPASSABLE AT SOME TIMES OF THE YEAR. BE SURE AND CHECK WITH LOCAL AUTHORITIES BEFORE ATTEMPTING ROADS OFF THE MAIN HIGHWAYS. ADDITIONAL INFORMATION IS ALSO AVAILABLE FROM THE BAKER FIELD OFFICE OF THE OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES.

Loop A, Baker to John Day. Permian oceanic terrane, disrupted ophiolites of the Greenhorn Mountains, and the coherent Canyon Mountain Complex (Maps 1, 1A, and 2).

Total miles	Map point number (**bold**) and comments
0	**Begin road log** at Baker Post Office. Go south on Oregon Highway 7.
9.0	Junction. Turn right toward Sumpter. **Begin using Map 1.**
14.7	**1:** Volcanic greenstone breccia and porphyritic greenstone intruded by fine diabase. Jurassic hornblende diorite dikes are also present.
16.4	**2:** Turn left on Black Mountain Road. Pillowed greenstones, thoroughly altered to chlorite and epidote.
16.8	Mason Dam spillway. Return to main road and continue west.
19.6	**3:** Union Creek Campground.
26.7	**4:** Junction. Continue right toward Sumpter.
29.6	Sumpter Post Office.
32.5	**5:** Begin USFS Road 73. Elkhorn Ridge Argillite outcrops are numerous in roadcuts for the next 6 mi to Granite Summit. In this area, the unit is quite argillitic and pervasively sheared.
41.9	**6:** Elkhorn Ridge Argillite ribbon chert. Beds of chert 1-4 in. thick, highly contorted, with recrystallized radiolarians.
46.3	**7:** Granite, Oregon. Turn south (left) onto USFS Road 10.
49.7	**8:** Junction to Greenhorn. Continue left on USFS Road 13. Red Boy Mine southwest of junction.



Pillowed greenstone associated with Elkhorn Ridge Argillite near Phillips Lake. Loop A, map point 2.

*For the first part of this paper, see last month's issue of Oregon Geology, v. 45, no. 6, p. 65-68.

50.3 **9:** Silicic sediments and cherts, pervasively sheared. Elkhorn Ridge Argillite dominates outcrops in this area. Volcanic breccias and volcaniclastics are rare in outcrop. **For map points 10 through 20 use detailed map 1A.**

55.1 **10:** Disharmonic folding in Elkhorn Ridge Argillite. Radiolarians present but recrystallized.

55.5 **11:** McWillis Gulch. Volcanic breccias on the north, stretched-pebble conglomerate with mafic volcanic and chert clasts on the southeast. Ribbon cherts occur on the hill above and east of the road here, and east-west shear zone (dextral?) is present along McWillis Creek.

56.0 **12:** Begin alkalic pillowed greenstones, alternating and intercalated with cherts and argillites. Relict titanaugite is present in rocks where pyroxenes are not completely obliterated by spilitization. Greenstones are exposed in roadcuts for approximately 1 mi.

56.4 **13:** Tone Spring. Contact with Jurassic tonalite. Good exposure of pillowed greenstone. Pillows are apparent in large blocks of rock to west of road and in roadcut. Contact metamorphism produced garnet and scapolite in these greenstones.

56.7 Junction. Turn right on USFS Road 1042.

57.5 **14:** Metagabbro. Amount of deformation varies. Both leucocratic and melanocratic phases of the gabbro are present. This is a clinopyroxene cumulate gabbro, metamorphosed to greenschist facies.

58.6 **15:** Junction. Turn right toward the Bi-Metallic Mine.

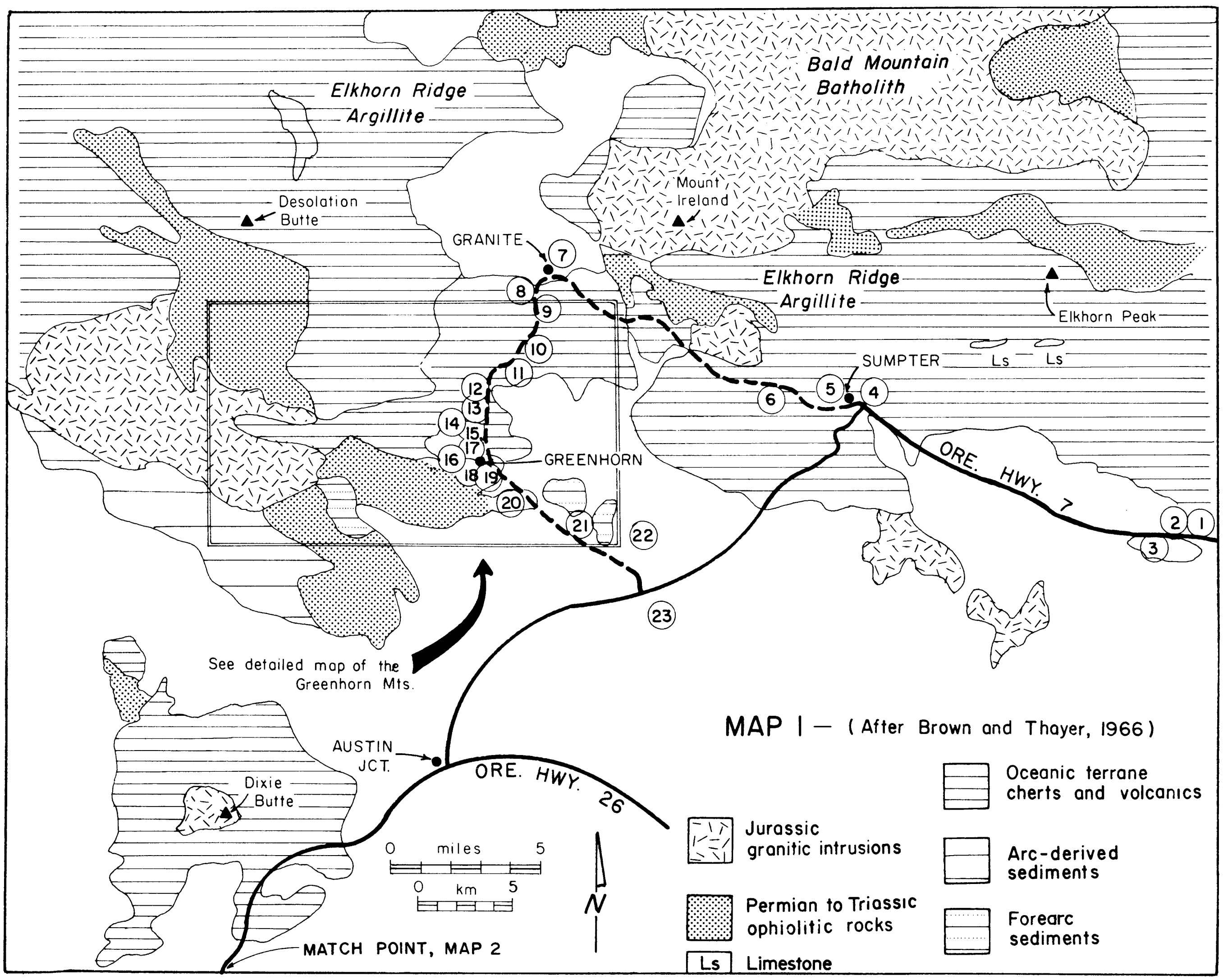
60.0 Left, right, then right on logging roads. The area was a famous high-grade gold district in the early 1900's and contains many mines and prospects, including the IXL and Humboldt Mines.

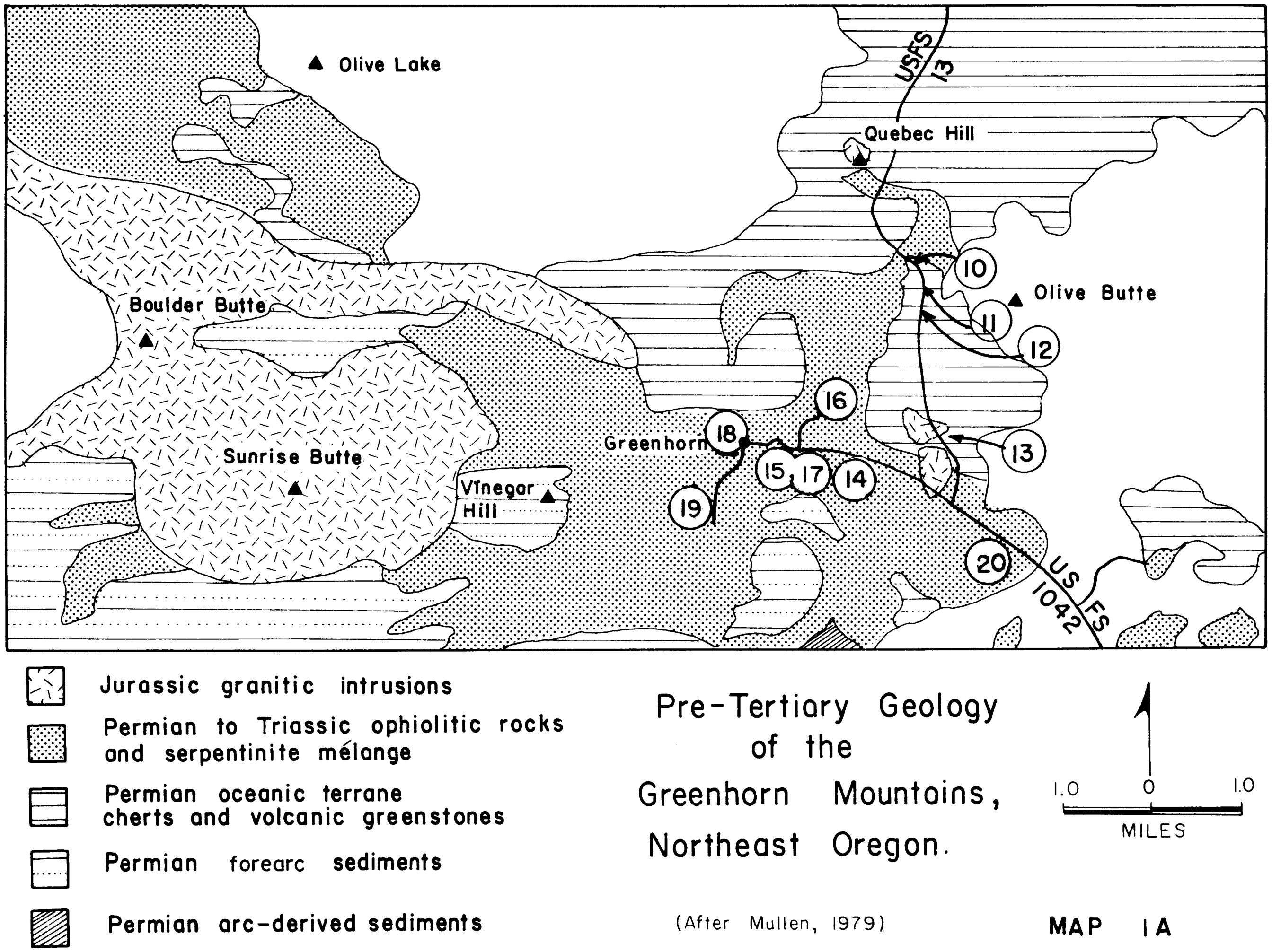
60.4 **16:** Cabin and mine, Irish Gulch. Mine tunnel exposes uniformly bedded ribbon cherts of the Elkhorn Ridge Argillite just east of the contact with sheared serpentinite. The serpentinite at this locality developed from a layered ultramafic body which grades into gabbros westward. Unsheared layered ultramafics and gabbros with cumulate textures and lack of tectonite fabric are exposed on the hill northwest of the cabin. Pyroxenite "knockers" (conspicuous blocks of erosionally resistant rocks) and rodingite dikes occur in the sheared matrix near the mine. Turn around and retrace path to USFS Road 1042.

61.3 **17:** Junction with USFS Road 1042. Turn west (right) toward Greenhorn.

61.6 **18:** Town of Greenhorn (elev. 6,271 ft). Nearly 700 people lived here in the early 1900's. Take USFS Road 1035 south (left).

61.9 **19:** Small clearing with low outcrops and "float" of Upper





Pre-Tertiary Geology of the Greenhorn Mountains, Northeast Oregon.

(After Mullen, 1979) MAP 1A

Triassic conglomerate. This conglomerate contains angular to subrounded clasts of tectonite gabbro, greenstone, chert, and (rarely) schists. It probably resulted from uplift and erosion during obduction and emplacement of ophiolites. Exposure is very limited. Similar conglomerates occur elsewhere in the oceanic and mélange terranes of northeast Oregon. Turn around here and retrace path on 1035 and 1042.

65.7 Junction with USFS Road 13. Continue southward (straight) on 1042.

66.9 **20:** Serpentinite matrix mélange with knockers of varied size and lithology. Gabbro, greenstone, and cherts are common.

68.4 **21 (Map 1):** North fork of the Burnt River. Follow the river on foot upstream about 300 ft to a large exposure of pumpellyite-bearing greenstone and volcaniclastics in mélange.

71.8 **22:** Turn north (left) onto USFS Road 1046. Turn right at all intersections, and right (east) on to Road 060 at mi 72.0. On Road 060, roadcuts expose conglomerates and volcaniclastics of the arc terrane. A large limestone pod of Permian (Wolfcampian) age is located about 450 ft northwest of the junction of Roads 1046 and 060. Follow Road 060 east to mi 73.8. The high-pressure schists in the Greenhorns are exposed in old logging-road cuts in Bennett Creek about 0.10 mi south of mi 73.8 and may be found by following an old logging road south on foot from this location. Return to Road 1042.

77.8 **23:** Junction with main John Day-Sumpter road. Turn south (right) toward John Day. **Begin using Map 2.**

105.2 **24:** Prairie City Post Office. Continue on U.S. Highway 26 to John Day and turn south on U.S. 395.

137.8 **25:** Canyon City Post Office.

138.3 **26:** Amphibolite in roadcut on left. Gradational into gabbros eastward.

138.4 **27:** Serpentinite.

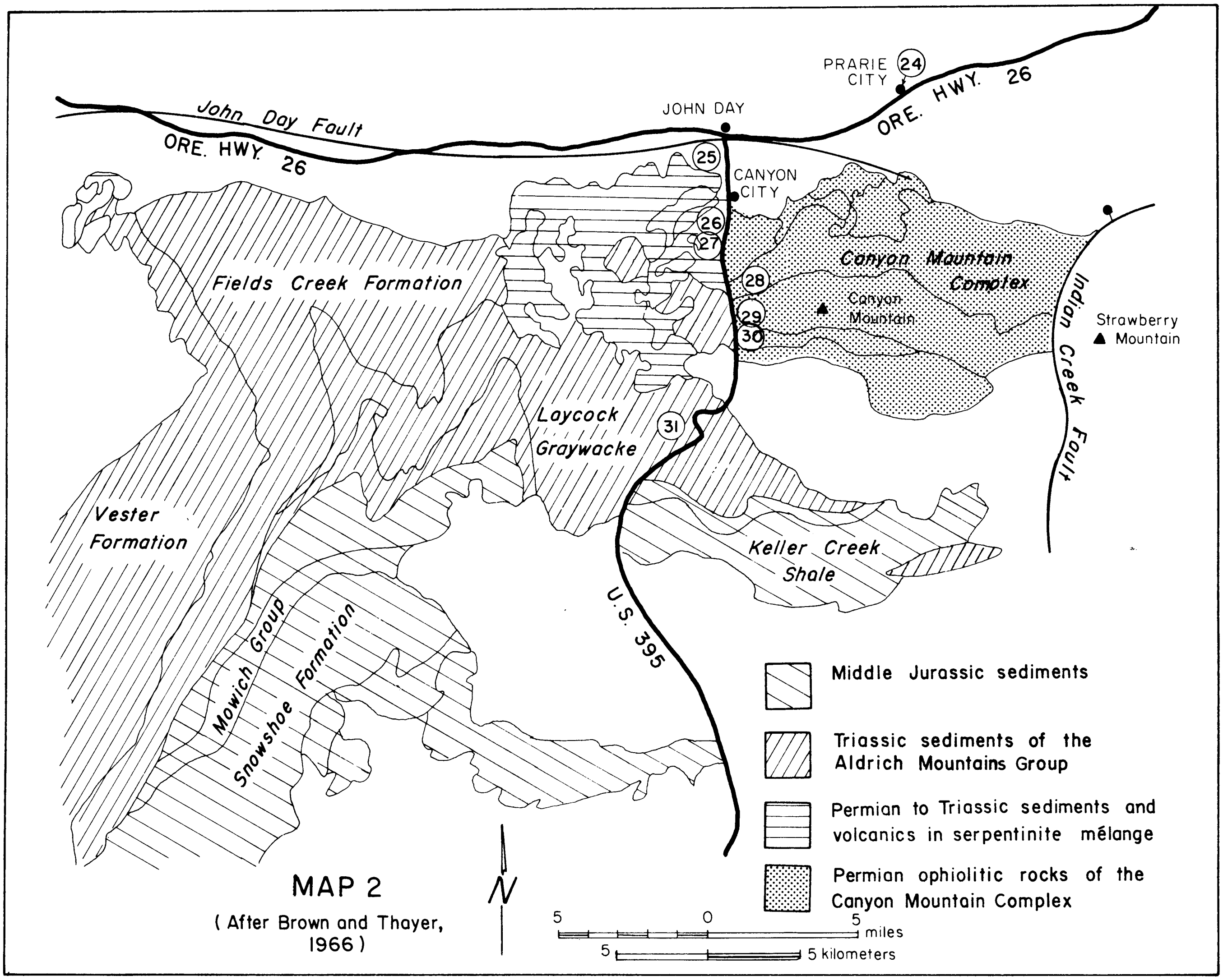
139.8 **28:** Gabbro of Little Canyon Mountain. Considered either a gabbro separate from Canyon Mountain Complex or part of the main gabbro of the complex which has been folded into place.

140.3 **29:** Fine mafic gabbros and very late diabase dikes which have chilled margins. Brecciation parallel to the dikes is apparent. A sulfide-bearing quartz diorite intrudes the Canyon Mountain gabbro here.

141.6 **30:** Serpentinite and serpentinized pyroxenite.

146.0 **31:** Jurassic "flysch" of Aldrich Mountain Group. Laycocke Graywacke is exposed in roadcut along this grade.

End of Loop A. Either return to Baker or pick up Loop B by returning to John Day, taking U.S. 26 east toward Unity and turning left (north) 2 mi west of Unity onto Hereford-Bridgeport Road. Begin at map point 36 (**Map 3**), junction of Bridgeport Road with Oregon Highway 245.



Loop B, Baker-Durkee-Richland. Elkhorn Ridge Argillite, Burnt River Schist, and Huntington arc terrane (Maps 3 and 4).

Total miles	Map point number (**bold**) and comments
0	**Begin road log** at Baker Post Office. Drive south on Oregon Highway 7.
9.0	**32 (off map):** Junction. Continue south (left) on Oregon Highway 245 toward Unity. **Begin using Map 3.**
16.8	**33:** Dooley Mountain Summit.
18.0	**34:** Coarse tuff breccia of the Dooley Mountain Rhyolite, Oligocene in age.
21.4	**35:** Perlite and flow-banded rhyolite, Dooley Mountain Rhyolite.
24.6	**36:** Junction. Turn left toward Durkee.
29.9	Junction. Turn north (left) onto Burnt River Canyon Road.
32.5	**37:** Greenstones associated with the Burnt River Schist. Pervasively sheared. Greenschist metamorphism.
32.6	**38:** Keratophyre. Less sheared than rocks at previous stop.
33.2	**39:** Limestone. Highly recrystallized and silicified dolomitic limestones. Large, isolated, allochthonous pods of carbonate occur in siliceous "matrix."
34.3	**40:** Burnt River Schist. Pelitic phyllite in low greenschist facies.
36.0	**41:** Recrystallized limestone – large pods enclosed in phyllite and keratophyre. Stretched-pebble conglomerate with clasts of chert, volcanic rock, and rare granite occur sporadically to north of limestone exposures.
36.5	**42:** Bedded, dolomitic, silicic limestone; rhythmic beds 2-6 in. thick give a chertlike appearance. Fossil hash occurs in some beds. Conodonts are probably Early Triassic.
38.3	**43:** Burnt River Schist. Two deformations can be seen.
42.9	**44:** "Burnt River Pluton." Quartz diorite deformed and metamorphosed to greenschist facies. Probably Lower Triassic.
49.5	**45:** Junction with Oregon Highway 30. Turn south (right) through Durkee.
55.1	**46:** Nelson Marble in large roadcut at junction with Interstate Highway I-84. Age of this highly deformed and recrystallized marble is probably Early Triassic according to poorly preserved conodonts. Continue south on I-84.
60.0	**47:** I-84 rest area.
60.4	**48:** Connor Creek Fault exposed in east roadcut on I-84. This fault is a high-angle reverse fault which juxtaposes

Jurassic flysch of the Weatherby Formation against the Permian to Triassic Burnt River Schist.

61.7 Cross Burnt River.

67.7 **49:** Weatherby Formation. Limestone enclosed in Jurassic flysch is exposed in a large quarry easily visible from I-84.

70.0 **50:** Exit 345. Take U.S. Highway 395 to Huntington. Distinctive red and green unit exposed in roadcut on west side of exit is a basal conglomerate of the Jurassic flysch.

73.0 **51:** Huntington Post Office. Turn left past post office onto Snake River Road and proceed across Burnt River.

74.3 **52:** Huntington Formation. Triassic volcanic and volcaniclastic rocks of the Huntington arc. No Permian rocks are known to occur in the Huntington arc assemblage. Triassic flows and breccias with some intercalated sediments are exposed in roadcuts for the next 7 mi.

75.5 **53:** Huntington Formation. Keratophyre, volcanic breccia, and pebble conglomerate which contains siliceous sediments and mafic volcanic clasts.

76.5 **54:** Spring Creek Recreation Site (camping).

78.1 **55:** Coarsely crystalline quartz diorite associated with the Huntington arc. Deformed and metamorphosed to greenschist assemblage.

81.9 **56:** Huntington arc sedimentary breccias and conglomerates which contain angular clasts of volcanics in a silty matrix. Siltstones and sandstones occur also.

82.9 **57:** Red and green basal conglomerate of Jurassic flysch; poorly exposed here.

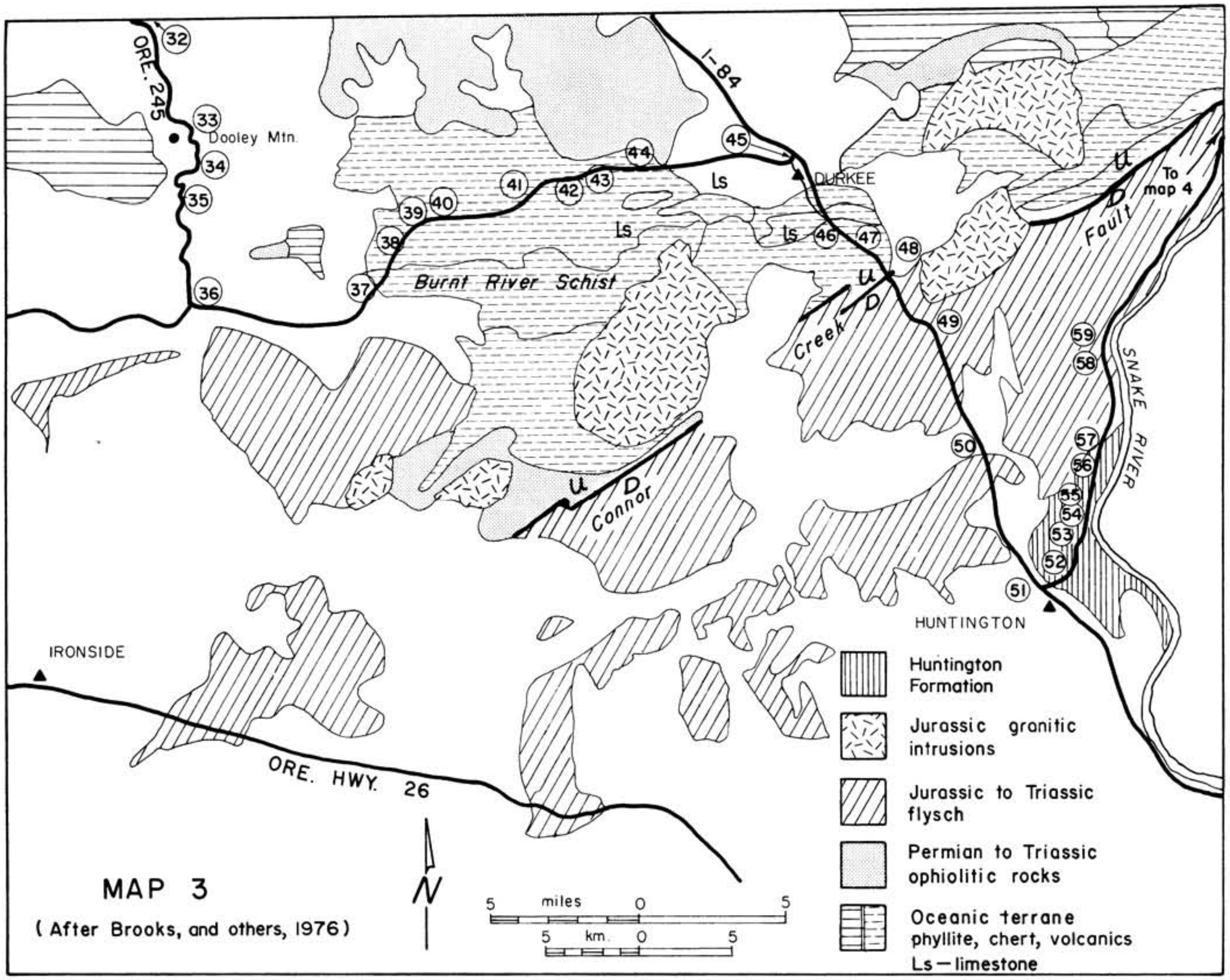
88.2 **58:** Jurassic Weatherby Formation visible in peak to the northwest.

89.8 **59:** Jurassic flysch. Pelitic and fine sandy beds. Subtle graded bedding in some exposures along road. Character of these rocks changes little in the next 7 mi. **Begin using Map 4.**

96.9 **60:** Connor Creek Fault. Not clearly exposed. High-angle reverse fault which juxtaposes Jurassic flysch to the south and Burnt River Schist to the north. Limestone float and vegetation obscure actual fault line. Right-lateral movement is apparent in Burnt River Schist drag folds.

97.5 **61:** Contact metamorphism of limestone coarsely recrystallized to marble by Columbia River Basalt Group dike.

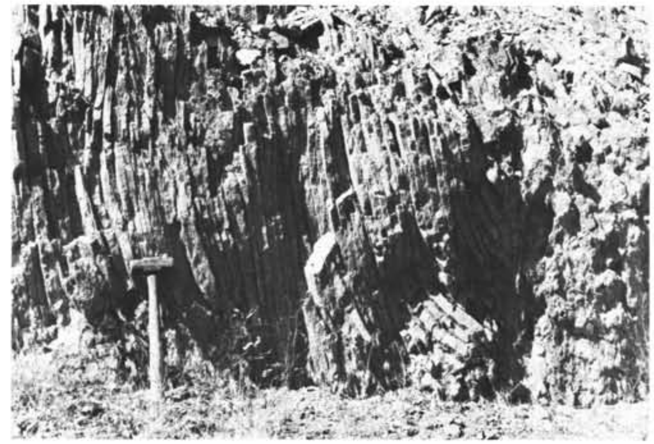
97.8 **62:** Burnt River Schist. Strongly deformed phyllite with some siliceous (cherty?) layers. F_2 folds here may be related to the development of the Connor Creek Fault. Less contorted Burnt River Schist is exposed in roadcuts for the next 4.5 mi. The decrease in shearing appears progressive.



Folds in Burnt River Schist phyllite north of the Connor Creek Fault. Loop B, map point 62.

102.3 **63:** Greenstone member of the Burnt River Schist. This outcrop contains a few relict titanaugites, suggesting that the original character of the rock was alkalic. Pelitic and siliceous rocks are present also. The more siliceous layers are chertlike in appearance.

103.1 **64:** Thinly bedded ribbon cherts characteristic of Elkhorn Ridge Argillite. Note phyllite developed on argillaceous

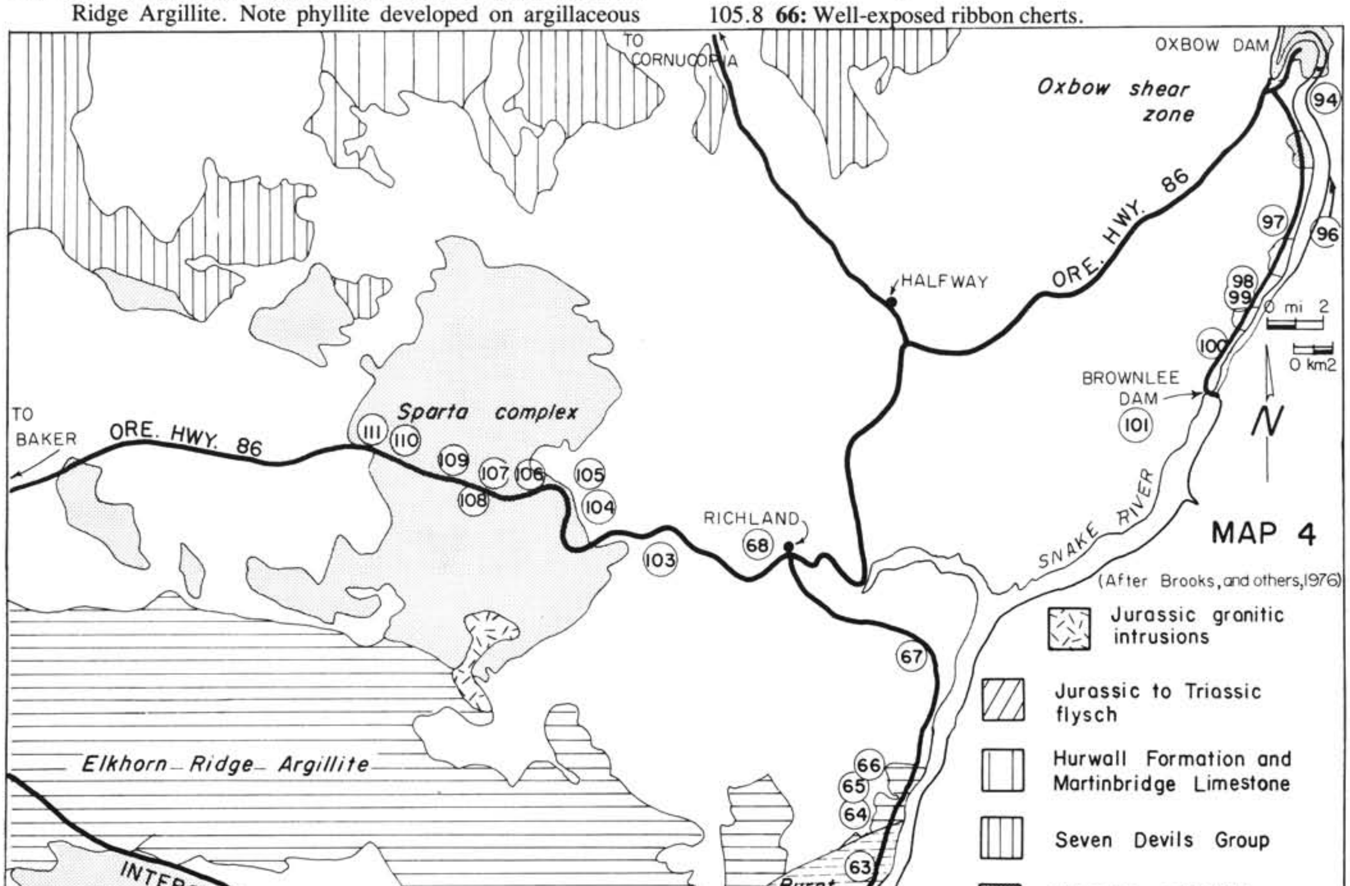


Ribbon cherts, Elkhorn Ridge Argillite, north of gradational contact with Burnt River Schist along the Snake River. Loop B, map point 64.

interbeds and isoclinal folding with limbs sheared by left-lateral movement.

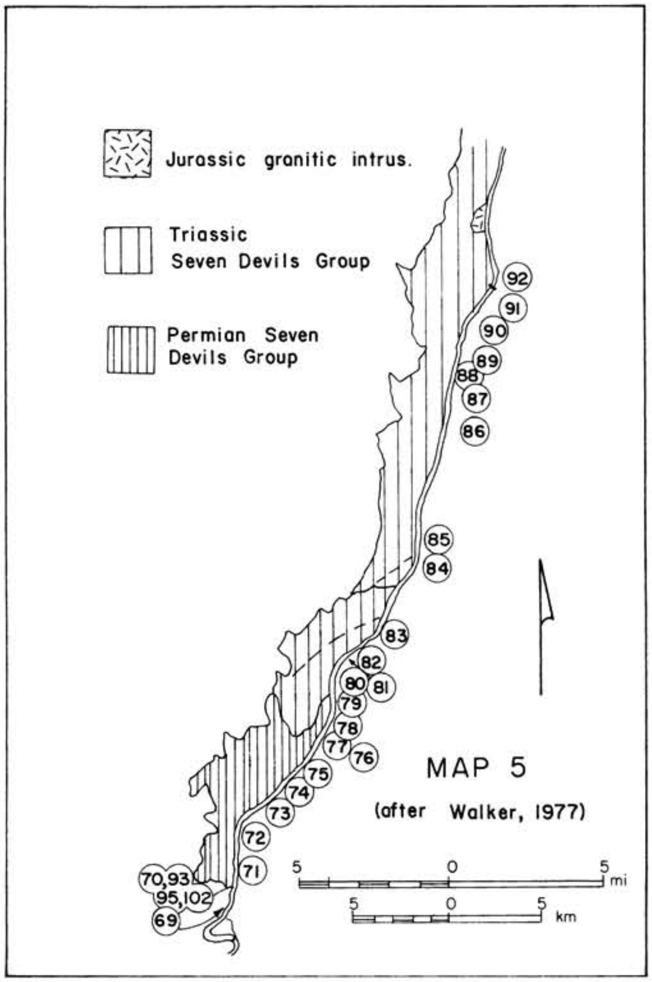
103.4 **65:** Alkalic pillowed greenstones associated with Elkhorn Ridge Argillite cherts. This exposure contains abundant relict titanaugite.

105.8 **66:** Well-exposed ribbon cherts.



105.9 **67:** Ruth Gulch Road and view of Snake River Canyon. Continue toward Richland on Snake River Road.

114.9 **68:** Junction with Oregon Highway 86. Either turn left to return to Baker or turn right toward Snake River and Loop C starting point (69, on **Map 5**).



Loop C, Snake River Canyon, Oxbow complex, and the Sparta ophiolite (Maps 4 and 5).

Total miles	Map point number (**bold**) and comments
0	**69:** Idaho Power Company Copperfield Park Campground. Take IPCo road northeast toward Hells Canyon Dam. **Use Map 5.**
0.2	**70:** Center, Snake River bridge. Follow IPCo road along Idaho side of Snake River.
0.6	**71:** Keratophyre of the Permian Windy Ridge Formation. Intruded by Permian to Triassic diabase dikes and also Columbia River Basalt Group dikes. This keratophyre contains albite phenocrysts with quartz reaction rims in a chlorite and quartz matrix.
2.6	**72:** Windy Ridge volcanic breccias which contain exclusively volcanic clasts.
3.1	**73:** Red volcanic breccias of the Windy Ridge Formation.
3.5	**74:** Bedded volcaniclastic sediments, Permian Hunsacker Creek Formation.
4.4	**75:** Spilitic flow rocks.
5.6	**76:** Bedded sediments of the Hunsacker Creek Formation which contain fine-grained volcaniclastic rocks and breccias, coarsening northward and overlain by white keratophyre.
6.2	**77:** Hells Canyon Park, IPCo (camping).
6.7	**78:** Hunsacker Creek clastics and volcaniclastics. Diabase dikes crosscut similar sediments and keratophyre at mi 6.9.
8.0	**79:** More Hunsacker Creek coarse volcaniclastic rocks. Light to dark green.
8.3	**80:** Triassic Doyle Creek red volcaniclastic rocks and breccias.
9.3	**81:** Copper Creek (on west side of river).
10.0	**82:** Porphyritic keratophyre of the Triassic Wild Sheep Creek Formation.
10.8	**83:** Gray, medium-coarse keratophyre of the Wild Sheep Creek Formation. Plagioclase (albite) phenocrysts are noteworthy.
12.9	**84:** Martin Bridge Limestone. Triassic (Norian to Carnian). This limestone contains ammonites as well as other good index fossils. It overlies the Seven Devils Group unconformably and contains sedimentary features suggesting deposition in a platform environment. Well-exposed bedding, shaly interbeds, and stromatolites occur near the base of the limestone at mi 13-13.2.
13.6	**85:** Big Bar (landslide).
16.5	**86:** Bedded sediments of the Doyle Creek Formation, with minor mafic flows, cut by diabase dikes.
17.1	**87:** Black Point. Mafic volcanic rocks intruded by keratophyre dikes.
19.2	**88:** Fine-grained Jurassic(?) gabbro intruding Doyle Creek mafic volcanics. Well-developed intrusion breccia and chilled contacts of the gabbro. This gabbro is relatively undeformed. Epidote is abundant in the volcanics.
19.6	**89:** Mafic flows with abundant epidote.
21.7	**90:** Fine- to medium-grained porphyritic keratophyres with occasional intercalated volcaniclastic sediments.
22.2	**91:** Porphyritic to glomeroporphyritic greenstones. Extremely large plagioclase phenocrysts. Strongly epidotized and thoroughly altered. Plagioclase altering to chlorite, albite, sericite, and epidote in a chlorite epidote matrix.
22.5	**92:** Centerline of Hells Canyon Dam. Turn around and retrace path toward Oregon side.
44.8	**93:** Same as point 70 – center line of Snake River bridge. Continue to the southeast. Take the road to the left for the Oxbow Dam. **Begin using Map 4.**
48.0	**94:** Oxbow shear zone (Oxbow complex). Stop at the "Y" intersection past the generators. Sheared and mylonized keratophyres and diabase are exposed in the roadcuts. Field evidence such as (rare) rotated gabbro xenoliths suggests right-lateral movement. The road to the left (north) leads to greenstones and volcaniclastic rocks which have been mylonized. The road to the right leads to Oxbow Dam and quartz diorite which intruded the complex and is unevenly deformed (i.e., less deformed on the margins).

Return to centerline of Snake River bridge to restart roadlog mileage.

0	**95:** Centerline, Snake River bridge. Drive south toward Brownlee Dam and Cambridge, Idaho.

3.7 **96:** Travertine, east bank of Snake River.

7.3 **97:** Boudinaged and folded cherts with interbedded volcanic breccias and fine argillite juxtaposed with conglomerate of chert and greenstone clasts. This conglomerate is very massive, with coarse grading which suggests that top of the beds is to the north.

7.9 **98:** Volcanic greenstone (spilite) and argillaceous rocks with conglomerate. Large blocks of limestone are tectonically included in these sediments (note shear around limestone margins).

8.2 **99:** Large blocks of allochthonous limestone in argillaceous sediments. These limestones of Carnian (Late Triassic) age may possibly be Martin Bridge equivalents. Good exposure of sheared contact with enclosing sediments. Diabase and quartz diorite intrude sediments here.

9.0 **100:** Triassic hornblende quartz diorite. Similar to pluton at Oxbow Dam. Faint northeasterly trending foliations and shearing increase southward toward Brownlee Dam.

12.1 **101:** Center, Brownlee Dam.

Return to Oxbow and center of Snake River bridge to restart road-log mileage.

0 **102:** Same as points 70 and 93 (Map 5) – center line, Snake River bridge. Go west on Oregon Highway 86 toward Baker. **Continue using Map 4.**

34.9 **103:** Milepost 34.9, Route 86.

35.5 **104:** First exposure of gabbros associated with the Sparta complex. Inhomogeneous, deformed gabbro, medium- to fine-grained and slightly foliated to intensely deformed. Intruded by quartz-diorite dikes and veins.

36.9 **105:** Sparta complex gabbro, fine-grained with tectonite and compositional banding. Intruded by pyroxene pegmatites and small diorite veins. Coarse hornblende gabbro and pegmatite occur on east end of outcrop.

37.6 **106:** Layered gabbros. Replacement of feldspar by quartz-albite-prehnite in some leucocratic layers.

Layered gabbro of the Sparta ophiolite. Loop C, map point 106.

39.2 **107:** Hornblendized gabbro and epidotized gabbro with quartz veins and silicified mylonite zones. Schlieren of more mafic, altered gabbros in leucocratic material.

39.6 **108:** Sheared, fine-grained mafic gabbro intruded by dikes of plagiogranite and diorite.

41.4 **109:** Beginning of diorite exposures in roadcuts.

ABSTRACT

This is the abstract of a paper given at the annual meeting of the Rocky Mountain and Cordilleran Sections of the Geological Society of America in Salt Lake City, Utah, May 2-4, 1983. It summarizes some of the findings of current geologic mapping in eastern Oregon by the geologists in the Baker field office of the Oregon Department of Geology and Mineral Industries.

SERPENTINITE-MATRIX MÉLANGES IN PARTS OF THE BLUE MOUNTAINS OF NORTHEAST OREGON, by Ferns, Mark L., and Brooks, Howard C., Oregon Department of Geology and Mineral Industries, 2033 First Street, Baker, OR 97814

Large areas of serpentinite-matrix mélange or megabreccia are exposed in the Mt. Ireland-Greenhorn-Vinegar Hill areas in the western part of the "dismembered oceanic crust terrane" of Brooks and Vallier (1978). Blocks in the mélange range from less than a meter to more than a kilometer across and are mainly gabbro, greenstone including pillow basalt, and chert-argillite sequences. Diorite, quartz diorite, amphibolite, schist, andesite, and limestone are included locally. The lithologic character, structural orientation, and size of the blocks appear totally chaotic. Some gabbro blocks have rodingite rinds, suggesting that their emplacement predated the serpentinization of the enclosing rocks. Locally, the mélange is unconformably overlain by sedimentary sequences consisting mainly of argillite and graywacke with very little chert. Associated conglomerates contain varying proportions of gabbro, diorite, greenstone, chert, and serpentine clasts. Limestones in these sediments reportedly contain fusilinids of Permian age (Mullen, 1978).

Rocks exposed in the eastern part of the "dismembered oceanic crust terrane," from Elkhorn Ridge eastward, are mainly argillite, chert, basaltic and andesitic volcanic rocks, gabbro, and plagiogranites. Ultramafic rocks are rare. Some of the plagiogranitic rocks probably represent younger, arc-related intrusives rather than basement.

The small exotic blocks of mixed serpentinite, greenstone, gabbro and chert in the Jurassic sedimentary terrane of the Weatherby Formation are replicas of the serpentinite-matrix mélange on Vinegar Hill.

– Geological Society of America Abstracts with Programs, v. 15, no. 5, p. 371 (no. 15538)

REFERENCES CITED

Brooks, H.C., and Vallier, T.L., 1978, Mesozoic rocks and tectonic evolution of eastern Oregon and western Idaho, *in* Howell, D.G., and McDougall, K.A., eds., Mesozoic paleogeography of the western United States: Pacific Coast Paleogeography Symposium 2, Sacramento, Calif., 1978, Society of Economic Paleontologists and Mineralogists, Pacific Section, p. 133-136.

Mullen, E.D., 1978, Geology of the Greenhorn Mountains, northeastern Oregon: Corvallis, Oreg., Oregon State University master's thesis, 372 p. □

43.2 **110:** Biggs Spring diorite. Quarry with good, fresh exposure. Fine mafic diorite is gradational into coarse, leucocratic phase. Schlieren and xenoliths of mafic rock in the leucocratic rock. Biotite occurs in the last phase.

44.9 **111:** Milepost 25, Oregon Highway 86.

End of guided trip. Continue west to Baker.

In memoriam: Philip Francis Brogan, 1896-1983

Phil Brogan, one of the best-known popularizers of Oregon geology, died May 30 in Denver where he had lived for the last several years. During 44 years as a journalist with the Bend Bulletin and for years into his retirement, he wrote prolifically for the Portland newspaper, *The Oregonian*, for the GSOC *Newsletter*, the DOGAMI *Ore Bin*, and the State Historical Society *Quarterly*, to name just a few, on Oregon's geology—as he discovered it for himself, encouraging his readers to discover it for themselves. Living in Bend, he was particularly devoted to the land around him, and "East of the Cascades" became the title of his book published in 1964.

Geology was only one of Brogan's interests. He was equally active as historian, geographer, meteorologist, and astronomer. As a frequent companion in exploring the Oregon country, Ralph Mason, former State Geologist, remembers him well:

"Phil Brogan wore any number of hats during his busy lifetime. In addition to his duties as a Bend journalist, he managed to research both local and regional geology phenomena and reported on them in a long series of articles for *The Oregonian*. The articles were written in layman language—a rather difficult feat, since describing complex processes in simple terms is infinitely harder than taking refuge behind imposing scientific phraseology understandable only to the professional. In this respect, Phil was years ahead of many other science writers who only recently have begun to popularize science.

"A journalist in a small town knows everything that is happening there, or is about to happen, and Phil Brogan was certainly on top of the news in central Oregon, except for one occasion. On June 17, 1961, the citizens of Bend very quietly organized a Phil Brogan Day to honor one of central Oregon's leading citizens. Invitations went out far and wide, and friends from all over the West gathered at the Bend High School. Keeping Phil from finding out required many stratagems but was achieved with complete success. As he walked up to the high school, Phil couldn't help but notice the totally filled parking lot, and he began to worry that he had overlooked some news event. To say that his surprise was complete would be an understatement. . . . It was, in retrospect, a wonderful evening, with friends from far and wide and from a broad spectrum of professions and other 'just plain friends' paying homage to a great man." □

U.S. Bureau of Mines assigns new Liaison Officer

Mr. Herbert R. Babitzke is now assigned to Spokane, Washington, as a Regional Liaison Officer for the U.S. Bureau of Mines. Mr. Babitzke, a graduate from Oregon State University, Corvallis, Oregon, has 25 years experience with the Bureau of Mines. He started his government career in 1958 at the Bureau's Research Center in Albany, Oregon, where he conducted metallurgy research.

As State Liaison Officer, Mr. Babitzke is responsible for monitoring State mineral-related activities of interest to the Bureau of Mines, such as mineral production, mineral reserves, existing mineral operations, plans for future mineral operations, and State tax information. He provides contact with State mineral-related agencies and organizations and prepares State-oriented Bureau of Mines publications, such as Minerals Yearbook chapters and Mineral Industry Surveys. His area of responsibility covers Oregon, Washington, Montana, and Hawaii. □

Most mineral management responsibilities given to BLM

In a move to promote efficiency, all management responsibility for minerals on federal lands, except for royalties, have been consolidated into the Bureau of Land Management (BLM).

Secretary of the Interior James G. Watt said that Minerals Management Service will retain full responsibility for offshore mineral leasing and production and for royalty management on all federal lands.

Watt said his new directive would eliminate duplication of effort by BLM and the Minerals Management Service, resulting in greater efficiency and economy. He said that BLM has long-established expertise in resolving potential conflicts among legitimate but competing interests in onshore resource management. Minerals Management Service has the special expertise required for effective collection of revenues from mineral leasing and production, as well as for offshore leasing.

"Each agency will handle what it is best qualified to do," Watt said.

BLM now has full responsibility for resource evaluation, determining fair market value, approval or rejection of drilling permits and mining production plans, and on-site inspection and lease enforcement.

Bureau of Indian Affairs will assume the same duties on Indian-owned lands.

Land disposals narrowed by BLM

Twenty thousand acres of U.S. Bureau of Land Management (BLM) land in Oregon and Washington will be disposed of during the next Federal fiscal year starting October 1, according to William G. Leavell, BLM Oregon State Director.

This will be selected from a "pool" of 43,800 acres, under BLM's asset management program.

Washington has 9,003.63 acres in five counties and Oregon has 34,797.83 acres in 15 counties.

Leavell said the land was narrowed down from 212,000 acres previously considered, with the screening accomplished through public comment, state and local government review, and tentative reviews of resource values and encumbrances.

He continued, "We still must do more screening. Some of the land which appears to be clear for disposal may be eliminated by such factors as additional public comment including that from state and local government, mining claims, endangered species, wildlife habitat, and archeological values."

Intensive field examinations to determine public and resource values and encumbrances are necessary before any public land tract is transferred to another ownership. A formal public comment period is required and notification must be made to Congressional delegations and U.S. Senate and House of Representatives committees. In addition, Congressional approval is required to sell tracts of 2,500 acres or more.

Most of the lands under review are in eastern Oregon and Washington. In Oregon, the largest acreage under consideration is Harney County's 13,919.8, while the smallest is 1.8 acres in Clackamas County. In Washington, the largest acreage is 2,793.64 acres in Douglas County and 280 acres in Franklin County.

—BLM News
Oregon and Washington

Thought for the day: Geologists are drifters.
—Gary Baxter

Governor Atiyeh presents Productivity Improvement Award to DOGAMI

On Wednesday morning, June 1, 1983, Governor Victor Atiyeh presented his Governor's Productivity Improvement Award to the Publications Section and the clerical staff of the Oregon Department of Geology and Mineral Industries (DOGAMI). The award was in recognition of DOGAMI's greatly increased productivity in terms of geologic maps and texts in recent years. The increased productivity is the result of numerous innovations including improved technology, streamlined management, volunteerism, and old-fashioned hard work.

During his presentation, which was made at DOGAMI's main offices in the State Office Building in Portland, Governor Atiyeh observed that a recently completed mineral resource assessment of the Bureau of Land Management (Open-File Report 0-83-2) contained over 100 maps and utilized microfiche for cost-effective

Governor Atiyeh holds Productivity Improvement Award during his presentation in DOGAMI's offices in Portland.

Governor Atiyeh presents Productivity Improvement Award to DOGAMI publications and clerical staff. Left to right: Klaus Neuendorf, editor-librarian; Kathleen Mahoney, secretary; Paul Staub, cartographer; Beverly Vogt, publications manager; Governor Atiyeh; Chuck Schumacher, cartographer; and Anne Bradley, secretary.

presentation of voluminous geochemical assay and statistical data. Other recent DOGAMI publications have benefitted oil and gas exploration, consolidated bibliographic information, and fostered geothermal exploration in the state by private industry.

Beverly Vogt discusses some recent publications with Governor Atiyeh.

Paul Staub, cartographer, shows DOGAMI map to Governor Atiyeh. Onlookers include (from left to right) Don Hull, State Geologist; Klaus Neuendorf, editor-librarian; and Denny Miles, press secretary.

The Governor noted previous distinctions earned by the staff including a map competition award received by Paul Staub, cartographer, and a suggestion award given to Kathleen Mahoney, secretary. Governor Atiyeh emphasized that DOGAMI's productivity has been achieved at a time of very difficult fiscal conditions and with no increase in staff. He expressed very sincere and personal appreciation for the efforts which led to this award.

The award was the fourth of its kind to be presented to a unit of state government by the Atiyeh administration, now in its fifth year. □

MLR permit fees will not be increased

On June 15, 1983, Donald Hull, State Geologist, announced that fees for permits under the Mined Land Reclamation Act would not have to be increased in the foreseeable future.

"It is a real pleasure to be able to interrupt the ever increasing cost of government," Hull observed.

The Mined Land Reclamation Act, which became law in July 1972, is intended to return mined land to other "beneficial" uses upon or before completion of mining. The reclamation program is administered by the Department of Geology and Mineral Industries, headed by Dr. Hull.

The program is 90 percent user funded, with 10 percent of its costs provided from the General Fund. The 62nd Legislature amended the law to provide an increase in permit fees to a maximum of $415 for a new site and a maximum of $315 for annual renewals. The amount of fee collected is to be established within these limits by the State Geologist, reviewed by the Executive Department, and approved by the Joint Committee on Ways and Means, or the Emergency Board if the Legislative Assembly is not in session. It is this new provision which led to a careful review of budgetary requirements and the decision that a fee increase can be deferred. Present permit fees are $390 for new sites and $290 for annual renewals. □

Teague Mineral Products begins micronizing of zeolites

Teague Mineral Products has installed a micronizing unit at its zeolite operations in Adrian, Oregon. (Bentonite is the principal product of the company. See DOGAMI's mineral-industry report in the April issue of this year's *Oregon Geology*.)

The company sold 1,200 tons of zeolites in 1982, mainly for use as a fungicide carrier for seed potatoes (replacing talc), as a suspension agent for liquid fertilizer (as a replacement for attapulgite), and as an anticaking agent in fertilizers. The new micronized grades are aimed at detergent markets (now using synthetic zeolites), also at uses for paint filler and filler in glue for plywood.

The micronizing unit has a capacity of about 25 tons per day of 10-micron product, although this will vary depending on the size being produced. There is also the possibility of producing micronized grades of bentonite at the plant. Regular production from the plant is ground in a Raymond mill. Apart from its own bentonite and zeolite grinding, the company has, on occasion, custom-ground material for other companies, including another zeolite producer.

Besides adding the new micronizing unit, Teague Mineral has been increasing its regular production of zeolites. The company's current production is about 200 tons per month and may increase even further.

—Industrial Minerals □

From *The Writings of Benjamin Franklin*, collected and edited by Albert H. Smyth, Vol. VIII, 1780-1782, p. 598, ". . . Such superficial parts of the globe seemed to me unlikely to happen if the earth were solid to the centre. I therefore imagined that the internal parts might be a fluid more dense, and of greater specific gravity than any of the solids we are acquainted with; which therefore might swim in or upon that fluid. Thus the surface of the globe would be a shell, capable of being broken and disordered by the violent movements of the fluid on which it rested."

—AGI Geospectrum

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.

GRAVITY ANOMALIES AND THEIR STRUCTURAL IMPLICATIONS FOR THE SOUTHERN OREGON CASCADE MOUNTAINS AND ADJOINING BASIN AND RANGE PROVINCE, by Cynthia Ann Veen (M.S., Oregon State University, 1981)

Gravity measurements made during 1979 and 1980, combined with existing gravity measurements, provide data for the interpretation of upper crustal structures relevant to the assessment of the geothermal potential of south-central Oregon.

West of Upper Klamath Lake, free-air gravity anomalies trend north-south and average near 35 mgals. East of Upper Klamath Lake, free-air gravity anomalies trend west to northwest and average near 10 mgals.

The complete Bouguer anomaly field exhibits a regional gradient of nearly 0.4 mgals/km, which is attributed to the existence of a low-density upper mantle layer beneath the Basin and Range province. The large northwest-trending negative anomaly associated with the Klamath graben suggests a depth of low-density fill of up to 2,300 m (7,500 ft).

The regional gravity field exhibits a broad regional high over the area surrounding Klamath Falls which may be caused by a shallow mantle or a large intrusive body at depth or may simply be due to intense silicification of the area by thermal waters.

The residual anomaly field exhibits broad bands of positive anomalies which enclose the negative anomaly associated with the Klamath graben. The easternmost of these broad, positive trends may correspond to the eastern flank of an anticline which may have existed prior to graben faulting. Positive anomalies west of the graben coincide with the Mount McLoughlin lineament. A large positive anomaly located south of Sprague River is interpreted to be a volcanic center and the heat source for thermal waters found in the Sprague River Valley.

A two-dimensional cross section near 42°26′ N. latitude suggests that steplike faults form the west side of the Klamath graben. The model indicates the presence of a high density body south of Sprague River that is interpreted to be a buried volcanic source for local extrusive volcanic rocks.

Northwest-trending gravity anomalies west of Upper Klamath Lake indicate that structural trends of the Basin and Range province extend into the Cascade Mountains and suggest that a heat source for thermal waters may exist beneath the High Cascades, rather than beneath the areas which exhibit geothermal activity.

STRATIGRAPHY, LITHOFACIES, AND ENVIRONMENT OF DEPOSITION OF THE SCAPPOOSE FORMATION IN CENTRAL COLUMBIA COUNTY, OREGON, by Kevin Blair Kelty (M.S., Portland State University, 1981)

The study area is located in central Columbia County and encompasses approximately 373 sq km. The purpose of the study was to map lithofacies to a scale of 1:31,250, study the petrography of the lithofacies, determine the stratigraphy, and develop a model for environment of deposition of the Scappoose Formation.

Sediments of the Scappoose Formation consist of feldspathic sandstones, siltstones, and mudstones. Constituents of Scappoose Formation sediments are quartz, volcanic rock fragments, potassium feldspar and plagioclase feldspar, granite, chert, quartzite, and phyllite clasts. Large amounts of hypersthene, hornblende, and volcanic and metamorphic rock fragments indicate that Scappoose Formation sediments were derived from a mixed volcanic and metamorphic provenance drained by the ancestral Columbia River.

The lower contact of the Scappoose Formation is a disconformity developed by erosion on the underlying Pittsburg Bluff and Keasey formations. The upper contact is an erosional surface that has been covered with Grande Ronde Basalt (low-magnesium geochemical type) of the Columbia River Basalt Group.

The oldest rocks within the Scappoose Formation are considered upper Oligocene in age and are predominantly tuffaceous, arkosic sandstones, siltstones, and mudstones deposited in a shallow-marine to brackish-water environment. Middle Miocene-coarse grained, pebbly, arkosic fluvial sandstones were deposited in channels eroded through the Pittsburg Bluff and into the Keasey formations. Grande Ronde Basalt clasts from the Columbia River Basalt Group form gravel lenses and line channel bottoms. Early flows of Grande Ronde Basalt flowed into valleys in middle Miocene time and contributed palagonite and gravels as fluvial sedimentation and uplift continued.

Intertonguing marine and nonmarine lithofacies, fluvial cross-bedded sands, coal and abundant plant material, and numerous transgressive and regressive sequences reflect a deltaic shoreline dominated by a high-energy wave-and-current marine environment during deposition of the Scappoose Formation. Predominantly marine lithofacies near the base and shallow-water fluvial lithofacies higher in the formation indicate a gradual shallowing environment of deposition. Finer grained structureless brackish-water sandstones overlain by coarse-grained fluvial sandstones demonstrate a westerly developing deltaic shoreline receiving sediments from the ancestral Columbia River drainage. A middle Miocene period of uplift and transgression shifted the Columbia River drainage to the northeast while later flows of Columbia River basalt continued to build westward interfingering with the Astoria embayment and infilling the paleotopography.

A STRATIGRAPHIC AND GEOCHEMICAL INVESTIGATION OF FERRUGINOUS BAUXITE DEPOSITS IN THE SALEM HILLS, MARION COUNTY, OREGON, by Charles William Hoffman (M.S., Portland State University, 1981)

Pacific Northwest ferruginous bauxite deposits have formed in four main areas of northwestern Oregon and southwestern Washington by laterization of flows of the Columbia River Basalt Group (CRBG). The deposits, averaging 36.3 percent Al_2O_3, 31.8 percent Fe_2O_3, and 5.9 percent SiO_2, generally occur near the surface of hilltops in gently rolling areas. Two very different views have been advanced regarding the setting in which the deposits have formed. The first hypothesis calls for a blanket-type laterization by erosion of much of the original deposit upon uplift and dissection of the area. The second proposes that laterization followed uplift, and only a limited amount of bauxite developed. Deposits found within the Salem Hills provide insight into this question and into questions involving the conditions under which the deposits formed and the role parent material played in controlling the distribution and composition of ferruginous bauxite. A very strong correlation, both in plan and section view, exists between the distribution of the informal Kelley Hollow flow of

the Frenchman Springs Member of the Wanapum Basalt Formation and the occurrence of ferruginous bauxite. Geochemical variation for 12 major, minor, and trace elements in three laterite profiles is markedly greater in the weathering products of the Kelley Hollow flow than those of the underlying high MgO Grande Ronde flow and appears to be related to structural and textural properties of the two flows. La, Sm, and Ce; Hf, Th, and Sc; and Co and MnO form three groups of elements which display sympathetic geochemical variation in concentration or depletion relative to parent material concentration within the laterite profiles. Al_2O_3 and Fe_2O_3 relative concentrations tend to vary oppositely, though both are significantly concentrated in most samples. SiO_2 and Cr variations do not relate to any of the other elements. Eh-pH equilibria for the Al-Fe-H-O system suggest that pH within the weathering environment was generally above 3-4 but less than 8-10 and that Eh was generally greater than 0. Silica depletion, the key process to the development of these ferruginous bauxites, was dependent upon removal of leachate by ground-water flushing action, a process which would presumably require topographic relief. Well-developed, lateral ground-water flow above a clay-rich interbed at the base of the Kelly Hollow flow further enhanced the flushing action. The deposits developed after deposition of the Kelly Hollow flow and after the development of an active ground-water system in the area. The mineralogy of the laterite profiles requires a climate having alternating wet and dry seasons during the development of the deposits. The ferruginous bauxite may have been more extensive than it presently is, but a blanket-type laterization is not supported by the evidence produced in this study.

GEOTHERMAL AND STRUCTURAL IMPLICATIONS OF MAGNETIC ANOMALIES OBSERVED OVER THE SOUTHERN OREGON CASCADE MOUNTAINS AND ADJOINING BASIN AND RANGE PROVINCE, by William Henry McLain (M.S., Oregon State University, 1981)

To assist in the assessment of the geothermal potential of south-central Oregon and to aid in the understanding of the tectonic mode of transition between the Basin and Range province and the Cascade Mountains province, personnel from the Geophysics Group in the School of Oceanography at Oregon State University conducted a detailed aeromagnetic survey extending from 42°00′ to 43°00′N. latitude and 121°00′ to 122°45′W. longitude.

Spectral analysis of the aerogmagnetic anomalies provided source-depth and depth-to-bottom calculations for south-central Oregon. The magnetic source-bottom depths were interpreted as Curie-point isotherm depths. Several regions with elevated Curie-point isotherm depths were mapped: (1) the Crater Lake area, (2) the Mount McLoughlin-Klamath Lake area, and (3) the Sprague River Valley. The elevated Curie-point isotherm depths within these areas, as shallow as 4 to 6 km below sea level in the Mount McLoughlin-Klamath Lake area and 5 to 7 km below sea level in the Crater Lake area and the Sprague River Valley, imply vertical temperature gradients in excess of 70°C/km and heat-flow values greater than 120 mW/m², assuming a Curie-point temperature of 580°C.

A N. 40° W. anomaly trend, observed on the total field magnetic intensity map and low-pass filtered anomaly maps, suggests the emplacement of volcanic intrusions occurred along a previously unmapped fracture zone associated with Mount Mazama. This proposed fracture zone parallels the Mount McLoughlin fracture zone and exhibits a similar magnetic expression. Fracture zones, that may include normal faults, were also mapped at the northern and southern ends of Klamath Lake.

The structural relationship between the Klamath Graben and the Cascades Graben remains unclear.

A moving-window technique, that uses Poisson's relation, when applied to the first vertical derivative of gravity data and magnetic intensity data reduced to the pole in the vicinity of Pelican Butte, yielded magnetization-to-density contrast ratios of −0.02 to 0.02 cgs. However, the misalignment of gravity and magnetic anomalies over Pelican Butte due to an undersampling of the gravity field casts doubt in these numbers.

CHEMICAL, GEOCHRONOLOGIC AND ISOTOPIC SIGNIFICANCE OF LOW-K, HIGH-ALUMINA OLIVINE THOLEIITE IN THE NORTHWESTERN GREAT BASIN, USA, by William Kenneth Hart (Ph.D., Case Western Reserve University, 1982)

Field, petrographic, chemical, geochronologic, and isotopic information has led to the identification and characterization of a widespread low-K, high-alumina olivine tholeiite (HAOT) magma type in the northwestern Great Basin. These basalts cover at least 22,000 km² and are estimated to represent a total volume of at least 650 km³. Stratigraphically, HAOT interfingers with lavas from the Cascade, Columbia River, Steens Mountain, Snake River, and Basin and Range provinces.

The time period over which HAOT lavas have been erupted extends from late Miocene to Recent (~10.5 m.y. to 0 m.y.). This interval overlaps with the timing of Snake River, Cascade, and northwestern Basin and Range volcanism but distinguishes HAOT from the main pulse of Columbia River volcanism (~15 m.y.B.P.). Furthermore, the data suggest HAOT magmatism has occurred in three major pulses: 0 to 2.5 m.y., 3.5 to 6 m.y. and 7 to 10 m.y.

The petrographic and chemical features of HAOT serve to distinguish this basalt from other basalts of the northwestern United States. Distinctive features are the holocrystalline, nonporphyritic, diktytaxitic texture, low LILE concentrations, and high MgO/FeO* values. These features emphasize the similarities between HAOT, mid-ocean ridge basalts, and back-arc basin basalts and support the idea that the northwestern Great Basin represents a continental back-arc basin.

$^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ ratios of HAOT are in the ranges of ~0.7030 to >0.7065 and >0.5130 to ~0.5124 respectively. Sr isotope ratios show a systematic increase from west to east. The combined Nd-Sr data indicate that the source region(s) producing HAOT experienced a complex enrichment and depletion history.

HAOT, Snake River olivine tholeiite (SROT), basalts transitional to these end-members, and alkaline basalts are observed in close geographic and geochronologic association in the Owyhee River/Western Snake River Plain region. These relationships require a combination of at least three chemically and isotopically distinct source regions, mixing of the HAOT and SROT source regions, varying degrees of partial melting and crystal fractionation, and varying amounts of lower crustal assimilation to explain the observed basalt suite.

THE GEOLOGY OF CASCADE HEAD, AN EOCENE VOLCANIC CENTER, by Melanie Ames Weed Barnes (M.S., University of Oregon, 1981)

Cascade Head is one of several late Eocene volcanic centers located in Oregon's central Coast Range. The Nestucca Formation is separated from the underlying formations by a regional unconformity and consists of 240 to 1,200 m of thin-bedded, tuffaceous, brackish-water and marine siltstones, interbedded with 300 to 600 m of submarine and subaerial basaltic flows, breccias, and pyroclastic rocks, which erupted to form low shieldlike accumulations.

The volcanic rocks are divided into (1) a submarine basaltic breccia, (2) lapilli tuff deposits, (3) olivine-pyroxene porphyritic basalt flows, (4) submarine to subaerial alkali basalt flows, (5) a hornblende dacite, and (6) a basaltic sandstone. Geochemical data illustrate a pattern consistent with fractional crystallization and suggest one or more repeatedly replenished magma chambers in a transitional zone between oceanic and continental crust.

GEOLOGY OF THE NORTHERN PART OF THE SOUTHEAST THREE SISTERS QUADRANGLE, OREGON, by Karl C. Wozniak (M.S., Oregon State University, 1982)

The northern part of the Southeast Three Sisters quadrangle straddles the crest of the central High Cascades of Oregon. The area is covered by Pleistocene and Holocene volcanic and volcaniclastic rocks that were extruded from a number of composite cones, shield volcanoes, and cinder cones. The principal eruptive centers include Sphinx Butte, The Wife, The Husband, and South Sister volcanoes. Sphinx Butte, The Wife, and The Husband are typical High Cascade shield and composite volcanoes whose compositions are limited to basalt and basaltic andesite. South Sister is a complex composite volcano composed of a diverse assemblage of rocks. In contrast with earlier studies, the present investigation finds that South Sister is not a simple accumulation of andesite and dacite lavas; nor does the eruptive sequence display obvious evolutionary trends or late stage divergence to basalt and rhyolite. Rather, the field relations indicate that magmas of diverse composition have been extruded from South Sister vents throughout the lifespan of this volcano. The compositional variation at South Sister is atypical of the Oregon High Cascade platform. This variation, however, represents part of a continued pattern of late Pliocene and Pleistocene magmatic diversity in a local region that includes Middle Sister, South Sister, and Broken Top volcanoes. Regional and local geologic constraints combined with chemical and petrographic criteria indicate that a local subcrustal process probably produced the magmas extruded from South Sister, whereas a regional subcrustal process probably produced the magmas extruded from Sphinx Butte, The Wife, and The Husband.

All of the volcanoes in the field area are probably less than 720,000 years old. Sphinx Butte, The Wife, and The Husband are older than South Sister and have been subjected to at least two glaciations. Late Pleistocene glaciers covered all but the upper ridges and summit of South Sister; however, evidence for multiple glaciation is obscure, and it is possible that the bulk of South Sister is younger than the second-to-last Pleistocene glaciation. Glaciated andesite lavas at the summit of South Sister are capped by a veneer of basaltic andesite lavas. The basaltic andesite lavas were extruded prior to 6840 yrs. B.P. but are probably of late Pleistocene rather than Holocene age. At some time between 12,000 and 2300 yrs. B.P., basaltic andesite lavas and cinders were extruded from the Le Conte vent at the southwest base of South Sister. The Le Conte lavas may bear only a spatial relation to South Sister. Between 2300 and 1900 yrs. B.P., a series of rhyodacite domes and block flows were extruded from flank vents on South Sister. Future eruptive activity is likely at this volcano.

GEOLOGY OF THE SILVER PEAK MINE, DOUGLAS COUNTY, OREGON, by Robert Erwin Derkey (Ph.D., University of Idaho, 1982)

Kuroko-type massive sulfide mineralization occurs in subaqueously deposited, Jurassic-age pyroclastic rocks at the Silver Peak mine. The stratigraphic sequence from the base upwards is (1) basaltic flows and tuffs, (2) dacite tuff, (3) foliated tuff and tuff breccia, and (4) bedded tuffs. Strata-bound massive sulfide mineralization occurs as interbeds in the foliated tuff and tuff breccia. Massive sulfide interbeds consist of varying amounts of subrounded pyrite grains containing blebs and matrix chalcopyrite, bornite, tennantite, and sphalerite. The zoning sequence in the massive sulfide from the base upwards is friable yellow ore, black ore, barite, and sulfide lapilli tuff with ferruginous chert fragments. Syndepositional features indicative of subaqueous, debris-flow deposition for the host foliated tuff and tuff breccia and the massive sulfide include graded bedding, flame structures, channel scour structures, load structures, disrupted bedding, floating clasts, rip-up-clasts, and poor sorting.

A genetic model for mineralization at Silver Peak includes rapid crystallization of pyrite in a hot spring plume, transport by debris flow to a small depression, and cementing of the detrital pyrite by Cu-Zn sulfides. Cu-Zn sulfide blebs were entrapped in rapidly crystallizing pyrite grains in the plume. The Cu-Zn sulfides surrounding the pyrite grains crystallized from brine which accumulated in the depression. When filled, oxygenation at the upper interface of the brine pool produced sulfate which combined with barium to produce barite. These changes in the brine pool produced the observed Kuroko-type zoning sequence.

Extensive pyroclastic deposits and evidence of mass deposition suggest the Silver Peak deposit could have formed in a submarine caldera. Suggested areas with potential for additional mineralization are in units equivalent to the foliated tuff and tuff breccia unit.

GEOLOGY, GEOMORPHOLOGY, AND DYNAMICS OF MASS MOVEMENT IN PARTS OF THE MIDDLE SANTIAM RIVER DRAINAGE BASIN, WESTERN CASCADES, OREGON, by Bryan A. Hicks (M.S., Oregon State University, 1982)

Landforms sculpted by mass movements comprise much of the landscape in the Middle Santiam study area. Bedrock in the area is mostly basalt and andesite flows and varied volcaniclastic rocks of the Little Butte Volcanic Series of Oligocene and early Miocene age, unconformably overlain by andesite flows and tuffs of the Sardine Formation of middle and late Miocene age. Some mass movements in the study area may have originally occurred during glacial or interglacial periods of the late Pleistocene, although this is largely speculative. Active slump-earthflows, debris avalanches, and debris torrents impact streams, timber resources and man-made structures.

Earthflows are associated with intercalated lava flows and volcaniclastics, especially stratified volcaniclastics which have low strength, high plasticity, and contain montmorillonite, an expandable clay mineral. Debris avalanches are associated with noncohesive soils on steep slopes.

Slump-earthflows show distinctive morphological and vegetative characteristics which reflect recency and rates of movement. Areas with different levels of activity can be mapped and the data used for certain land-planning applications.

Surface movement rates can be measured on active earthflows by conventional surveying and the use of stake arrays. Results indicate that rapid surface movement exceeding 20 ft/yr is occurring on at least two earthflows, and that intra-annual and annual periods of accelerated movement coincide with periods of greater water input from precipitation and snowmelt. Movement of the Jude Creek earthflow also appears to be related to erosion of the toe by Jude Creek. Movement on the Middle Santiam earthflow has greatly accelerated in the last three years (since 1978), compared with average rates for the previous 13 years. Road construction in 1965 preceded the most recent pulse of movement at this site.

Inventory of debris avalanches in the study area indicates a link between road construction, storm history and debris avalanche occurrence. Rates of soil transfer for road-related events is much greater than those for either forested or clearcut events. □

Fireballs sighted in Oregon

On May 21, 1983, at midnight, an observer facing west at the north end of Swan Island, Multnomah County, saw a fireball coming from above and dropping in a curved path at about a 45° angle to the west. The fireball was visible for about 3 to 5 seconds before it disappeared below the horizon. The fireball, which was white and slightly larger than a full moon, got brighter as it descended. No tail, sound, or breakup was observed.

At 3:55 a.m., May 22, Dale Corah, who was climbing at the 8,300-ft level of the south side of Mount Hood, Clackamas County, saw a fireball that came from the zenith and went north. The flight, which lasted 3 seconds, covered 45° of the sky and followed a straight path that was parallel to the earth's surface. The fireball was one-eighth the size of a full moon and changed in color from white to red during its flight. The long white tail was three-fourths the length of the path. The fireball left a glittering train that hung in the sky for 3 to 5 seconds after the fireball disappeared. No sound or breakup was noted.

At 9:43 p.m., June 6, Wayne West was looking to the west from the corner of 189th and SE Powell, Gresham, Multnomah County, and saw a fireball in the west-southwest sky, traveling in a northerly direction about 15°-18° above the horizon before going out in the west-northwest part of the sky. The duration of the flight was 6.5 seconds. The yellow-white, magnitude 4 fireball had no real head but had a cigar-shaped tail half a degree wide and 10° long. An afterglow was visible for about 1 second after the fireball went out.

These sightings have been reported to the Scientific Event Alert Network, Smithsonian Institution. Anyone with any additional information about these or other meteorite sightings should contact Dick Pugh, Cleveland High School, 3400 SE 26th Ave., Portland, OR 97202, phone (503) 233-6441. □

USGS plans mapping program realignment

The U.S. Geological Survey (USGS), a bureau of the Department of the Interior, is the nation's largest civilian mapping agency. Through its National Mapping Program, it expects to sell and distribute this year more than nine million copies of its nearly 67,000 published topographic maps.

The USGS National Mapping Division recently announced plans to realign mapping center production activities in response to growing and changing customer demand for map information and products, the need for greater production efficiency, and the need to reduce operating costs.

Under the new plans, the more traditional map production activities will be located in the Rocky Mountain Mapping Center in Denver, Colorado, and the Mid-Continent Mapping Center in Rolla, Missouri. The more specialized mapping activities, including the technologies involved in computer-generated image and digital mapping, will be focused in the Eastern Mapping Center in Reston, Virginia, and the Western Mapping Center in Menlo Park, California. Division chief R.B. Southard expects that the majority of necessary personnel adjustments will be accomplished through voluntary reassignments and normal attrition. □

TO OUR READERS

You may have already noticed that this extra-long issue covers two months. The length of the field trip guide that concludes in this issue, the amount of other material waiting to get into print, and the exigencies of our summer schedule forced us into the decision to bring you a double issue. The next number of *Oregon Geology* will be Number 9 and come out in September.

Capitol display case features South Douglas Gem and Mineral Club specimens

The South Douglas Gem and Mineral club has installed a new collection of minerals in the Oregon Council of Rocks and Mineral Clubs' display case on the main floor of the Capitol Building in Salem. Specimens featured in the display include several varieties of agate, petrified wood, fossils, and jasper, along with specimens of calcite, garnierite, orbicular chromite, pyrite on soapstone, huntite on dunite, and nephrite jade. The collection was put on display on June 2, 1983, and will remain in the case until September 1. □

Miners' Jubilee in Baker

Miners' contests will highlight the Miners' Jubilee to be held in Baker, Oregon, July 22-24. Sponsored by the Baker County Chamber of Commerce, the three-day Jubilee will include the Oregon State Championship Gold Panning Contest, a rodeo, carnival, square dance, street dance, parade, mining equipment displays, and a golf tournament.

Miners will vie for trophies and prize money in hand mucking, hand drilling, 12-B mucking, jackleg drilling, and the all-around miner's award. A two-man team drilling contest will conclude the festivities on the 24th. It has an entry fee of $50 per team, and the winner takes all. The purse for the Jubilee is expected to exceed $1000, with contributions from local suppliers, mining companies and exhibitors.

Registration forms and information on exhibit space is available from the Baker County Chamber of Commerce, P.O. Box 69, Baker, OR 97814. □

GSOC luncheon meetings announced

The **Geological Society of the Oregon Country** (GSOC) holds noon meetings in the Standard Plaza Building, 1100 SW Sixth Ave., Portland, OR, in Room A adjacent to the third-floor cafeteria. Upcoming meetings, topics, and speakers:

August 19—*From Hong Kong to Xian*, by Frank Dennis, railroad inspector, retired.

September 2—*Early Man in America: Artifacts or Geofacts?* by Lloyd A. Wilcox, communications engineer, Burlington Northern, retired.

September 16—*A Look at the Planetary Surfaces in the Solar System*, by Gary Bogner, Planetarium Education Coordinator at OMSI.

October 7—*Archaeology of the Northwest*, by Harvey Steele, import specialist for U.S. Customs.

For additional information, contact Viola L. Oberson, Luncheon Program Chairwoman, phone (503) 282-3685. □

Correction

We apologize for two oversights in last month's paper, "Paleozoic and Triassic terranes of the Blue Mountains, northeast Oregon": On page 67, the first sentence of the section "Forearc Basin Terrane" should, of course, read "... which extends from the Snake River west to the Aldrich Mountains..." And the bibliographic reference that you may have missed is: Hillhouse, J.W., Grommé, C.S., and Vallier, T.L., 1982, Paleomagnetism and Mesozoic tectonics of the Seven Devils volcanic arc in northeastern Oregon: Journal of Geophysical Research, v. 87, no. B5, p. 3777-3794.

NEW DOGAMI PUBLICATIONS

Gold-mining district geology

Geology and Gold Deposits Map of the Greenhorn Quadrangle, Baker and Grant Counties, Oregon, DOGAMI map GMS-28, is the latest addition to the Department's map coverage of the traditional gold mining districts in the Blue Mountains.

Mainly in cooperation with and supported by funding from the U.S. Forest Service, DOGAMI has now published geologic maps of six 7½-minute quadrangles (Bullrun Rock, Rastus Mountain, Bourne, Mount Ireland, Granite, Greenhorn) and three 15-minute quadrangles (Mineral, Huntington, Olds Ferry)—to which, in the current series, three quarters of the Bates 15-minute quadrangle will soon be added.

The new multicolor map of the Greenhorn quadrangle (scale 1:24,000), by M.L. Ferns, H.C. Brooks, and D.G. Avery, shows the geology and structure of an area that includes rock units dating back as far as the pre-Permian. As in the preceding maps of the series, mines, prospects, and rock-sample sites are located on the map. In addition, the area's mineral deposits and past and present mining activities are discussed; and two tables present detailed information on 84 identified mines and prospects and the results of chemical analyses of rock samples.

The Greenhorn quadrangle map (GMS-28) connects to the north with the Granite quadrangle map (GMS-25) announced last month. Both maps are now available at the DOGAMI offices in Portland and Baker, each selling for $5.

Surface plant at the Bonanza Mine, the most productive gold mine of the Greenhorn district around the turn of the century. Mine is located in the eastern half of the district which is included in the newly mapped Greenhorn quadrangle, DOGAMI's new map GMS-28. Photo originally published in DOGAMI Bulletin 61.

Comprehensive Index for Ore Bin/Oregon Geology

A new, comprehensive index for this magazine, from the first *Ore Bin* issue through volume 44 (1982) of *Oregon Geology*, has been published by DOGAMI as Special Paper 16, entitled **Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982)**. It was compiled by DOGAMI staff member Kathleen A. Mahoney, with assistance by former staff member Margaret L. Steere.

The 46-page reference work consists of (1) an author index which includes about 600 titles by approximately 300 authors and contributors, (2) a subject index covering such items as, e.g., "Cascade Range," "Coastal Geology," "Earthquakes," "Geologic Formations," and "Mineral Occurrences," (3) a county index showing references to 32 of Oregon's 36 counties, and (4) a list of the geologic mapping published in volumes 16 through 41 (1954-1979) from DOGAMI's GMS-14 ("Index to Geologic Mapping").

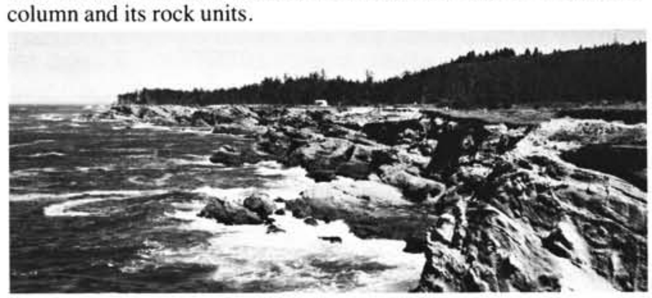
The new index, Special Paper 16, is now available at the offices of the Department for a price of $4.

View of Crack-in-the-Ground in northern Lake County and of author and now-retired DOGAMI staff member Norm Peterson. Article on this unusual geologic feature appeared in The Ore Bin *and is referenced in the new index, Special Paper 16, under the author's name, the subject heading "volcanic features," under "Lake County" in the county index, and in the index of geologic mapping.*

Stratigraphic correlation update for Oregon and Washington

Correlation of Cenozoic Stratigraphic Units of Western Oregon and Washington, DOGAMI Oil and Gas Investigation 7, presents updated information on stratigraphic correlations for geologic units from the last 66 million years of geologic history in the Pacific Northwest.

The 91-page text and the accompanying correlation chart (approximate size two by three feet) represent the current knowledge of 28 leading stratigraphers on the rock units of 20 local stratigraphic columns, ten from each of the two states. On the chart, these columns are correlated with global, oceanic, and regional chronostratigraphic units and with the absolute and geomagnetic time scales. The text contains the essential data on each local column and its rock units.



Middle Eocene Coaledo Formation cliffs exposed at Shore Acres State Park south of Coos Bay. These are some of the rocks described in the Coos Bay area stratigraphic column in Oil and Gas Investigation 7. *Photo courtesy Oregon State Highway Commission.*

DOGAMI's report is part of the results of the national project COSUNA (Correlation of Stratigraphic Units of North America). Supported by the American Association of Petroleum Geologists (AAPG), the U.S. Geological Survey, and the Geological Society of America (GSA) and with contributions from many state and university geologists and volunteer workers, the six-year project is now nearing completion. From it, AAPG will publish about 25 modern stratigraphic correlation charts, updating the first comprehensive efforts of this nature by GSA in the 1940's.

The new report, DOGAMI Oil and Gas Investigation 7, is now available at the DOGAMI Portland office and may be purchased for $8. All publication orders under $50 must include payment. □

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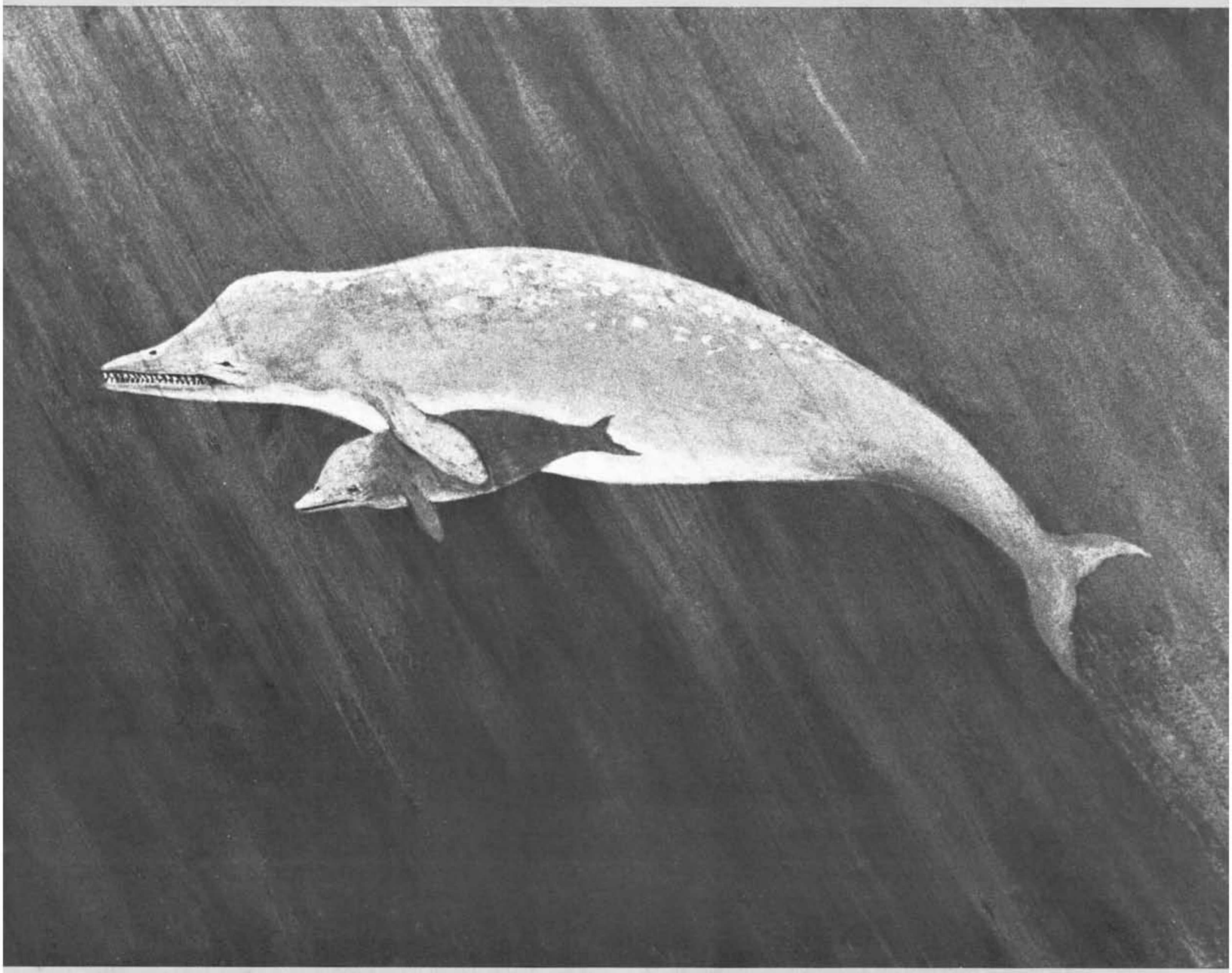

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COVER PHOTO

The primitive mysticete whale *Aetiocetus cotylalveus* Emlong. Taken from a painting by Pat Ray, University of Oregon, 1982. Article beginning on next page discusses some fossil whale discoveries in Oregon.

OIL AND GAS NEWS

Mist Gas Field

Reichhold Energy Corporation drilled Columbia County 43-5 in sec. 5, T. 6 N., R. 5 W. in 1982. The well was plugged and suspended, but had gas shows that were cased off by the surface casing. The company has recently reentered the well to perforate the shallow gas zone. Results of the August tests were poor, the formation appearing to be either tight or cement-damaged. Reichhold may plan a future new well to test the shallow gas.

DOGAMI well-sample collection

In July, the well-sample collection was improved by the processing of about 2,000 individual samples from 19 different wells. Many were duplicate samples which required washing, sieving, and proper storage for future use. These samples are available for use by anyone who desires to generate data from the well cuttings. More on the Oregon well-sample collection will appear in a future issue of *Oregon Geology*.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
240	RH Exploration Rose 1 005-00002	NE¼ sec. 20 T. 5 S., R. 1 E. Clackamas County	Application; 3,500
241	RH Exploration Anderson 1 005-00003	SW¼ sec. 29 T. 5 S., R. 1 E. Clackamas County	Application; 3,500
242	RH Exploration Rose 2 005-00004	SW¼ sec. 20 T. 5 S., R. 1 E. Clackamas County	Application; 4,000
243	Reichhold Energy Corporation Investment Management 21-20 009-00117	NW¼ sec. 20 T. 6 N., R. 4 W. Columbia County	Location; 2,500

□

OAS announces awards and new officers

At its annual meeting in February, the Oregon Academy of Science (OAS) honored Carl Bond by presenting him with the Oregon Academy of Science Citation for Outstanding Scientific Achievement.

Each year, the Academy honors two young people, one male and one female, who have presented outstanding papers at the meeting, by offering them a full membership to OAS. This year, those chosen were H.B. Davis, Portland State University, and Louise Parsons, Oregon State University.

New OAS officers for 1983-1984 are President, Jay F. Evett; Vice-President, Michael L. Cummings; Secretary, Susan K. Humphreys; and Treasurer, Frederick A. Hirsch. □

CONTENTS

Fossil Cetacea (whales) in the Oregon Western Cascades

by William N. Orr and Paul R. Miller, Geology Department, University of Oregon, Eugene, OR 97403.

ABSTRACT

The fossil whale *Aetiocetus*, first described from Oregon Coast Range exposures of the Oligocene Yaquina Formation in Lincoln County, could be one of the specimens most important to the evolutionary study of Cetacea. The origin of Mysticeti or baleen (whale-bone) whales is obscured by their poor mid-Tertiary fossil record. The recovery of *Aetiocetus* remains in Marion County, Oregon, is followed here by notes on fragmentary remains of at least two juvenile specimens of *Aetiocetus* in the same area. In spite of a lull in mid-Tertiary cetacean diversity, the paleontological record of these large mammals in this interval is one of progressive discoveries. Several formations in the Coast Range, Willamette Valley, and Western Cascades show promise for future finds of fossil whale remains.

INTRODUCTION

Many significant fossil finds in Oregon have been made by interested lay persons. It is often difficult to distinguish plant and invertebrate remains from manganese stains, rock fracture patterns, and sedimentary structures. The distinctive appearance of fossil bone, however, seldom leaves any doubt in the mind of the amateur of the significance of the find. Fossil mammals are rarely abundant in marine rocks, and the history of their discovery in Oregon owes much to observant amateurs. Of the several occurrences of Cetacea reported here and from the northern Marion County area in the past, all of the initial finds were made by local residents (see Acknowledgments).

The fossil record of whales in Oregon is limited. In view of the abundance of favorable paleoenvironments here for preserving marine animals, there is every indication that more material will turn up as study of the paleontology of the marine rocks west of the Cascades proceeds. There is a pronounced worldwide lull in the diversity of Cetacea during the middle Tertiary. This lull aligns with the appearance of baleen (whale-bone) whales and may be indirectly related to major global environmental/temperature changes that were occurring in this interval.

FOSSIL CETACEA IN OREGON

Most Oregon cetacean fossils are from exposures of Tertiary rocks in the Coast Range. To date, the most productive formations for whale fossils are in the Neogene (Figure 1). Easily the most prolific in this regard is the Miocene Astoria Formation. From the early 1800's up to the present day, the Astoria has yielded a variety of marine mammals including cetacean remains. Best known of these are the mysticete cetothere *Cophocetus oregonensis* and porpoise remains reported by Packard and Kellogg (1934) and Kellogg (1928). The upper Miocene Empire Formation in the vicinity of Coos Bay south to Cape Blanco bears cetacean bone material and even fossil baleen (Packard, 1947). A well-preserved primitive toothed whale represented by the skull and most of the skeleton was described and illustrated by Emlong (1966) from a locality in the Oligocene Yaquina Formation in Lincoln County (Figure 2). Additional cetacean material from Emlong's extensive collection (now at the Smithsonian Institution) is reported from several Coast Range exposures (Ray, 1976). Whitmore and Sanders (1976) have briefly discussed three cetacean skulls from the upper Eocene-Oligocene Alsea Formation in Emlong's collection. As work on Oregon paleontology continues, additional cetacean remains will almost certainly turn up in other Tertiary marine formations. The Pittsburg

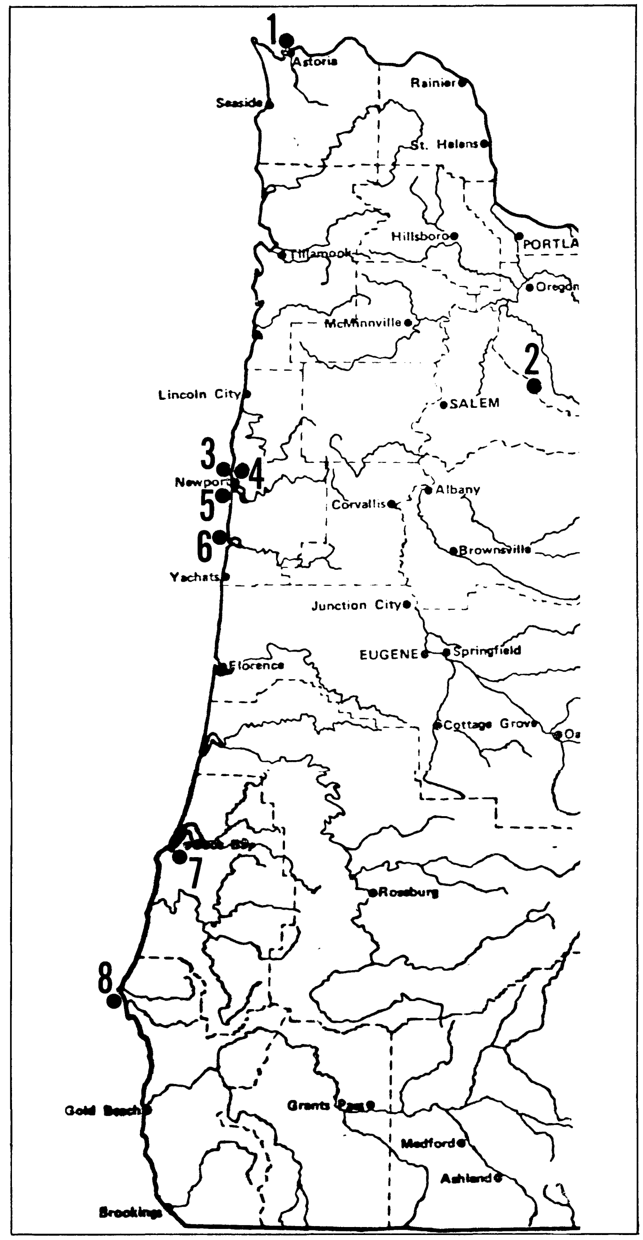

Figure 1. Distribution of fossil Cetacea in Oregon. Numbers on map indicate locations where fossils were found: 1. Astoria (Astoria Formation, Miocene, see Dana, 1849). 2. Scotts Mills ("Butte Creek beds," upper Oligocene, see Orr and Faulhaber, 1975). 3. Newport (Astoria Formation, Miocene, see Packard and Kellogg, 1934, and Kellogg, 1928). 4. Newport area (Astoria Formation [probably], Miocene, see Packard, 1940). 5. Seal Rocks (Yaquina Formation, upper Oligocene, see Emlong, 1966). 6. Alsea (Alsea Formation, Oligocene, see Emlong, 1966, and Whitmore and Sanders, 1976). 7. Coos Bay (Empire Formation, Miocene, see Packard, 1947). 8. Cape Blanco (Empire Formation, Miocene, see Packard, 1947).

Bluff and Cowlitz Formations in northwest Oregon have yielded bone fragments, but nothing has been described to date. Shallow-water intervals of the Eocene Yamhill as well as the Coaledo, Nestucca, Flournoy, Lookingglass, and Roseburg Formations also hold promise for cetacean remains. The Nye Formation has preserved marine vertebrates (turtles and desmostylids, Ray, 1976; sharks, Welton, 1972), but no cetacean remains from the unit are known to the present authors. In the Oregon upper Tertiary rocks, small bone pieces and fragments are not uncommon in the Port Orford Formation as well as the Cape Blanco beds of late Tertiary-Pleistocene age. Orr and Faulhaber (1975) described nine articulated vertebrae of a large cetacean from the "Butte Creek beds" of Oligocene age, exposed in northern Marion County. Although their specimen lacked the definitive skull, they regarded it as assignable to *Aetiocetus cotylalveus* described by Emlong (1966) from the Yaquina Formation. To date, this area of the Western Cascades is geographically the farthest inland unit bearing fossil cetaceans in Oregon. A thorough review of fossil marine mammals in Oregon is to be found in Ray (1976).

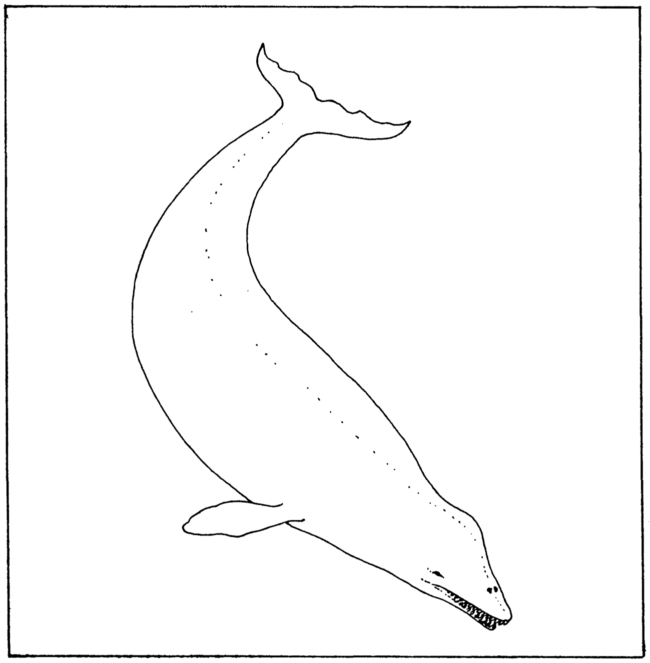

Figure 2. Aetiocetus cotylalveus *Emlong, showing position of nares. Sketch by Pat Ray, 1982.*

LOCALITY AND STRATIGRAPHY

In addition to several bone fragments, the "Butte Creek beds" have yielded whale cetacean fossil bones at three separate localities (Figure 3). These sites are all located within sec. 29, T. 6 S., R. 2 E. and are at almost the same stratigraphic interval. Orr and Miller (1982a,b) have delineated and mapped three informal subunits within the "Butte Creek beds" on the basis of lithology (Figure 4). Cetacean fossils here have all come from the lowermost of these three subunits very near the base of the section. The "Butte Creek beds" as originally recognized by Harper (1946) crop out over a 120-km² area in northern Marion and southern Clackamas Counties in the Western ("older") Cascades. A series of parallel streams running southeast to northwest deeply dissect the relatively soft Tertiary rocks and drain into the Willamette River to the northwest. These stream valleys, including (north to south) Butte Creek, Abiqua Creek, Silver Creek, and Drift Creek, afford the best look at the nearly flat-lying unit and permit a three-dimensional perspective. The "Butte Creek beds" are locally up to 500 m thick and comprise a broad range of shallow-water marine tuffaceous silt-

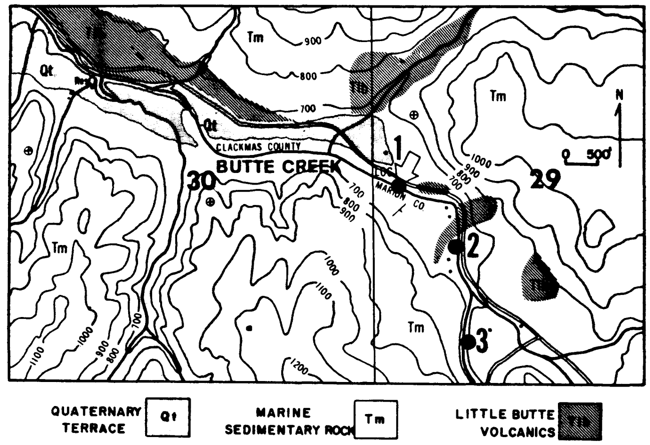

Figure 3. Fossil whale localities in northern Marion County, Oregon.

stones and sandstones with some thin bioclastic limestones. The unit rests unconformably on volcanic rocks of the Little Butte Volcanic Series and is overlain unconformably by the Miocene basalts of the Columbia River Basalt Group. Laterally the "Butte Creek beds" grade into the nonmarine volcanic rocks of the Little Butte Volcanic Series to the east. To date, the "Butte Creek beds" lack a formal formational designation.

The lowermost lithologic subunit designated by Orr and Miller (1982b) locally bears a prolific well-preserved assemblage of shallow, warm- (tropical-) water marine invertebrates dominated by molluscs. Addicott (1981) has reported a late Oligocene (Juanian molluscan Stage) scallop, "*Chalamys* sp. B," from this interval. Durham and others (1942) regarded the molluscs here as "lower Miocene" correlative in part with the "Vaqueros" of California. Orr and Miller (1982a,b) assigned the unit, on the basis of fossil molluscs, to the upper Oligocene Juanian Stage. More recently, Orr and Linder (1983a,b) identified several species of late Oligocene Echinoids from the same stratigraphic interval bearing cetacean bones. Butte Creek forms the Marion/Clackamas County line where it flows northwestward into the Willamette River. Detailed mapping has revealed that the stream trend here is following an old shoreline, with the Eocene basalt headlands (of the Little Butte Volcanic Series) to the northeast in Clackamas County and the Oligocene marine sequence to the southwest in Marion County. A traverse along the stream valley shows an intermittent chain of exhumed basalt sea stacks and mollusc-rich calcareous beach deposits. It is in the beach deposits that the best articulated cetacean fossils are preserved.

SYSTEMATICS

Order Cetacea
Suborder Mysticeti
Family Aetiocetidae Emlong
Genus *Aetiocetus*
Aetiocetus cf. *cotylalveus* Emlong

Materials from the lowermost unit of the "Butte Creek beds" recovered to date include nine vertebrae described by Orr and Faulhaber (1975; Locality 1 on map), a single vertebra of the same species 500 m upstream from the 1975 locality (Locality 3 on map), and an accumulation of vertebrae and ribs in stream-bed exposures about halfway between the two above sites (Locality 3 on map). The new material at Localities 2 and 3 is uncrushed and far better preserved than the 1975 material (Locality 1).

SINGLE VERTEBRA

A single worn vertebra was found on Butte Creek, 75 m upstream from the confluence of Coal Creek and Butte Creek. The

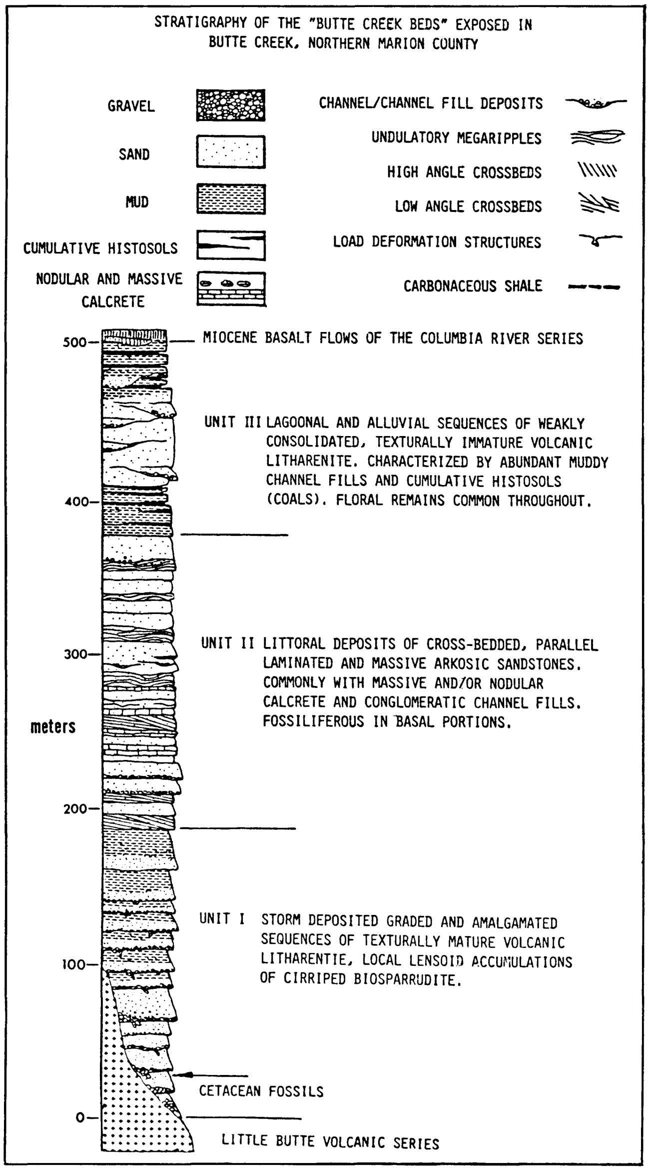

Figure 4. Stratigraphy of the "Butte Creek beds" in northern Marion County, Oregon.

specimen (Figure 5) measures 35 mm in diameter across the anterior centrum face and 36 mm across the posterior centrum face. Transverse processes are worn but display a spatulate shape. The latter processes project 40 mm beyond the centrum face in anterior view. Anterior-posterior length at the centrum faces is 50 mm. Metapophyses are also worn but project in an anterior direction 12 mm beyond the centrum face. The neural spine is damaged but projects 30 mm above the centrum face. The specimen compares well to lumbar vertebrae described by Orr and Faulhaber (1975) but is only half the size of the latter specimens.

VERTEBRAE AND RIBS

A series of seven vertebrae with ten associated ribs was collected on Butte Creek, about 150 m downstream from the confluence of Butte Creek and Coal Creek. Although most of the ribs are preserved lying in a parallel position, it is not clear that they are actually articulated with the vertebrae. These vertebrae bear a close resemblance to the specimens described by Emlong (1966) but are only about one-half their size. Average diameter of the centrum faces is 40 mm. The neural spine projects up to 27 mm above the centra and have a posterior rake. Anterior-posterior length of the vertebrae at the centra is 50 mm.

Ribs are up to 30 cm in length and are preserved whole. In cross section, the ribs are oval shaped with a longer diameter of 18 mm and shorter diameter of 13 mm.

DISCUSSION

Emlong (1966) originally classified his new genus and species *Aetiocetus cotylalveus* as an archaeocete (or primitive toothed whale) rather than as a mysticete (or baleen whale), predominantly because of the presence of multiple leaf-shaped teeth in the skull. Since its discovery and description, the genus has been the object of controversy. Thenius (1969) recognized that, in spite of its teeth, many of the anatomic features of *Aetiocetus* were, in fact, characteristic of a mysticete (Figure 6). He furthermore regarded the genus as transitional between archaeocetes and mysticetes. Van Valen (1968) similarly noted that, except for the teeth, *Aetiocetus* is a mysticete in every respect. In their review of Oregon Oligocene Cetacea, Whitmore and Sanders (1976) note several features of the skull, including the geometry of the nares, that might well be anticipated in ancestors to mysticete whales. They refer to *Aetiocetus* as a primitive mysticete, and there seems to be general agreement that the form is in the Archaeoceti-Mysticeti evolutionary line. Gastin (1976) suggests that evolving cetaceans might characteristically have a limited distributional range, which makes discovery of their fossils very fortuitous. He goes on, however, to note the transitional position of the toothed *Aetiocetus* of Emlong (1966) with its mysticete bone morphology.

We have followed Van Valen's (1968) designation here of *Aetiocetus* as a toothed mysticete. The evolutionary origin of the mysticetes or baleen whales is as unclear as the origin of the order Cetacea itself. With respect to the latter, much has been written on monophyly (single origin) or diphyly (double origin) for that order, and clearly the record awaits transitional forms between terrestrial vertebrates and Cetacea that will resolve the problem.

The potential for discovery of additional mid-Tertiary Oregon specimens to contribute to knowledge of the origin of mysticetes, however, remains high. Probably as significant as the taxonomic position of *Aetiocetus* is the fact that individuals of different growth stages are represented in the Marion County localities. The specimen described by Orr and Faulhaber (1975) was very close in size to the original described by Emlong (1966). Vertebrae and ribs described in the present work are all only about half as large as previous specimens. The rudiments of a population here are very encouraging with regard to future discoveries of additional specimens.

Many workers have alluded to the mid-Tertiary lull in cetacean diversity. Using data from Lipps (1970) and Romer (1966), Orr and Faulhaber (1975) were able to demonstrate a simultaneous

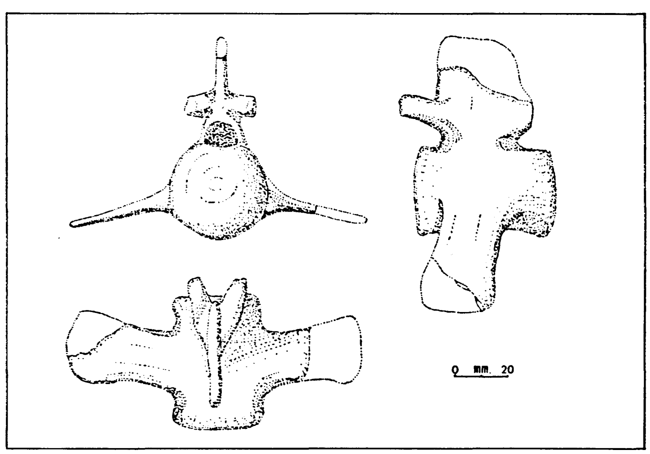

Figure 5. Lumbar vertebra from Butte Creek locality 3, northern Marion County, Oregon. Posterior, lumbar, and dorsal views.

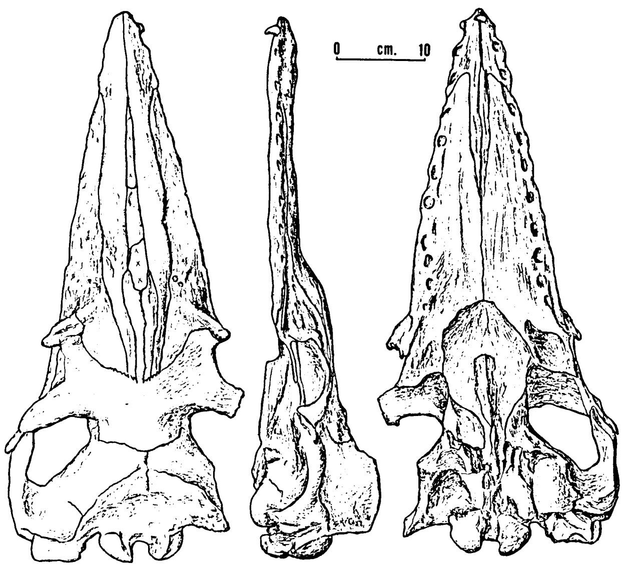

Figure 6. Aetiocetus cotylalveus *Emlong, after Emlong, 1966. Dorsal, lateral, and ventral views of the skull of Emlong's 1966 specimen, showing nares and tooth sockets.*

diversity lull in the Cetacea and marine plankton in this time interval. An inverse relationship suggested by them with respect to paleotemperature was that high water temperature accompanied low diversity. The thrust of this thesis was the notion that high ocean temperatures and subsequent thermal destratification of the water column somehow homogenized the plankton faunas with a resultant diversity crash. This diversity crash was then passed along to the ultimate consumers, the Cetacea. Barnes (1976) similarly produced graphs of cetacean diversity from the mid-Tertiary to the Holocene in the North Pacific and noted a related but not identical lull in the Oligocene as well as an even more profound dip in the middle Miocene. Although several explanations are reviewed, the latter author seems to favor a climatological relationship. Gastin (1976) records the close correlation between ocean temperature and modern cetacean distribution. He has correlated major events in cetacean evolution with known major temperature fluctuations in the Tertiary period. Lipps and Mitchell (1976) attribute the Oligocene diversity lull of Cetacea directly to the depauperate plankton faunas and flora that also characterize this interval. They appeal in turn to upwelling and the subsequent nutrient supply to explain the increasing and waning diversity of plankton. More recently, Fordyce (1977) and Kennett and others (1975) have looked at the timing of the remarkable post-Oligocene diversity recovery in Cetacea as well as in most groups of marine plankton and nekton. The latter authors have correlated these documented increases worldwide to the opening of the channel separating Australia and Antarctica by the sea-floor-spreading mechanisms (Figure 6). The development of this channel as Australia moved northward on the Indo-Australian Plate began well back in the early Tertiary. At about 38.5 m.y. B.P. in the late Oligocene, the geometry and width of the channel permitted the onset of the circum-Antarctic current. This current with its characteristic rich nutrient supply must have profoundly changed the food-chain structure within the oceans at that time.

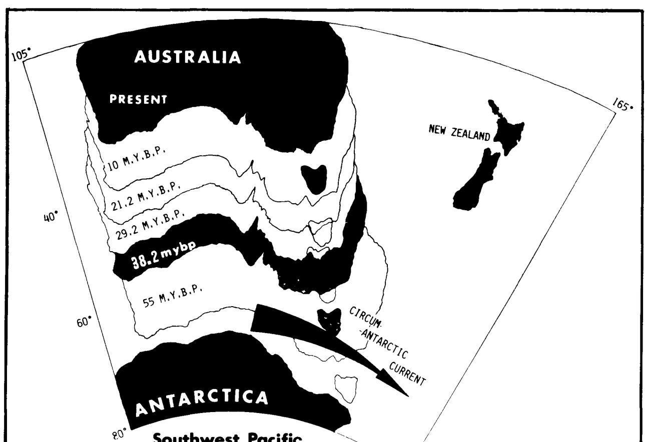

Figure 7. Tertiary paleogeography in the southern hemisphere. Modified after Fordyce (1977) and Kennett (1982).

ACKNOWLEDGMENTS

Several individuals materially helped in the recognition and acquisition of the cetacean fossils noted herein. Jake Fryberger and Glen Slentz are thanked for permitting the authors to map and collect on their property. Peter Schmidt and Dave Taylor recognized the cetacean remains and called them to the authors' attention. This work was funded by the National Science Foundation Division of Earth Sciences, Grant No. EAR 8108729.

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(Continued on page 102, **Fossil Cetacea***)*

North American Commission on Stratigraphic Nomenclature produces New Code

The 1982 North American Commission on Stratigraphic Nomenclature has adopted a new code which was printed in the *American Association of Petroleum Geologists Bulletin* (v. 67, no. 5, p. 841-875). Copies of the new code are available at $1 per copy postpaid from the American Association of Petroleum Geologists (AAPG), Box 979, Tulsa, OK 74101.

The Oregon Department of Geology and Mineral Industries has adopted the Code for its own geologic work.

For our readers' information, we are reprinting, with permission of AAPG, the foreword of the new code. Geologists are urged to obtain copies of the entire code and study it carefully.

FOREWORD

"This code of recommended procedures for classifying and naming stratigraphic and related units has been prepared during a four-year period, by and for North American earth scientists, under the auspices of the North American Commission on Stratigraphic Nomenclature. It represents the thought and work of scores of persons, and thousands of hours of writing and editing. Opportunities to participate in and review the work have been provided throughout its development, as cited in the Preamble, to a degree unprecedented during preparation of earlier codes.

"Publication of the International Stratigraphic Guide in 1976 made evident some insufficiencies of the American Stratigraphic Codes of 1961 and 1970. The Commission considered whether to discard our codes, patch them over, or rewrite them fully, and chose the last. We believe it desirable to sponsor a code of stratigraphic practice for use in North America, for we can adapt to new methods and points of view more rapidly than a worldwide body. A timely example was the recognized need to develop modes of establishing formal nonstratiform (igneous and high-grade metamorphic) rock units, an objective which is met in this Code, but not yet in the Guide.

"The ways in which this Code differs from earlier American codes are evident from the Contents. Some categories have disappeared and others are new, but this Code has evolved from earlier codes and from the International Stratigraphic Guide. Some new units have not yet stood the test of long practice, and conceivably may not, but they are introduced toward meeting recognized and defined needs of the profession. Take this Code, use it, but do not condemn it because it contains something new or not of direct interest to you. Innovations that prove unacceptable to the profession will expire without damage to other concepts and procedures, just as did the geologic-climate units of the 1961 Code.

"This Code is necessarily somewhat innovative because of: (1) the decision to write a new code, rather than to revise the old; (2) the open invitation to members of the geologic profession to offer suggestions and ideas, both in writing and orally; and (3) the progress in the earth sciences since completion of previous codes. This report strives to incorporate the strength and acceptance of established practice, with suggestions for meeting future needs perceived by our colleagues; its authors have attempted to bring together the good from the past, the lessons of the Guide, and carefully reasoned provisions for the immediate future.

"Participants in preparation of this Code are listed in Appendix I, but many others helped with their suggestions and comments. Major contributions were made by the members, and especially the chairmen, of the named subcommittees and advisory groups under the guidance of the Code Committee, chaired by Steven S. Oriel, who also served as principal, but not sole, editor. Amidst the noteworthy contributions by many, those of James D. Aitken have been outstanding. The work was performed for and supported by the Commission, chaired by Malcolm P. Weiss from 1978 to 1982.

"This Code is the product of a truly North American effort. Many former and current commissioners representing not only the ten organizational members of the North American Commission on Stratigraphic Nomenclature (Appendix II), but other institutions as well, generated the product. Endorsement by constituent organizations is anticipated, and scientific communication will be fostered if Canadian, United States, and Mexican scientists, editors, and administrators consult Code recommendations for guidance in scientific reports. The Commission will appreciate reports of formal adoption or endorsement of the Code, and asks that they be transmitted to the Chairman of the Commission (c/o American Association of Petroleum Geologists, Box 979, Tulsa, Oklahoma 74101, U.S.A.).

"Any code necessarily represents but a stage in the evolution of scientific communication. Suggestions for future changes of, or additions to, the North American Stratigraphic Code are welcome. Suggested and adopted modifications will be announced to the profession, as in the past, by serial Notes and Reports published in the *Bulletin* of the American Association of Petroleum Geologists. Suggestions may be made to representatives of your association or agency who are current commissioners, or directly to the Commission itself. The Commission meets annually, during the national meetings of the Geological Society of America."

—1982 NORTH AMERICAN COMMISSION ON STRATIGRAPHIC NOMENCLATURE

Field trip guide to zeolite deposits available

The International Committee on Natural Zeolites announces the publication of *Zeo-Trip '83*, a 72-page field trip guide to selected zeolite deposits in eastern Oregon, southwestern Idaho, and northwestern Nevada and to the Tahoe-Truckee Water Reclamation Plant in Truckee, California.

The International Committee on Natural Zeolites (ICNZ) is an informal organization created at Zeolite '76, the International Conference on the Occurrence, Properties, and Utilization of Natural Zeolites held in Tucson, Arizona, in 1976. The stated purpose of ICNZ is to promote and encourage the growing interest in natural zeolite materials throughout the scientific and technical community. During its seven-year history, ICNZ has served as a focal point of worldwide interest in natural zeolites and has been instrumental in the organization of conferences, symposia, and special sessions at national and international meetings on the subject of natural zeolites.

This field trip guide is the latest in a series of publications by ICNZ. *Oregon Geology* readers will be particularly interested in the trip guides by U.S. Geological Survey geologists Richard Sheppard and Arthur Gude, 3rd, to the Durkee, Sheaville, and Rome, Oregon, zeolite deposits. Included in the trip guides are geologic maps, discussions of the local geology, lithologic descriptions, chemical and mineralogical analyses, and photographs and scanning electron micrographs of interesting units and minerals.

Cost of this book is $12. It may be obtained by mail from Dr. F.A. Mumpton, Chairman, International Committee on Natural Zeolites, c/o Department of the Earth Sciences, State University College, Brockport, New York 14420. Additional information about ICNZ and its other publications may also be obtained from the same address. □

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.

GEOPHYSICAL AND GEOCHEMICAL ANALYSES OF SELECTED MIOCENE COASTAL BASALT FEATURES, CLATSOP COUNTY, OREGON, by Virginia Josette Pfaff (M.S., Portland State University, 1981)

The proximity of Miocene Columbia River basalt flows to "locally erupted" coastal Miocene basalts in northwestern Oregon and the compelling similarities between the two groups suggest that the coastal basalts, rather than being locally erupted, may be the westward extension of plateau basalts derived from eastern Oregon and Washington. Selected coastal basalts in Clatsop County, Oregon, were examined geochemically and geophysically; the data lend credence to a plateau origin for the coastal basalts.

Analysis by Instrumental Neutron Activation Analysis and fluxgate magnetometer allowed classification of 36 coastal basalt samples into three chemical types correlative with only those Columbia River basalt plateau flows also found in western Oregon: reversed (R_2) and normal (N_2) low Mg Depoe Bay Basalt, high Mg Depoe Bay Basalt, and Cape Foulweather Basalt (coastal) correlate respectively with reversed (R_2) and normal (N_2) low Mg Grande Ronde Basalt, high Mg Grande Ronde Basalt, and the Frenchman Springs Member of the Wanapum Basalt (plateau). Older Miocene coastal basalts (low Mg Depoe Bay) are found to occur furthest inland, separating the Eocene and plateau basalts to their east from the younger Miocene coastal basalts to their west. A seemingly regional series of low Mg Depoe Bay basalt dikes trending southwest from Nicolai Mountain is actually composed of both reversed and normal flows and can no longer be presumed to indicate a single long fissure. The high Mg Depoe Bay basalt breccia at Saddle Mountain overlies older low Mg basalt; adjacent dikes are also low Mg basalt and could not have served as feeders for the breccia peak. Although Cape Foulweather basalt outcrops along the South Fork of the Klaskanine River are abundantly phyric (Ginkgo unit), geochemically distinct Cape Foulweather basalt along Youngs River and west of the Lewis and Clark River is sparsely porphyritic (Sand Hollow unit). Distribution patterns based on isolated outcrops of basalt types lend themselves to varied interpretations but suggest topographic control by the Eocene highlands and stream valleys.

Gravity traverses conducted over coastal basalt features allow the formulation of models indicating the depth to which such features might extend. The linear, low Mg Depoe Bay basalt dikes underlying Fishhawk Falls (normally polarized) and Denver Point (reversed) extend only 107 m and 45 m, respectively, below the surface. The U-shaped Cape Foulweather basalt dike at Youngs River Falls may be modeled as a shallow (maximum depth 0.23 km below sea level) or deep (minimum depth 0.3 km below sea level) syncline. Alternatively, the basalt might encircle either a hill of somewhat denser sedimentary rock or a buried Eocene volcanic high, in which cases the basalt limbs independently extend 200-300 m below sea level. Arcuate segments of the low Mg Depoe Bay basalt "ring dike" on the Klaskanine River apparently are not connected at depth; the southwest crescent is 100 m deep, while the northeast crescent is an apophysis from a 150-m-thick basalt mass. Abundantly phyric Cape Foulweather basalt outcrops consistently proved to be shallow (100 m or less below the surface). Vertical dikes extending to the Eocene volcanic basement are not suitable for any of the features investigated, while shallow, near-surface basalt masses are either preferred or distinctly possible in all cases.

THE STRATIGRAPHIC RELATIONSHIPS OF THE COLUMBIA RIVER BASALT GROUP IN THE LOWER COLUMBIA RIVER GORGE OF OREGON AND WASHINGTON, by Terry Leo Tolan (M.S., Portland State University, 1982)

The western end of the lower Columbia River Gorge provides a natural cross section through the western flank of the Cascade Range. The oldest exposed unit in this area is the Oligocene to lower Miocene(?) Skamania Volcanic Series, which consists of basalt, andesite, and dacite flows and associated volcaniclastic material. The Skamania Volcanic Series formed a paleotopographic high in the Crown Point-Latourell, Oregon, area which later Columbia River Basalt Group (CRBG) flows surrounded but failed to cover. Flows of the Miocene CRBG within this area belong to the Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt of the Yakima Basalt Subgroup. Thickness of the CRBG in this area ranges from 0 m to greater than 335 m at Multnomah Falls, Oregon. Because of pre-existing topography, regional deformation, and channel and canyon cutting by the ancestral Columbia River no one section contains all 22 CRBG flows that are found in this area. The Grande Ronde Basalt consists of five units recognizable on the basis of chemistry, paleomagnetic polarity, and lithology. These units are, from oldest to youngest, N_1 low-MgO unit, R_2 low-MgO unit, N_2 low-MgO unit, N_2 low-MgO Winter Water flow, and N_2 high-MgO unit. Few interbeds occur in the Grande Ronde section here along the northern margin of the CRBG, whereas the opposite is true for the southern margin in the Clackamas River area. The Wanapum Basalt consists of the Frenchman Springs and Priest Rapids Members. The Frenchman Springs Member is represented by five plagioclase-phyric to aphyric flows in the western half of this area. The Rosalia chemical type of the Priest Rapids Member is present in this area as a 220-m-thick intracanyon flow which overfilled a northwest-trending ancestral Columbia River channel at Crown Point, Oregon. The lower portion of this intracanyon flow consists of a thick, allogenic, bedded hyaloclastite deposit. The burial of the ancestral Columbia River channel by this intracanyon flow forced the Columbia River to shift northward and re-establish a new channel. Because this new channel, the Bridal Veil channel, of the ancestral Columbia River was only partially filled by an intracanyon flow of the Pomona Member of the Saddle Mountains Basalt, the Columbia River continued to occupy the Bridal Veil channel in post-Pomona time.

The Troutdale Formation in the thesis area was deposited by the ancestral Columbia River which occupied the Bridal Veil channel. This formation has been found to be divisible into lower and upper members. The lower member of the Troutdale Formation consists of quartzite-bearing, basaltic conglomerates and micaceous, arkosic sandstones which are confined to the Bridal Veil channel. Two Rhododendron lahars are also intercalated with the lower member conglomerates in the Bridal Veil channel. The upper member of the Troutdale Formation consists of vitric/lithic sandstones with minor basaltic conglomerates which contain Boring Lava clasts. Two Boring Lava flows are intercalated with the upper member, and Boring flows also cap the Bridal Veil channel in this area. Continued alluviation and Boring volcanism appear responsible for the final shift of the Columbia River to its present-day position. Field relationships now suggest the lower age of the Troutdale Formation is 12 million years. Circumstantial evidence suggests the upper age of this formation may be less than 2 million years.

The western end of the lower Columbia River Gorge appears to be relatively undeformed, with no major faults or folds discernible. This area has a relatively uniform 2° to 4° southwesterly dip attributable to Cascadian uplift. Stratigraphic evidence suggests that Cascadian uplift and erosion of the present-day gorge in this area may have begun as recently as 2 million years B.P. □

DOGAMI Governing Board adds new member

Sidney R. Johnson of Baker has been appointed by Governor Victor Atiyeh and confirmed by the Oregon Senate for a four-year term as member of the Governing Board of the Oregon Department of Geology and Mineral Industries. He succeeds C. Stanley Rasmussen, also of Baker, who was board chairman until his term ended on June 30.

Sidney R. Johnson (right) with Governor Atiyeh at swearing-in ceremony on April 27, 1983, in Salem.

Johnson is president of Johnson Homes in Baker. He is a graduate of Baker High School and, after serving in the U.S. Navy, attended the University of Washington and Eastern Oregon State College. He has served on the Baker City Council and as vice president of the Oregon Jaycees.

Serving with Johnson on the three-member board are Allen P. Stinchfield, a resident of North Bend and vice president of Menasha Corporation, Land and Timber Division; and Donald A. Haagensen, a Portland attorney and member of the law firm of Schwabe, Williamson, Wyatt, Moore, and Roberts. □

Salem meteorite to be on display at DOGAMI during October

Pieces of the Salem meteorite that fell on a house in Salem on May 13, 1981 (see *Oregon Geology*, v. 45, no. 6, p. 63-64) will be on display during the month of October in the Portland office of the Oregon Department of Geology and Mineral Industries. People wishing to see the pieces of meteorite should come to the main office, Room 1005, State Office Building, 1400 SW 5th, in downtown Portland. □

Check ownership of sand and gravel before planning development

Sand and gravel developers on private land in eastern Oregon and Washington should be certain that they own the materials before investing in development, according to William G. Leavell, Bureau of Land Management Director for the two states.

Leavell said that a recent U.S. Supreme Court decision confirms the fact that the sand and gravel is federally owned on land where only the surface is privately owned but where the U.S. has retained title to all coal and minerals in the original patent. This is the situation on 3.4 million acres in Oregon and 513,000 acres in Washington.

The decision deals with land passed from federal to private ownership under the Stock-Raising Homestead Act of 1916. A section of the act reserved federal title to all the coal and minerals. The key point is the Supreme Court confirmed that sand and gravel are minerals reserved to the U.S.

Leavell said, "This was the last of the homestead acts, providing for settlement of homesteads on land where the surface was chiefly valuable for grazing and raising forage crops."

Nationally, 33 million acres were transferred under the act to private owners who lived on the land for three years and made permanent improvements to increase the land's value for stock raising. In Oregon there were 8,282 such homesteads, and in Washington there were 1,600.

The recent ruling reversed a decision of the U.S. Tenth Circuit Court of Appeals in the case of James G. Watt, Secretary of the Interior, et al., petitioners v. Western Nuclear, Inc.

—BLM News

Member clubs of Oregon Council of Rock and Mineral Clubs listed

The following clubs are all members of the Oregon Council of Rock and Mineral Clubs, Inc. For more information about the Council and its activities, contact the Council's information officer, Harold Dunn, 91218 Donna Road, Springfield, OR 97477, phone (503) 746-3063. For information about specific clubs, contact the address given for that club.

Blue Mountain Gem and Mineral Club
504 N. Ave.
La Grande, OR 97850

Columbia Gorge Rockhounds
Rt. 2, Box 1380
Corbett, OR 97010

Columbia Rock and Gem Club
Rt. 5, Box 5838
St. Helens, OR 97051

Eugene Mineral Club
2708 Potter St.
Eugene, OR 97405

Far West Lapidary and Gem Society
PO Box 251
Coos Bay, OR 97420

Laneco Earth Science Organization
4057 Camellia St.
Springfield, OR 97477

Mile Hi Rock Rollers
936 No. 7th St.
Lakeview, OR 97630

Newport Agate Society
PO Box 411
Newport, OR 97365

Oregon Agate and Mineral Society
8242 SE 74th Ave.
Portland, OR 97206

Oregon Coast Agate Club
Box 293
Newport, OR 97365

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233 NW Hillcrest Dr.
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2945 NE 108th
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PO Box 370
Springfield, OR 97477

Tek Rock Club
PO Box 491
Beaverton, OR 97075

Trails End Gem and Mineral Club
Rt. 3, Box 612
Astoria, OR 97103

Willamette Agate and Mineral Society
2511 Wayside Terr. NE
Salem, OR 97303 □

NEW DOGAMI PUBLICATIONS

NEW GEOLOGIC MAP OF BATES NE QUAD, EASTERN OREGON GOLD-MINING COUNTRY

A new geologic map of the northeastern portion of the Bates 15-minute quadrangle in eastern Oregon has just been published by the Oregon Department of Geology and Mineral Industries (DOGAMI). The new map, *Geology and Gold Deposits Map of the Northeast Quarter of the Bates Quadrangle, Baker and Grant Counties, Oregon*, by Howard C. Brooks, Mark L. Ferns, Greg R. Wheeler, and Dan G. Avery, has been released as Map GMS-29 in DOGAMI's Geological Map Series.

This new map is the latest eastern Oregon gold-country geologic map done by DOGAMI in cooperation with and funded in part by the U.S. Forest Service. Earlier maps of this series, which are also available from DOGAMI, include the Bullrun Rock, Rastus Mountain, Bourne, Mount Ireland, Granite, and Greenhorn 7½-minute quadrangles and the Mineral, Huntington, and Olds Ferry 15-minute quadrangles.

The new, four-color geologic map of the Bates NE quadrangle is at a scale of 1:24,000. It shows sedimentary, volcanic, and metamorphic geologic units that were deposited or formed over a period of time extending from the present day back to the pre-Permian (more than 280 million years ago). The geology of this area is very complex, and two cross sections are included to show the relationships of the 15 geologic units presented on the map.

Parts of this area have been mineralized, and the map covers the western part of the Greenhorn mining district. Shown on the map, therefore, are locations of numerous mines, prospects, and quartz veins. Included on the map sheet are a data table of mines and prospects, a list of references about the area, a table with chemical analyses of rock samples, and a discussion of mineral deposits in the Bates NE quadrangle. Cost of Map GMS-29 is $5.

RESULTS OF STREAM-SEDIMENT SAMPLING PROGRAM IN OCHOCO NATIONAL FOREST

The Oregon Department of Geology and Mineral Industries has released the results of a pilot program of geochemical surveying in the Ochoco National Forest. The report has been published as DOGAMI Open-File Report 0-83-4 and is entitled *Geochemical Survey of the Western Part of the Ochoco National Forest, Crook and Wheeler Counties, Oregon.*

The report consists of three parts: (1) a 38-page text discussing the geology and the mineral potential of the study area, sampling and analytical techniques used in the study, and computer-generated-element abundance maps; (2) a one-color map of the combined Lookout Mountain and Ochoco Reservoir 15-minute quadrangles, a nearby area of special interest, showing geology, sample locations, and analytical data; and (3) three microfiche containing raw data, statistical data, and sample location maps.

Funded by the U.S. Forest Service, the geochemical survey was conducted by DOGAMI staff members M.L. Ferns and H.C. Brooks in September and October of 1982. A total of 352 stream-sediment samples and 23 rock-chip samples were collected and analyzed for gold, silver, arsenic, copper, mercury, molybdenum, lead, and zinc. Results of the study show that geochemical sampling is an effective means to identify potential mineral resource areas for USFS land-use planning. Cost of Open-File Report 0-83-4 is $6.

NEW GEOLOGIC MAP OF WEST HALF OF VANCOUVER 1° BY 2° QUAD

A new geologic map published by the Oregon Department of Geology and Mineral Industries features about 55 million years of geologic history of Oregon's northwest corner, including the area of the Mist gas field and the coast from Seaside to Lincoln City. It is released jointly by DOGAMI and the U.S. Geological Survey.

The new map is published by DOGAMI as Open-File Report 0-83-6 in the Department's open-file series. Entitled *Preliminary Geologic Map of the West Half of the Vancouver 1° by 2° Quadrangle, Oregon*, the three-by-four-foot blackline map extends from Tillamook Head in the northwest to the edge of the Salem-Keizer area in the southeast. Produced in cooperation with the U.S. Geological Survey and funded in part by the Office of Coastal Zone Management, the map (scale 1:250,000) depicts 47 bedrock and surficial geologic units, reflecting the latest geologic thinking by leading scientists in the area and in universities of the region. Cost of Open-File Report 0-83-6 is $6.

All of the above publications may be purchased from the Portland office of the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR 97201. All orders under $50 must include payment. □

New cartography fellowship available

The American Congress on Surveying and Mapping (ACSM) and the American Society of Photogrammetry (ASP) have announced a new fellowship, the John W. Pumpelly Fellowship Award in Cartography. The fellowship has been made possible through National Tire Wholesale, Inc. by John Reed Pumpelly and W. Pumpelly, topographic engineer and cartographer of the U.S. Geological Survey for more than 38 years.

The purpose of the award is to provide financial assistance to persons pursuing a full-time course of graduate study in cartography or a related field. The award consists of a $2,000 check to the recipient. Any member of the ACSM or ASP may apply. For details and application forms contact: Education Director, ACSM-ASP, 210 Little Falls Street, Falls Church, VA 22046.

—Design Graphics World

(**Fossil Cetacea**, *continued from page 98*)

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Available publications

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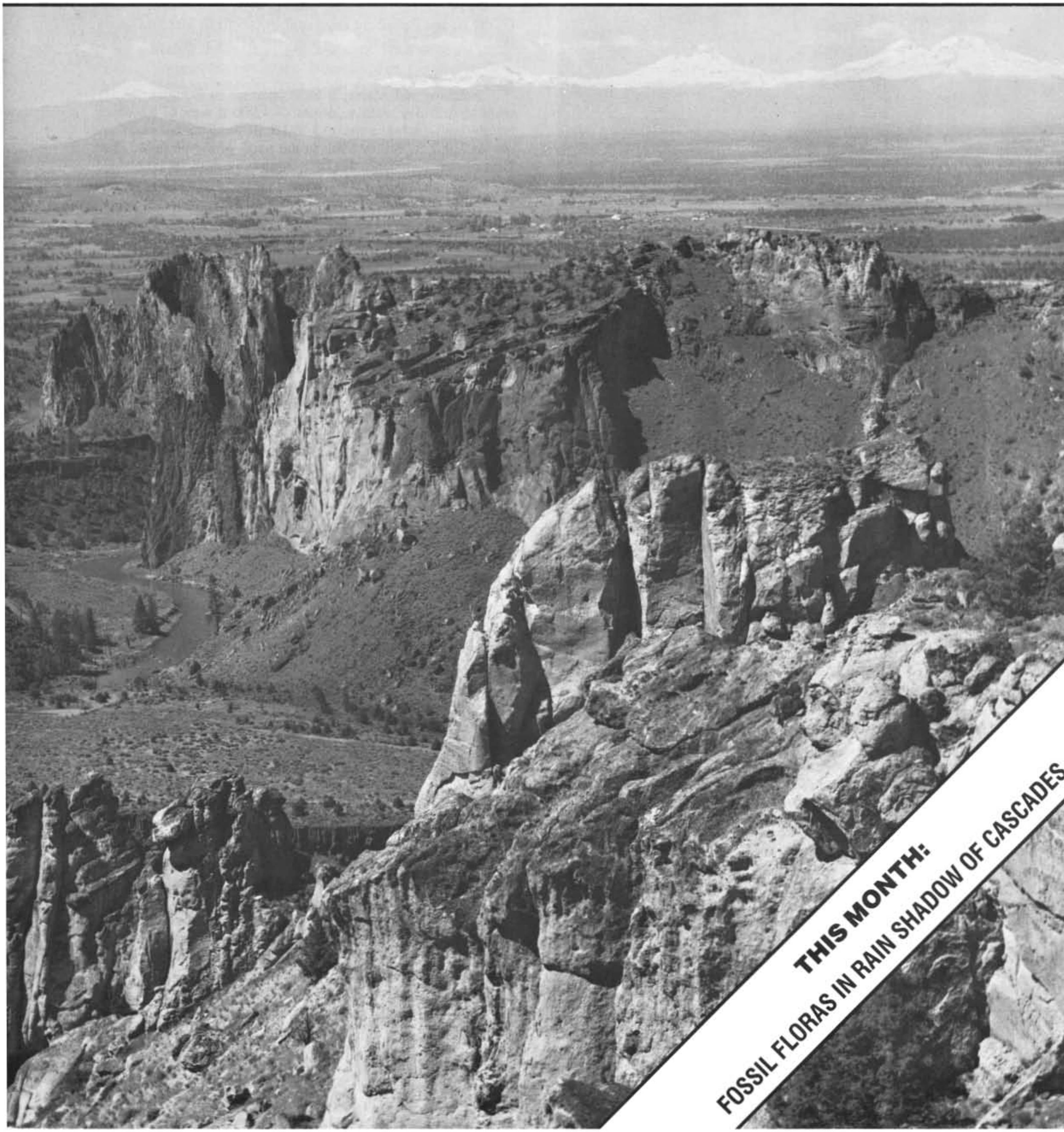

THIS MONTH:
FOSSIL FLORAS IN RAIN SHADOW OF CASCADES

OREGON GEOLOGY

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COVER PHOTO

Smith Rock, central Oregon. Fossils found near this point document developing rain shadow effect as Cascade Mountain Range in background was forming. Photo courtesy Oregon State Highway Division.

OIL AND GAS NEWS

Clackamas County exploration

After nearly 75 years, Clackamas County will see oil and gas exploration again. A 1,200-ft well drilled in 1910 north of Oregon City was the last well drilled for hydrocarbons in the county. Now, RH Exploration of Portland has applied for permits to drill three locations near Molalla (table below). The wells are planned for 3,500 to 4,000 ft. The nearest existing wells are Humble, Wicks 1 (7,797 ft) and Reichhold Bagdanoff (6,005 ft) in Marion County. Both are about 12 mi from the proposed RH locations.

Douglas County

Hutchins and Marrs, a local operator in Douglas County, plans to drill five wells to depths of 4,000 ft west of Roseburg. Nearby wells include a well to 3,693 ft, drilled 5 mi to the east, and one to 7,002 ft, drilled 9 mi to the north of the proposed sites. Drilling may commence this fall as soon as a contractor is obtained.

Columbia County

Reichhold Energy Corporation plans to resume drilling this fall in the Mist Gas Field area. The company has submitted applications to drill for five new locations (table below). These wells will seek new pools in the Clark and Wilson sand of the Cowlitz Formation.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
240	RH Exploration Rose 1 005-00002	NE¼ sec. 20 T. 5 S., R. 1 E. Clackamas Co.	Application; 3,500
241	RH Exploration Anderson 1 005-00003	SW¼ sec. 29 T. 5 S., R. 1 E. Clackamas Co.	Application; 3,500
242	RH Exploration Rose 2 005-00004	SW¼ sec. 20 T. 5 S., R. 1 E. Clackamas Co.	Application; 4,000
243	Reichhold Energy Corp. Investment Management 21-20 009-00117	NW¼ sec. 20 T. 6 N., R. 4 W. Columbia County	Location; 2,500
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

(Continued on page 114, **Recent permits***)*

CONTENTS

Seven fossil floras in the rain shadow of the Cascade Mountains, Oregon

by Melvin Ashwill, 940 SW Dover Lane, Madras, Oregon 97741

This paper represents a progress report of work on fossil flora found just east of the Cascade Range in Oregon. The plants of seven fossil floras (Table 1), selected from a number in the Madras, Oregon, area (Figure 1), give some indication of changes in climate from late Eocene time to early Pliocene time. Since all of the floras are found immediately east of the Cascade Range, it is thought they may help to document the "rain shadow" effect of the growing mountain range.

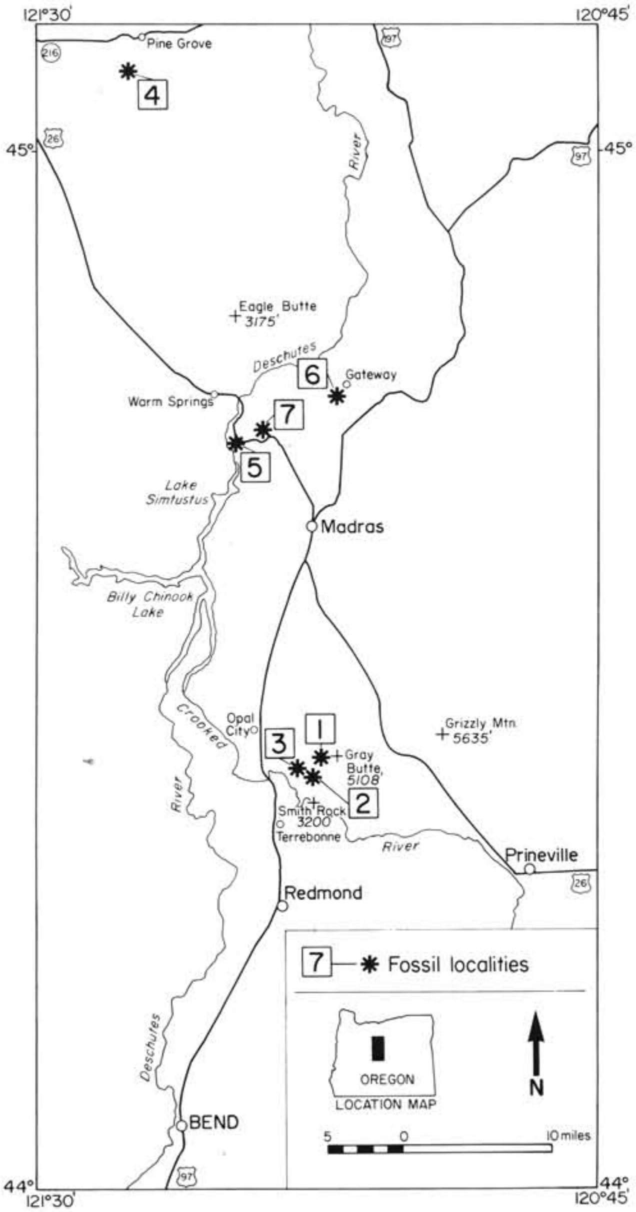


Figure 1. Map showing area of central Oregon discussed in this paper. Numbers indicate locations where the following fossil floras are found: 1. Sumner Spring flora; 2. Nichols Spring flora; 3. Canal flora; 4. Foreman Point flora; 5. Pelton flora; 6. Vibbert flora; and 7. Deschutes flora.

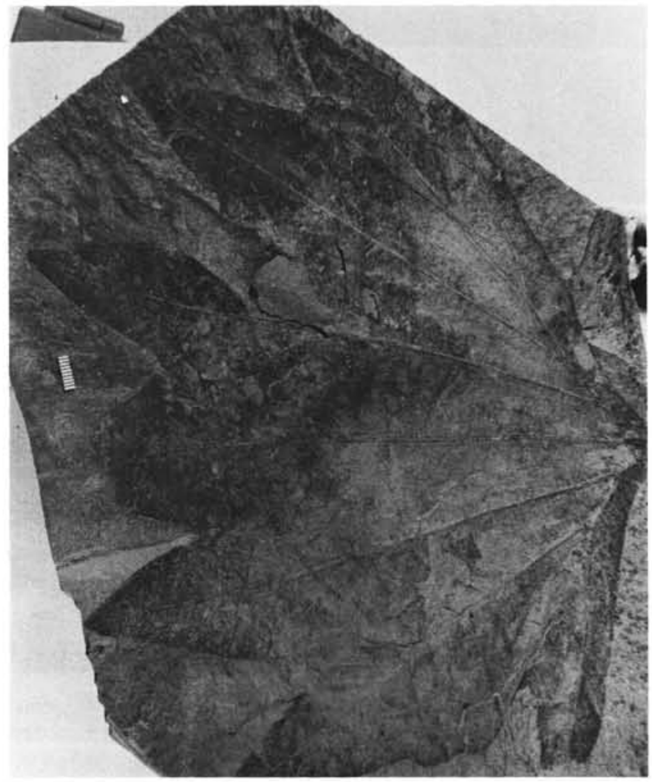
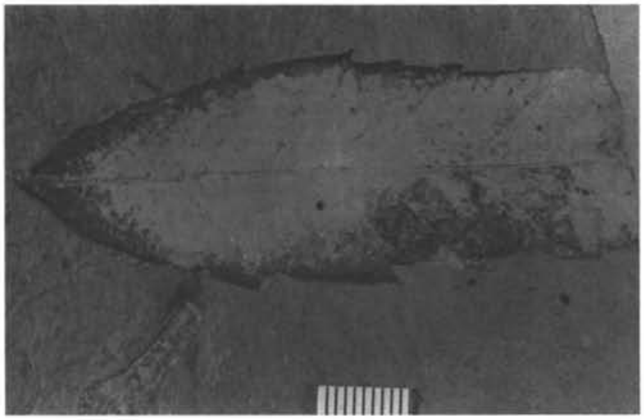


Figure 2. Platanophyllum whitneyi *(Lesquereux) MacGinitie (sycamore), Sumner Spring flora, late Eocene or early Oligocene age. Scale in millimeters.*

It is known that the change of climate in central and eastern Oregon from the Eocene moist subtropical conditions to the harsher semiarid environment found there today is partly a response to the hemispheric climatic changes. It is clear, however, that a large part of the change is also due to the developing Cascade Range that acted as a barrier to precipitation. Documentation of the rate of the change in climate remains inadequate because of gaps in the fossil record. Some recently discovered fossil floras near Madras, however, when considered in addition to the classic Deschutes flora of Chaney (1938), are helping to fill those gaps.

These seven sites, all located within a circle with a 39-km radius, range in age from late Eocene to early Pliocene (time scale of Berggren and Van Couvering, 1974). One of the floras is immediately below a basalt flow of the Columbia River Basalt Group, and three other floras lie above basalts of the same group in sediments that accumulated in the valley lying between the developing Cascade Range to the west and the older Ochoco and Blue Mountains to the east. All seven floras are less than 48 km from the summit of the Cascade Range.

The oldest flora considered here is the Sumner Spring flora (Figures 2 and 3), which is found 24 km southeast of Madras (SE¼SE¼ sec. 24, T. 13 S., R. 13 E.). The area includes a florule long known locally and was once visited briefly by Chaney (Vance, 1936). The general area was originally mapped as Clarno Formation (Eocene) by Hodge (1942) and later as John Day Formation



3a△ *3b*▽

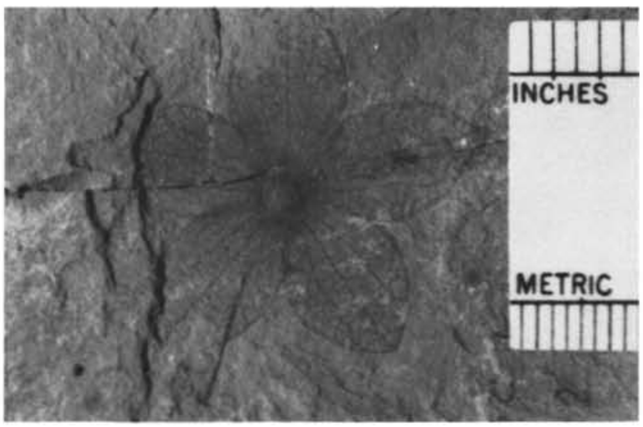


Figure 3. Sumner Spring flora, late Eocene or early Oligocene age: a. Quercus simulata *Knowlton (oak); b. five-petaled flower of* Viburnum palmatum *Chaney and Sanborn (high bush cranberry). Scale of Figure 3a in millimeters, lower edge of scale in Figure 3b in millimeters.*

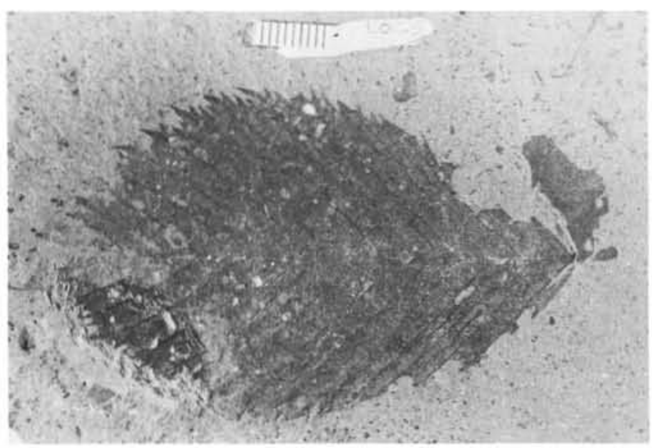
(Oligocene and early Miocene) by Waters (1968). More recent mapping by Robinson and Stensland (1979) indicates that exposures of both the Clarno and John Day Formations are found locally. The site of the Sumner Spring flora is mapped by Robinson and Stensland (1979) as Clarno Formation. Although the writer has no stratigraphic evidence as to the age of the rocks, the floral composition of the fossil assemblage suggests a late Eocene or early Oligocene time of deposition. Leaf margin analysis of a small assemblage suggests a warm, temperate paleoclimate. By far the dominant element in this flora is *Platanophyllum whitneyi* (Lesquereux) MacGinitie, an extinct type of sycamore common in some Eocene floras (Figure 2). The oaks in this flora are the evergreen type, while oaks of later floras here are the deciduous lobed varieties consistent with a change toward more temperate conditions (Figure 3). The presence of the fossil fish *Amyzon*, a member of the sucker family (Cavender, written communication, 1981), confirms that the deposit consists of pond or lake sediments. Negative evidence as to the age of the sediments includes the conspicuous absence of the moisture-loving *Metasequoia*, the so-called "dawn redwood," not common in Eocene floras but abundant in Oligocene floras of central Oregon.

A few kilometers from this flora, a second site (SW¼SW¼ sec. 26, T. 13 S., R. 13 E.) with a different floral assemblage holds the Nichols Spring flora (Figure 4). It appears to be early Oligocene or older in age and includes fruits of the tropical vine *Paleophytocrene* (Figure 4c), an extinct genus of the Icacineae family, as well as lauraceous leaves. Again, *Metasequoia* is not found here.

A third flora located in the same general area (NW¼NE¼ sec. 34, T. 13 S., R. 13 E.) is the Canal flora. The site is mapped as Clarno Formation by Robinson and Stensland (1979) and is 61 m above a brownish saprolite typical of soils near the top of the Clarno Formation. The floral elements here (*Metasequoia*, *Alnus*, *Betula*, *Ulmas*, *Crataegus*, and *Ptelea*) are typical of John Day Formation assemblages in the region. A probable middle Oligocene age is suggested. *Metasequoia* (Figure 5) is the dominant element. In south-central China, where some of these trees are found today (Chu and Cooper, 1950), annual rainfall is 115 cm, the climate is mild, and freezing temperatures are rare. Other trees growing in China today with the *Metasequoia* include the conifer *Cunninghamia*, as well as *Castanea* (chestnut), *Liquidambar* (sweet gum), *Rhus* (sumac), and *Cornus* (dogwood). It should be noted, in contrast, that the present annual rainfall at Madras is about 29 cm.

The modern Cascade Range was not in existence in its present form when the Sumner Spring, Nichols Spring, and Canal floras were flourishing. Although there is some disagreement about details of timing and events, it appears that the expanse between Madras and the ocean strand, then located along the eastern edge of the present Willamette Valley, was not high enough in elevation to greatly modify the interior climate.

Near Pine Grove, the Foreman Point flora is found immediately below a flow of the Columbia River Basalt Group (NE¼NE¼ sec. 2, T. 6 S., R. 11 E.), and the unit is interpreted as uppermost John Day Formation. This level may represent an interval in time during the development of the Cascade Range. Floral constituents include *Salix* (willow), *Alnus* (alder), three species of *Quercus* (oak) (Figure 6), *Ulmus* (elm), and *Platanus* (sycamore). Oaks are dominant in this assemblage. One indication of the trend toward less precipitation is the absence of *Taxodium* (bald cypress) and *Sequoia* (redwood). These two types of trees are abundant in a



4a△ *4b*▽ *4c*▽

Figure 4. Nichols Spring flora, late Eocene or early Oligocene age: a. Ostrya oregoniana *Chaney (hop hornbeam); b.* Carya *sp. (hickory) fruit; c.* Paleophytocrene *sp. fruit. Scale in millimeters.*

Figure 5. Metasequoia occidentalis *Chaney ("dawn redwood"), Canal flora, Oligocene age. Left edge of scale in millimeters.*

nearby upper John Day flora lying about 152 m below the base of a flow of the Columbia River Basalt Group. In the Blue Mountains to the east, these same genera remained plentiful several millions of years later in the Mascall flora (Chaney and Axelrod, 1959).

Near Pelton Dam on the Deschutes River, 13 km northwest of Madras, the Pelton flora (Figure 7), which is roughly correlative in time with the Blue Mountains flora of eastern Oregon (Chaney and Axelrod, 1959) and the Clarkia flora near Moscow, Idaho (Smiley and Rember, 1979), rests immediately atop the Columbia River Basalt Group (SE¼SE¼ sec. 12, T. 10 S., R. 12 E.). Donald A. Swanson (written communication, 1981) considers the Grande Ronde flows of the Columbia River Basalt Group to be in the neighborhood of 15 to 16 million years old. Steven Reidel (written communication, 1981) reports that Saleem Farooqui, who had the ages determined for several basalt flows in the vicinity, considers the sediments containing the flora to be 13 ± 1 million years old. The flora is thus regarded here as mid-Miocene. Leaves are preserved here in a rolled attitude typical of mudflow entrapment. The flora, consisting, in part, of *Robinia* (locust), *Quercus* (oak) (Figure 7a), and *Crataegus* (hawthorn) (Figure 7b), and lack of the conifers typical of a moist environment suggest a climate that was drier than that of the mountains to the east, where the flora included *Taxodium* (bald cypress), *Picea* (spruce), *Fagus* (beech), and *Sequoia* (redwood). The Foreman Point flora and the Pelton flora together suggest a drier condition in the rain shadow of the Cascade Range than existed farther to the east. Thus, the barrier created by the developing Cascade Range may have already been having some

Figure 6. Quercus dayana *Knowlton (oak), Foreman Point flora, Miocene age. Scale in millimeters.*

Table 1. Plants identified in each of the seven fossil floras

CANAL FLORA
Pteris silvacola Hall (fern)
Polypodiaceae (fern)
Metasequoia occidentalis Chaney (dawn redwood)
Alnus sp. (alder)
Betula sp. (birch)
Ulmus sp. (elm)
Crataegus sp. (hawthorn)
Ptelea sp. (hop tree)
Rosa sp. (rose)

FOREMAN POINT FLORA
Cocculus sp. (moonseed)
Salix sp. (willow)
Salix hesperia Knowlton (willow)
Alnus corrallina Lesquereux (alder)
Quercus dayana Knowlton (oak)
Quercus sp. (oak)
Quercus sp. (black oak)
Ulmus sp. (elm)
Zelkova sp. (keaki tree)
Liquidambar sp. (sweet gum)
Platanus sp. (sycamore)
Acer sp. (maple)

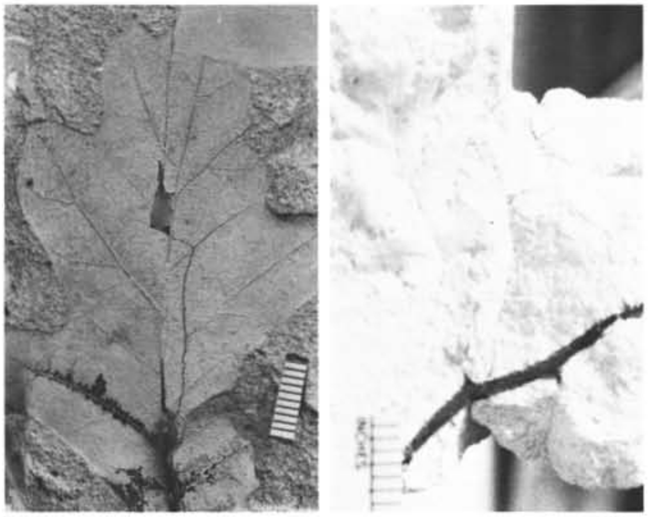
PELTON FLORA
Quercus sp. (oak)
Quercus sp. (black oak)
Ulmus sp. (elm)
Liquidambar sp. (sweet gum)
Platanus sp. (sycamore)
Crataegus sp. (hawthorn)
Acer sp. (maple)
Robinia sp. (locust)

VIBBERT FLORA
Populus sp. (poplar)
Quercus sp. (black oak)
Platanus sp. (sycamore)
Acer sp. (maple)

DESCHUTES FLORA
Populus pliotremuloides Axelrod (quaking aspen)
Populus alexanderi Dorf (cottonwood)
Salix florissanti Knowlton and Cockerell (willow)
Quercus sp. (oak)
Prunus irvingi Chaney (cherry)
Acer negundoides MacGinitie (box elder)

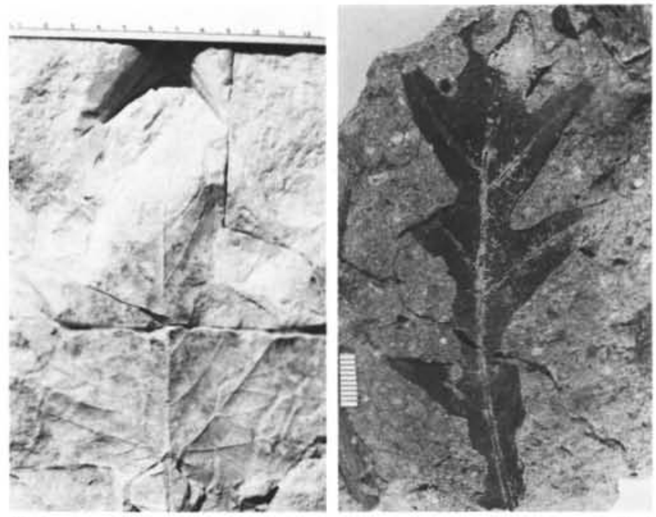
SUMNER SPRING FLORA
Equisetum sp. (horsetail)
Keteleeria sp.
Picea sp. (spruce)
Pinus sp. (pine)
Typha sp. (cattail)
Englehardtia sp. (walnut family)
Quercus simulata Knowlton (oak)
Liquidambar sp. (sweet gum)
Platanus sp. (sycamore)
Platanophyllum whitneyi (Lesquereux) MacGinitie (sycamore)
Ailanthus sp. (tree of heaven)
Acer sp. (maple)
Tetrapteris-like fruits

NICHOLS SPRING FLORA
Cinnamomum sp. (cinnamon)
Salix sp. (willow)
Carya sp. (hickory)
Alnus sp. (alder)
Ostrya oregoniana Chaney (hop hornbeam)
Castanea sp. (chestnut)
Sapindus sp. (soapberry)
Platanus nobilis Newberry (sycamore)
Paleophytocrene sp.



7a△ 7b△

Figure 7. Pelton flora, mid-Miocene age: a. Quercus *sp. (oak), scale in millimeters; b. leaves of* Crataegus *sp. (hawthorn) still attached to silicified stem. Scale in sixteenths of inches.*



8a△ 8b△

Figure 8. Vibbert flora, late Miocene age: a. Platanus *sp. (sycamore), scale in both English and SI units; b.* Quercus *sp. (oak), scale in millimeters.*

effect on the weather by mid-Miocene time.

Somewhat higher in the stratigraphic sequence, a flora (Figure 8) at the Vibbert gravel pit (SE¼SE¼ sec. 19, T. 9 S., R. 14 E.) near Gateway adds a significant chapter to the record. In a study of vertebrate fauna at this site, Cavender and Miller (1972) assign a tentative "mid-Pliocene" age (late Miocene, according to the time scale of Berggren and Van Couvering, 1974). Leaves of *Platanus* (sycamore) (Figure 8a) and two species of *Quercus* (oak) (Figure 8b) extend the known range of these genera considerably later in time than previously documented in the area. These plants, along with large leaves of *Populus* (poplar) and *Acer* (maple), indicate that late Miocene conditions obviously did not approach the present state of aridity in central Oregon.

The final flora to be noted in this paper is the Deschutes flora of Chaney (1938). Fossil localities are about 18 m below the basalt rimrock 10 km northwest of Madras (NW¼NE¼ sec. 8, T. 10 S., R. 13 E.). The age of this flora has been determined to be 4.3 million years (Evernden and James, 1964). As noted in Chaney's study, the assemblage of *Salix* (willow), *Populus* (cottonwood and quaking aspen) (Figure 9), *Prunus* (chokecherry), and *Acer* (box elder) clearly indicates a condition nearing modern semiaridity. To Chaney's floral list for this locality may now be added a lobed form of *Quercus* (oak) recently collected from the bottom layers of the deposit. A newly discovered assemblage called the Rehermann flora lies less than 1 km from the Deschutes flora site and stratigraphically 5.5 m above it. Lithologic and floral similarities in the material from the Rehermann and Deschutes sites suggest that they are correlative. *Alnus* (alder) has been identified in the Rehermann flora and may be added to the list of plants growing there in early Pliocene time. Alder and willow are found today on the banks of the Deschutes River 3 km away.

The snow-capped peaks of the youthful High Cascades rise to heights of 2,379 to 4,395 m above sea level (Harris, 1976). Between the peaks, there are scores of kilometers where the elevation of the skyline is in the range of 1,220 to 1,830 m (Highsmith and Leverenz, 1962). Since the stratovolcanoes of the High Cascades were not present until after the deposition of the seven floras discussed here (Baldwin, 1964; Taylor, 1981), the peaks were not a factor in the paleoclimate affecting the floras. The older portions of the Cascade Range, however, may have begun to affect the Madras area as early as late Miocene time, as shown by the Foreman Point flora.

Many oak trees (*Quercus garryana* Douglas) presently grow at the Foreman Point site, making this genus one of the few represented in every age in central Oregon from the Eocene down to the present, excepting the Pleistocene which awaits documentation. Other persistent genera found in some central Oregon floras through the ages and still growing there today include *Celtis* (hackberry), *Crataegus* (hawthorn), *Alnus* (alder), and *Salix* (willow). *Platanus* (sycamore), although extinct in Oregon now, grew profusely from Eocene time until the time of the late Miocene Vibbert flora. *Acer* (maple) is documented in all ages from Eocene to early Pliocene time (Deschutes flora) but is found locally now only in isolated patches of escaped *Acer negundo* (box elder) or in small islands of *Acer macrophyllum* (big-leaf maple) in canyons that are tributary to the Deschutes River near the base of the Cascade Range. The Pelton flora, several millions of years younger than the Foreman Point flora, reflects a still drier trend. These two floras indicate that the Cascade Range, even in its juvenile stages, was affecting the climate of central Oregon to an unexpected degree. On the other hand, the Vibbert flora shows that enough precipitation still fell in the area in early Miocene time to sustain a healthy growth of *Populus* (poplar), *Platanus* (sycamore), *Quercus* (oak), and *Acer* (maple). The change from a warm, moist, temperate climate to one that is semiarid has been, not surprisingly, a gradual process.

Figure 9. Populus pliotremuloides *Axelrod (quaking aspen), Deschutes flora, early Pliocene age. Scale in millimeters.*

This article on some Tertiary fossil floras in central Oregon is a preliminary report. Future discussions, based on ongoing studies, will include leaf-margin and size analyses and comparisons of floral diversity between localities.

The writer maintains a substantial educational display of central Oregon fossils at his home near Madras. Numerous individuals and several school and summer science camp groups make use of the collection each year. Those readers interested in the display or in precise information on the locations of the fossils discussed in this paper are invited to contact the writer.

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BLM calls for public input on areas of mineral potential

The U.S. Bureau of Land Management (BLM) is inviting recommendations from both the public and industry nominating "Areas of Critical Mineral Potential" (ACMP).

The move stems from President Reagan's April 5, 1982, report to the Congress on his National Materials and Minerals Management Program Plan calling for an invitation to the public to nominate areas of high mineral interest. Nominations will be used to identify areas of critical mineral potential for priority withdrawal review.

Robert F. Burford, director of the BLM, said that information gathered in the process will help to stimulate review of areas presently withdrawn or "off-limits" to energy and mineral entry or development. The nominations will also provide a basis for negotiating access to minerals on public lands withdrawn by other agencies.

Withdrawn areas in Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming can be nominated, except for Indian reservations and other Indian holdings; lands in the National Wildlife Refuge System; and other lands administered by the U.S. Fish and Wildlife Service, National Park System, Wild and Scenic Rivers System, National System of Trails, and designated wilderness areas. Areas within BLM or Forest Service Wilderness Study Areas may be nominated and will be treated as part of the wilderness study program.

Nominations should be in the form of a letter written as specifically as possible and including the following information:

1. Minerals of interest.
2. A map or land description showing the area nominated.
3. A brief statement of the rationale for the nomination, i.e., mineral occurrence or exploration potential.
4. A brief description of the nature and the effect of the withdrawal or segregation, if known.
5. The name, address, and telephone number of a person who may be contacted by BLM to review the nomination.

Geologic maps, cross-sections, and sample analyses may be included. Published literature and reports may be cited in support of the nominations. Any data considered confidential should be appropriately marked. Nominations should be limited to no more than three typewritten pages excluding any maps or bibliographic materials. Send nominations to: Director (690), Bureau of Land Management, 1800 C Street N.W., Washington, D.C. 20240.

After Washington Office review, nominations will be sent to BLM State and District offices for processing. Each party making a nomination will be notified of the action BLM plans to take regarding the nominated area.

If you have any questions or desire further information about the review process or status of your nomination, please call the Division of Mineral Resources, Oregon State Office, (503) 231-6812. □

USGS High-Altitude Photography Program nearly complete for Oregon

The U.S. Geological Survey's high-altitude photography of Oregon is nearing completion. As of July 1, 1983, only the extreme southeastern corner of the state has not been completed. That area includes the Adel and parts of the Burns (east half), Boise, and Jordan Valley (Oregon parts of both) 1°×2° quadrangles.

For more information, see the announcement on p. 62 in the June issue of *Oregon Geology*. □

DOGAMI sells geologic publications over-the-counter or by mail

Some of our readers may not be aware that as part of its mission to provide geologic and related information to the public, the Oregon Department of Geology and Mineral Industries (DOGAMI) sells a wide variety of geologic publications in the main office in Portland and in the Baker and Grants Pass field offices. Many of the publications summarize our own studies and were published by DOGAMI; others are from other sources but are made available to the public by DOGAMI because the material is related to the geology of Oregon, is timely, and fills a general public demand.

DOGAMI PUBLICATIONS

Available DOGAMI serial publications are listed on the back cover of the magazine as long as a sufficient supply remains available. Because they are printed in rather limited numbers, some go out of print all too quickly. Since Department resources are allocated for the publication of results of current investigations, out-of-print items are usually not reprinted.

The following publications are close to going out of print and should be ordered by interested buyers as soon as possible. The supply of some, in fact, is so low that their names have already been taken off the publication list:

BULLETINS

26. Soil: Its origin, destruction, and preservation (Twenhofel, 1944)	$1.00
60. Engineering geology of the Tualatin Valley region (four maps only, text is out of print) (Schlicker and Deacon, 1967)	4.00
77. Geologic field trips in northern Oregon and southern Washington (GSA field trip guides, 1973)	5.00
79. Environmental geology of inland Tillamook and Clatsop Counties (Beaulieu, 1973)	7.00
83. Eocene stratigraphy of southwestern Oregon (Baldwin, 1974)	4.00
84. Environmental geology of western Linn County (Beaulieu and others, 1974)	9.00
85. Environmental geology of coastal Lane County (Schlicker and others, 1974)	9.00

MAPS

Geologic map of the Albany quadrangle (Allison, 1953)	1.00

MISCELLANEOUS PAPERS

6. Oil and gas exploration in Oregon (Stewart and Newton, 1965)	3.00
16. Mosaic of Oregon from ERTS-1 imagery (1973)	2.50
17. Geologic hazards inventory of the Oregon coastal zone (Beaulieu and others, 1974)	5.00

SHORT PAPERS

2. Industrial aluminum – a brief survey (Motz, 1940)	1.00
18. Radioactive minerals the prospector should know (White and others, 1976)	.75
23. Oregon King mine, Jefferson County (Libbey and Corcoran, 1962)	3.00
26. Rock material resources of Umatilla County (Schlicker and others, 1976)	4.00

DOGAMI periodically releases open-file reports containing such material as geothermal-gradient data, geophysical data, geologic maps, micropaleontological data, bibliographic information, geochemical data, and mineral resource assessments. These reports have not been edited to usual DOGAMI standards but because they are of immediate interest they are released in a preliminary form, often with such signal words as "preliminary" or "reconnaissance" in their titles. A list of the currently available 66 open-file reports is available *free upon request* from the Portland office.

Back copies of the Department's magazine, both the current *Oregon Geology* and its predecessor, the *Ore Bin*, are also for sale.

Clerical assistant Pat Maloney (left) assists a customer in finding the right topographic quadrangle maps.

Single issues of *Oregon Geology* cost $.75 over the counter and $1 mailed; single issues of the *Ore Bin* cost $.50 over-the-counter and $1 mailed. Complete *Ore Bin* volumes (12 issues) are still available for the years 1963, 1966, 1972, 1973, 1974, 1975, 1977, and 1978 and when ordered as a complete set may be purchased at the reduced rate of $3 for each year.

The publication sales staff has assembled a number of packets of still-available back issues of the *Ore Bin* and *Oregon Geology* so that readers interested in specific subjects may, without the need to study indexes or reference lists, buy all still in-print pertinent materials published in the magazine since it was started in 1939. The number of magazines in each packet varies, of course, depending on how many articles were published on a specific subject, but the cost of each packet is roughly half the cost of the magazines if they were purchased individually.

There are three groups of such packets. The first consists of special interest subjects: Mount St. Helens ($3), geothermal exploration and development ($6), fossils ($6.50), oil and gas exploration and development ($3), state parks ($3), coastal geology ($7), meteorites ($3), earthquakes ($3), field trip guides ($5), landslides ($2), caves/lava tubes ($2), and offshore geology (continental shelf, etc.) ($3).

The second group of packets is by location. Areas covered by individual packets include the John Day area ($3.50), Baker County ($3), Wasco and Jefferson Counties ($3), Tillamook and Lincoln Counties ($4), Grant County ($3), Gilliam and Wheeler Counties ($3.50), Clatsop and Columbia Counties ($4), Coos and Douglas Counties ($4), Harney and Malheur Counties ($2.50), Deschutes and Crook Counties ($3), Umatilla/Union/Wallowa Counties ($4), Yamhill/Washington/Multnomah/Clackamas Counties ($4), Jackson and Klamath Counties ($3), Lake County ($3), Lane County ($2), Benton/Marion/Linn Counties ($3), Curry County ($3.50), and Josephine County ($3).

The third group of packets is devoted to minerals. Subjects of packets on metallic minerals and their costs are as follows: gold ($4), chromite/black sands ($2), sulfide ores ($2), copper/silver/nickel ($2), aluminum (bauxite) ($2), platinum/iron/manganese/uranium ($2), and mercury ($1.50). A "superpacket" containing articles on all the metallic minerals costs $15. A superpacket for nonmetallic minerals costs $9, while individual nonmetallic mineral packets cost as follows: marble/limestone/sodium chloride/soapstone/silver/perlite/diatomite/coal ($3), rock materials ($2.50), lightweight aggregate/pumice ($2), and clinoptilolite/cement/carbon dioxide/boron/asbestos ($2). There are also packets for miscellaneous minerals and strategic minerals that sell for $2 each.

Pat fills mail orders every day.

The packets are available by mail or over-the-counter *from the Portland office only*. Readers are reminded that the packets contain only those issues that are still in print. Some of the most popular issues have been out of print for years.

USGS PUBLICATIONS

Most of the non-Department publications available from DOGAMI are those published by the U.S. Geological Survey (USGS). The Portland, Grants Pass, and Baker offices all sell USGS topographic maps over-the-counter and through the mail (folded). The 7½-minute quadrangles (scale 1:24,000) and 15-minute quadrangles (scale 1:62,500) cost $2; the 1° by 2° quadrangles (scale 1:250,000) cost $3.25. Topographic quadrangle indexes of Oregon are available free from DOGAMI or from the USGS, Box 25286, Denver Federal Center, Denver, CO 80225. A topographic map of the entire state (scale 1:500,000) and a planimetric map of the same scale with more cultural features but no topography sell for $3.25 each. Topographic maps of national parks in the Pacific Northwest (Crater Lake, Mount Rainier, North Cascades, and Olympic National Parks) are also available for $3.25 each.

The USGS has also produced many geologic studies based on work done in Oregon. Those sold by DOGAMI are listed below.

A limited number of copies of Bulletin 1119, *The Geology of Portland and Adjacent Areas*, by Trimble (1963), is still available for $5 (number limited to two per order). Geologic quadrangle maps (GQ series) sell for $3 each and are available for the Galice, Portland, Medford, Aldrich Mountain, Monument, and Mt. Vernon quadrangles.

Geologic investigation maps (I series) are available at a variety of prices. Maps I-325 (Oregon west of the 121st meridian) and I-902 (Oregon east of the 121st meridian) each sell for $5. Map I-1091-D (distribution, composition, and age of late Cenozoic volcanism in Oregon and Washington) sells for $3. The rest of the Oregon maps in the I series sell for $2.50 each and cover geology of the following quadrangles: I-457 (west half of Jordan Valley), I-493 (east half of Crescent), I-540 (Eagle Rock), I-541 (Ochoco Reservoir), I-542 (Post), I-543 (Lookout Mountain), I-555 (Madras), I-556 (Dufur), I-568 (east half of Bend), I-727 (Pendleton), I-866 (Waldport and Tidewater), I-867 (Yaquina and Toledo), I-868 (Cape Foulweather and Euchre Mountain), and I-1116 (Oregon part of Grangeville). Other I-series geologic maps selling for $2.50 cover the following areas or subjects: I-587 (tectonic structure of the main part of basalt of the Columbia River Group, Oregon and Washington), I-595 (geologic map of Oregon), I-872 (John Day Formation in the southwest part of the Blue Mountains and adjacent areas), I-1021 (pre-Tertiary rocks in the eastern Aldrich Mountains and adjacent areas to the south), and I-1142 (Smith Rock area).

In addition, the Department sells a rapidly growing number (currently 35) of Miscellaneous Field Studies Maps (MF series). A list of these maps, which cover a variety of subjects including geology, potassium-argon dates, mineral resource assessments, geophysical data, geochemical analyses, and biostratigraphy, is available *free upon request* from DOGAMI.

All of the USGS publications mentioned above are available by mail or over-the-counter from the Portland office of DOGAMI. Field offices carry USGS publications pertaining to their geographical areas only. □

World oil reserves higher than previously estimated

World oil reserves are about 12 percent more than previously reported in petroleum trade journals, a U.S. Geological Survey (USGS) energy expert told the World Petroleum Congress in London recently.

Charles D. Masters estimated world reserves of economically recoverable petroleum at approximately 723 billion barrels of conventional crude oil. He also estimated that there is a 90-percent probability that the amount of oil available for future discovery is between 321 and 1,417 billion barrels, with 550 billion barrels being the most likely amount for future discovery.

The U.S. share of world reserves exceeds 29 billion barrels plus about 80 billion barrels available for future discovery, the USGS scientist said. As an agency of the Department of the Interior, the USGS prepares estimates of mineral and energy resources to aid planning by all levels of government.

In remarks prepared for the London meeting, Masters said the present world production of oil is about 20 billion barrels per year, about twice the discovery rate of 10 to 12 billion barrels of new reserves per year. Thus, at the current rate of production and discovery, the estimate by Masters of 723 billion barrels of reserves plus 550 billion barrels of future potential would be enough to last for about another half-century.

Masters, a geologist at the Survey's National Center in Reston, Virginia, said his estimates were based on a variety of data from national governments, scientific and trade publications, and field files of Petroconsultants, Ltd., a world-wide petroleum data organization. The new estimates were compiled in a study by Masters; David Root, a mathematician with the USGS in Reston; and W.D. Dietzman, a petroleum engineer with the U.S. Energy Information Administration (EIA) in Dallas, Texas.

Data from fields comprising 80 percent of the world's oil reserves were examined, Masters said. Authoritative and comprehensive data on oil are lacking for a few nations, but he and his coauthors are confident their estimates are proportionally and geographically reasonable.

–USGS News release

New mineral display in State Capitol

The mineral display case in the State Capitol in Salem which was donated last year by the Oregon Council of Rock and Mineral Clubs is showing a new collection during September, October, and November. The exhibit was furnished and arranged by members of the Oregon Agate and Mineral Society (see list of the Council's member societies on p. 101 in the last issue of *Oregon Geology*) and consists of specimens of petrified wood from Oregon.

The collection of about two dozen items displays 13 different kinds of petrified wood from eight Oregon counties. Most of the pieces are polished slabs, rounds, and limb ends; one represents a large butterfly with wings made of oak from Crook County and a body of sycamore from Linn County.

The member societies of the Oregon Council of Rock and Mineral Clubs take turns supplying exhibits for the State Capitol display case. Each collection is shown for a period of about three months. □

Gem and mineral show to be held in Portland in October

The 1983 Cascade of Gems, a regional gem and mineral show, will be held October 21-23 at the Multnomah County Exposition Center, 2060 N. Marine Drive, Portland, Oregon. The show will include numerous displays, competitions, dealers, demonstrations, programs, camping, and special opal exhibits.

The doors will be open from 10 a.m. to 9 p.m. on October 21 and 22 and from 10 a.m. to 5 p.m. on October 23. Cost of admittance is $1.50 for adults, $.50 for children from 6 to 12 years of age when accompanied by an adult, and on Friday, October 21, $1 for seniors. □

Address changes

The **American Geological Institute** (AGI) is moving its headquarters, and access to its Datapoint computers, including the GeoRef information system, will be limited until about September 20. Beginning September 16, the new AGI address will be **4220 King Street, Alexandria, VA 22302**. The phone number, which will probably remain unchanged, is (703) 379-2480.

The address of the **Association of Engineering Geologists** (AEG) has been changed to **Box 506, Short Hills, NJ 07078**. And the address for **AEG newsletter editor** and former Portland resident **Richard C. Kent** is now **Box 9291, College Station, TX 77840**, phone (409) 845-3224. □

GSOC luncheon meetings announced

The **Geological Society of the Oregon Country** (GSOC) holds noon meetings in the Standard Plaza Building, 1100 SW Sixth Ave., Portland, OR, in Room A adjacent to the third-floor cafeteria. Upcoming meetings, topics, and speakers:

October 21—*Bicycling through Germany, France, Austria, and Ireland*, by Gerhardt Meng.

November 4—*Wild Flowers of Oregon*, by Vance L. Terrall, M.D., retired.

November 18—*Spring in the Mojave Desert*, by Donald Barr, naturalist.

December 2—GSOC *Grand Tour No. 1: Parks and Monuments of the Southwest*, slide presentations by Al and Ruth Keene, leaders, and Robert Richmond, Donald Parks, Claire Stahl, and Frances Rusche.

For additional information, contact Viola L. Oberson, Luncheon Program Chairwoman, phone (503) 282-3685. □

NWMA course to study precious-metal mines

The Northwest Mining Association (NWMA) has announced a course on the exploration, discovery, and development of five important Western precious-metal mines.

Titled "An In-depth Study of Five New Silver and Gold Mines," the NWMA's Short Course will be held November 28-30 at the Davenport Hotel in Spokane, Washington, preceding the NWMA 89th annual convention, "Domestic Mining—An Era of Change."

The course is designed to provide practical information to those who are interested in any phase of precious-metal development, according to William B. Booth, manager of environmental and public affairs for Sunshine Mining Co. Booth is co-director of the course with George J. Beattie, a consultant and international lecturer on mine management.

The program provides an in-depth look, from concept to closure plan, of Equity Silver Mines, British Columbia; Hecla's Silver Shaft Development, Idaho; Placer Amex's Golden Sunlight Mines, Montana; Ranchers' Escalante Silver Mine, Utah; and Sunshine's 16-to-1 Mine, Nevada.

The total review of these five properties will cover exploration, development, operating, and plans for further development and/or completion of mining.

Booth said the course will provide valuable insight to the prospector; explorationist; mine planner and operator; and mill operator, refiner, engineer, and manager.

Registration is limited. For additional information or registration materials, contact Northwest Mining Association, 633 Peyton Building, Spokane, WA 99201, 509/624-1158. □

USGS provides northern California earthquake information

The U.S. Geological Survey (USGS) Office of Earthquakes, Volcanoes, and Engineering is offering a new service called "Information Update," a recording that gives current information 24 hours a day about earthquakes occurring in northern California. The phone number for Information Update is (415) 327-9164. The information is updated each day, except during periods of high or unusual activity, when it is updated more frequently. □

(**Recent permits**, *continued from page 106*)

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
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	Application; 4,000
249	Reichhold Energy Corp. Busch 14-15 009-00119	SW¼ sec. 15 T. 6 N., R. 5 W. Columbia County	Application: 2,800
250	Reichhold Energy Corp. Longview Fibre 33-36 009-00120	SE¼ sec. 36 T. 6 N., R. 5 W. Columbia County	Application; 4,000
251	Reichhold Energy Corp. Grimsbo 11-16 009-00121	NW¼ sec. 16 T. 6 N., R. 5 W. Columbia County	Application; 2,600
252	Hutchins & Marrs Great Discovery 1 019-00022	SE¼ sec. 3 T. 27 S., R. 7 W. Douglas County	Application; 4,500

□

Available publications

ORDER FORM — CUT ON DASHED LINE

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	$ 3.00		
35. Geology of the Dallas and Valsetz quadrangles, rev. 1964: Baldwin (map only)	3.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart, and Stewart, 1949: v. 2	3.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	3.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	3.00		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	3.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
61. Gold and silver in Oregon, 1968: Brooks and Ramp	17.50		
62. Andesite Conference guidebook, 1968: Dole	3.50		
65. Proceedings of the Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley (copies)	5.00		
77. Geologic field trips in northern Oregon and southern Washington, 1973	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah, Clackamas Counties, 1974: Beaulieu	6.50		
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00		
84. Environmental geology of western Linn County, 1974: Beaulieu and others	9.00		
85. Environmental geology of coastal Lane County, 1974: Schlicker and others	9.00		
87. Environmental geology of western Coos and Douglas Counties, 1975	9.00		
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp	4.00		
89. Geology and mineral resources of Deschutes County, 1976: Peterson and others	6.50		
90. Land use geology of western Curry County, 1976: Beaulieu	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon, 1977: Beaulieu	8.00		
92. Fossils in Oregon (reprinted from *The Ore Bin*), 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977	7.00		
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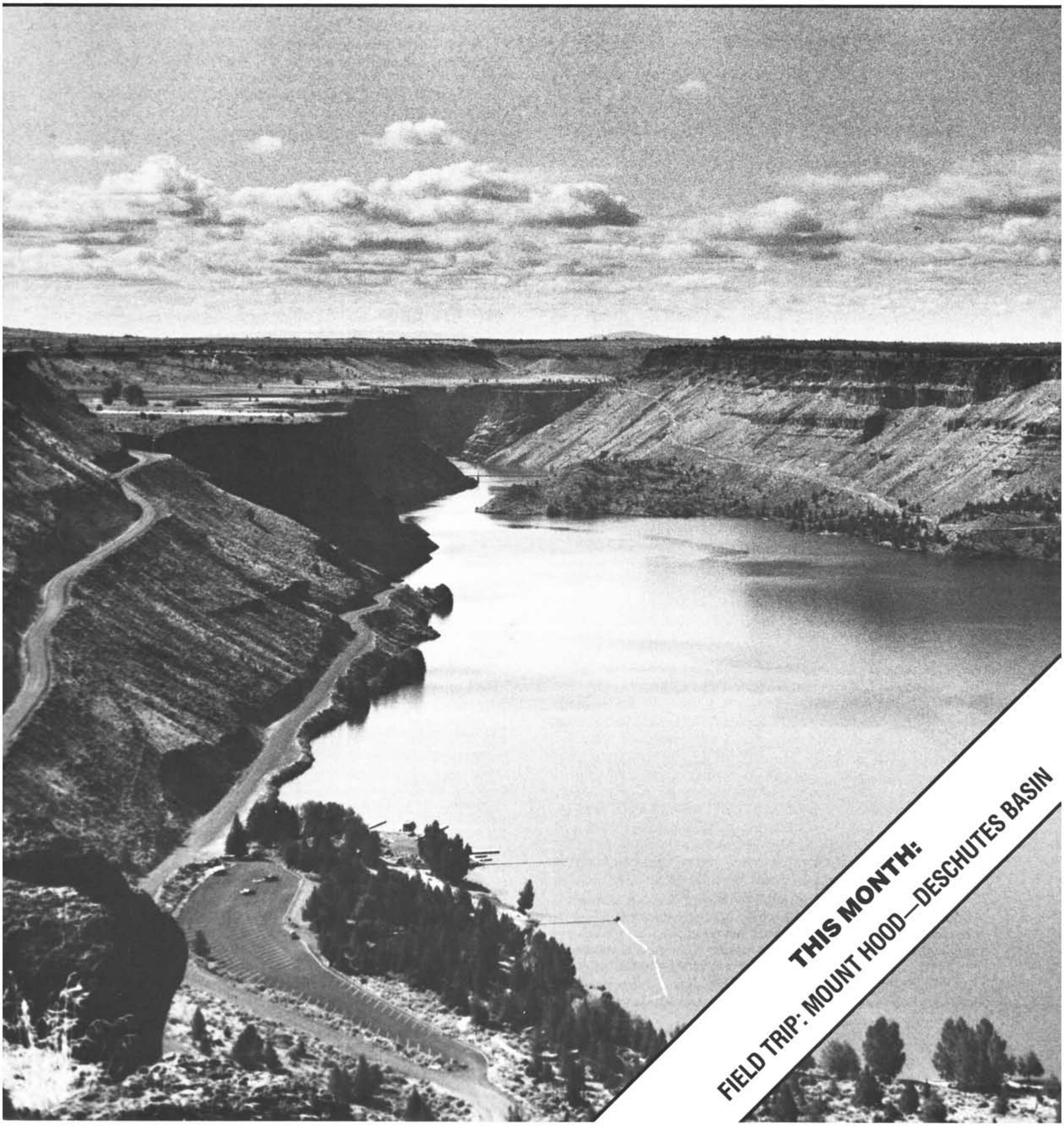

THIS MONTH:

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

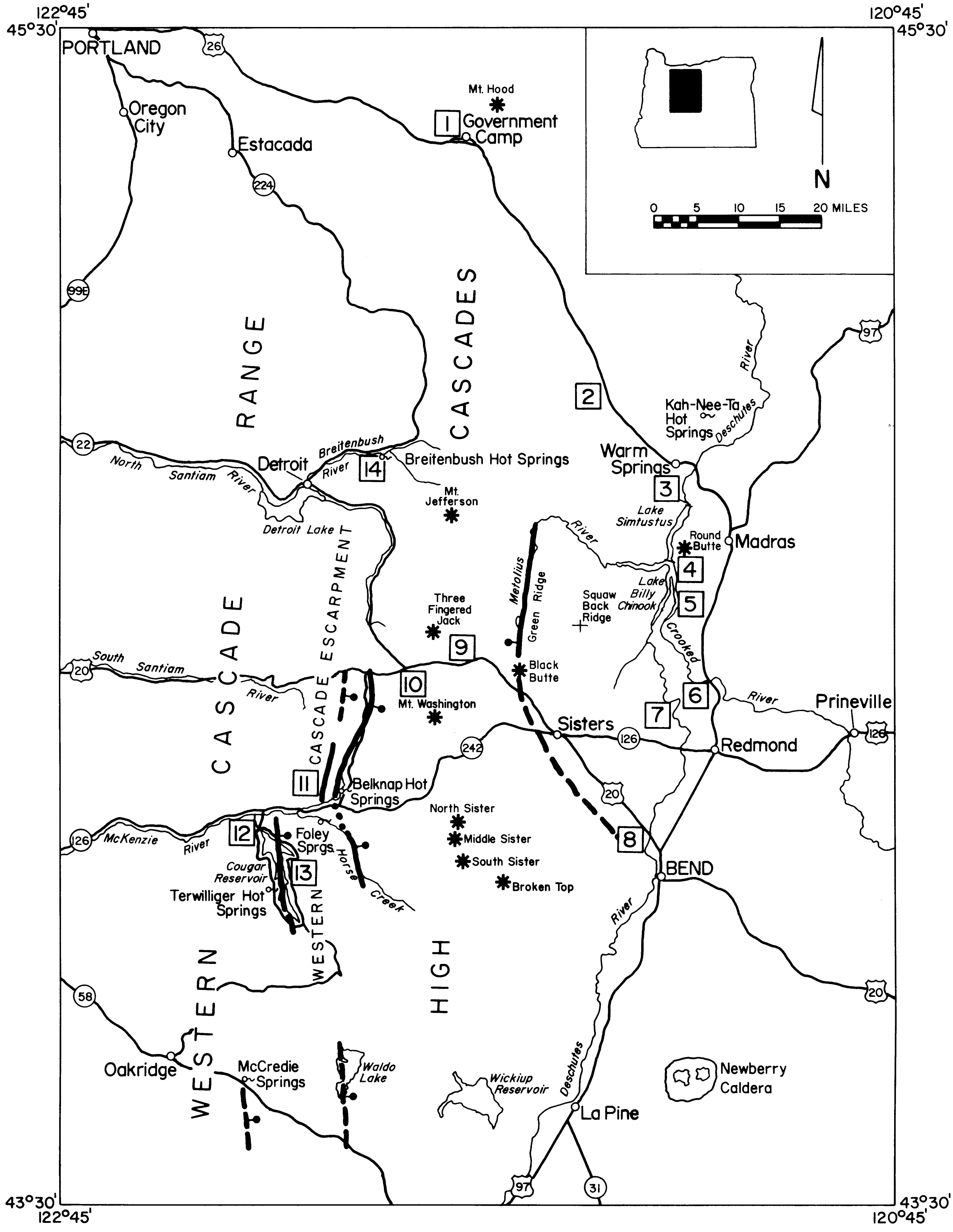

Figure 1. Location map for the central Oregon Cascade field trip. Numbers surrounded by squares are the field trip stops.

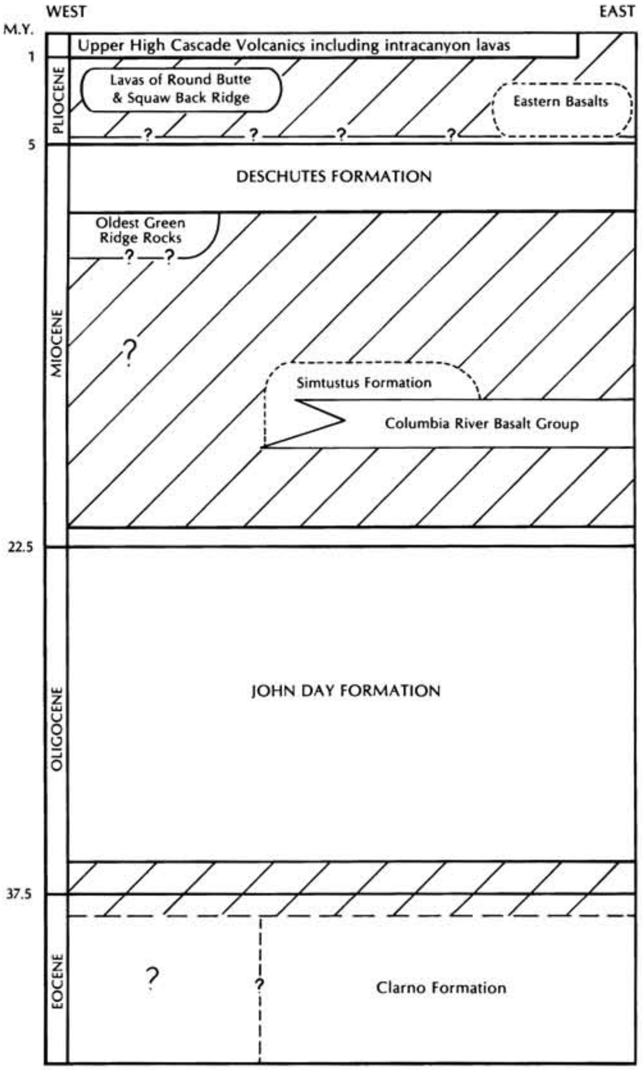

Figure 2. Cenozoic stratigraphy of the Deschutes basin and vicinity.

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 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.*

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.

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.*

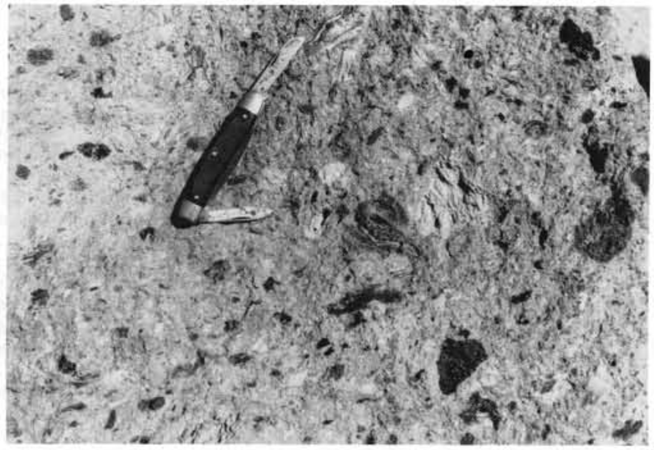

Figure 6. Close-up of McKenzie Canyon tuff at Lower Bridge. Note different types of pumice—white (rhyolite), black (andesite), and mixed (e.g. at upper knife point). Body of knife is 3.5 in long.

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.

* Total Fe recalculated as volatile-free FeO.

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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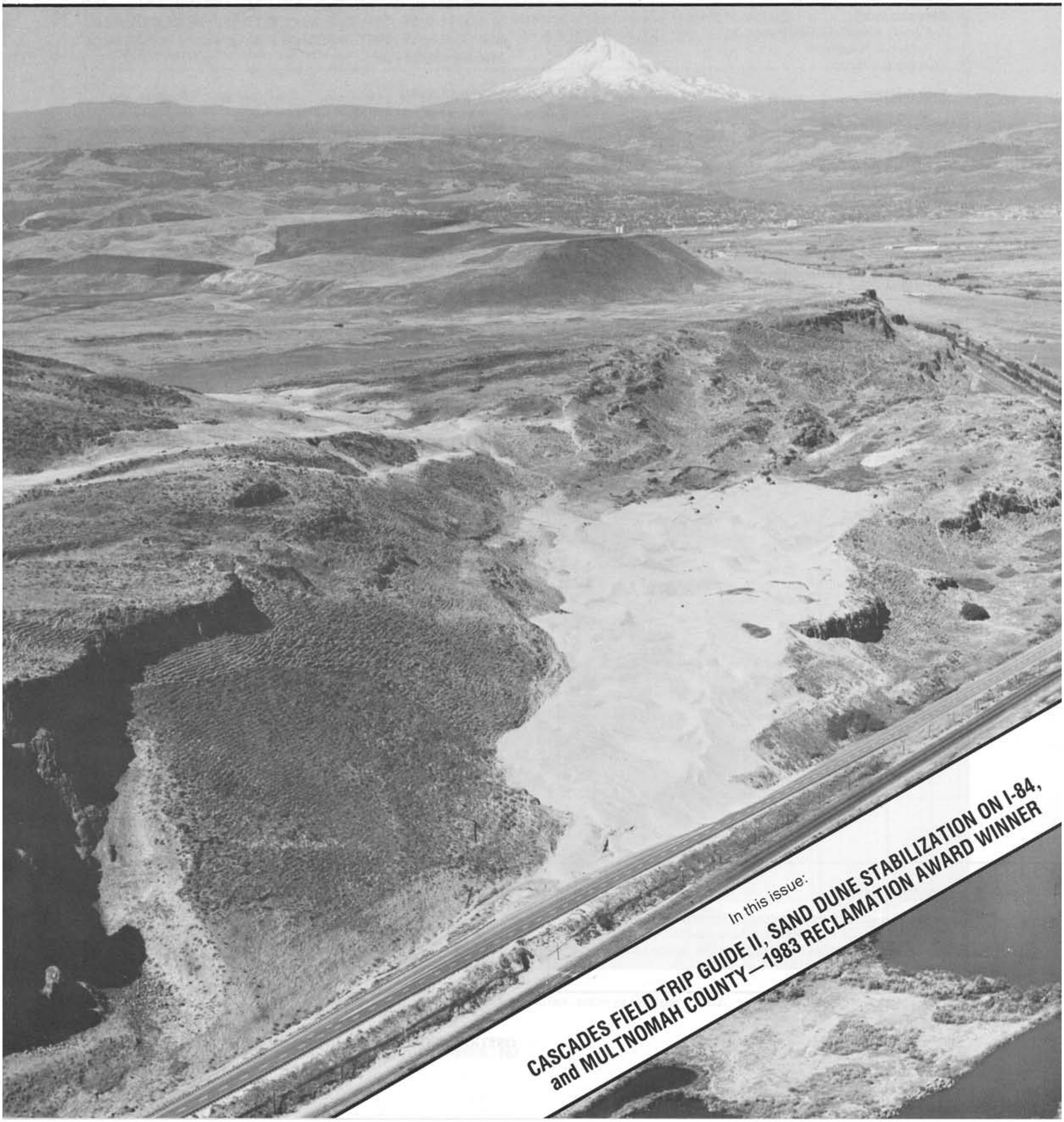

In this issue:

CASCADES FIELD TRIP GUIDE II, SAND DUNE STABILIZATION ON I-84, and MULTNOMAH COUNTY—1983 RECLAMATION AWARD WINNER

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COVER PHOTO

Active sand dune encroaching on Interstate Highway 84. This mid-1981 view is from northeast to southwest; The Dalles and Mount Hood are visible in background. See article on recent stabilization efforts on page 131.

OIL AND GAS NEWS

Clackamas County

RH Exploration, Rose 1, located in sec. 20, T. 5 S., R. 1 E., was abandoned as a dry hole on October 24, 1983. RH has given no indication that it plans to drill Rose 2, permit 242.

Mist Gas Field

Reichhold Energy Corporation has drilled and suspended Wilson 11-5. The total depth was 2,827 ft, and the suspension date was October 14, 1983. Additional drilling will be carried out at Mist later in the year.

Douglas County

Drilling has begun in Douglas County on the Hutchins and Marrs Glory Hole 1 in sec. 10, T. 27 S., R. 7 W. The operator spudded the well on October 28, 1983, with a proposed total depth of 4,500 ft and has plans for four additional wells in the immediate area.

Lane County

Leavitt Exploration and Drilling is preparing to spud its Maurice Brooks 1 well in sec. 34, T. 19 S., R. 3 W. The well has a proposed total depth of 3,000 ft.

Recent permits

Permit no.	Operator, well API number	Location	Status, proposed total depth (ft)
253	Reichhold Energy Corp. Adams 32-34 009-00122	NE¼ sec. 34 T. 7 N., R. 5 W. Columbia County	Application; 2,800

□

GSOC luncheon meetings announced

The **Geological Society of the Oregon Country** (GSOC) holds noon meetings in the Standard Plaza Building, 1100 SW Sixth Ave., Portland, OR, in Room A adjacent to the third-floor cafeteria. Upcoming meetings, topics, and speakers:

December 16—*The German Village Passion Play, Oberammergau*, by Robert L. and Louise Gamer.

January 6—*The Geology of the Lake Oswego and West Lynn Area*, by Donald D. Barr, past president of GSOC.

January 20—*Antiques* (Bring one for identification!), by Harvey Steele, import specialist for U.S. Customs.

February 3—*Xian to Hong Kong and Home (Part II)*, by Frank Dennis, railroad engineer inspector, retired.

February 17—*Yellow Knife and the Canadian Shield*, by Phyllis Bonebrake, member GSOC.

March 2—*Geology of the Owyhee*, by Donald D. Barr, past president of GSOC.

March 16—*Indian Ruins of the Southwest*, by Lloyd A. Wilcox, past president of GSOC, active member of the Archaeologic Society, participant in dig at the Calico Man site.

For additional information, contact Viola L. Oberson, Luncheon Program Chairwoman, phone (503) 282-3685. □

CONTENTS

Stabilization of the I-84 sand dune

Many of our readers will have heard of the active sand dune encroaching on Interstate Highway 84 along the Columbia River, just east of The Dalles, Oregon. Some may have experienced directly the hazard the blowing sand can pose to highway traffic. So far, only the tip of the wandering dune has reached the highway, while the main body of sand is still upwind, waiting to be blown toward the river. The State Highway Department has estimated that by the year 1995 the annual cost of removing the sand from the highway will be $100,000.

The following article describes attempts to avert this threat by stabilizing the dune. In the latest, recently completed effort, the final decisions were based in part on consultation with the Oregon Department of Geology and Mineral Industries.

The article is reprinted here with permission from Pacific Builder & Engineer, *July 4, 1983, p. 18–19, where it appeared under the title "Migrating Sand Dune Taking Over Interstate 84." (ed.)*

Wind-blown sand originating from a 50-acre sand dune is encroaching upon the travel lanes of Interstate 84 east of The Dalles, Oregon. This sand has been creating a safety hazard to vehicles on I-84 and trains on the adjacent Union Pacific tracks. Annual costs to both agencies have increased significantly in recent years and will continue to increase as the dune moves at a rate of about 250 ft every 10 years.

A combination mineral blanket/vegetative stabilization of the sand dune was undertaken in January and February 1983. The stabilization should create vegetative growth over the sand. Before describing this recent stabilization process, following is a description of the area and other attempts at stopping or slowing movement of this dune.

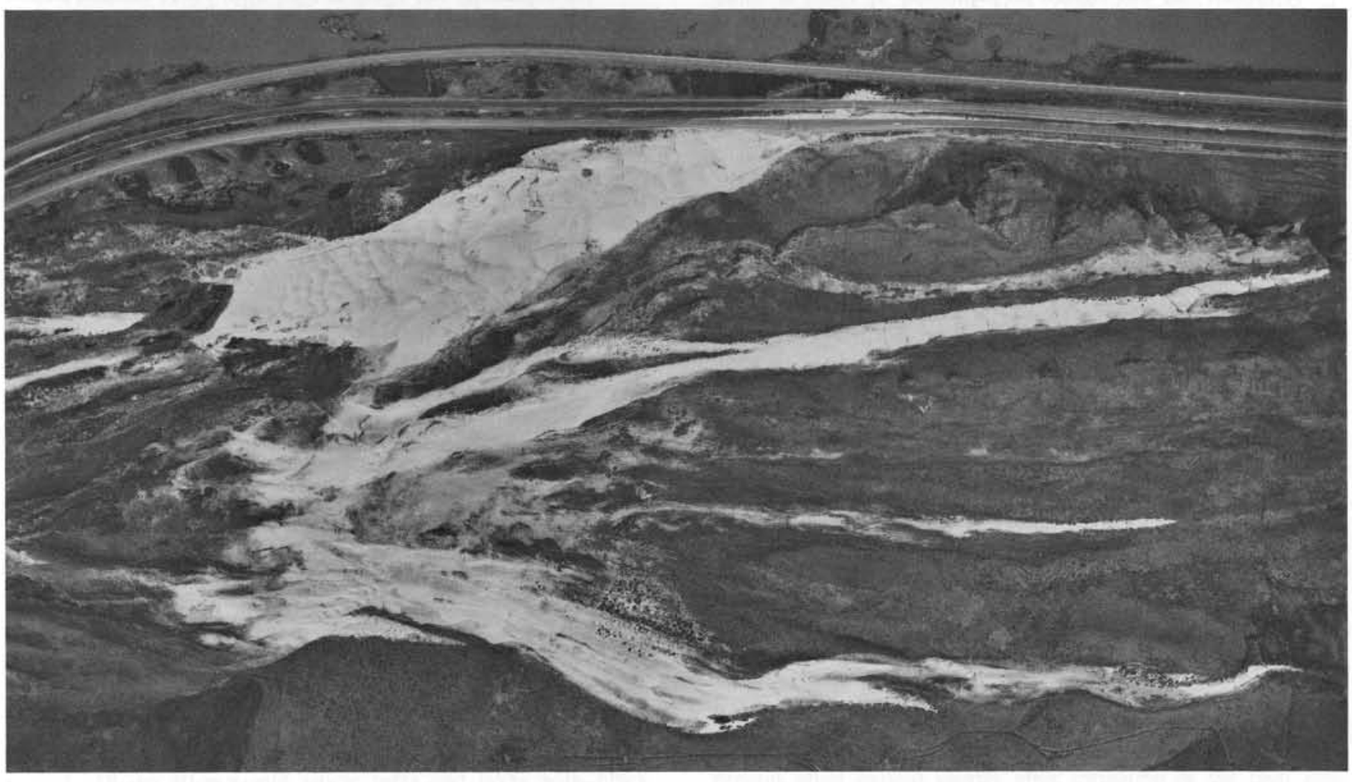
Numerous alternative treatments for physical stabilization of sand dunes have been attempted. The list includes (1) mineral blankets; (2) snow/wind fences; (3) covering with tires; (4) spraying with asphalt and other commercial stabilizing agents; (5) spraying with water and/or water with sewage sludge; (6) mixing agents into surface including cement, straw paper mulch, and bark mulch; (7) planting trees for wind breaks; (8) seeding and mulching; and (9) using straw bales as wind breaks.

The surface area of the dune – believed to be the largest active sand dune in the Northwest – includes an estimated 1.5 million to 2 million cu yd of sand. Relief of the dune varies from 200 ft elevation at the highway (I-84) to 350 ft at its southwestern end. Mobile heaps of sand on the dune have an asymmetrical form, with a nearly equal streamlined gentle slope to the windward side and a steeper slope over the crest on the leeward side. The leeward slope assumes the angle of repose for loose sand.

Dune movement is related to wind velocity, constancy of wind direction, rainfall, sand source supplying the dune, and grain size. The direction of the wind in the dune area is from 270 to 280 degrees from the north over 50 percent of the time, which is nearly along the axis of the dune. Semiarid climate in the area limits the rainfall to 14.5 in annually. During the winter and spring months when the sand is wet, little movement occurs.

The active dune will continue migrating toward the Columbia River. At its current rate, and on level ground, this dune could move across the highway in about 130 years.

Over the years, many attempts have been made to halt or slow the dune. In the 1940's, Union Pacific Railroad, then adjacent to the dune, sprayed crude oil over a large portion of the foredune. This



Vertical aerial view of sand dune area, taken in February 1982.

was a common treatment in the 1920's–1940's and provided short-term control. Again, in the 1940's and 1950's, Union Pacific attempted to control the area with snow fences over large portions, with no success. The fences slowed the sand movement until the weight of the sand tipped them over or buried the fence. In 1966, a suggested method of control was to place several hundred old tires on the dune. The local kids had a field day rolling these down and onto the highway, increasing the hazard and not controlling the dune. Then in 1972, State forces seeded and mulched six to seven acres on the dune face. This involved covering this area with straw, seeding, and punching the straw into the dune. Snow fences were also placed across the dune in front of the covered area. While growth was established, most of the treatment area was covered with blown sand within few months.

Late in 1981, an agreement was reached for developing a stabilization plan through the Oregon State Highway Division, Warm Springs Agency, Wasco County Soil and Water Conservation District, and Union Pacific Railroad.

The contract involved several phases, with completion scheduled for February 1983. First was the development of access roads within the dune followed by rounding the steep faces. Producing the aggregate for the mineral blanket and reclaiming the site was followed by placing the mineral blanket and reseeding. The crushed aggregate had a maximum size of 1½ in and was placed in a thin layer. The selected vegetation procedures involved six different types of treatment according to wind exposure, steepness of slopes, moisture conditions, livestock exposure, accessibility to area, and visual impact.

The major type of treatment involved placing a thin layer of crushed aggregate over the sand followed by seeding and fertilizing. The second largest treatment type was used on that area immediately adjacent to the highway. This area was seeded and fertilized, covered with straw mulch which was punched into the sand by a special roller, and reseeded. The natural terrain protects this area from the direct wind force, and it is further protected from livestock grazing by the right-of-way fencing. The remaining treatment types addressed special problems of access or took advantage of moisture or existing growth on the dune perimeter.

A commercial fertilizer was applied at the rate of 275 lb per acre. Areas too steep to apply a mineral blanket satisfactorily were mulched with a straw mulch at the rate of 2½ tons per acre. The straw was then punched into the sand with a sheepsfoot roller especially designed for this work. In some areas, the straw was covered with netting to prevent it from blowing away.

Some of the area was seeded and fertilized by helicopter to prevent equipment from disturbing the mineral blanket after it had been placed. Treatment areas where straw mulch was applied were seeded with a hydro-seeder. Half of the seed was applied prior to application of the mulch and the other half of the seed and all of the fertilizer were applied after the straw had been planted in or covered with netting. Some areas required hand planting.

Spot reseeding and refertilization may be required in some areas to establish a satisfactory stand of grass. After two years, a second treatment with fertilizer will take place to promote good root development so the vegetative cover will be better able to withstand drought.

The Soil Conservation Service will be monitoring the establishment of the grass cover and will control livestock grazing access to ensure that the livestock grazing does not damage the vegetative cover.

The Oregon State Highway Division and Union Pacific Railroad will be watching, too, to see if this stabilization attempt will at last hold off this 50-acre mountain of sand. □

Fireballs sighted

A fireball that was sighted on September 3, 1983, at 10:05 p.m. PDT, was reported by two different sets of observers: (1) Christie Galen and Marshall Gannett, at lat. 44°51′ N., long. 121°22′ W. at Sparks Lake in Deschutes County, were looking straight up in the sky and first sighted the fireball 15° east of north at an altitude of 60°. The fireball was last seen 15° east of south at an altitude of 40°. The angle of descent was 20°, and the duration of flight was four seconds. The blue-colored fireball was one-tenth the size of the full moon, had a short yellow-white tail, and cast a shadow. Although there was no sound or breakup, a very bright blue flash shot out in front of the fireball at the end of its flight. (2) Two other observers, Bert and Davis Vollans, saw the same fireball at the same time from west of China Hat, also in Deschutes County. They first saw the fireball due north at an altitude of 75° in the sky and watched it descend at an angle of 20° until it disappeared to the south at an altitude of 40°. The duration of the flight was three seconds. The blue-yellow-white fireball was one-third the size of a full moon and had a yellow-white tail that covered 40° of the sky. There was no sound, but the fireball broke up into five or six fragments. The fireball cast a shadow and left a glowing train for one second. According to the observers, the fireball "increased in size and ended like an exploding skyrocket."

Four different observers in the Portland area observed a daylight fireball on September 15, 1983, at 4:15 p.m. PDT. The observers, Anthony Covington, Ron Eilers, Richard Giusti, and Paul Owenby, were at lat. 45°29′ N., long. 122°40′ W. looking to the south. The fireball was first seen 15° west of south at an altitude of 45° and was last seen 15° west of south at an altitude of 35°. The angle of descent was straight down, apparently toward the observers, and the flight lasted for four seconds. The white fireball was one-fourth the size of a full moon and had a white tail that was five times the size of the fireball. There was no sound or breakup. The fireball, which appeared to be falling very slowly, left a vapor trail that lasted several seconds.

On September 30, 1983, at 5:55 a.m. PDT, Gordon Bolton saw a fireball at lat. 45°34′ N., long. 123°9′ W., just south of Banks in Washington County. He first saw the fireball in the north sky at an altitude of 70°. The fireball was last seen at an altitude of 10°, still in the north sky, and appeared to be coming straight down. The duration of the flight was two seconds. The white fireball was one-fifteenth the size of a full moon and had a short white tail. There was no sound and no breakup. The fireball cast a shadow.

A fireball reported by Jason Matthews was observed October 26, 1983, 6:20 a.m. PDT, at lat. 45°33′ N., long. 122°35′ W., in Gresham, Multnomah County. Observer was facing north and first saw the fireball 2° west of north at an altitude of 15°. The fireball was last seen 10° east of north at an altitude of 5°. The angle of descent was 10°, the duration of the flight two seconds. The blue fireball was one-fourth the size of a full moon and had a blue-white tail that covered 40° of the sky. It broke into three or four fragments. No sound, shadow, or train were observed.

These sightings have been reported to the Scientific Event Alert Network, Smithsonian Institution. Anyone with any additional information about these or other meteorite sightings should contact Dick Pugh, Cleveland High School, 3400 SE 26th Ave., Portland, OR 97202, phone (503) 233-6441. □

Available Again

The popular geologic map of the western half of Oregon, out of print for some time, is now available again as a reprint for 1983. It is the *Geologic map of Oregon west of the 121st meridian*, Miscellaneous Geologic Investigations Map I-325 of the U.S. Geological Survey, scale 1:500,000.

The map is available for purchase at the Oregon Department of Geology and Mineral Industries Portland office. The price is $5. □

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.

The second part of the trip is presented in this issue; the trip of the first day, from Government Camp at Mount Hood to Bend, was published in the last (November) issue. The trip route is indicated by trip stop numbers in Figure 1, with the numbering error of the previous issue corrected. Note that, because of the correction, there is no trip stop number 8.

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.

Second day: Santiam Pass—Belknap Hot Springs—Breitenbush Hot Springs

by George R. Priest, Oregon Department of Geology and Mineral Industries

INTRODUCTION

This portion of the trip is aimed at showing the evidence for down-to-the-east faulting on the eastern margin of the Western Cascade Range. Although brief descriptions of High Cascade volcanic features are given in the guide, most of the following discussion centers on the stratigraphy and structure at Belknap Hot Springs, Cougar Reservoir, and the North Santiam area. The trip begins in Bend, proceeds across Santiam Pass to Belknap Hot Springs, Cougar Reservoir, north to Breitenbush Hot Springs, and back to Portland.

Central Oregon Cascades

The central Oregon Cascade Range consists of the mature, deeply dissected Western Cascade Range and youthful, undissected volcanic terrane of the High Cascade Range. The two ranges are separated by a topographic low in most areas, causing the headwaters of many of the major streams such as the McKenzie and North Santiam Rivers to swing into a north-south trend where they are deflected by the escarpment of the Western Cascade Range (Figure 1).

The High Cascade Range is composed primarily of a low platform of 4-m.y.-old and younger basalt and basaltic andesite, overlain by much smaller quantities of more silicic volcanic rock. Many of the more fluid basalt flows have flowed west into drainages of the uplifted Western Cascade Range. The major composite cones are a relatively small part of the total volcanic pile and are composed of basaltic andesite to rhyodacite lavas and pyroclastic rocks. The greatest quantity of silicic volcanic rocks occurs in the vicinity of the South Sister, where a silicic highland 15 mi wide has developed (Taylor, 1978).

Some of the most recent eruptions in the central High Cascade Range have been from the mafic platform west of the North and Middle Sisters. Vents in the vicinity of Four-in-One-Cone, South Belknap Cone, Belknap Crater, Nash Crater, Collier Cone, and Yapoah Cone were active between about 1,500 and 2,900 years ago (Taylor, 1980, 1981). Spectacular outcrops of these young basalt and basaltic andesite flows can be seen along the roads near Santiam Junction.

The central Western Cascade Range consists of a thick pile of late Eocene to late Miocene volcanic rocks with minor Pliocene to Pleistocene intracanyon lavas derived from the High Cascades or rare local vents. From oldest to youngest, the Western Cascade Range consists of four main units:

1. 18- to 40-m.y.-old silicic tuffs and lavas with black tholeiitic lavas interbedded in the upper part.
2. 9- to 18-m.y.-old calc-alkaline basalt, basaltic andesite, and andesite lavas with subordinate dacite tuffs and lavas.
3. More than 4- to 9-m.y.-old compact to diktytaxitic basalt and basaltic andesite flows with lesser amounts of andesite and dacite. These rocks which cap the highest Western Cascade ridges were erupted prior to uplift and faulting along the east margin of the Western Cascade Range. The basalts reach compositions more mafic than those in basalts of unit 2.
4. 0- to 4-m.y.-old intracanyon diktytaxitic basalt and basaltic andesite flows from the High Cascade Range.

Unit 3 is compositionally identical to unit 4 and other rocks of the High Cascade Range. Unit 3 was probably erupted from vents in and adjacent to the High Cascades. Units 1 and 2 were erupted from many vents west of known High Cascade volcanic centers, although some of these older vents are probably buried beneath the High Cascade Range. Figure 2 shows a schematic summary of the stratigraphic relationships. For a more detailed summary of central Western Cascade stratigraphy, the reader is referred to DOGAMI Special Paper 15 (Priest and others, 1983b).

Horse Creek-McKenzie River fault

A major north-south fault system with down-to-the-east displacement bounds the Western Cascade Range and controls the north-south trends of parts of the upper McKenzie River and Horse Creek. An east-facing topographic scarp extends along the fault zone and is, in places, breached by drainages (Figure 1). The McKenzie River has cut through the scarp near McKenzie Bridge at Foley Ridge, and unfaulted High Cascade basalt flows, dated at 2.0 to about 4.0 m.y. B.P. (Sutter, 1978; Taylor, 1980; Priest and others, 1983b), have flowed westward through the breach in the fault scarp (Taylor, 1980, Flaherty, 1981). Flows dated at about 5.0 m.y. B.P. (Sutter, 1978) cap the highest ridges at the top of the scarp. Offset, therefore, appears to have occurred over a short time span between 5 and 4 m.y. B.P. (Taylor, 1980; 1981). Structural relief on the fault is about 1,970 ft at Horse Creek (Flaherty, 1981). The fault zone has been mapped north to Santiam Junction (see Brown and others, 1980b; Avramenko, 1981). Belknap Hot Springs is located on this fault zone.

Topographic relief in the area is about 3,300 ft, which is characteristic of the eastern part of the Western Cascade Range. The base of the oldest Foley Ridge flows lies at about the same elevation as the present McKenzie River, indicating that all of the present relief existed shortly after formation of the fault zone (Flaherty, 1981). This leads to the speculation that much of the

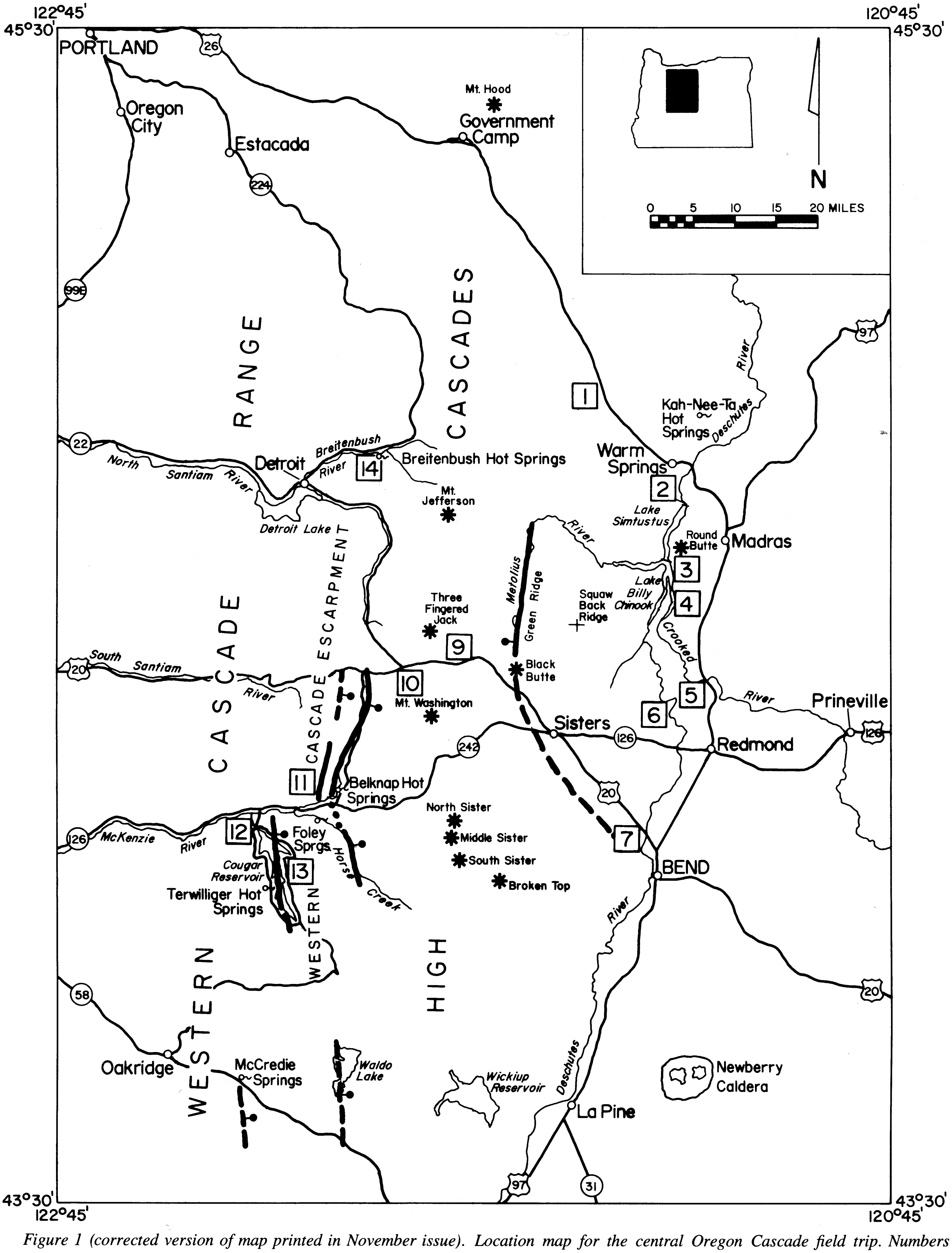


Figure 1 (corrected version of map printed in November issue). Location map for the central Oregon Cascade field trip. Numbers surrounded by squares are the field trip stops. Because of the map correction mentioned above, there is no stop number 8.

present relief in the larger stream valleys of the central Western Cascade Range may also have developed during uplift in the interval of 5-4 m.y. B.P. A topographic escarpment similar to, and on strike with, the scarp of the McKenzie River-Horse Creek fault continues to the north-south segment of the upper North Santiam River (Figure 1). Geologic mapping in the North Santiam area has, however, thus far failed to show stratigraphic evidence for offset along that part of the escarpment (e.g., Rollins, 1976; Hammond and others, 1980, 1982). If down-to-the-east displacement along the North Santiam portion of the escarpment can be proven, the associated north-south faults would form the western boundary of a major graben bounded by the Green Ridge fault zone on the east.

The north-south topographic escarpment of the Western Cascade Range ends at the elbow of the North Santiam River. North of the elbow, preliminary mapping by this author indicates that an andesite ash-flow sheet older than 6.3 m.y. crops out at high elevations (about 4,800 ft above sea level) from the Outerson Mountain area (2.5 mi north of the elbow) to within 3 mi northwest of the flank of Mount Jefferson. Therefore, an essentially unbroken block of rocks older than the McKenzie River-Horse Creek faulting forms a roughly east-west trending highland north of the Western Cascade escarpment.

Cougar fault

The Cougar fault is a major north-south fault with down-to-the-east displacement and controls the north-south trend of the South Fork of the McKenzie River at Cougar Reservoir. This fault has no obvious topographic scarp but does juxtapose Oligocene (?) tuffaceous rocks against middle Miocene andesite lavas. Terwilliger Hot Springs is 0.7 mi west of the fault.

The Cougar fault definitely cuts rocks dated at 13.2±0.7 m.y. B.P. and is overlain by unfaulted Pleistocene gravels (Priest and Woller, 1982, 1983). The fault has a minimum dip-slip offset of 500 ft, based on drill-hole data, and probably has more than 1,400 ft of displacement, based on stratigraphic arguments (Priest and Woller, 1982; 1983). According to Priest and Woller (1983) there is some evidence that the Cougar fault may be older than the Horse Creek fault, and they speculated that much of the fault offset may have occurred between 13.2 and 9 m.y. B.P.

Probable southerly extent of the faults

Faults roughly on strike with the Cougar fault and Horse Creek-McKenzie River fault zone have been tentatively identified in the McCredie Hot Springs and Waldo Lake areas, respectively (Woller and Black, 1983). Continuity of distinctive gravity anomalies from the Horse Creek area to the Waldo Lake area and from the Cougar Reservoir area to the McCredie Hot Springs area (Couch and others, 1982a, 1982b) suggests that the faults may be regional structures extending well beyond present map areas (Priest and others, 1983a,b; Woller and Black, 1983).

Discussion

Priest and others (1983a,b) speculated that the Cougar faulting may have been caused by an extensional event earlier than, but analogous to, the event which caused the McKenzie River-Horse Creek faulting. They concluded that the two faulting events, one about 8-10 and the other about 4-5 m.y. ago, may have occurred during two accelerations in Basin and Range spreading which caused a microplate of western Oregon lithosphere to rotate toward the west. They postulated that faulting during the two events may have been localized where the relatively cool microplate was in contact with the more plastic, hotter crust underlying the Cascade volcanic arc. Where the microplate was in contact with the subducting Juan de Fuca Plate, an acceleration in the rate of subduction should have accompanied the two faulting events. A 10-m.y.-B.P. acceleration of underthrusting of the Juan de Fuca Plate has been documented (see the summary of Drake, 1982). Magmatic withdrawal and loading of the crust by the volcanic rocks generated over the subduction zone probably caused increased downfaulting under the Cascade arc relative to adjacent areas.

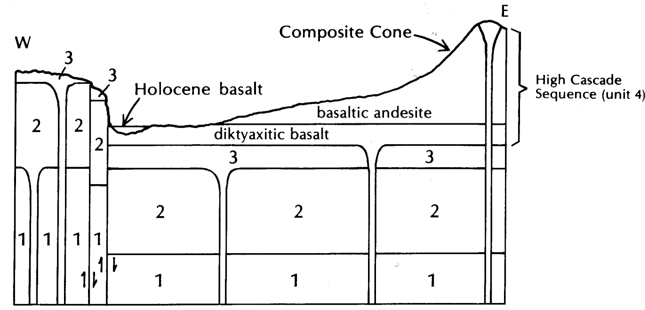


Figure 2. Schematic cross section across the eastern margin of the central Western Cascade Range, Oregon. See text for explanation of units. Modified after Taylor (1980b, 1981).

Geothermal exploration aimed at high-temperature hydrothermal systems should be focused on areas at, and east of, the youngest microplate boundary at the McKenzie River-Horse Creek zone of faulting. Areas of young silicic volcanism, as at the South Sister, are particularly attractive exploration targets for shallow magmatic heat sources.

ROAD LOG

(Start from Bend, going north on U.S. Highway 20/97. Mileage count begins just north of Bend city limit.)

Miles	Comments
0	Junction; U.S. 20 and 97 separate. *Take U.S. 20 to Sisters.* From north to south, Mount Jefferson, Three Fingered Jack, Mount Washington, the Three Sisters, and Broken Top volcano are Pleistocene composite cones which can be seen on the skyline to the west while you are traveling from Bend toward the High Cascades. The composite cones have the following compositions (Taylor, 1968, 1981; Sutton, 1974; Davie, 1980):

Mount Jefferson—basaltic andesite with less andesite and dacite

Three Fingered Jack—basaltic andesite

Mount Washington—chiefly basaltic andesite

North Sister—chiefly basaltic andesite

Middle Sister—basalt and minor basaltic andesite, andesite, dacite and rhyodacite

South Sister—andesite and minor dacite and rhyodacite

Broken Top—basaltic andesite and minor dacite, rhyodacite, and ash-flow tuff

The Middle Sister and South Sister were active during the late Pleistocene and are much less glaciated than the other, older composite cones. Eruptions of silicic lavas have occurred on the flanks of South Sister as recently as 2,300 to 1,900 years B.P. (Wozniak, 1982).

Miles	Comments
12.8	Suttle Lake Road. Suttle Lake lies in a basin enclosed by lateral and terminal moraines of the Suttle Lake advance of the Cabot Creek glaciation (less than 30,000 years B.P., according to Scott, 1977).
14.2	**STOP 9.** *Wide turnout on south side of highway.* The north-south-trending Green Ridge fault scarp can be clearly seen to the northeast. Black Butte, a reversely magnetized basaltic composite cone, lies on the south end of the fault (Taylor, 1981). The Green Ridge fault formed

approximately 4.5 m.y. B.P., when the High Cascade block subsided (Taylor, 1981).

14.6 *Narrow turnout on south side of highway.* A better view of Black Butte and Green Ridge to the east (not suitable for a large bus).

15.2 View of Cache Mountain and Mount Washington to the south.

22.5 Highly jointed aphyric andesite dome of Hogg Rock (Taylor, 1981). Three Fingered Jack, a heavily glaciated basaltic andesite composite cone, is visible to the north. To the south is the Hoodoo Butte cinder cone and the Hayrick Butte andesite dome; to the northwest is Maxwell Butte and to the west the Lost Lake chain of cinder cones. Davie (1980) determined that Three Fingered Jack is normally polarized but older than the Abbott Butte Glaciation (200,000-120,000 years B.P.) and that Maxwell Butte is composed of basaltic andesite which erupted between the Abbott Butte Glaciation and the Jack Creek Glaciation (80,000-40,000 years B.P.). The Lost Lake chain of basaltic cinder cones has a C^{14} age of $1{,}950 \pm 150$ years (Taylor, 1967).

23.5 On the north side of the road is Lost Lake and one of the young cinder cones which dammed up the lake on its west end.

25.4 **STOP 10.** Santiam Junction, highways U.S. 20 and Oregon 22. Nash Crater can be seen to the south, and Little Nash Crater is the low hill to the west. Basaltic andesite flows erupted from the base of these cinder cones about 3,000 C^{14} years ago (Taylor, 1981). These volcanic centers are part of a larger Holocene volcanic field which extends northward from the White Branch of the McKenzie River near North Sister (Taylor, 1967). The field experienced numerous eruptions between about $3{,}850 \pm 215$ C^{14} years and about $1{,}400 \pm 100$ C^{14} years ago (Taylor, 1967). *Continue on U.S. 20 (left).*

28.6 Junction of highways U.S. 20 and Oregon 126. *Turn south onto Highway 126.* From this point on, the road lies east of the heavily dissected Western Cascade escarpment. Avramenko (1981) inferred down-to-the-east faults along the escarpment in this area.

35.5 Highway crosses a basalt flow from Belknap Crater which flowed out of the north base of the cinder cone about 1,500 years ago (Taylor, 1981).

37.8 Kink Creek area. Mafic lavas in the road cuts are from intracanyon flows following canyons cut into the High Cascade platform lavas. Avramenko (1981) inferred that the platform lavas cover a down-to-the-east fault with 426-755 ft of displacement and that the fault was last active between 0.7 and 1.0 m.y. B.P.

39.8 Trailbridge Reservoir parking area. A distinctive basaltic andesite ignimbrite (52-53 percent SiO_2) dated at 5.0 m.y. B.P. crops out along the east side of the highway (Taylor, 1981).

45.9 Frissel-Carpenter Road. [Recommended side trip, but not suitable for large buses. The road leads to the Frissel Point area where Brown and others (1980b) showed extensive down-to-the-east, north-northwest step faulting along the Western Cascade escarpment. The Trailbridge ignimbrite is an important stratigraphic marker for faulting in this area (Taylor, 1981)].

47.5 Sign to Belknap Hot Springs. *Turn west.* **STOP 11.** Belknap Hot Springs. The springs discharge 188° F water (Mariner and others, 1980) at 80 gal/min with a mean calculated reservoir temperature of $235° \pm 57°$ F (Brook and others, 1979). These springs and Bigelow Hot Springs to the north are on a major boundary fault along the Western Cascade escarpment (Brown and others, 1980b; Taylor, 1981). The fault continues south to Horse Creek, where Flaherty (1981) documented about 1,970 ft of offset. Faults of this zone offset the Trailbridge ignimbrite (5.0 m.y. B.P.) and do not offset High Cascade platform lavas of Foley Ridge which Taylor (1980) inferred from Sutter's (1978) K-Ar data to be as old as 3.98 m.y. (age recalculated by Fiebelkorn and others, 1982). The faulting thus occurred between about 5 and 4 m.y. B.P. *Continue south on Oregon Highway 126.*

48.6 Junction, McKenzie Pass Highway (Oregon 242). Foley Ridge is visible to the south. It is composed of highly diktytaxitic basalt flows which flowed through a breach in the Horse Creek-McKenzie River fault scarp between about 2 and 4 m.y. B.P. (Taylor, 1980, 1981; Flaherty, 1981; Priest and others, 1983b). The basal flows lie at about the same elevation as the present McKenzie River channel; therefore, all of the present erosional relief on the uplifted Western Cascade block had developed by 4 m.y. B.P. (Flaherty, 1981; Priest and others, 1983b). *Continue west on Oregon 126.*

53.3 McKenzie Bridge. Restrooms, gasoline, and food are available here. Intracanyon, diktytaxitic flows of the Foley Ridge sequence make up the hills to the northwest and southeast.

55.3 Castle Rock, the prominent peak to the south, is an andesite plug (60 percent SiO_2) K-Ar dated at 9.3 ± 0.4 m.y. B.P. (Priest and Woller, 1982). Lookout Ridge to the north and McLennen Mountain to the southeast are middle Miocene andesitic sequences (lavas of Walker Creek) that are capped by moderately diktytaxitic basaltic lavas (lavas of Tipsoo Butte) with K-Ar dates between about 9.4 and 7.8 m.y. B.P. (Priest and Woller, 1982). As previously explained the uppermost part of the capping sequence (here mostly eroded away) is probably about 5 m.y. old, corresponding to the Trailbridge ignimbrite.

58.3 Rainbow. *Turn south on the Cougar Dam road and proceed south to the upper rim of the dam (take the right-hand road when the road forks).* Outcrops near the road junction are the tuffs of Cougar Reservoir, which are lower Miocene and lower altered ash flows, tuffaceous lahars, and epiclastic rocks.

59.1 The large peak to the west is Deathball Rock, a sequence of middle Miocene two-pyroxene andesite flows of the lavas of Walker Creek.

61.2 Outcrops along the road are a complex mixture of a glassy dacite intrusion (63.6 percent SiO_2) and the tuffs of Cougar Reservoir.

61.7 West abutment of Cougar Dam. Outcrops on both the east and west abutments of the dam are the previously mentioned glassy dacite. Note the prominent northwest- to west-trending shear zones, dikes, and breccia dikes which cut the intrusion on the east abutment. The intrusion is a large, north-south-trending dikelike mass forming the ridge to the east. The west abutment appears to be more of a sill-like body. *Turn east and cross the dam.*

62.1 **STOP 12.** East abutment. A K-Ar date of 16.2±1.8 m.y. B.P. was obtained on the intrusion at this locality. The ridge to the west is Katsuk Butte, which is capped by middle Miocene two-pyroxene andesite (andesites of Walker Creek) interfingering with ash-flow, air-fall, and epiclastic tuffs (tuffs of Rush Creek). The basal rocks are the tuffs of Cougar Reservoir and the dacite intrusion. The contact between the tuffs of Cougar Reservoir and the younger rocks can be seen to dip off toward the south. The younger rocks lap onto an old highland of the tuffs of Cougar Reservoir. *Continue south along the lake shore road.*

65.6 South side of the East Fork of the South Fork of the McKenzie River. Observe shear zones associated with the north-south-trending Cougar fault which are here cutting basalts interbedded in the middle Miocene andesite sequence. The fault zone was followed by a Pleistocene channel of the South Fork, but Pleistocene gravels cropping out at this locality are not cut by the fault. The fault zone passes through the north-south lineament formed by the saddle to the north. The fault juxtaposes the tuffs of Cougar Reservoir on the upthrown block to the west with the middle Miocene sequence to the east.

66.6 **STOP 13.** East side of Cougar Reservoir. This locality is the most prominent outcrop of the Cougar fault. Altered breccias of the andesites of Walker Creek and the tuffs of Cougar Reservoir are exposed. Just south of this stop, a 500-ft temperature-gradient well was drilled about 150 ft east of the fault on the downthrown side. The hole encountered only the andesites of Walker Creek. The minimum offset on the fault is thus 500 ft down to the east. With various stratigraphic arguments, Priest and Woller (1982) suggested that the offset is probably more than 1,400 ft.

Several temperature-gradient wells in this area show that the heat flow (80-100 mW/m^2) is transitional to the high heat flow (over 100 mW/m^2) characteristic of the High Cascades (Black and others, 1982). Terwilliger Hot Springs, located on the west side of the reservoir, reflects this lower heat flow by having lower temperature water (111° F) than Belknap Hot Springs (188° F) to the east (temperatures from Mariner and others, 1980). *Turn back north to Santiam Junction (stop 10) and take Oregon Highway 22 to the northwest.*

108.6 At 0.8 mi northwest of Santiam Junction, Highway 22 crosses a spectacular Holocene basaltic andesite flow which was erupted from Little Nash Crater to the south.

121.3 View of Mount Jefferson to the east. Mount Jefferson is a heavily dissected Pleistocene composite cone of basaltic andesite with lesser amounts of andesite and dacite (Sutton, 1974).

121.4 View to the west of middle(?) to late Miocene mafic lavas of Rollins' (1976) Nan Creek volcanics which form much of the north-south topographic escarpment of the Western Cascade Range in this area. To the west, these lavas are capped by late Miocene(?) tuffs and lavas. To the east, the Nan Creek volcanics are capped by Quaternary intracanyon lava flows (the Pigeon Prairie flows). Rollins (1976) and Hammond and others (1982) did not find evidence of any large-scale down-to-the-east faulting along this part of the Western Cascade escarpment.

126.3 Southeast-dipping sequence of middle Miocene(?) mafic lavas and epiclastic rocks of the Grizzly Creek lavas of Rollins (1976). These rocks underlie the Nan Creek volcanics.

126.9 Pamelia Creek. The northernmost end of the Western Cascade escarpment is at Mount Bruno to the west.

127.9 A Quaternary block-and-ash flow which flowed down the Whitewater River from Mount Jefferson (Hammond and others, 1982) crops out on the east side of the highway. Close inspection of the angular blocks reveals some prismatic joints, indicating that the flow was probably quite hot.

128.9 Elbow of the North Santiam River. At this point the river veers sharply toward the west. As explained in the summary, a nearly east-west highland of rocks of late Miocene and older age occurs to the north of the elbow. The Pigeon Prairie flows crop out intermittently along the highway. Most road cuts to the west are composed of altered ash flows of the Breitenbush formation which underlies the Grizzly Creek lavas (Rollins, 1976; Hammond and others, 1982).

139.6 Detroit. Junction with U.S. Forest Service (USFS) Road 4600. *Take USFS Road 4600 to the northeast up the Breitenbush River.* Roadcuts in this area expose the beds at Detroit, a sequence of altered tuffaceous epiclastic sediments older than the ash flows of the Breitenbush tuff (Hammond and others, 1982).

148.7 Junction with USFS Road 2231. Cleator Bend picnic area. Outcrops of green nonwelded ash-flow tuff are visible along the road (Cleator Bend member of the Breitenbush formation of Hammond and others, 1982). *Take USFS Road 2231 to the southeast.*

149.5 Road divides. *Turn left onto USFS Road 2231-890 and follow the signs to Breitenbush Hot Springs (Breitenbush Community).*

150.2 **STOP 14.** Breitenbush Hot Springs. The springs discharge 900 gal/min of water with temperatures up to 198° F and a mean reservoir temperature of 257°±50° F, according to Brook and others (1978). Shallow wells in the area have encountered water up to 230° F with a SiO_2 geothermometric (adiabatic) temperature of 325° F (Mariner and others, 1980). Background heat flow in the area is in excess of 100 mW/m^2 (Black and others, 1982). The springs flow out of highly jointed basaltic lavas probably similar in age to the Grizzly Creek lavas of Rollins (1976). *Return to Oregon Highway 22.*

End of second-day road log.

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(Continued on page 141, **References)**

Multnomah County: 1983 Mined Land Reclamationist in Oregon

by Paul F. Lawson, Supervisor, Mined Land Reclamation Program, Albany Field Office, Oregon Department of Geology and Mineral Industries

Multnomah County is this year's winner of the award for the Outstanding Mined Land Reclamation Project. The selection committee, composed of the supervisor of the Mined Land Reclamation Program and representatives from a major environmental organization and the mining industry, found it easy to make the final choice unanimously. The county, which received a plaque for its permanent retention, is also temporary custodian of another plaque which lists the annual winners.

Through this accomplishment, Multnomah County has set a commendable example for other mining operators in the county and also for all other county governments. The award was given in recognition of the county's multiple use of land it has reclaimed. The entire operation has been voluntary, since the mining long preceded the reclamation act. It is an emphatic illustration that often reclamation is possible and economically attractive without being mandated.

The award was given for a specific 15-acre parcel located on SE 190th Avenue between Stark and Division Streets, although the county has mined and reclaimed still more land and will continue to mine nearby. In 1940, this was rural land. About 1942, extraction of sand and gravel began. At an average depth of 10 yards, approximately 725,000 cubic bank yards or, conservatively, 870,000 cubic yards as delivered, was harvested. By 1958, mining on this parcel had ceased, and its use as a landfill began. The site was filled

Outstanding Reclamation Project in Oregon for 1983, Multnomah County's energy-efficient operations and maintenance headquarters at 1620 SE 190th Avenue, Portland. Background and foreground show evidence of ongoing and past mining activity here. (State Highway Division air photo)

Dennis O'Meara (left), of Multnomah County Executive's Office, and Tor Lyshaug, Director, Division of Operations and Maintenance, receiving this year's Outstanding Mined Land Reclamation Project Award.

Excavation starting in 1980 on former mining-landfill site in preparation for Multnomah County's new operation and maintenance headquarters (center). Note continuing mining-related activities on all sides. (State Highway Division air photo)

Excavation through landfill to base of former mined area for foundation of county headquarters building. (State Highway Division air photo)

by 1970. By the time construction of I-205 forced the relocation of the county's shops from their long-time location at Rocky Butte, this site had ceased to be chemically active and was ready for further use. After considering approximately 200 sites, the county chose this site for the new home of their Division of Operations and Maintenance. In order to obtain stable foundation footing, the fill in the actual area to be occupied by the new building was excavated to the mined pit floor. Removed material was stored securely and neatly on another part of the property.

The building, which was carefully planned by Tor Lyshaug, Director, Division of Operations and Maintenance, Multnomah County, and by the architects, Zimmer Gunsul Frasca Partnership, who, for their contribution, received an award of excellence in 1982 from the Portland Chapter of the American Institute of Architects. The building is especially energy efficient. It is approximately three quarters below grade. Energy is provided by a combination of solar collectors and gas-fired radiant heaters with an oil-fired boiler for backup. Lighting is also special through window design, use of skylights, and incremental lighting utilizing a sophisticated electric eye.

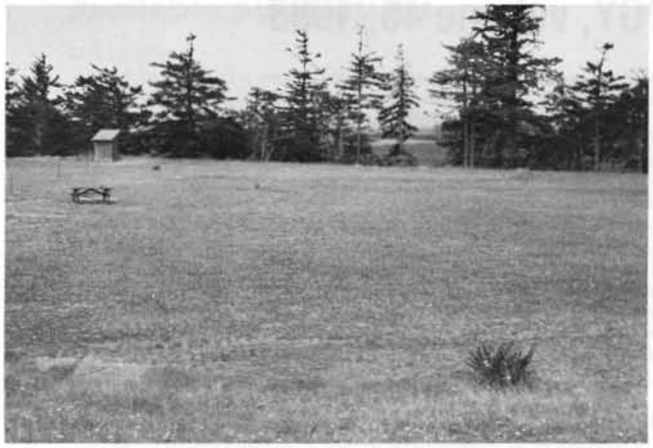
Space is provided within the building for parking of equipment, dispatching and tool rooms for district road crews, service and repairs to county vehicles and equipment (approximately 1,500 pieces), offices, storage rooms, specialty shops, computer room, materials-testing laboratory, training area, and lunch room. Through the use of grassy berms, the landscaping is designed to minimize the visual impact of the building upon future neighbors and of the activities of neighbors upon the building's occupants, a technique used successfully in Japan years ago by Frank Lloyd Wright. A tour of this facility is an exciting and educational experience.

The building is named the John B. Yeon Shops, for Multnomah County's first roadmaster. John Yeon served from 1913 to 1917. It is said he sought the job for $1.00 per year so that he might facilitate the construction of the Columbia River Highway.

Mining continues on other parts of this property and mining and mineral processing continues on other adjacent properties.

There is only one winner, but there are several finalists who are highly deserving of recognition and approbation:

Harold Knapp of Knapp Ranches, Port Orford, has returned approximately five acres of his gravel pit to neatly contoured pasture, while mining continues nearby. A local rifle club also uses the reclaimed area as a rifle range.



Knapp Ranches, Port Orford. Reclaimed mined land now serving as pasture and rifle range.

The Oregon State Highway Division, Department of Transportation, has done a fine job in reclaiming a site 2.7 mi south of Junction City on Pacific Highway West. The site is smoothed and revegetated, and underwater slopes are gentle. The Oregon Department of Fish and Wildlife has stocked the lake for public fishing. This author has watched model seaplane enthusiasts flying their aircraft on it. The reclaimed area, parts of which had been mined at earlier times, totals about 10 acres of water and 10 acres of land; about half of each are from the most recent operation.

Vernon Egge of Egge Sand and Gravel, Eugene, has completed an excellent job in filling, recontouring, and revegetating the Clearwater sand and gravel pit on Clearwater Lane, southeast of Springfield. One acre was reclaimed to wildlife habitat, five acres to agricultural use, and one acre to a solid waste disposal site. The latter is now in use under a permit from another agency.

In making its decision, the selection committee considers these criteria: (1) Compliance with the approved reclamation plan (when reclamation is mandatory), (2) imagination and/or innovativeness in accomplishing the planned reclamation, (3) future value of the site, (4) appropriateness to the local environment, (5) safety, and (6) aesthetics. The purposes of the award program are to (1) recognize and commend the outstanding example of mined land reclamation and the operator performing it, in Oregon each year; (2) acknowledge and praise other operators and their projects which were nominated and considered for the annual award; and (3) encourage and further the goal of sensible mined land reclamation, both mandatory and voluntary.

Oregon State Highway Division reclamation site near Junction City. The 10-acre lake, open to public fishing, has a "drown-proofed" shoreline, i.e., a shallow 3:1 slope extending 18 ft out from water's edge into lake. This also encourages growth of aquatic plants.

The law, ORS 517.750-517.990, with some exemptions, requires lands affected by surface mining after July 1, 1972, to be reclaimed or restored to some "beneficial use." In addition, the Mined Land Reclamation Program tries to insure that a site is left reasonably safe and nonpolluting. Stronger provisions apply to surface mines producing coal and metal-bearing ores which first obtained a permit after August 16, 1981. In October 1983, the law became applicable to the surface impacts of underground mines by amendment of the 1983 legislature. Beyond the limits of the law's applicability, the State of Oregon encourages and assists any operator considering to undertake voluntary reclamation.

Over 3,000 acres of mining lands are currently under performance bond or other security to guarantee reclamation required under the law. To date, over 1,200 acres of mined lands have been reclaimed to agriculture, forestry, wildlife, housing, industrial, recreational, and other uses.

Nominations for the Outstanding Mined Land Reclamation Project Award are invited at any time from anyone with knowledge of a deserving site. Such nominations should be sent to Mined Land Reclamation Program, 1129 SE Santiam Road, Albany, Oregon 97321. □

OAS to meet in February at U of O

The Oregon Academy of Science (OAS) will hold its annual meeting on Saturday, February 25, 1984, at the Erb Memorial Union at the University of Oregon in Eugene. Abstract forms are available from Jay F. Evett, Western Oregon State College, Monmouth, Oregon 97361, until the abstract deadline (January 5, 1984).

Day registration at the meeting is only $2. For $8, one can register for the meeting, become a member of the Academy, and receive a copy of the published proceedings of the meeting. □

PNMMC calls for papers for 1984 meeting

Papers on the regional geology, geophysics, petroleum geology, and economic mineral deposits of the Pacific Northwest are invited for the 1984 Pacific Northwest Metals and Minerals Conference to be held April 30-May 2, 1984, at the Lloyd Center Red Lion Inn. Abstracts are due on January 15, 1984. For more information about the abstracts, contact Mike Cummings, Portland State University, P.O. Box 751, Portland, OR 97207, phone (503) 229-3029. For additional information about the conference, contact Al Rule, Bureau of Mines, P.O. Box 70, Albany, OR 97321, phone (503) 967-5841. □

(References, *continued from page 138)*

Wise, W.S., 1969, Geology and petrology of the Mount Hood area: A study of High Cascade volcanism: Geological Society of America Bulletin, v. 80, no. 6, p. 969-1006.

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Note: The double issue published for July and August this year is referred to simply as issue number 7.

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