

# OREGON GEOLOGY

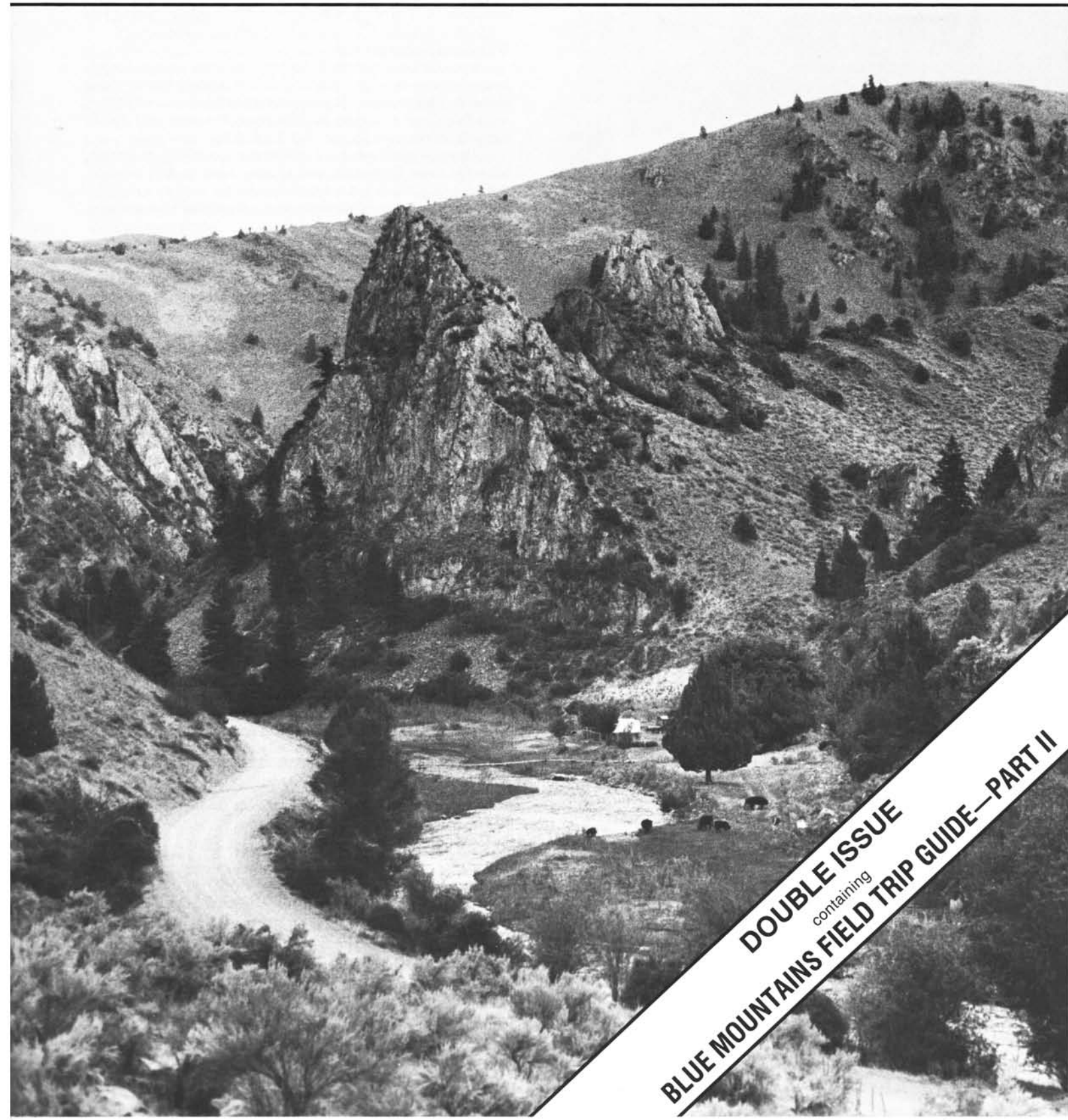
published by the

Oregon Department of Geology and Mineral Industries



VOLUME 45, NUMBER 7/8

JULY/AUGUST 1983



**DOUBLE ISSUE**  
containing  
**BLUE MOUNTAINS FIELD TRIP GUIDE—PART II**

# OREGON GEOLOGY

(ISSN 0164-3304)

VOL. 45, NO. 7/8

JULY/AUG. 1983

Published monthly by the State of Oregon Department of Geology and Mineral Industries (Volumes 1 through 40 were entitled *The Ore Bin*).

## Governing Board

C. Stanley Rasmussen . . . . . Baker  
Allen P. Stinchfield . . . . . North Bend  
Donald A. Haagenzen . . . . . Portland

**State Geologist.** . . . . Donald A. Hull

**Deputy State Geologist** . . . . . John D. Beaulieu

**Publications Manager/Editor** . . . . . Beverly F. Vogt

**Associate Editor** . . . . . Klaus K.E. Neuendorf

**Main Office:** 1005 State Office Building, Portland 97201, phone (503) 229-5580.

**Baker Field Office:** 2033 First Street, Baker 97814, phone (503) 523-3133.

Howard C. Brooks, Resident Geologist

**Grants Pass Field Office:** 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496.

Len Ramp, Resident Geologist

**Mined Land Reclamation Program:** 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039.

Paul F. Lawson, Supervisor

Subscription rates: 1 year, \$6.00; 3 years, \$15.00. Single issues, \$.75 at counter, \$1.00 mailed.

Available back issues of *The Ore Bin*: \$.50 at counter, \$1.00 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

Send news, notices, meeting announcements, articles for publication, and editorial correspondence to the editor, Portland office. The Department encourages author-initiated peer review for technical articles prior to submission. Any review should be noted in the acknowledgments.

Permission is granted to reprint information contained herein. Credit given to the Oregon Department of Geology and Mineral Industries for compiling this information will be appreciated.

Second class postage paid at Portland, Oregon.

Postmaster: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

## 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.

Elsewhere 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	NE ¼ sec. 34 T. 19 S., R. 3 W. Lane County	Location; 3,000
239	Petrol. & Min. Analysis Keech 1 047-00015	NE ¼ sec. 15 T. 9 S., R. 2 W. Marion County	Location; 3,600

## CONTENTS

Blue Mountains field trip guide—Part II . . . . .	75
Abstract of Department paper presented at GSA . . . . .	82
In memoriam: Philip Francis Brogan, 1896-1983 . . . . .	83
U.S. Bureau of Mines assigns new Liaison Officer . . . . .	83
U.S. Bureau of Land Management news . . . . .	83
Productivity Improvement Award to DOGAMI . . . . .	84
Mining news from Oregon . . . . .	85
Abstracts of theses . . . . .	86
Fireballs sighted in Oregon . . . . .	89
USGS mapping program realignment . . . . .	89
Announcements . . . . .	89
New DOGAMI publications . . . . .	90

# 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 ( <b>bold</b> ) and comments
0	<b>Begin road log</b> at Baker Post Office. Go south on Oregon Highway 7.
9.0	Junction. Turn right toward Sumpter. <b>Begin using Map 1.</b>
14.7	<b>1:</b> Volcanic greenstone breccia and porphyritic greenstone intruded by fine diabase. Jurassic hornblende diorite dikes are also present.
16.4	<b>2:</b> Turn left on Black Mountain Road. Pillowed greenstones, thoroughly altered to chlorite and epidote.

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



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

- 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.

50.3 **9:** Silicic sediments and cherts, pervasively sheared. Elkhorn Ridge Argillite dominates outcrops in this area. Volcanic breccias and volcanoclastics 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 titanite 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.

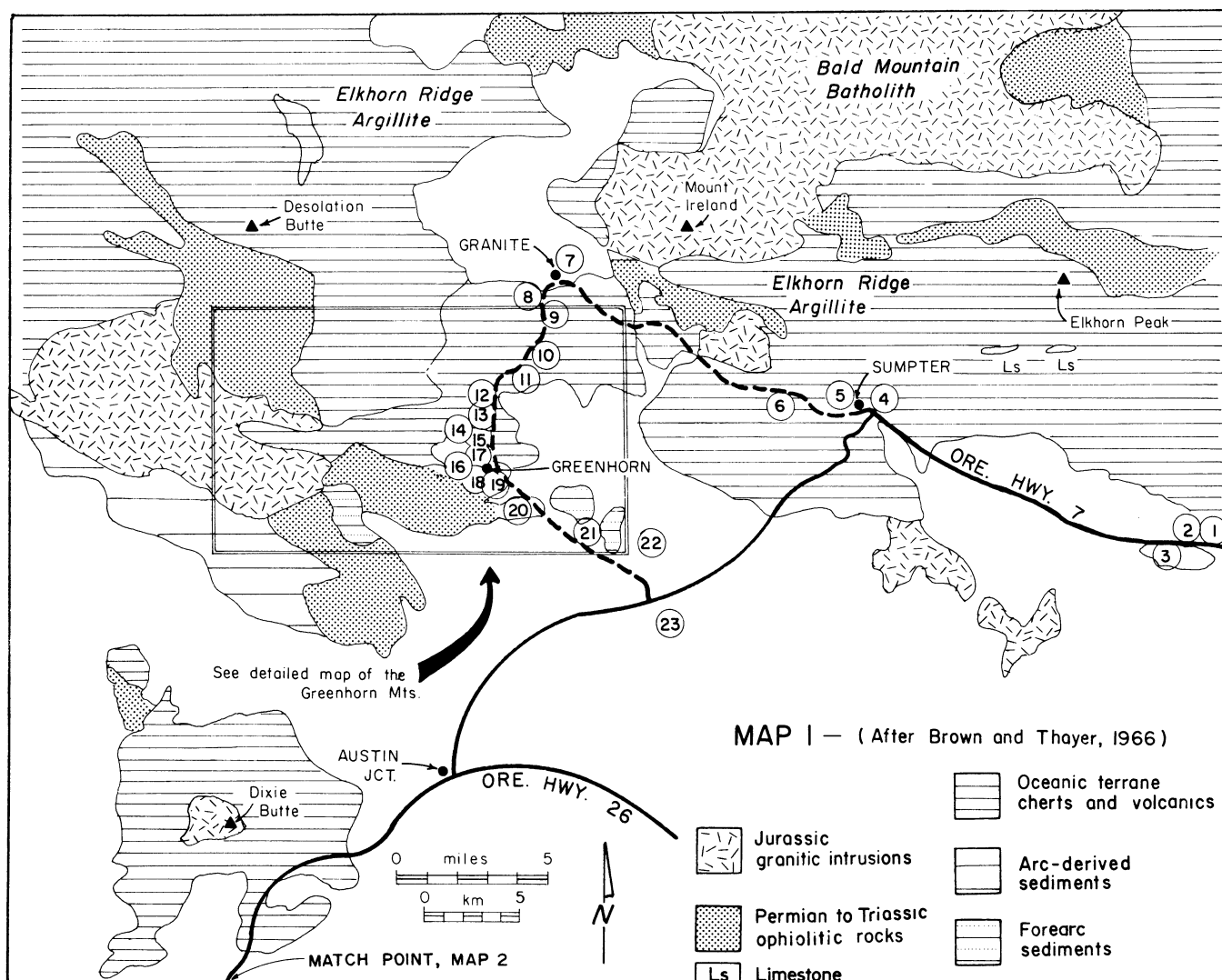
60.0 Left, right, then right on logging roads. The area was a famous high-grade gold district in the early 1900's and contains many mines and prospects, including the IXL and Humboldt Mines.

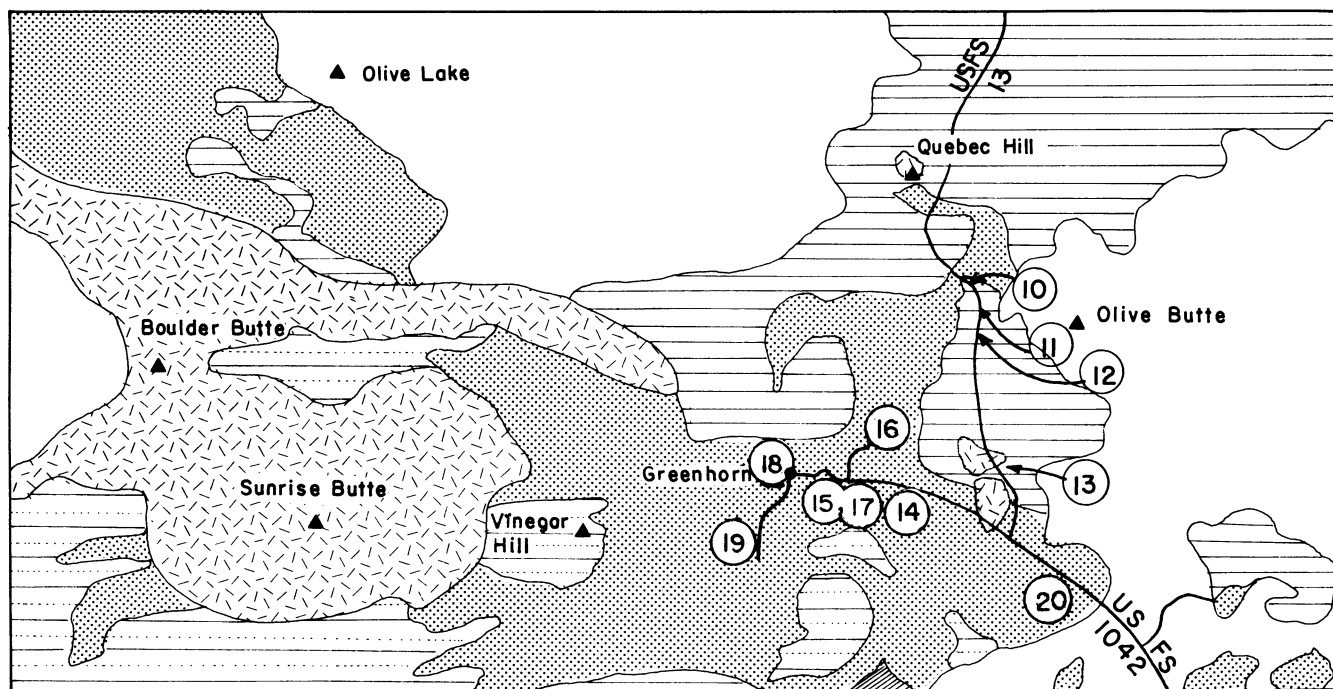
60.4 **16:** Cabin and mine, Irish Gulch. Mine tunnel exposes uniformly bedded ribbon cherts of the Elkhorn Ridge Argillite just east of the contact with sheared serpentinite. The serpentinite at this locality developed from a layered ultramafic body which grades into gabbros westward. Unsheared layered 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).

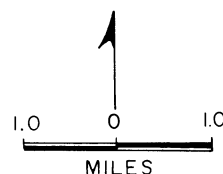
61.9 **19:** Small clearing with low outcrops and "float" of Upper





-  Jurassic granitic intrusions
-  Permian to Triassic ophiolitic rocks and serpentinite mélangé
-  Permian oceanic terrane cherts and volcanic greenstones
-  Permian forearc sediments
-  Permian arc-derived sediments

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



(After Mullen, 1979)

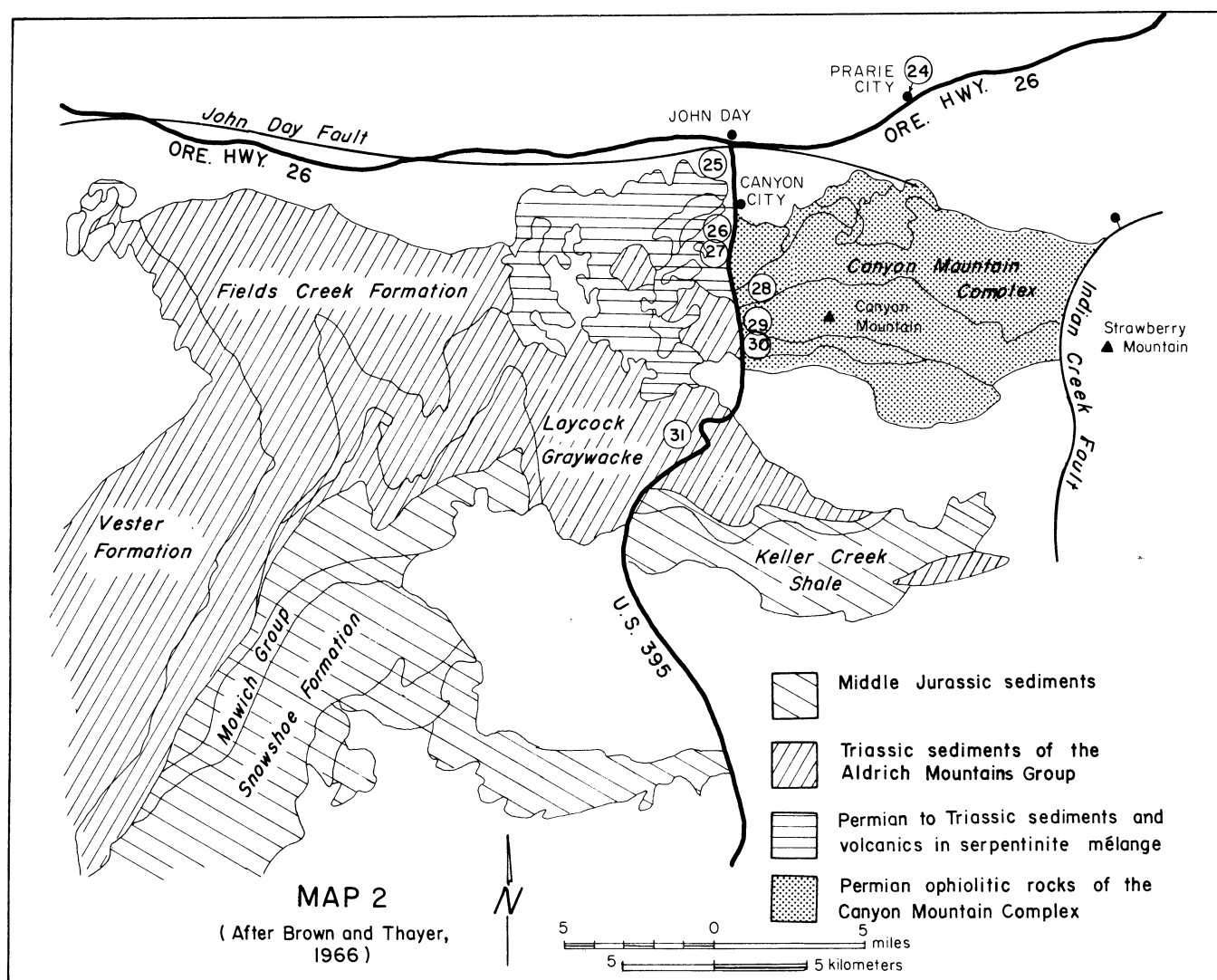
MAP 1A

- 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 mélangé 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 mélangé 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 volcanoclastics in mélangé.
- 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 volcanoclastics 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 ( <b>bold</b> ) and comments
0	<b>Begin road log</b> at Baker Post Office. Drive south on Oregon Highway 7.
9.0	<b>32 (off map):</b> Junction. Continue south (left) on Oregon Highway 245 toward Unity. <b>Begin using Map 3.</b>
16.8	<b>33:</b> Dooley Mountain Summit.
18.0	<b>34:</b> Coarse tuff breccia of the Dooley Mountain Rhyolite, Oligocene in age.
21.4	<b>35:</b> Perlite and flow-banded rhyolite, Dooley Mountain Rhyolite.
24.6	<b>36:</b> Junction. Turn left toward Durkee.
29.9	Junction. Turn north (left) onto Burnt River Canyon Road.
32.5	<b>37:</b> Greenstones associated with the Burnt River Schist. Pervasively sheared. Greenschist metamorphism.
32.6	<b>38:</b> Keratophyre. Less sheared than rocks at previous stop.
33.2	<b>39:</b> 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 volcanoclastic 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 green-schist 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.

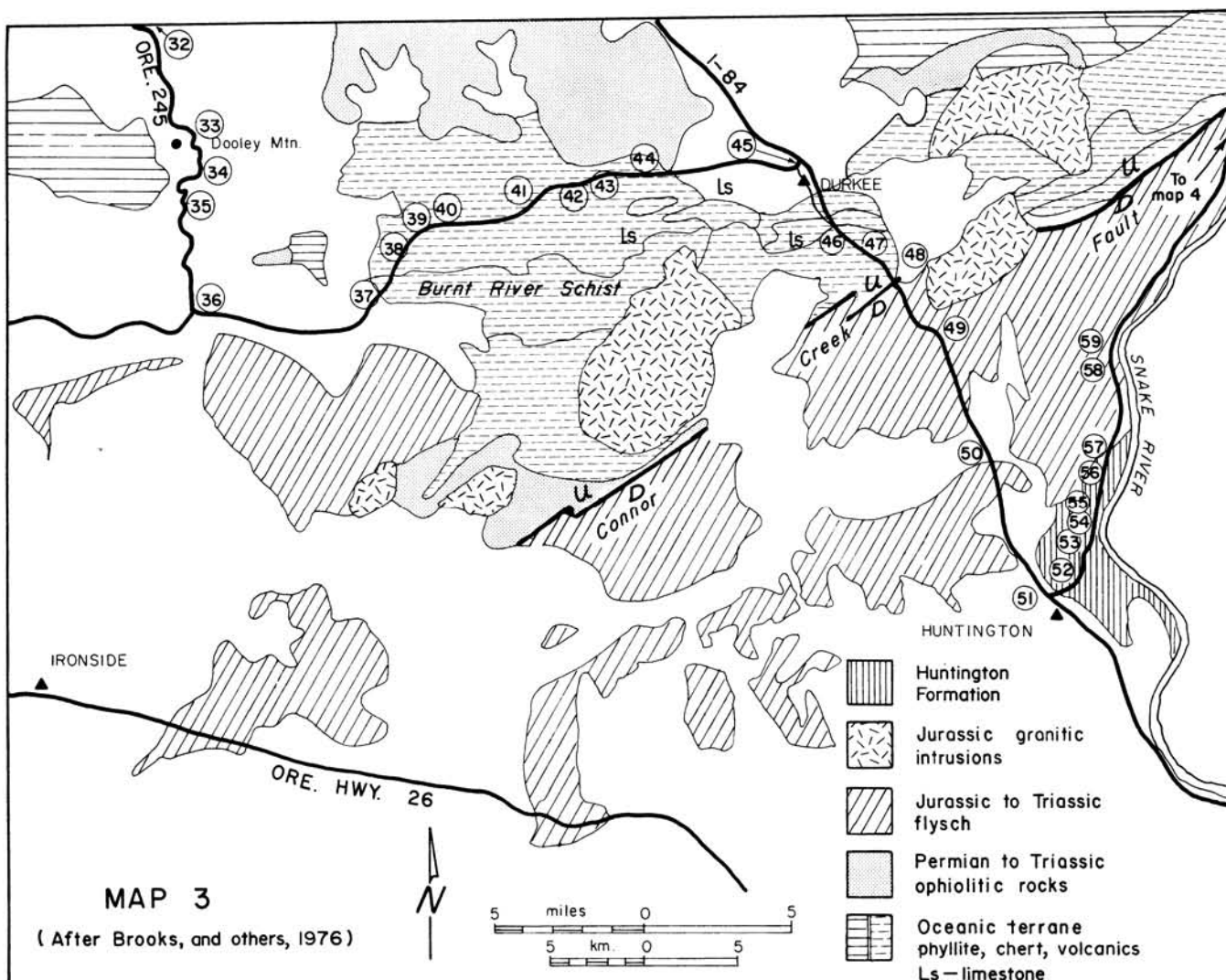
88.2 **58:** Jurassic Weatherby Formation visible in peak to the northwest.

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 titanagites, 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

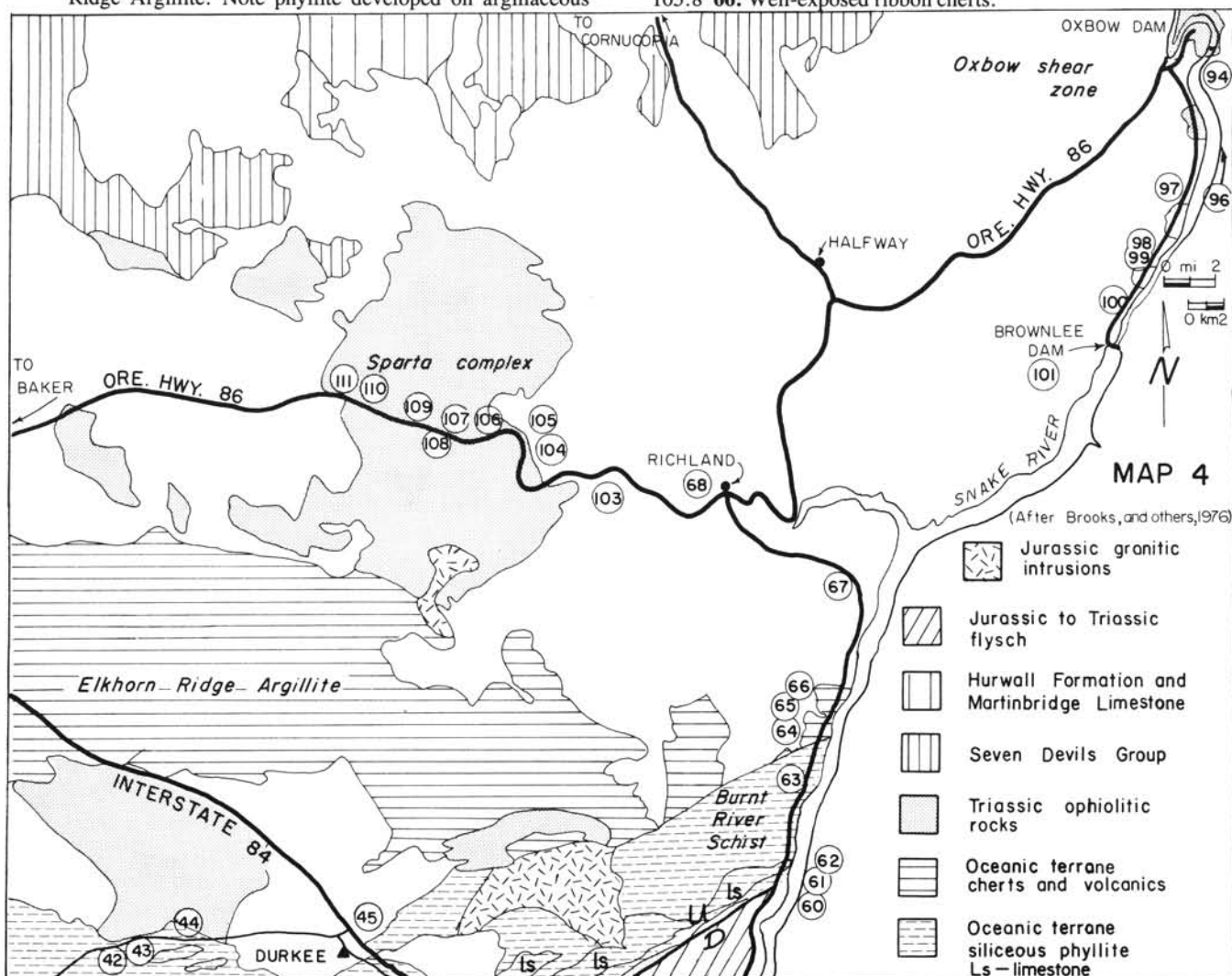


Ribbon cherts, Elkhorn Ridge Argillite, north of gradational contact with Burnt River Schist along the Snake River. Loop B, map point 64.

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

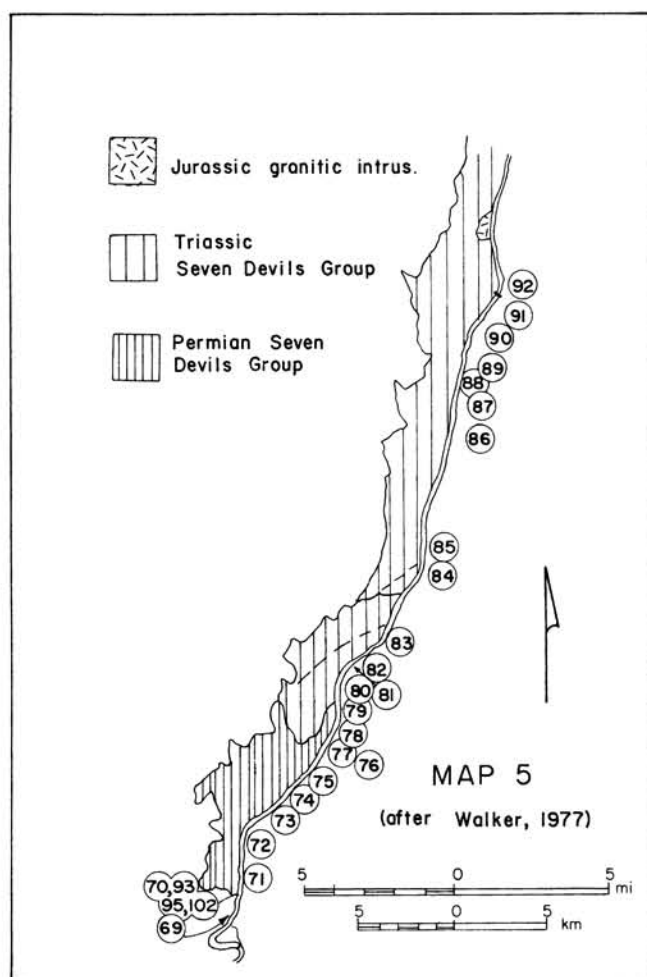
103.4 **65:** Alkalic pillowed greenstones associated with Elkhorn Ridge Argillite cherts. This exposure contains abundant relict titanagite.

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 ( <b>bold</b> ) and comments
0	<b>69:</b> Idaho Power Company Copperfield Park Campground. Take IPCo road northeast toward Hells Canyon Dam. Use <b>Map 5</b> .
0.2	<b>70:</b> Center, Snake River bridge. Follow IPCo road along Idaho side of Snake River.
0.6	<b>71:</b> 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	<b>72:</b> Windy Ridge volcanic breccias which contain exclusively volcanic clasts.
3.1	<b>73:</b> Red volcanic breccias of the Windy Ridge Formation.
3.5	<b>74:</b> Bedded volcanoclastic 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 volcanoclastic 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 volcanoclastics. Diabase dikes crosscut similar sediments and keratophyre at mi 6.9.
- 8.0 **79:** More Hunsacker Creek coarse volcanoclastic rocks. Light to dark green.
- 8.3 **80:** Triassic Doyle Creek red volcanoclastic 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 volcanoclastic 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 volcanoclastic 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 road-log 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 fusulinids 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 step-like 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  $\text{Al}_2\text{O}_3$ , 31.8 percent  $\text{Fe}_2\text{O}_3$ , and 5.9 percent  $\text{SiO}_2$ , 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.  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$  relative concentrations tend to vary oppositely, though both are significantly concentrated in most samples.  $\text{SiO}_2$  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.

**GEOHERMAL 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 aeromagnetic 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/m<sup>2</sup>, 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 under-sampling 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 km<sup>2</sup> and are estimated to represent a total volume of at least 650 km<sup>3</sup>. 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.

<sup>87</sup>Sr/<sup>86</sup>Sr and <sup>143</sup>Nd/<sup>144</sup>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 volcanoclastic 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 volcanoclastic 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 volcanoclastics, especially stratified volcanoclastics 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. □



## Available publications

### 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 Vaisetz 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 <i>The Ore Bin</i> ), 1977 .....	4.00	_____	_____
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977 .....	7.00	_____	_____
94. Land use geology of central Jackson County, Oregon, 1977: Beaulieu .....	9.00	_____	_____
95. North American ophiolites, 1977 .....	7.00	_____	_____
96. Magma genesis: AGU Chapman Conference on Partial Melting, 1977 .....	12.50	_____	_____
97. Bibliography (6th supplement) geology and mineral resources of Oregon, 1971-75, 1978 .....	3.00	_____	_____
98. Geologic hazards of eastern Benton County, Oregon, 1979: Bela .....	9.00	_____	_____
99. Geologic hazards of northwestern Clackamas County, Oregon, 1979: Schlicker and Finlayson .....	10.00	_____	_____
100. Geology and mineral resources of Josephine County, Oregon, 1979: Ramp and Peterson .....	9.00	_____	_____
101. Geologic field trips in western Oregon and southwestern Washington, 1980 .....	9.00	_____	_____
102. Bibliography (7th supplement) geology and mineral resources of Oregon, 1976-1979, 1981 .....	4.00	_____	_____

### GEOLOGIC MAPS

Reconnaissance geologic map of Lebanon quadrangle, 1956 .....	3.00	_____	_____
Geologic map of Bend quadrangle and portion of High Cascade Mountains, 1957 .....	3.00	_____	_____
Geologic map of Oregon west of 121st meridian (USGS I-325), 1961 .....	3.50	_____	_____
Geologic map of Oregon east of 121st meridian (USGS I-902), 1977 .....	5.00	_____	_____
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded) .....	3.00	_____	_____
GMS-5: Geologic map of Powers quadrangle, Oregon, 1971 .....	3.00	_____	_____
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974 .....	6.50	_____	_____
GMS-7: Geology of the Oregon part of the Baker quadrangle, Oregon, 1976 .....	3.00	_____	_____
GMS-8: Complete Bouguer gravity anomaly map, Cascade Mountain Range, central Oregon, 1978 .....	3.00	_____	_____
GMS-9: Total field aeromagnetic anomaly map, Cascade Mountain Range, central Oregon, 1978 .....	3.00	_____	_____
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon, 1978 .....	3.00	_____	_____
GMS-12: Geologic map of the Oregon part of the Mineral quadrangle, 1978 .....	3.00	_____	_____
GMS-13: Geologic map of the Huntington and part of the Olds Ferry quadrangles, Oregon, 1979 .....	3.00	_____	_____
GMS-14: Index to published geologic mapping in Oregon, 1898-1979, 1981 .....	7.00	_____	_____
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, northern Oregon, 1981 .....	3.00	_____	_____
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, southern Oregon, 1981 .....	3.00	_____	_____
GMS-17: Total-field aeromagnetic anomaly map, Cascade Mountain Range, southern Oregon, 1981 .....	3.00	_____	_____
GMS-18: Geology of the Rickreall, Salem West, Monmouth, and Sidney 7½-minute quadrangles, Marion, Polk, and Linn Counties, Oregon, 1981 .....	5.00	_____	_____
GMS-19: Geology and gold deposits map of the Bourne quadrangle, Baker and Grant Counties, Oregon, 1982 ....	5.00	_____	_____
GMS-20: Map showing geology and geothermal resources of the southern half of the Burns 15-minute quadrangle, Oregon, 1982 .....	5.00	_____	_____
GMS-21: Geology and geothermal resources map of the Vale East 7½-minute quadrangle, Oregon, 1982 .....	5.00	_____	_____
GMS-22: Geology and mineral resources map of the Mt. Ireland quadrangle, Baker and Grant Counties, Oregon, 1982 .....	5.00	_____	_____
GMS-23: Geologic map of the Sheridan quadrangle, Polk and Yamhill Counties, Oregon, 1982 .....	5.00	_____	_____
GMS-24: Geologic map of the Grand Ronde quadrangle, Polk and Yamhill Counties, Oregon, 1982 .....	5.00	_____	_____
<b>NEW!</b> GMS-25: Geology and gold deposits map of the Granite quadrangle, Baker and Grant Counties, Oregon, 1982 ....	5.00	_____	_____
GMS-26: Residual gravity maps of the northern, central, and southern Cascade Range, Oregon, 1982 .....	5.00	_____	_____
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1° by 2° quadrangle, 1982 ....	6.00	_____	_____
<b>NEW!</b> GMS-28: Geology and gold deposits map of the Greenhorn quadrangle, Baker and Grant Counties, Oregon, 1983 ..	5.00	_____	_____

### OIL AND GAS INVESTIGATIONS

3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well .....	3.00	_____	_____
4. Preliminary identifications of foraminifera, E.M. Warren Coos County I-7 well, 1973 .....	3.00	_____	_____
5. Prospects for natural gas production or underground storage of pipeline gas, upper Nehalem River Basin, Columbia-Clatsop Counties, Oregon, 1976 .....	5.00	_____	_____
6. Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane Counties, Oregon, 1980: Newton and others .....	9.00	_____	_____
<b>NEW!</b> 7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington, 1983 .....	8.00	_____	_____

## Available publications (continued)

	Price	No. Copies	Amount
<b>SPECIAL PAPERS</b>			
1. Mission, goals, and programs of Oregon Department of Geology and Mineral Industries, 1978 . . . . .	3.00	_____	_____
2. Field geology of SW Broken Top quadrangle, Oregon, 1978: Taylor . . . . .	3.50	_____	_____
3. Rock material resources of Clackamas, Columbia, Multnomah, and Washington Counties, Oregon, 1978: Gray and others . . . . .	7.00	_____	_____
4. Heat flow of Oregon, 1978: Blackwell, Hull, Bowen, and Steele . . . . .	3.00	_____	_____
5. Analysis and forecasts of the demand for rock materials in Oregon, 1979: Friedman and others . . . . .	3.00	_____	_____
6. Geology of the La Grande area, Oregon, 1980: Barrash and others . . . . .	5.00	_____	_____
7. Pluvial Fort Rock Lake, Lake County, Oregon, 1979: Allison . . . . .	4.00	_____	_____
8. Geology and geochemistry of the Mt. Hood volcano, 1980: White . . . . .	3.00	_____	_____
9. Geology of the Breitenbush Hot Springs quadrangle, Oregon, 1980: White . . . . .	4.00	_____	_____
10. Tectonic rotation of the Oregon Western Cascades, 1980: Magill and Cox . . . . .	3.00	_____	_____
11. Theses and dissertations on the geology of Oregon: Bibliography and index, 1899-1982, 1982: Neuendorf and others . . . . .	6.00	_____	_____
12. Geologic linears of the northern part of the Cascade Range, Oregon, 1980: Venkatakrishnan, Bond, and Kauffman . . . . .	3.00	_____	_____
13. Faults and lineaments of the southern Cascades, Oregon, 1981: Kienle, Nelson, and Lawrence . . . . .	4.00	_____	_____
14. Geology and geothermal resources of the Mount Hood area, Oregon, 1982: Priest and Vogt . . . . .	7.00	_____	_____
<b>NEW!</b> 16. Index to the <i>Ore Bin</i> (1939-1978) and <i>Oregon Geology</i> (1979-1982), 1983 . . . . .	4.00	_____	_____
<b>SHORT PAPERS</b>			
21. Lightweight aggregate industry in Oregon, 1951: Mason . . . . .	1.00	_____	_____
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey . . . . .	3.00	_____	_____
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows . . . . .	3.00	_____	_____
27. Rock material resources of Benton County, 1978: Schlicker and others . . . . .	4.00	_____	_____
<b>MISCELLANEOUS PAPERS</b>			
1. A description of some Oregon rocks and minerals, 1950: Dole . . . . .	1.00	_____	_____
5. Oregon's gold placers (reprints), 1954 . . . . .	1.00	_____	_____
8. Available well records of oil and gas exploration in Oregon, rev. 1982: King, Olmstead, and Newton . . . . .	4.00	_____	_____
11. Collection of articles on meteorites, 1968 (reprints from <i>The Ore Bin</i> ) . . . . .	3.00	_____	_____
13. Index to <i>The Ore Bin</i> , 1950-1974 . . . . .	3.00	_____	_____
15. Quicksilver deposits in Oregon, 1971: Brooks . . . . .	3.00	_____	_____
17. Geologic hazards inventory of the Oregon coastal zone, 1974: Beaulieu, Hughes, and Mathiot . . . . .	5.00	_____	_____
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975 . . . . .	3.00	_____	_____
19. Geothermal exploration studies in Oregon—1976, 1977 . . . . .	3.00	_____	_____
20. Investigations of nickel in Oregon, 1978: Ramp . . . . .	5.00	_____	_____
<b>MISCELLANEOUS PUBLICATIONS</b>			
Landforms of Oregon (17 × 12 inches) . . . . .	1.00	_____	_____
Mining claims (State laws governing quartz and placer claims) . . . . .	1.00	_____	_____
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG) . . . . .	5.00	_____	_____
Geothermal resources of Oregon map, 1982 (published by NOAA) . . . . .	3.00	_____	_____
Fifth Gold and Money Session and Gold Technical Session Proceedings, 1975 . . . . .	5.00	_____	_____
Sixth Gold and Money Session and Gold Technical Session Proceedings, 1978 . . . . .	6.50	_____	_____
Back issues of <i>The Ore Bin</i> . . . . .	50¢ over the counter; \$1.00 mailed	_____	_____
Back issues of <i>Oregon Geology</i> . . . . .	75¢ over the counter; \$1.00 mailed	_____	_____
Colored postcard, <i>Geology of Oregon</i> . . . . .	10¢ each; 3 for 25¢; 7 for 50¢; 15 for \$1.00	_____	_____
Oregon Landsat mosaic map, 1983 (published by ERSAL, OSU) . . . . .	\$8.00 over the counter; \$11.00 mailed	_____	_____

# OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter  
POSTMASTER: Form 3579 requested

### PUBLICATIONS ORDER

Minimum mail order \$1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than \$50.00. Foreign orders: please remit in U.S. dollars.

Fill in appropriate blanks and send sheet to Department.

YOUR NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

\_\_\_\_\_ Zip \_\_\_\_\_

Amount enclosed \$ \_\_\_\_\_

### OREGON GEOLOGY

\_\_\_\_ Renewal      \_\_\_\_ New Subscription      \_\_\_\_ Gift

\_\_\_\_ 1 Year (\$6.00)      \_\_\_\_ 3 Years (\$15.00)

NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

\_\_\_\_\_ ZIP \_\_\_\_\_

(If Gift, From: \_\_\_\_\_)