The
Ore Bin

OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Oregon's mineral production during 1969 slackened somewhat from that of the previous year, largely because of local economic conditions. The minerals industry is remarkably resilient, however, and it is predicted that there will be an upswing in activity during the coming decade, particularly in the field of industrial minerals. Petroleum exploration in the state was at its lowest level in many years, mostly because of the recent discovery of several large oil fields in northernmost Alaska.

As in past years, the Department staff has summarized Oregon's mineral and metallurgical industry and petroleum exploration in the January ORE BIN. This year, in addition to the summary, we are reporting on other current geological studies in the state, particularly those with which our Department is concerned. Although we are continuing the fundamental programs of geologic mapping and economic mineral investigations, we have become increasingly involved in several other projects that were not even thought of when the Department was formed more than 30 years ago. Large-scale urbanization in the United States began in the latter part of the 19th century, and this phenomenon, coupled with the population "explosion," has created an environment that is threatening the health and welfare of the general public.

Our Department is working in cooperation with other state agencies and with county and local planning commissions to carry out environmental geologic studies in the more heavily populated areas of Oregon. Those who are charged with the responsibility of preventing further environmental pollution are relying on data provided by our geologists and engineers in order to establish a basic geological framework for urban planning.   R.E.C.

OREGON'S MINERAL AND METALLURGICAL INDUSTRY IN 1969

By Ralph S. Mason*

Responding to the economic pressures of the times, Oregon's mines and metallurgical plants slacked up a bit on their productive efforts during the year. Both mining and metallurgy are productive only in response to demand, and since they are neither subsidized for producing surplus materials nor paid for nonproduction, they must necessarily trim their activities to fit the requirements of industry and the public generally. Total mineral production for 1969 has been estimated by the U.S. Bureau of Mines at $63 million, down 2.4 percent from the previous year.

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* Mining Engineer, State of Oregon Dept. Geology & Mineral Industries.

Some of Oregon's Minerals at a Glance. Preliminary Figures for 1969 (in thousands of dollars)		
	1968	1969
Clays	$ 284	$ 253
Diatomite	W	W
Gem stones	750	750
Gold (recoverable content of ores, etc.)	1	15
Lime	2,407	2,387
Mercury	502	24
Nickel (content of ore and concentrate)	W	W
Peat	11	10
Pumice and volcanic cinders	977	960
Sand and gravel and stone	42,625	42,400
Silver (recoverable content of ores, etc.)	1	7
Talc and soapstone	1	W
Value of items that cannot be disclosed: Cement, copper (1968), lead (1968), and values indicated by symbol "W"	16,890	16,137
Total	$64,449	$62,943

The Metals

The ferrous metals industry in the state saw two developments during the year. In the Rivergate district of Portland, Oregon Steel Mills, a subsidiary of Gilmore Steel Co., approached completion of a $35 million steel manufacturing complex which will use iron ore from Peru. The imported ore, which leaves Peru in a semiliquid state, arrives at its destination as a firmly compacted, dense concentrate containing about 8 percent water. High-pressure water jets are needed to return the material to a slurry for pumping ashore into reservoirs. The material is then converted into metallized pellets in a plant owned by Midland Ross adjacent to the steel complex. At McMinnville, Cascade Steel Rolling Mills began operating on steel scrap obtained locally.

Production of aluminum from the two smelters located in the state declined 2.4 percent compared with that of the previous year. Reynolds Metals produced 100,000 tons of metal at its Troutdale plant and began construction of a fifth potline which will increase its present capacity by 30 percent when completed in 1971. At The Dalles, Harvey Aluminum produced 87,000 tons of aluminum and made plans to spend $3.25 million on a fluoride fume recovery installation.

Reynolds Metals announced that it had acquired the ferruginous bauxite holdings of the Aluminum Co. of America in Columbia, Washington, and Multnomah Counties. The State of Oregon Department of Geology and Mineral Industries discovered the extensive low-grade aluminum deposits in 1944. Reynolds has additional holdings in the same general area as well as in the Salem Hills district of Marion County.

The Lower Powder River and Sparta districts of Baker County were the scene for additional exploration for copper during the year. Baker Mountain Copper, Ltd. of Vancouver, B.C. conducted a soil-sampling program in the same general area reported on by the Department as a result of its geochemical survey there a number of years ago. Baker Mountain's activities are centered on 100 claims owned by the Oregon Copper Co.

Plans for a major gold and silver mining and milling operation in the Bourne area of Baker County were abandoned late in the fall by Omega Mines Co., Ltd. of Vancouver, B.C. Omega had done extensive work on one of the strongest vein systems in the district for several years. The mineralized zone extends for approximately 18,000 feet. Mines in the Bourne area include the Columbia, North Pole, E and E, Tabor Fraction, and others which have produced at least $8 million since the first production in the 1870's, with principal activity during the period 1874-1916. Also in Baker County, the Bald Mountain mine operated by Tony Brandenthaler shipped concentrate, following a development program. Placer mining in the state was confined to a few small seasonal operations. Cornucopia Placers, Inc. in Baker County diverted the waters of Pine Creek and opened a gold placer pit during the year. The operation reuses its water and no stream pollution has resulted. Pine Creek, which flows past the famous and now defunct Cornucopia mine, contains many large boulders and the bedrock is deep. Early efforts to work the stream were thwarted by these factors.

As has been the case for the past 10 years, recreational gold panning and skin diving for gold constituted a favorite pastime for many vacationing individuals and families in both northeastern and southwestern Oregon.

The state, which has been an important mercury producer over the years, ended 1969 without a single operator despite an average annual price per flask of mercury of $504. During the year only 47 flasks were produced, an extreme reduction from the 938 furnaced the previous year. In Jefferson County an exploration program, partly financed by Office of Minerals Exploration funds, was under way just west of the famous old Horseheaven mine which closed in 1958, twenty-five years after its discovery. The Canyon Creek mine just south of Canyon City in Grant County was being negotiated for by Dennis Holdings, Ltd. of Vancouver, B.C. Active prospects also included the Elkhead mine in Douglas County and the Polaris in Lake County. A few flasks were recovered during clean-up operations at the Black Butte mine in Lane County following its closure late in 1968.

Hanna Mining Co. continued its nickel operations at Riddle, Douglas County, at about the same level as in recent years. Hanna mined slightly more than 1 million tons of nickel laterite containing 1.41 percent nickel. The company marketed 25,991 tons of ferronickel containing 13,227 tons of nickel.

Large areas of Harney and Malheur Counties were explored again this year by the Nuclear Fuels Division of Gulf Oil Corp. in its search for uranium. In addition to using airborne sensing equipment, Gulf drilled some of the more critical areas.

The metallurgical treatment of various modern metals continued to increase during 1969. Oregon Metallurgical Corp. at Albany began construction of a plant to process rutile, a titanium ore, into titanium tetrachloride, an intermediate product before final reduction to titanium metal.

The Million-Dollar-a-Year Club, 1968*			
County	Value	County	Value
Baker	$5,812,000	Jackson	$1,191,000
Clackamas	11,439,000	Klamath	1,097,000
Columbia	1,068,000	Lane	6,944,000
Curry	1,911,000	Multnomah	7,448,000
Douglas	9,295,000	Washington	2,054,000

* In addition to the values shown, there was a total of $7,706,000 which could not be assigned to specific counties. Production from Clatsop, Gilliam, Grant, Harney, Malheur, Union, and Wasco Counties was concealed to avoid disclosing individual company confidential data. If the state's total mineral production had been divided equally among the 36 counties, each county would have produced an average of $1,785,000 during the year.

The first boatload of ore from Australia arrived late in the year in anticipation of a March 1970 start-up. Wah Chang Albany Corp. developed a columbium alloy suitable for airplane castings and REM Metals Corp., also located in Albany, produced the first contamination-free casting with the new alloy. Wah Chang, which produces a variety of modern metals and alloys, entered the fertilizer business late in the year when it began producing ammonium sulfate from waste fumes developed by some of its reduction processes. The plant will produce about 10 tons of crystals daily.

Precision Castparts, which has been turning out precision castings in various metals for a number of years, has added investment casting of titanium to its operations located in Portland. Investment casting, also known as the "lost wax" method, has been used by artisans and dentists for many years to make small metal objects patterned after a wax model. Precision can pour castings measuring up to 3 feet in diameter and weighing several hundred pounds. Ti-Line Corp., Albany, originally producing titanium-lined castings backed up by common metals, has now switched to all-titanium spun castings. The company can pour shapes 100 inches in diameter and weighing more than a ton. Zirconium Technology Corp. completed its 30,000-square-foot facility at Albany for drawing small-diameter high-alloy tubing and bar stock. The company specializes in forming zirconium for nuclear reactors and aircraft. Ground was broken in midyear by Advanced Alloys, Inc. for a space-age metals plant in the Tualatin area. The company will produce alloy metals for the aerospace industry. Refractory Metals Fabrication announced plans early in the year for a 16,000-square-foot plant to be erected in the Albany area. Initial plant and equipment investment would amount to $250,000.

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Growth Minerals

One of the minor miracles of the mineral industry is its ability to take common sand and gravel, limestone, clay, and a few other minerals and, with a bit of alchemy, produce an endless variety of concrete structures limited only in size and design by the needs, the financial resources, and the imagination of man. The final value of the raw materials, by the time they become incorporated into structural concrete, becomes evident when the total picture is seen. As the raw materials leave the pit, they are worth approximately $1.25 per cubic yard; when delivered to a job, their value is about 10 times greater; and when placed in a steel-reinforced concrete building, they are worth more than 100 times their original cost.

There is no substitute construction material available for sand and gravel, the principal ingredient in concrete. Even though communities are dependent upon these raw materials for continued growth, the sand and gravel reserves are being treated, in many instances, as though they were inexhaustible. Unfortunately, although the total state reserves are large, some areas will be critically short of readily available sand and gravel within 10 years, unless immediate steps are taken to protect deposits from urbanization until they can be utilized.

In a period characterized by rapid price increases, the sand and gravel industry has held prices down to less than a one-percent annual gain for the past 10 years. In 1969 the industry produced 33 million cubic yards of stone, sand, and gravel worth $42.4 million. These figures compare with the previous year's very closely, since volume increased slightly but value declined fractionally, resulting in a 2-cents-per-yard drop in average value. Another stabilizing economic factor is also provided by the sand and gravel industry in the form of steady work. Labor statistics show that the industry enjoys almost total full-year employment, in sharp contrast to many other segments of the economy which have seasonal fluctuations.

Natural Hot Water

At Klamath Falls, hot water continues to be sought for and utilized. During 1969 at least three wells were drilled, one to heat the new Ponderosa Retirement apartments and two to provide heating and hot water for the new Ponderosa Junior High School.

At Lakeview, Desert Farms, Inc. is evaluating an interesting pilot greenhouse project where tomatoes are being grown for local markets. The greenhouse is heated from a hot-water well on the property. Initial results have been successful and construction is under way on a larger greenhouse. Near-surface natural heat at this location appears to be sufficient for any considered expansion.

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OIL AND GAS EXPLORATION IN OREGON IN 1969

By V. C. Newton, Jr.*

Petroleum exploration in Oregon during 1969 was at the lowest level in many years. The slump in activity can be attributed to large discoveries of oil in Alaska and to recent disappointment with results of drilling offshore in Oregon. Oregon has never produced commercial amounts of oil or gas, but there are still regions in the state that have not been tested and that may prove to be productive at some time in the future. Drilling in Oregon has been cyclic in the past, with the latest cycles showing the greatest amplitude. The last cycle, represented by the 1960-1967 period of exploration of the continental shelf, terminated after eight deep holes were drilled offshore. During that 7-year period, 12 firms spent approximately $60 million on exploration studies along the Oregon coast.
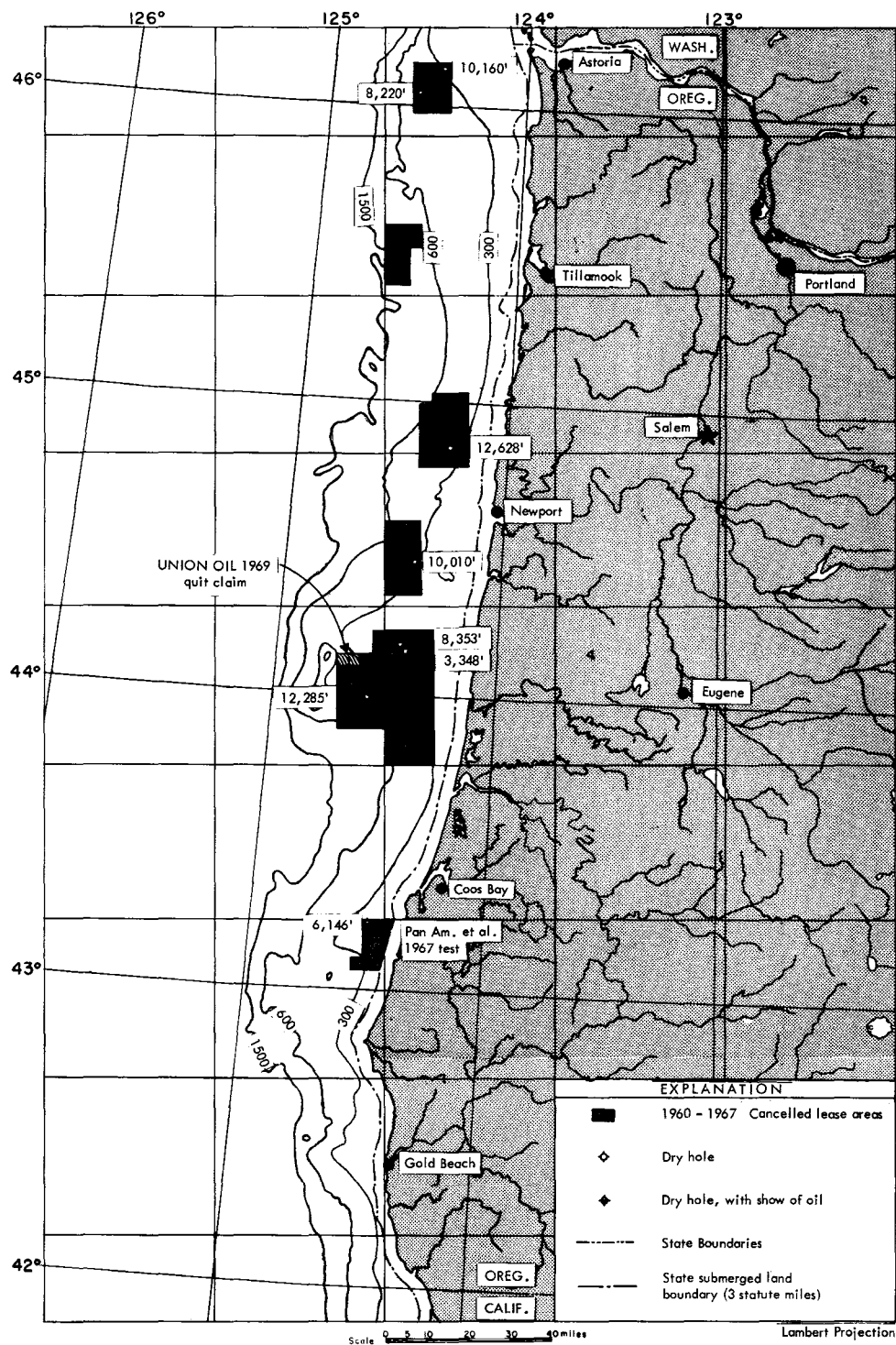
Onshore Activity

Approximately 85,000 acres of land are presently under lease in the state for oil and gas minerals. This total, compared to more than a million
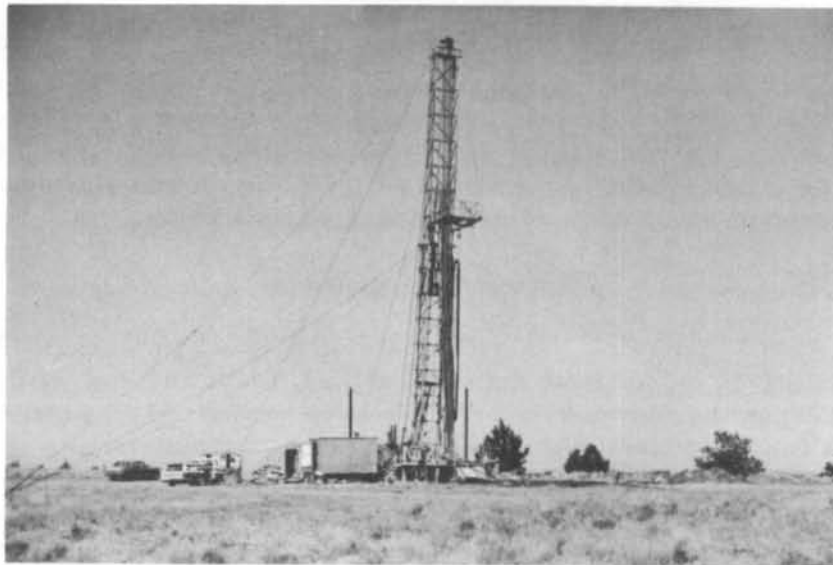
R. F. Harrison - Morrow No. 1
located 8 miles southeast of Madras in central Oregon.

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* Petroleum Engineer, State of Oregon Dept. Geology & Mineral Industries.

OREGON OFFSHORE EXPLORATION

acres leased in 1962, demonstrates the low level of activity in 1969. An estimated 60,000 acres of leases in western Oregon obtained in 1967 by Mobil, Texaco, and Standard Oil Companies are still in effect. The R.F. Harrison Group from Seattle, Wash. (formerly Central Oils, Inc.) has retained at least 5000 acres of federal leases in central Oregon. The U. S. Bureau of Land Management reported it had 37 oil and gas leases in effect in 1969 totaling 23,905 acres. The State Lands Division did not lease any lands for oil and gas minerals in 1969.

Active permit

Company	Lease	Location	Status
R.F. Harrison	Morrow ranch	Sec. 18, T. 12 S., R. 15E. Jefferson County	Depth 3300'. Attempting to deepen original hole.

Offshore Activity

The latest hole drilled offshore from Oregon was begun in April 1967 and abandoned in May of that year at a depth of 6146 feet. This wildcat, located 7 miles offshore from Cape Arago on the southern Oregon coast, was the joint effort of Pan American Petroleum and eight other companies. By 1967 most of the companies had terminated their offshore drilling leases. Union Oil Co.'s two remaining parcels (P-085 in tract No. 39, and P-086 in tract No. 40) offshore from Florence, Ore., expired November 30, 1969 (see accompanying map).

During the past few years several oil companies have been conducting limited seismic surveys off the coast in order to refine earlier data. In 1969, five firms held exploration permits to conduct geological and geophysical studies on state and federal lands off Oregon.

Active Exploration Permits in 1969

Company	Outer Continental Shelf	State Submerged Lands
Mobil	1- 1-69 to 6-30-69	-
Shell	12-31-68 to 6-30-69	-
Standard	-	9- 1-69 to 9- 1-71
Texaco	4-16-69 to 11- 6-69	5-14-68 to 5-14-70
Humble	10-23-69 to 4-23-70	-

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FIELD WORK IN OREGON

During the 1969 field season the number of geologists working in Oregon, excluding private-company personnel, totaled nearly 90. This number is approximately the same as last year, and reflects a general leveling off of field activity over the past two or three seasons.

Listed below are the various geologic studies in the state. For convenience in showing where these field projects are located, the state is divided into six districts. Separate sections are added which list water resource, oceanographic, and soils studies. It should be noted that this list probably is not complete, and the Department would appreciate receiving information about other geologic field studies in progress in Oregon of which we are not aware.

REGIONAL STUDIES

Northwest Oregon

1. Sedimentary petrology of the upper Nehalem River basin, Oregon. R. O. Van Atta, doctoral candidate, OSU.
2. Geology of the Oregon Coast Range. P. D. Snavely, Jr., and Norman Mac-Leod, U.S. Geological Survey, Menlo Park, Cal.
3. Paleomagnetism of late Tertiary intrusives in the Western Cascades. Michael Fuller, Chairman, Department of Earth and Planetary Sciences, Univ. Pittsburgh.
4. Engineering geology of the northern Willamette Valley. H. G. Schlicker, DOGAMI*, and R. J. Deacon, consulting geologist, Shannon & Wilson Co.
5. Geology of the Columbia River Gorge. A. C. Waters, Chairman, Division of Natural Sciences, Univ. California Santa Cruz.
6. Petrology of the Scott Creek pillow basalt, upper McKenzie River valley. E. H. Lund, Professor of Geology, UO.
7. Trace-element geochemistry, Western Cascades. R. L. Beyer, Center for Volcanology, UO.
8. Chemical and paleomagnetic stratigraphy of the Yakima Basalt in northwestern Oregon and southwestern Washington. Clive Kienle, doctoral candidate, Univ. California Santa Barbara.
9. Remanent magnetism and cooling histories of igneous materials: Cedar Creek sill and other small intrusives in the Coast Range. Alice E. Hickcox, doctoral candidate, Rice Univ.

Southwest Oregon

1. Oregon black sands project. H. E. Clifton, U.S. Geological Survey, Menlo Park, Cal.

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* DOGAMI = Abbreviation for State of Oregon Department of Geology and Mineral Industries.

2. Marine-fluvial interface, coastal Oregon. R. J. Janda, U. S. Geological Survey, Menlo Park, Cal.
3. Alpine-type ultramafic rocks. Robert Loney, U.S. Geological Survey, Menlo Park, Cal.
4. Oregon blueschist tectonic belt, Roseburg to Gold Beach. Robert Loney, U.S. Geological Survey, Menlo Park, Cal.
5. Petrology of an alpine-type gabbro and its bearing on the origin of the Josephine peridotite, Klamath Mountains, Oregon. David Jorgenson, doctoral candidate, Univ. California Santa Barbara.
6. Geology of the upper Chetco River area. Len Ramp, DOGAMI.
7. Sand and gravel deposits of Jackson County. H. G. Schlicker, DOGAMI, and R. J. Deacon, consulting geologist, Shannon & Wilson Co., Portland, Ore.
8. Geology of the Tiller area. M. A. Kays, Professor of Geology, UO.
9. Petrologic significance of plutonic ejecta at Crater Lake, Oregon. John Lidstrom, doctoral candidate, OSU.
10. Geochemistry of late stage Mount Mazama rocks. Frank Radke, Jr., doctoral candidate, Center for Volcanology, UO.
11. Stratigraphy and sedimentary petrology of the Late Cretaceous Hornbrook Formation in the vicinity of Hornbrook, Siskiyou County, Cal., and Jackson County, Ore. Monty Elliott, doctoral candidate, OSU.
12. Geology of the NW$\frac{1}{4}$ of the Bone Mountain qudarangle. A. Krans, master's candidate, UO.
13. Geology of the Camas Valley and Tyee quadrangles. E. M. Baldwin, Professor of Geology, UO.
14. Geology of the Tiller and Days Creek quadrangles. M. A. Kays, Professor of Geology, UO.
15. Petrology and structure of the Preston Peak area. Arthur W. Snoke, doctoral candidate, Stanford Univ.
16. Trace element geochemistry, Western Cascades. R. L. Beyer, Center for Volcanology, UO.
17. Petrography of quartz diorites in southwest Oregon. E. H. Lund, Professor of Geology, UO.
18. Fluorescent tracer analysis of fluvial sediments, southwestern Oregon. Sam Boggs, Jr., Professor of Geology, and Charles Jones, master's candidate, UO.
19. Size and shape sorting of pebbles in the Elk River, southwestern Oregon. Fred Swanson, master's candidate, UO.
20. Petrology and structure of the Ashland pluton, southwestern Oregon. M. Allan Kays, Professor of Geology, UO.
21. Petrology and structure of the May Creek Schist belt. M. Allan Kays, UO.
22. Geology and mineral deposits of Eden Valley-Saddle Peak and vicinity, southeast Coos County, Oregon. Wm. C. Utterback, master's candidate, OSU.
23. Stratigraphy and sedimentary petrology of the Colestin Formation from the type locality at Colestin Springs, Jackson County, Oregon to Hornbrook, Siskiyou County, California. Richard W. Carlton, doctoral candidate, OSU.
24. Differentiation of vaporous and ionic origin of trace mercury in soils. Paul B. Trost, doctoral candidate, Colo. School of Mines, and Ramon E. Bisque, Professor of Geochemistry and Head, Dept. Chemistry, Colo. School of Mines.

North-central Oregon

1. The Yakima Basalt of western Oregon and Washington. Clive Kienle, doctoral candidate, Univ. California Santa Barbara.
2. Geologic and paleomagnetic mapping of volcanic units of east slope of Cascades between Broken Top volcano and town of Sisters, southern one-half of Green Ridge and westward to crest line. E. M. Taylor, Professor of Geology, OSU.
3. Geology and petrology of the Rattlesnake Formation, central Oregon. H. E. Enlows, Professor of Geology, OSU, and the late W. D. Wilkinson, Professor of Geology, OSU.
4. Petrography of the Rattlesnake Formation of the upper Crooked River drainage area in central Oregon. Ronald E. Davenport, doctoral candidate, OSU.
5. Geochemical prospecting, western Blue Mountains. R. G. Bowen, DOGAMI.
6. Petrology of the Oregon Cascade Range. A. R. McBirney, Chairman, Dept. of Geology, UO.
7. Trace element geochemistry: Columbia River Basalt and High Cascade Range, Oregon. G.G. Goles, Professor of Geology, and M. Osawa, Visiting Professor, Center for Volcanology, UO.
8. Trace element geochemistry: Three Sisters area in Oregon, Mount Shasta in California, Mount Adams in Washington. T. L. Steinborn, Center for Volcanology, UO.
9. Strontium and lead isotopic compositions of Cascade andesite and their bearing on andesitic genesis. Stanley Church, doctoral candidate, Univ. California Santa Barbara.
10. Mammalian fauna from the Clarno Formation, Camp Hancock locality, Oregon. Bruce Hanson, doctoral candidate, Dept. of Paleontology, Univ. California Berkeley.
11. Middle and Lower Jurassic faunas of eastern Oregon. R. W. Imlay, U. S. Geological Survey, Washington, D.C.
12. Geology and petrology of the Rattlesnake Formation, central Oregon. H. E. Enlows, Professor of Geology, OSU.
13. Tethyan fusuline fauna of central Oregon. David A. Bostwick, Professor of Geology, OSU.
14. Cretaceous marine embayment, central Oregon. Also,
    Bedrock geology, SE¼ Mitchell quadrangle. Keith F. Oles, Professor of Geology, OSU.

South-central Oregon

1. Geology of Hole-in-the-Ground and Big Hole maars. V. W. Lorenz, Center for Volcanology, UO.
2. Geothermal steam investigations in south-central Oregon. R. G. Bowen and N. V. Peterson, DOGAMI.
3. Geology of proposed waste management areas, Lake and Klamath Counties, Oregon. V. C. Newton, Jr., DOGAMI.
4. Petrology of the Oregon Cascade Range. A. R. McBirney, Chairman, Department of Geology, UO.
5. Seismicity investigations in the Cascade Range. H. R. Blank, Professor of Geology, and M. M. Brown, doctoral candidate, Center for Volcanology, UO.

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6. Trace element geochemistry, Newberry Crater.   D. J. Lindstrom, Center for Volcanology, UO.

Northeast Oregon

1. Geology of the Olds Ferry and Huntington quadrangles, Oregon. H.C. Brooks, DOGAMI.
2. Geology of the Snake River Canyon. T. L. Vallier, Professor of Geology, Indiana State Univ.
3. Tertiary geology of the Baker AMS quadrangle. James McIntyre, DOGAMI.
4. State Geologic Map project. G.W. Walker, U.S. Geological Survey, Menlo Park, Cal.
5. Middle and Lower Jurassic faunas of eastern Oregon. R.W. Imlay, U.S. Geological Survey, Washington, D.C.
6. Permian stratigraphy of central and eastern Oregon. David A. Bostwick, Professor of Geology, OSU.
7. Sulfur isotope investigation of sulfate and sulfide minerals of the Oregon-Idaho border area. C. W. Field, Professor of Geology, and Wayne R. Bruce, OSU.
8. Evolution of the Wallowa Mountains. W.H. Taubeneck, Professor of Geology, OSU.
9. Paleomagnetism of the Miocene(?) Strawberry Volcanics, Strawberry Lake area. Donald Heinrichs, Professor of Geology, Dept. of Oceanography, OSU.

Southeast Oregon

1. Geology of the Diamond Craters volcanic field. L. C. Rowan, U.S. Geological Survey, Denver, Colo.
2. Geology and mineralization of the Cordero quicksilver district, Oregon-Nevada. R. C. Greene, U.S. Geological Survey, Menlo Park, Cal.
3. Trace element geochemistry, Owyhee area. D. J. Lindstrom, Center for Volcanology, UO.
4. Geology of south-central Pueblo Mountains, Oregon-Nevada. W. A. Rowe, master's candidate, OSU.
5. Geology of the southern Pueblo Mountains. H. E. Enlows, Professor of Geology, OSU.

WATER RESOURCE STUDIES

1. Relationship between sedimentary environment and radionuclide concentrations In the Columbia River estuary. David Hubbell and Jerry Glenn, U.S. Geological Survey, Portland, Ore.
2. Ground-water study of the Klamath Basin. A. R. Leonard and A. B. Harris, U.S. Geological Survey, Portland, Ore.
3. Ground-water studies in Medford-Ashland area, Jackson County, Oregon. James H. Robison, U.S. Geological Survey, Portland, Ore.
4. Ground-water studies in Eugene-Springfield area, southern Willamette Valley. F. J. Frank, U.S. Geological Survey, Portland, Ore.

5. Water resources in the Harney Basin, Harney County, Oregon. A. R. Leonard, U.S. Geological Survey, Portland, Ore.
6. Ground-water and dam-site feasibility studies; problems of sanitary land fill. W. S. Bartholomew, State Engineers Office, Salem, Ore.
7. Dam-site investigations, Little Luckiamute River and Teal Creek tributary, Polk County; Lower Powder River area, Baker County, Oregon. Roger Paul, U.S. Soil Conservation Service, Baker, Ore.
8. Erosion and sedimentary damage studies, Succor Creek and Upper Bully Creek, Malheur County, Oregon. Frank F. Reckendorf, U.S. Soil Conservation Service, Salem, Ore.
9. Flood-plain studies, Goshen area, Lane County, and Milk Creek-Molalla and Pudding Rivers, Clackamas County, Oregon. Frank F. Reckendorf, U.S.Soil Conservation Service, Salem, Ore.
10. Dam-site investigations and sedimentation studies, Big Creek watershed, Baker and Union Counties; Malloy Dam site, upper Succor Creek, Malheur County. Peter V. Patterson, Soil Conservation Service, Portland, Ore.
11. Sedimentation and erosion study, Rock Creek watershed, Gilliam and Morrow Counties. Peter V. Patterson, Soil Conservation Service, Portland, Ore.
12. Design investigation, Wolf Creek Dam site, Union County. Peter V. Patterson, Soil Conservation Service, Portland, Ore.

OCEANOGRAPHIC STUDIES

1. The economic minerals of the Oregon shelf, present and future potential. K.C. Bowman, Dept. of Oceanography, OSU.
2. Seasonal ecology of benthic foraminifera on the central Oregon shelf. Fred J. Gunther, Dept. of Oceanography, OSU.
3. Paleoecology and biostratigraphy of Cenozoic strata, Heceta Bank, central Oregon shelf. Gary B. Muehlberg, Dept. of Oceanography, OSU.
4. The geology of the Juan de Fuca and Gorda Ridges with specific emphasis on gross sediment distribution and clay mineralogy. James B. Phipps, Dept. of Oceanography, OSU.
5. Petrology and petrography of deep-sea volcanic ash layers. Kenneth F. Scheidegger, Dept. of Oceanography, OSU.
6. Marine geology of the Oregon continental margin from Cape Blanco to the Oregon-California border. Joseph J. Spigai, Dept. of Oceanography, OSU.
7. Stratigraphy of Globigerina pachyderma in deep-sea cores from the Juan de Fuca Ridge. Sandra G. Sumich, Dept. of Oceanography, OSU.

SOILS STUDIES

1. Physico-chemical properties of soils from volcanic ash. M. E. Harward, D.P. Moore, R. A. Schmitt, and W. H. Doak, Dept. of Soils, OSU.
2. Crystalline and amorphous clays in fine volcanic ash deposits from Mount Mazama, Oregon. M. E. Harward, D. G. Knox, C. T. Youngberg, Delmar Dingus, Marvin Dudas, and Billy Harris, Dept. of Soils, OSU.

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STATE MAP PROJECT

During the past year, field work on the State Geologic Map project has shown excellent progress. Most of the eastern half of the state has been completed through the efforts of geologists and graduate students from the State of Oregon Department of Geology and Mineral Industries, the U.S. Geological Survey, and the universities. Personnel from the Federal Survey are beginning to compile all available geologic maps of eastern Oregon in order to assemble the final map at a scale of 1:500,000. Progress on some of the last areas under investigation is summarized below.

G.W. Walker, Chief, Oregon State Map Project, U.S. Geological Survey, continued geologic studies in different parts of eastern Oregon directed primarily toward resolving several major problems of Tertiary stratigraphy. Reconnaissance mapping was completed in Paulina Basin and mapping was extended discontinuously eastward to Bear and Silvies Valleys and into the upper Malheur River drainage to the vicinity of Castle Rock in an attempt to establish a stratigraphic column keyed to several widespread early and middle Pliocene ash-flow tuffs. The "basal," crystal-rich ash-flow tuff of the Danforth Formation (lowest in the Devine Canyon sequence north of Burns) has been recognized and traced discontinuously throughout most of this region and, hence, serves as an extremely useful marker horizon.

Systematic reconnaissance mapping was continued in several other areas in eastern Oregon in the southwest part of the Baker (AMS) quadrangle, the southeast corner of the Pendleton (AMS) quadrangle and southwest corner of the Grangeville (AMS) quadrangle.

Samples of ash-flow tuffs and some rhyolite flows of Miocene or older age were collected for isotope dating from outcrops near Silvies, Castle Rock, Ironside Mountain, and Dooley Mountain.

An uncolored geologic map of the east half of the Bend (AMS) quadrangle (scale 1:250,000) by D. A. Swanson was placed in open file and a full-color map of the area is in press. Also, compilation of a geologic map of the Burns (AMS) quadrangle by R. C. Greene, G. W. Walker, and R.E. Corcoran was completed.

Tracy Vallier, Department of Geology, Indiana State University, completed the first of a two-phase reconnaissance geologic mapping program in Snake River Canyon north of Hells Canyon Dam. The project has been financially supported by the Department and, to a lesser extent, the Idaho Bureau of Mines and involves the northward continuation of mapping that Vallier did for his doctoral dissertation during 1963-65. Part of this work has been published in The ORE BIN (December 1967 and December 1968).

Phase one of the project, which was in progress during parts of the 1967, 1968, and 1969 field seasons, involved compilation of a strip map of

the canyon bottom (ranging up to 1000-2000 feet in elevation above river level) between Hells Canyon Dam and the Washington border. Except for an area near that border, very little geologic information had been available for this extremely rugged and inaccessible region. Most of the mapping was accomplished by back-packing from base camps which were moved periodically by boat.

Phase two, which will involve the upper reaches of the canyon walls above the limits of phase one, remains to be done. It is hoped that funds will be made available for Vallier to continue and complete this highly important project.

James McIntyre, consulting geologist for the Department, spent the 1969 field season studying the Tertiary geology in the Baker AMS sheet area. His purpose is to try to alleviate confusion regarding the stratigraphic relationships of some of the Tertiary units which has developed over the years among students of the region. McIntyre is remapping critical areas, particularly parts of the old Baker 1:125,000 quadrangle, for which 1:24,000-scale topographic coverage has recently become available.

Howard Brooks continued detailed stratigraphic study of the Triassic and Jurassic sedimentary and volcanic rocks in the Huntington and Olds Ferry quadrangles. He has spent parts of several field seasons in that area and hopes to complete work by the end of 1970, but notes that indistinctive lithologies, structural complexities, and scarcity of fossils make detailed mapping difficult and slow.

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DEPARTMENT PROGRAMS

Environmental Geology

Oregon is beginning to feel the pressures of a population increase which is destined to become a major problem within a very few years. Planners and government officials are already faced with decisions that require professional geologic knowledge. They need information on the stability of foundation sites, the availability of ground water, and the potential for mineral resources. Population growth always gives rise to contamination problems because of increased consumption of surface and ground water combined with the increased use of septic tanks, dumping of refuse, and disposal of industrial waste. To understand the limits to which the ground can be utilized, the geology must be studied and the data made available to the persons responsible for land-use planning.

The Department has been involved in a number of studies related to environmental geology. The work has consisted of land-use studies in urban areas of western Oregon and of waste-disposal investigations in south-central and southeastern Oregon.

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Land-use studies in urban areas

After completing a report on the engineering geology of the Tualatin Valley region, Herbert G. Schlicker and Robert J. Deacon began a study of the Mid-Willamette Valley. At the request of the Mid-Willamette Valley Council of Governments, the project was temporarily diverted to Marion County and the data restricted to that which was needed to complete the county's Water and Sewer Study. The information was published by Marion County in 1969.

The Jackson County Court requested an immediate study of the sand and gravel resources of Rogue River and Bear Creek valleys, so that land-use planning could include the construction resources needed for development of this area and still protect the scenic beauty of Bear Creek and the sport fishing in Rogue River. Schlicker and Deacon completed this study in December 1969. Several important facts were brought out by their report; one, that unless other gravels are made available the present supply of Bear Creek and Rogue River flood-plain gravels will be gone by 1982; another, that about 800 acres of land in the Agate Desert and adjacent terraces will be required to produce the gravel needed by the year 2005. The report also pointed out that, although some of these gravels have been considered in the past to be of marginal quality, suitable treatment will allow satisfactory production of gravel aggregate.

The Mid-Willamette Valley study, which includes part of Polk, Yamhill, and Clackamas Counties, will be continued and should be completed after about one year's additional work.

Waste disposal investigations

The Department participated in cooperative studies with the Environmental Health Science Center of Oregon State University by investigating waste-disposal sites at two locations in eastern Oregon in 1969. The OSU project, which was funded by a National Science Foundation research grant, was designed to determine biodegradation rates of herbicide wastes and ion exchange-absorption reactions with other chemicals in clay soils. Alkali Lake in Lake County and Merrill dump in Klamath County were selected as possible sites for the experiments, and the Department did auger drilling at both localities to determine relationships between the regional geology and local conditions at the project sites, so that residents in the two areas could be assured that no hazard would result from the waste-disposal experiments.

Public concern about pollution of the environment, along with promulgation of stringent disposal regulations, has stimulated research by the staff into the possibilities of underground disposal of chemical wastes. Concurrent studies were also begun to define some of the geologic parameters required for storage of radioactive chemicals. The Department made recommendations regarding a proposal by a chemical firm to store radioactive

wastes at a remote location in Harney County. The geologic requirements were for a site underlain by impermeable sediments and removed from contact with surface water and ground water. The advent of nuclear power generation and increased use of radioisotopes in industry and medicine presage wider utilization of underground storage and disposal sites.

Geothermal Steam Energy

During 1969 activities within the Department relating to geothermal steam exploitation consisted of a field trip to the Geysers steam field in northern California, shallow temperature measuring projects at specific locations in southern and central Oregon, and continuing research and promotional work.

The highlight of the year occurred in May, when three members of the Department staff, R. G. Bowen, E. A. Groh, and N. V. Peterson, spent a day in the Geysers area escorted by James Koenig of the California Division of Mines and Geology. The tour included a close look at the developing steam field, a visit to well sites, and a tour through one of the power plants. During the tour there was ample opportunity to discuss geothermal power development with Mr. Koenig, a leading expert in the field.

Field work consisted of shallow temperature probing by Bowen and Peterson in the Klamath Falls geothermal zone, where temperatures were taken with a thermistor at a depth of one meter. A rough grid survey, in which 70 measurements were made in two days, outlined two northwest-southeast-trending zones which closely correlated with areas where hot water is known to exist at shallow depths. This inexpensive type of survey appears to have promise in predicting areas where hot water for heating or industrial processing might be found at shallow depths. Several square miles could be surveyed in this manner for the cost of one shallow well.

Preliminary studies were also made in the Burns area by Bowen, Groh, Peterson, and V. C. Newton, Jr. to determine the feasibility of measuring geothermal gradients in shallow holes. Here holes were drilled from 30 to 40 feet deep and temperature measurements taken with a thermistor at intervals up the hole. By this technique areas of anomalous heat flow can be detected and outlined for deeper exploration. The theory behind this method is that the only source that would produce a large heat-flow rate over an area of more than just a few acres would be an intrusion of magma cooling at depth. This is the type of heat source needed for geothermal power generation.

Staff members are continuing to accumulate published information on geothermal power and related subjects, and the file of data is growing increasingly valuable as more individuals and industry are becoming aware of the capabilities of this form of energy. Because we feel that this low-cost natural energy has a potential to supply a large share of the new generating

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facilities needed by Oregon and the western United States in the future, members of the Department are taking every opportunity to acquaint the public with the advantages of geothermal power.

Large-scale exploration and development of geothermal energy remain in limbo until a federal steam-leasing law is passed that will allow private enterprise to appraise the risks and rewards of tapping the earth's own "boiler."

Assistance to Other Agencies

During 1969 the Department provided assistance to a large number of governmental agencies throughout the state, and to service groups, schools, and private individuals.

At the federal level, cooperative help was expended with the U. S. Geological Survey on field examinations in connection with the state geologic mapping program which is nearing completion after many years. Assistance was also provided to the topographic mapping section. Considerable effort was given to the preparation of the bulletin "Mineral and Water Resources of Oregon." Cooperation with the U.S. Bureau of Mines included reviewing the annual reports on mineral activity in the state and checking the list of active mineral producers for the Bureau's annual canvass. Considerable time was spent with the U.S. Bureau of Land Management in investigating the lava tubes in the Rome area of Malheur County, in working on the Mining Law Review subcommittee, and serving on two Multiple Use Advisory Committees.

At the state government level, assistance was given to more than 25 agencies during the year. Services were provided the Game Commission at its Kelly Prairie Reservoir site in Morrow County, the Department of Revenue on mineral evaluations, the Corporation Division on offering circulars by mining companies, the Department of Agriculture on waste disposal, the Division of State Lands on mineral leases, and the Highway Department on the geology of some state parks.

At the county government level, the Department assisted: Jackson County with a sand and gravel study; Coos County with mineral evaluations of county land; Baker County with a mineral economics study of the county; Josephine County with an economic development study; Curry County with advice on conducting an over-all economic study; and Douglas County with assistance on leasing mineral lands.

Assistance was also given to various other local governments on problems ranging from solid waste disposal sites to information on rockhounding and other recreational activities based on geology. The Department continued its educational program by giving talks and leading field trips for youth leaders and teachers, with emphasis placed on the role of geology in environmental planning.

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Analytical Activities

Assay and chemical laboratory

During 1969 the assay and chemical laboratory had a moderate increase in activity over that of 1968, which was a very active year. We received a total of 995 samples, of which 257 were sent in by the Grants Pass office, 158 by the Baker office, and the balance of 580 were either brought in or sent in by mail directly to the Portland office. These 995 samples represented 2764 determinations, or an average of 2.77 determinations per sample. This is compared to 1968 which had an average of 2.52 determinations per sample from a total of 963 samples and 2429 determinations. For the year we averaged 83 samples per month, the peak month being August with 136.

We received samples from 30 of the 36 counties in Oregon, with the bulk coming from three general areas: 1) southwest Oregon (Josephine, Jackson, Douglas, and Curry Counties), 409 samples; 2) eastern Oregon (Baker and Grant Counties), 247 samples; and 3) Western Cascades (Linn and Lane Counties), 134 samples.

Thirty-eight different elements were analyzed for and seven different physical tests, such as specific gravity, loss on ignition, moisture, and expansion, were made.

There were 742 gold, 730 silver, 122 platinum, 225 copper, and 96 mercury assays. The 849 remaining determinations were scattered among the other 33 elements and 7 physical tests.

Spectrographic laboratory

The spectrographic laboratory of the Department uses an emission spectrograph to analyze rocks, minerals, metals, glass, paint, water, or unknown materials for the various elements present. An estimate is made of the percentage of each contained. During 1969 a total of 345 analyses was made for Department projects and tests. Besides ore samples, crystals and minerals were identified and 11 possible meteorites were checked.

The spectrographic laboratory also assists many commercial firms and individuals in identifying unknown materials. Corrosion products, scales, and dusts were checked to determine sources of trouble. Research projects were assisted by analyses of chemical compounds, paper ash, slags, and coke. Metal producers were helped during the year by identification of inclusions in both slags and castings.

Problems concerned with health which were brought into the laboratory included analyses of polluted water and drink mixes, and paper-mill waste.

Spectrographic analyses of suspected criminal evidence boomed in 1969 with 40 glass samples and 32 pieces of fire residue. Other possible

criminal samples included bullet lead, drugs, automobile paint, and fire-
clay from safes. Criminal evidence was examined for the State Crime
Detection Laboratory, City of Portland Police Laboratory, and County
Courts. Glass sample studies during the year were primarily concerned
with matching pieces of broken window glass with particles found on a
suspect's clothing or in automobiles.

Geochemical investigations

During 1969 the data collected by the Department on the geochem-
istry of stream sediments in southwestern Oregon were released in the form
of an open-file report. This information consisted of approximately 400 pages
of analytical data from more than 3000 sites where samples were collected.
As a service to those who wanted copies of this report, photocopies were
sold for $25 a set. For those who did not wish to buy a set, copies were
available for public inspection at the Department's Portland, Baker, and
Grants Pass offices. The information is now being compiled into a bulletin
for publication at a future date.

The sediment-sampling program was moved in 1969 to central Oregon.
For the next few years the work will be concentrated in the eastern half of
the Bend AMS quadrangle and in the Canyon City AMS quadrangle. During
the summer field season, collecting centered around Prineville in an area
that has a history of mercury and gold and silver production. Because of
this past productivity and because of the numerous shows of quicksilver scat-
tered around this region, it was felt that a geochemical study would have a
good chance of uncovering some overlooked mineral deposits. The stream
sediments will be analyzed for mercury using a modified Lemaire mercury
detector, and for copper, silver, lead, zinc, nickel, and molybdenum by
an atomic absorption spectrophotometer recently purchased for this purpose
by the Department.

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OREGON ACADEMY OF SCIENCE IN EUGENE

The annual meeting of the Oregon Academy of Science is to be on Saturday,
February 28, 1970 at the Science Building, University of Oregon, Eugene.
Chairmen of the Geology Section are Ray Broderson, Oregon College of
Education, and Harold E. Enlows, Oregon State University. There will be
morning and afternoon sessions, with registration starting at 8:30 a.m. The
main part of the program will be a symposium at 3:15 p.m. on the chemis-
try and geology of Apollo 11 and Apollo 12 moon rocks by Gordon G.
Goles, Roman A. Schmitt, and Daniel F. Weill.

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AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

2.	Progress report on Coos Bay coal field, 1938: Libbey	$ 0.15
8.	Feasibility of steel plant in lower Columbia River area, rev.1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev.1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole, editor	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor	2.00

GEOLOGIC MAPS

Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka	1.50
Geologic map of Oregon west of 121st meridian: (over the counter)	2.00
folded in envelope, $2.15; rolled in map tube, $2.50	
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat	2.00
folded in envelope, $2.25; rolled in map tube, $2.50	

The Ore Bin

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Available Publications, Continued:

SHORT PAPERS

2.	Industrial aluminum, a brief survey, 1940: Motz	.$ 0.10
18.	Radioactive minerals the prospectors should know (2nd rev.), 1955:	
	White and Schafer	0.30
19.	Brick and tile industry in Oregon, 1949: Allen and Mason	0.20
20.	Glazes from Oregon volcanic glass, 1950: Jacobs	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Mason.	0.25
23.	Oregon King mine, Jefferson County, 1962: Libbey and Corcoran. . . .	1.00
24.	The Almeda mine, Josephine County, Oregon, 1967: Libbey	2.00

MISCELLANEOUS PAPERS

1.	Description of some Oregon rocks and minerals, 1950: Dole	0.40
2.	Key to Oregon mineral deposits map, 1951: Mason	0.15
	Oregon mineral deposits map (22" x 34"), rev. 1958 (see M.P.2 for key). .	0.30
3.	Facts about fossils (reprints), 1953	0.35
4.	Rules and regulations for conservation of oil and natural gas (rev. 1962)	1.00
5.	Oregon's gold placers (reprints), 1954.	0.25
6.	Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . .	1.50
7.	Bibliography of theses on Oregon geology, 1959: Schlicker	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . . .	0.50
8.	Available well records of oil & gas exploration in Oregon, rev.'63: Newton.	0.50
10.	Articles on Recent volcanism in Oregon, 1965: (reprints, The ORE BIN) . .	1.00
11.	A collection of articles on meteorites, 1968: (reprints, The ORE BIN) . .	1.00
12.	Index to published geologic mapping in Oregon, 1968: Corcoran	Free

MISCELLANEOUS PUBLICATIONS

Oregon quicksilver localities map (22" x 34"), 1946	0.30
Landforms of Oregon: a physiographic sketch (17" x 22"), 1941	0.25
Index to topographic mapping in Oregon, 1968	Free
Geologic time chart for Oregon, 1961	Free

OIL and GAS INVESTIGATIONS SERIES

1.	Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:	
	Newton and Corcoran.	2.50
2.	Subsurface geology of the lower Columbia and Willamette basins, Oregon,	
	1969: Newton	2.50

The
Ore Bin

OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

THE KLAMATH FALLS IRON METEORITE

by Erwin F. Lange*

It seems incredible that an important meteorite found in 1952 has taken 18 years to be authenticated for the people of Oregon. Such is the story of the Klamath Falls iron.

The writer has sought to discover the whereabouts of this elusive 30-pound iron since 1962 when it was first mentioned by Brian Mason in his book, "Meteorites," published by John Wiley and Sons. On writing to Mason, then in New York with the American Museum of Natural History, it was learned that the meteorite was in the H. H. Nininger collection, which had been sold to Arizona State University in Tempe.

When he visited the Nininger collection in the spring of 1964, the writer was much surprised and also disappointed to find that only a small fragment, weighing probably less than 10 grams, of the Klamath Falls meteorite was in the collection. The staff members had no knowledge of the main mass, estimated to weigh more than 30 pounds. They were, however, willing to seek more information from Dr. H. H. Nininger. Several months after the Arizona visit, copies of a number of letters were received. These letters were the correspondence between Dr. Nininger and J. D. Howard, an assayer in Klamath Falls.

From these letters it was learned that an unidentified rancher or logger had brought a small metallic specimen to Mr. Howard for analysis in January 1952. The piece had been badly beaten and had been broken off a 30-pound mass. Mr. Howard, suspecting the specimen to be a meteorite, forwarded it to Dr. Nininger at Winslow, Arizona, for verification. Dr. Nininger found it to be a meteorite and asked to have the opportunity to examine and purchase the main mass. Meanwhile, Howard reported that he had failed to get the name of the finder and that this person had never returned for the analysis. Advertising in the Klamath Falls newspaper was unsuccessful in locating the finder of the meteorite, Howard also stated.

The above information, derived from the letters, was interpreted by this writer as meaning that a meteorite of some 30 pounds was still somewhere in the Klamath Falls area, but technically it could be considered as lost. This view was reported in The ORE BIN for February 1965 in an article

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* Professor of General Science, Portland State University, Portland, Ore.

entitled "Oregon's Lost Meteorites." Then on April 12, 1965 the ORE BIN article was reported in the Klamath Falls Herald and News in a major feature article entitled "Basin Hunt under Way for Missing Meteorite." During the next several days the newspaper received a number of callers who reported they had the lost meteorite, but it turned out that not one of their specimens was found in the Klamath Falls area. To date not any of these specimens have been verified as meteorites. Although there was much good advertising for the search of what was believed to be a lost or missing meteorite, no trace of the Klamath Falls iron meteorite was forthcoming.

When the third edition of the "Catalogue of Meteorites" by Max H. Hey was published in 1966 by the British Museum of Natural History, there was mentioned as an addendum to the regular listing of all known meteorites an Oregon iron with the indication it might possibly be a fragment of the Willamette meteorite. The so-called Oregon iron was designated as being in the collection of the Institute of Meteorites at the University of New Mexico in Albuquerque. Among the regular listings in the "Catalogue of Meteorites" was also the Klamath Falls iron in the Nininger collection at Arizona State University. The data given for the two meteorites were strikingly similar:
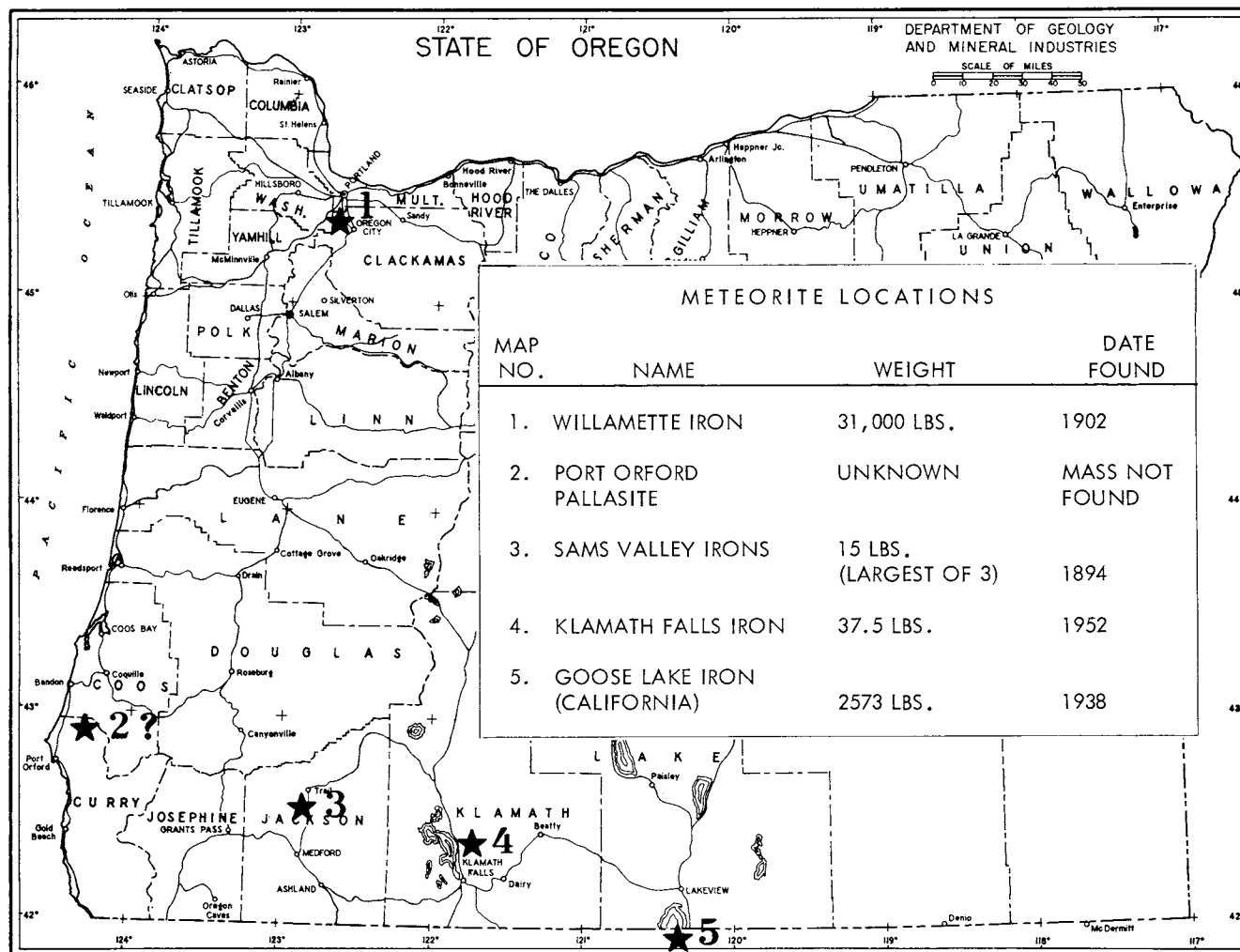
Name	Type	Found	Weight
Klamath Falls	iron, octahedrite	1952	13.6 Kg.
Oregon	iron, octahedrite	1952	12.96 Kg.

It seemed inconceivable that two new separate meteorites from Oregon could be so similar. The feeling was that these two represented the same meteoritic fall. This hypothesis or viewpoint was conveyed to the staffs at both the University of New Mexico and Arizona State University in an effort to ascertain if the two meteorites were really just one.

Correspondence to the University of New Mexico was eventually forwarded to Dr. Lincoln LaPaz, who had been director of the Institute of Meteoritics from 1944 to 1966. Dr. LaPaz kindly forwarded a copy of a chapter, "An Octahedrite from Klamath Falls, Oregon" from a forthcoming book, "Hunting Meteorites: Their Recovery, Use, and Abuse from Paleolithic to Present." This book is being published by the University of New Mexico Press.

In this brief chapter Dr. LaPaz relates how he purchased in 1952 a 37.5-pound iron meteorite from Jack Halsell of Klamath Falls. The account indicates that Mr. Halsell had found the meteorite in the Klamath Falls area but was reluctant to reveal the exact place of discovery. The meteorite was not a recent fall, since the outer surface had undergone prolonged weathering.

This new information was forwarded by R.E. Corcoran, Oregon State

STATE OF OREGON

SCALE OF MILES

METEORITE LOCATIONS

MAP NO.	NAME	WEIGHT	DATE FOUND
1.	WILLAMETTE IRON	31,000 LBS.	1902
2.	PORT ORFORD PALLASITE	UNKNOWN	MASS NOT FOUND
3.	SAMS VALLEY IRONS	15 LBS. (LARGEST OF 3)	1894
4.	KLAMATH FALLS IRON	37.5 LBS.	1952
5.	GOOSE LAKE IRON (CALIFORNIA)	2573 LBS.	1938

Geologist, and Norman Peterson of the State of Oregon Department of Geology and Mineral Industries to Alfred D. Collier at Klamath Falls. Mr. Collier was able to locate the finder, Jack J. Halsell, living at 2830 Kane Street in Klamath Falls. From him Mr. Collier learned that he had found the meteorite in 1952, when he was a logger for the Ellingson Lumber Company. While he was building a road from Barkley Spring up into Antelope Flat north of Klamath Falls, he had noted the unusual rock and was very surprised that he was unable to pick it up with one hand. It was the heaviest rock he had ever lifted. He took a small fragment to J. D. Howard (now deceased) for analysis. Through Mr. Howard, Halsell was able to sell the main mass to the Institute of Meteoritics at Albuquerque. Halsell reported to Collier that Howard kept the small piece for himself. This undoubtedly is the fragment now in the Nininger collection at Arizona State University.

The data presented confirms the hypothesis that the Oregon and the Klamath Falls irons are one and the same. This important iron has been named by Dr. LaPaz as the Klamath Falls Meteorite and in the future it will be known in science by this name.

The Klamath Falls iron is the fourth known meteorite found in Oregon. The others are the Port Orford, the Sams Valley, and the Willamette. The Port Orford is a pallasite, while the other three are irons. When a new meteoritic specimen is found there is always some concern that it may be part of a known fall. Therefore, the chemical analysis of the Oregon irons is given below, so that the differences can be noted. The analysis of the great Goose Lake iron, which was found less than a mile out of Oregon in northern California, is included because of its geographical position.

The alignment of four of the meteorites, as shown on the accompanying map, is interesting but deceiving, since the three irons (Sams Valley, Klamath Falls, and Goose Lake) are compositionally and structurally different, and the Port Orford meteorite is a stony iron.

Name	Iron	Nickel	Cobalt
Goose Lake	90.80%	8.39%	0.42%
Klamath Falls	92.48	7.24	0.31
Sams Valley	89.35	9.76	0.68
Willamette	91.65	7.88	0.21
Port Orford (iron portion)	89.0	10.29	-

The discovery of the Klamath Falls meteorite is of great interest to Oregonians, because it is the first in 50 years since the discovery of the great Willamette iron in 1902. It is hoped that the announcement of the Klamath Falls meteorite will be instrumental in making yet more new meteorites known. Evidence indicates that more meteorites should be found, particularly in the great open spaces of eastern Oregon.
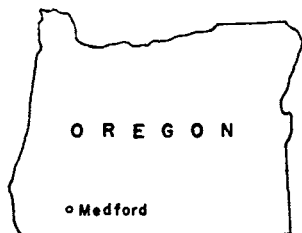
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UNUSUAL SLUMP STRUCTURE FROM CRETACEOUS (?) SANDSTONES NORTHERN KLAMATH MOUNTAIN REGION, OREGON

Sam Boggs, Jr.* and Frederick J. Swanson*

Abstract

A unit of massive sandstone which crops out in a highway cut near Medford, Oregon encloses a large, deformed segment of a mudstone-siltstone bed. The mudstone-siltstone segment is unusual in that it is bent into a nearly complete loop. Portions of the bed are squeezed out into the enclosing sandstone forming flame structures. The relationship of the deformed segment to the enclosing sandstone and to an underlying mudstone-siltstone bed suggests that the segment (while still in a semi-consolidated condition) became detached from the underlying unit by slumping; an edge of the detached block was caught by an accompanying, overriding flow of coarse sand which folded part of the segment back upon itself. Subsequent compaction caused additional bending of the segment and squeezing of mudstone into the enclosing sand to form flame structures.

Introduction

A unique sedimentary structure is exposed in beds of Cretaceous (?) sandstone along Interstate Highway 5 about one mile south of Medford, Oregon. This structure, shown in figure 1, is basically a 27-foot-long segment of a mudstone-siltstone bed which has been deformed in such manner that the bed is bent back over itself in a nearly 360° arc. Folding was accompanied by squeezing and distortion of part of the segment, resulting in anomalous thickening of the layer at the point of maximum bending, formation of flame structures, and truncation and thinning of the layer in one flank of the fold.

Discussion

The structure occurs about 8 feet above the base of a 30-foot-thick sandstone bed which contains a few thin layers of finely laminated mudstone and siltstone. The sandstone is poorly sorted with mainly medium to

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* University of Oregon, Eugene, Oregon.

Figure 1. Mudstone–siltstone layer which has been bent
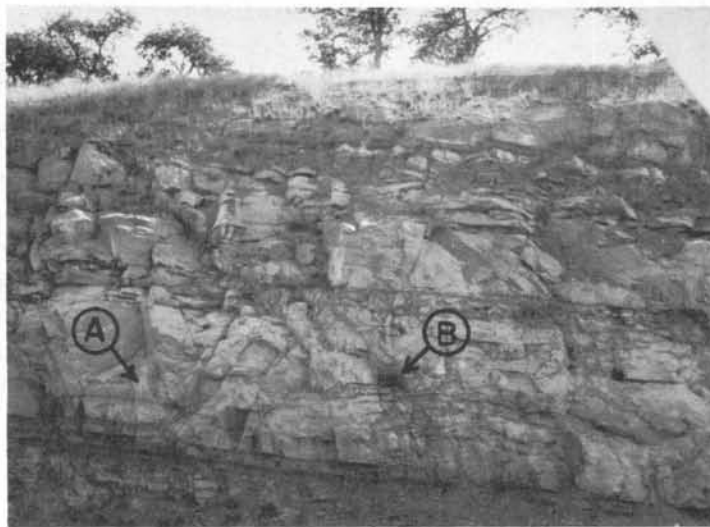and squeezed into a nearly complete loop.

Figure 2. View of the sandstone and mudstone–siltstone beds which
encompass the deformed mudstone–siltstone structure (at point A).
Note the sharply terminated, thin mudstone layers a few feet to
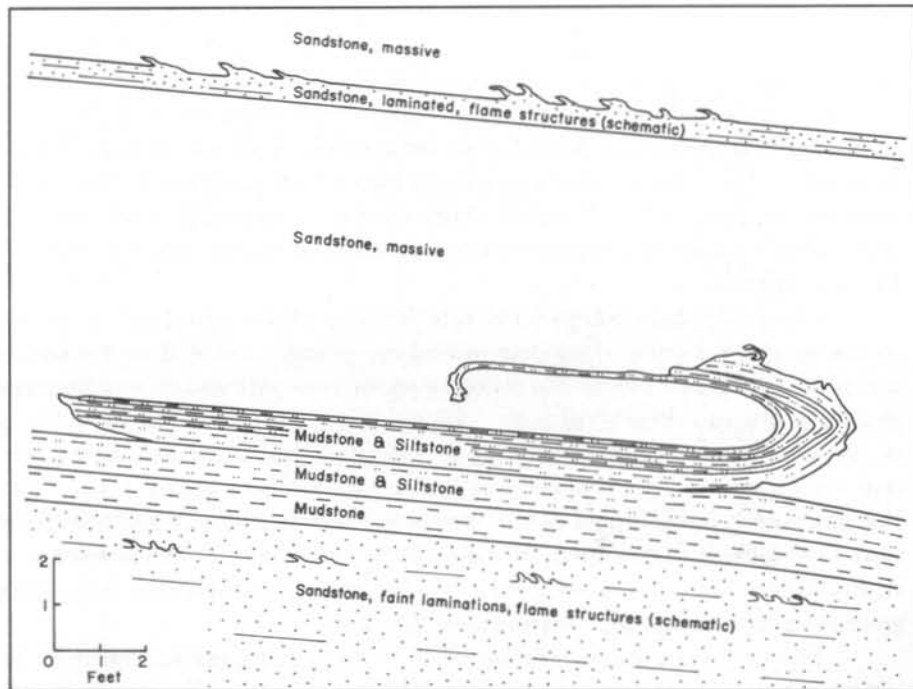the right of the structure (at point B).

Figure 3. Sketch showing relationship of deformation structure to enclosing beds.

Figure 4. Close-up view showing thickening of the mudstone-siltstone unit in the crest of the fold. (Coin is a nickel.)

coarse, angular to subangular grains. Rock fragments are abundant, and shale chips a few millimeters in length and small wood fragments are scattered through some of the beds. Most of the sandstone is massive and shows no megascopic evidence of grading. Some thin interbeds of finer grained sandstone are laminated and display moderately well-developed flame structures (fig. 3). The mudstone-siltstone bed which constitutes the deformed structure is about 9 to 10 inches thick where undeformed, and lies immediately above an 8- to 10-inch-thick mudstone-siltstone layer of very similar appearance.

Figure 2 shows the general relationship of the structure (at point A) to the enclosing units of sandstone and mudstone. Note that the bedding surfaces above and below the massive sandstone unit which encompasses the structure are essentially planar. Figure 3 is a sketch which shows in greater detail the contact relationships of the structure to the enclosing rocks, and figure 4 is a close-up view of the thickened part of the fold. Note the extreme thickening of all of the beds making up the mudstone-siltstone unit in the crest of the fold, the abrupt truncation of all beds except one in the upper limb of the fold, and the squeezing of mudstone into adjacent sandstone to produce flame structures (fig. 4).

Figure 2 also shows a series of thin mudstone beds (at point B) located about 10 feet south and a few feet stratigraphically above the deformed mudstone-siltstone structure. These mudstone layers are 1 to 2 inches thick and are separated by fine- to medium- and coarse-grained sandstone interbeds about 8 to 10 inches thick. The length of each mudstone layer is about 15 feet; they all terminate at roughly the same point to the north and south, and the ends of the layers give the appearance of being squeezed and "smeared" out. The sandstone enclosing these mudstone layers and the deformation structure shows no laminations or megascopic internal lineations of any type.

The features described above are not primary sedimentary structures, but are due in part to some type of deformation. The planar contacts with beds above and below the unit containing these structures indicate that deformation must have been penecontemporaneous with deposition of the coarse sandstone while the mudstone-siltstone beds were still in a semiconsolidated state. The close resemblance of the undeformed portion of the structure to the underlying mudstone-siltstone bed in thickness, general composition, and bedding characteristics strongly suggests that the mudstone-siltstone segment became detached from the underlying unit and then slid into its present position together with a "slurry" of unconsolidated, coarse sand. Deformation probably occurred when one edge of the detached block, caught by an overriding flow of coarse sand, was folded back upon itself. The orientation of flame structures and the fold geometry of the deformation structure indicate that the direction of sediment transport was to the northwest (from right to left in figure 1).

The sequence of thin mudstone beds just south of the structure appears

to have a similar origin. The abrupt termination of these beds suggests that they may be portions of a block which became detached from an underlying mudstone-siltstone unit. The strong similarity of all the beds in thickness and character further indicates that the beds may represent one mudstone-siltstone and sandstone unit that was imbricated or stacked up during slumping, or was folded into a series of recumbent folds which have been truncated.

Slump structures are common in many sedimentary deposits and have been described numerous times in the literature (see Potter and Pettijohn, 1963). The structure discussed in this paper appears to be unique, however, in that it is quite large and is folded or bent into an almost complete loop. We know of no similar structure that has been described previously.

Reference Cited

Potter, P. E. and Pettijohn, F. J., 1963, Paleocurrents and basin analysis: Berlin, Springer Verlag, 296 p.

* * * * *

WILDERNESS ACT GETS LIVELY DISCUSSION

Interest was extremely high at recent public hearings on the proposed Blue Range Wilderness in Arizona, and all who indicated a desire to testify were heard. Most of the testimony was well prepared and demonstrated a thorough knowledge of the issues, but some was poorly put together and based strictly on an emotional appeal.

A spokesman for the New Mexico Mountain Club said it was not true that wilderness was a single use, stating, "Why, one can hunt, fish, take pictures, watch birds, etc. If this isn't multiple use, then I don't know what it is." He also proposed limiting future population to reduce the demand for minerals, timber, and other natural resources. A spectator voiced the opinion that one way to cut down population growth would be for everyone to go to the wilderness alone.

Dean Lynch, land manager for Duval Corporation, departed from his prepared statement as a mining industry witness and, addressing himself to the preservationists, explained why Duval was mining very low-grade copper ore in the Southwest. He said, "We do it because we make money. If you people want to put the miners, the timber industry, and the cattlemen out of business, just quit buying automobiles, quit eating beef, and grow clothes on trees. We'll only supply these products if there is a demand and money to be made. Incidentally, how many of you walked here today from Tucson and Scottsdale?" (Nevada Mining Assn. News Letter No. 202, Jan. 15, 1970.)

* * * * *

PIERRE R. HINES

An Appreciation by Fay Wilmott Libbey

Pierre Rossiter Hines (Legion of Honor, 50-year member AIME) was born in Toledo, Ohio on January 25, 1887, and died at his home in Portland, Oregon, on December 26, 1969. He is survived by a son, John T. Hines of Portland, four grandchildren, and one great-grandchild.

Pierre was attracted to mining as a career and entered the New Mexico School of Mines. Later he became influenced by published descriptions of the Michigan copper mines and entered Michigan College of Mines and Technology, from which he graduated with an EM degree in 1907. From 1907 to 1917 he worked for mining companies in Canada, United States, Mexico, and Russia. He became interested in mill operation and design, and for a time he worked for David Cole of El Paso, one of the best-known design engineers of that period.

Preceding World War I, he accepted a job with the Caucasus Copper Co. in southwestern Russia – a company financed by American capital. In this work he was involved in a study of the application of flotation, an innovation at that time, to the treatment of the Caucasus Co. ore. The early experiments were successful, but World War I came suddenly and the mine was shut down. Pierre returned to the United States at a time when the whole country was preparing for war. He applied for U.S. Army Engineers Reserve Officers' training in 1917, was accepted and sent to Vancouver Barracks, Vancouver, Wash. He completed the training, was married to Charlotte Brady of Portland, commissioned Captain, and sent to France with the A.E.F., where he remained until the Armistice in 1919.

He returned to his old position with Allis Chalmers, and as a result of his experience in Russia the company offered him a job to promote machinery sales in eastern Russia. He sailed from San Francisco to Vladivostok at a precarious time of civil war in Russia with Japan waiting in the wings, and the waiting period was short. He was lucky to get out alive on one of the last ships sailing from Vladivostok at the time of the crisis.

In 1920, Pierre became associated with Dings Magnetic Separator Co., Milwaukee, and was occupied in several installation jobs.

From 1921 to his death, he was the owner of his own engineering and machinery business, and for many years he was Stephens-Adamson's representative in Oregon, specializing in materials handling. He gave a course of lectures on the subject at the Crown Zellerbach Corp. Paper Makers' School at Camas, Wash. He also was engaged in special flotation research and one especially interesting study was his invention and patenting of the application of flotation to the de-inking of old printed material.

Other studies at this period included the design of a cyanide mill at the Benton gold mine west of Grants Pass in Josephine County, and a rock

crushing plant for the Pacific Building Materials Co. of Portland.

Pierre was active in AIME over the years, serving as Secretary and Chairman of the Oregon Section in its early organizational period, and as a Director from 1931 through 1937. In 1966 he became eligible for the Legion of Honor award and a special meeting of the Section was held to confer the honor and to present a scroll to him from the Institute's head office in New York.

Aside from his professional work, Pierre was greatly interested in some outside activities, including the Portland Fruit and Flower Mission of which he was Treasurer and Board Member. He was also a Board Member of the Doernbecher Memorial Hospital Guild for several years up to the time of his death.

He served 6 years on the Oregon Technical Council and for 10 years was a member of the State Board of Engineering Examiners. He was the author of the chapter entitled "Before Flotation" in the Centennial Volume published by the Minerals Beneficiation Division of AIME in 1962; he also co-authored with J.D. Vincent the chapter titled "The Early Days of Froth Flotation" in the same volume. Recently he wrote an article called "Notes on the History of the Sand and Gravel Industry in Oregon," which was published in the December 1969 issue of The ORE BIN.

During recent years, Pierre gave much of his time to the study of the economics of gold in our monetary system and in publishing articles on the subject in The ORE BIN. He was instrumental in organizing the Gold and Money Sessions of the AIME regional conferences which have had world-wide attention and discussion. The planning and administration of these sessions have been under the direction of a committee headed by Pierre Hines and Hollis Dole. Their primary objective has been to present the facts in our monetary management to as wide an audience as possible. From the viewpoint of this writer, the subject is of paramount importance to our economy, not just to the gold-mining industry but to everyone who wishes to protect the integrity of our money.

Pierre's passing has left a large gap in this program, but its essentials will be continued by the many thoughtful persons who believe in it.

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ROCKHOUND MAP AVAILABLE

"The Rockhound's Map of Oregon," in its third edition, is available from its originator and publisher, J. R. Rodgers, 6844 S. W. 33rd Place, Portland, Oregon 97219. It is a road map of the state showing more than 60 localities where one can find gem-quality crystals or agate material and it includes directions for finding the sites. The map is priced at 75 cents.

* * * * *

Commodity	Percent		Commodity	Percent	
	Domestic	Foreign		Domestic	Foreign
Antimony	22	14	Dolomite [6/]	14	14
Arsenic	14	14	Feldspar	14	14
Asbestos	22	10	Fluorspar	22	14
Ball clay [1/]	14	14	Fuller's earth	14	14
Barite	14	14	Garnet	14	14
Bauxite	22	14	Gem stones	14	14
Beryllium	22	14	Germanium	14	14
Bismuth	22	14	Gilsonite	14	14
Borax	14	14	Gold	15	14
Bromine [2/]	5	5	Graphite	22	14
Brucite	10	10	Granite [6/]	14	14
Cadmium	22	14	Gypsum	14	14
Calcium carbonates	14	14	Ilmenite	22	14
Calcium chloride [2/]	5	5	Iodine	14	14
Celestite	22	14	Iron ore	15	14
Cesium and rubidium	14	14	Kyanite	22	14
Chromium	22	14	Lead	22	14
Clay [3/]	22	NA	Limestone [6/]	14	14
Clay [4/]	5	5	Lithium	22	14
Clay and shale [5/]	$7\frac{1}{2}$	$7\frac{1}{2}$	Magnesium carbonates	14	14
Coal and lignite	10	10	Magnesium chloride [2/]	5	5
Cobalt	22	14	Manganese	22	14
Columbium	22	14	Marble [6/]	14	14
Copper	15	14	Mercury	22	14
Corundum	22	14	Mica	22	14
Diamond, industrial	14	14	Molybdenum	22	14
Diatomaceous earth	14	14	Natural gas	22	22

* The Federal Tax Reform Act of 1969, signed by the President on December 30, 1969, authorized changes in certain mineral and metal percentage depletion rates, effective with taxable years beginning after October 9, 1969.

Commodity	Percent		Commodity	Percent	
	Domestic	Foreign		Domestic	Foreign
Nickel	22	14	Silver	15	14
Nitrogen compounds	14	14	Slate 6/ 7/	5	5
Olivine 6/	22	14	Sodium carbonate	14	14
Peat	5	5	Sodium chloride	10	10
Perlite	10	10	Sodium sulfate	14	14
Petroleum	22	22	Stone 6/	14	14
Phosphate rock	14	14	Sulfur	22	22
Platinum and platinum-			Talc (block		
group metals	22	14	steatite)	22	14
Potash	14	14	Talc, all other	14	14
Pumice	5	5	Tantalum	22	14
Quartz crystals (radio			Tellurium	14	14
grade) 6/	22	14	Thorium (monazite)	22	14
Quartzite 6/	14	14	Other rare earth		
Radium	14	14	minerals	14	14
Rhenium	14	14	Tin	22	14
Rutile	22	14	Tungsten	22	14
Salt	10	10	Uranium	22	22
Sand and gravel	5	5	Vanadium	22	14
Selenium	14	14	Vermiculite	14	14
Shale	5	5	Wollastonite	10	10
Shale, oil	15	14	Zinc	22	14

NA   Not applicable.

1/   Ball clay, bentonite, china clay, sagger clay and clay used or sold for purposes dependent on its refractory properties.

2/   If from brine from wells or a saline perennial lake within the United States.

3/   Anorthosite, clay, laterite and nephelite syenite to the extent that alumina and aluminum compounds are extracted therefrom.

4/   Used or sold for use in manufacture of drainage and roofing tile, flower pots, and kindred products.

5/   Clay and shale used for making brick, tile, and lightweight aggregate.

6/   Except 5 percent if used for riprap, ballast, road material, rubble, concrete aggregate, or similar purposes.

7/   Except $7\frac{1}{2}$ percent if used for making lightweight aggregate.

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PRICEITE IN CURRY COUNTY

By Charles S. Hoffman
Brookings, Oregon

It was recently suggested to me that a record should be made of the location and manner of deposit of the borax mineral named priceite*. My wife and I are probably the only two people in the state who have dug out a complete borax "pod."

Priceite was discovered in Curry County, Oregon in 1873. It is one of eight minerals not previously found anywhere in the world except Oregon. The seven other minerals are josephinite, johannsenite, mansfieldite, erionite, heinrichite, metaheinrichite, and oregonite.

We had been searching for priceite because rockhounds from other areas had frequently visited our lapidary shop inquiring about the existence of this material. Although I had prospected the surface outcroppings of borax in the Lone Ranch area near Brookings, I had not found any of the priceite until highway construction crews started building a road from the new stretch of Highway 101 down to the picnic site at Lone Ranch.

According to local records, borax was mined from this location and loaded onto sailing vessels anchored offshore. In 1890, the land and mineral rights were bought by Borax Consolidated, Ltd. of London. The site is 3 miles north of Brookings, between U.S. Highway 101 and the Pacific Ocean. The company made a gift of this land for a state park, marked by a plaque dedicated in May 1962.

When a grader operator brought some of the brown, peanut-cluster-type of crystalline material to us, we felt reasonably certain that it was priceite. We got in touch with Mr. H. P. Gower, retired superintendent of Pacific Borax Co., who identified the mineral as "priceite, a high grade of borate."

The deposit crops out in several places in the small basin at the mouth of the creek which empties into the ocean at this point. The entrance road to the site leaves the highway in a northerly direction for approximately 150 yards and turns left toward the ocean at a small knoll capped by several pine trees. The country rock is serpentine, with quartz showing on the surface.

When we arrived to check the occurrence, the grader had cut into the top of a short adit which opened onto the south side of the knoll. Fifteen

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*A hydrated calcium borate of uncertain formula, which is probably $Ca_4B_{10}O_{19} \cdot 7 H_2O$, named after Thomas Price, San Francisco metallurgist who first analyzed it [Ed.].

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feet west of the top of the exposed adit, priceite nodules were showing where the grader had cut partly through the serpentine.

With rock picks we cut away the serpentine from the sides of the borax pod, which was approximately oval in shape and about $2\frac{1}{2}$ feet by $3\frac{1}{2}$ feet in horizontal dimensions. The pod was thickest at the center, where it was about 12 inches through, and tapered out to about 3 inches or less at the margin. The pod was originally completely encased in serpentine.

Priceite nodules of all sizes covered the sides, top, and bottom of the pod. They ranged from bird-shot size up to deformed shapes about an inch across. They occurred in layers which averaged approximately an inch in thickness, although some chunks of the material were 4 to 5 inches thick.

The white borax center of the pod was criss-crossed with vertical "veins" of priceite in exceedingly thin seams, most of which broke apart upon being handled. The remaining portion of the pod was the pure white borax which came out in large chunks; within a few days most of it apparently absorbed moisture and disintegrated into a white powder.

The peanut-shaped nodules are a brownish ochre color and the inside of them is a lighter shade of the same color. The outside of the nodule can be scratched easily with a knife blade. The inside part is slightly harder. The nodules show a concentric or fortification pattern near their outside edges.

Priceite is not particularly attractive, but it is rare and therefore of interest. For a more detailed description of the Curry County priceite, see the report by Dr. L. L. Staples, "The occurrence of priceite in Oregon," Northwest Science, May 1948.

When rockhounds now inquire about priceite, we tell them about Lone Ranch, but advise them to search only on the surface and not dig up a state park.

* * * * *

STORY OF MOUNT RAINIER PUBLISHED

"The Geologic Story of Mount Rainier," by Dr. Dwight Crandell, has been published by the U.S. Geological Survey as Bulletin 1292. This highly illustrated publication, containing color and black-and-white photographs and diagrams, is written in a nontechnical manner. It is for sale by the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402, for 65 cents per copy.

The bulletin describes the volcanic history of Mount Rainier and gives geologic evidence for an eruption of pumice 100 to 150 years ago. A new "warm spot" on the summit cone, recently revealed by infrared photography, suggests to Crandell that the mountain needs close watching, particularly for melting of glacial ice and attendant flood waters.

* * * * *

URBAN PLANNING NEEDS EARTH SCIENTISTS' SKILLS

The Nation must make better use of its earth scientists in order to solve some of its deepening environmental problems resulting from urban growth. Thus warned Hollis M. Dole, Interior's Assistant Secretary for Mineral Resources, at a recent meeting of the Association of Engineering Geologists. He stated:

"Too often a housing development is planned, a complex industrial facility is laid out, a bridge built, a road constructed, without knowledge of the terrain conditions or hazards that might have been avoided. It's after an earthquake occurs, or a hill slides -- after the hand-wringing -- that the realization dawns: An application of basic knowledge of terrain and its geologic and hydrologic characteristics might have averted disaster, and high economic loss."

"The fact is," Dole emphasized, "that there has to be more meaningful and practical dialogue among those who are in the geologic profession on one hand, and those who must make decisions at the planning and engineering level on the other. Those who possess geologic and hydrologic knowledge must make their findings known to planners before the action starts."

"Let's face it -- the engineer, the public official, or the planner is not necessarily a geologist, yet he must know where to place his housing, where to place his industrial parks and his recreation areas, and where, for example, to preserve grounds for the extraction of sand and gravel. We may know such things, but we have to communicate our knowledge to those who make decisions. Our geologic maps may or may not provide the kind of information or provide it in a form useful to the nongeologist. If such maps make sense only to a geologist, and not to a construction man, we must make the maps more meaningful. And our published words - learned though they be - are of little value if they aren't used, or cannot be used by the people who should have the information."

*   *   *   *   *

BRUER NAMED CHIEF OF CALIFORNIA MINES DIVISION

Wesley G. Bruer has been named chief of the California Division of Mines and Geology, replacing Ian Campbell, who retired last fall. Bruer, a former consulting petroleum geologist, has been program development officer in the Department of Conservation in Sacramento, and was active in promoting the Registration of Geologists Act in California. He holds a bachelor's degree from Oregon State College, Corvallis.

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AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

2.	Progress report on Coos Bay coal field, 1938: Libbey	$ 0.15
8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
27.	Geology and coal resources of Coos Bay quad., 1944: Allen and Baldwin .	1.00
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin .	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch . .	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
56.	Fourteenth biennial report of the State Geologist, 1963–64	Free
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors.	3.50
58.	Geology of the Suplee–Izee area, Oregon, 1965: Dickinson and Vigrass .	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
61.	Gold and silver in Oregon, 1968: Brooks and Ramp	5.00
62.	Andesite Conference Guidebook, 1968: Dole, editor	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966–68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor . . .	2.00

GEOLOGIC MAPS

Geologic map of Oregon (12" x 9"), 1969: Walker and King . . .	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . .	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37) .	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker. . . .	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts . . .	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams. . .	1.00
GMS–1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka . .	1.50
GMS–2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al..	1.50
GMS–3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka . .	1.50
Geologic map of Oregon west of 121st meridian: (over the counter)	2.00
folded in envelope, $2.15; rolled in map tube, $2.50	
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat	2.00
folded in envelope, $2.25; rolled in map tube, $2.50	

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Available Publications, Continued:

SHORT PAPERS

2.	Industrial aluminum, a brief survey, 1940: Motz	$ 0.10
18.	Radioactive minerals the prospectors should know (2nd rev.), 1955:	
	White and Schafer.	0.30
19.	Brick and tile industry in Oregon, 1949: Allen and Mason	0.20
20.	Glazes from Oregon volcanic glass, 1950: Jacobs	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Mason	0.25
23.	Oregon King mine, Jefferson County, 1962: Libbey and Corcoran.	1.00
24.	The Almeda mine, Josephine County, Oregon, 1967: Libbey	2.00

MISCELLANEOUS PAPERS

1.	Description of some Oregon rocks and minerals, 1950: Dole	0.40
2.	Key to Oregon mineral deposits map, 1951: Mason	0.15
	Oregon mineral deposits map (22" x 34"), rev.1958 (see M.P.2 for key).	0.30
3.	Facts about fossils (reprints), 1953	0.35
4.	Rules and regulations for conservation of oil and natural gas (rev. 1962)	1.00
5.	Oregon's gold placers (reprints), 1954.	0.25
6.	Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton	1.50
7.	Bibliography of theses on Oregon geology, 1959: Schlicker	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts	0.50
8.	Available well records of oil & gas exploration in Oregon, rev.'63: Newton.	0.50
10.	Articles on Recent volcanism in Oregon, 1965: (reprints, The ORE BIN)	1.00
11.	A collection of articles on meteorites, 1968: (reprints, The ORE BIN)	1.00
12.	Index to published geologic mapping in Oregon, 1968: Corcoran	Free

MISCELLANEOUS PUBLICATIONS

Oregon quicksilver localities map (22" x 34"), 1946	0.30
Landforms of Oregon: a physiographic sketch (17" x 22"), 1941	0.25
Index to topographic mapping in Oregon, 1968	Free
Geologic time chart for Oregon, 1961.	Free

OIL and GAS INVESTIGATIONS SERIES

1.	Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:	
	Newton and Corcoran.	2.50
2.	Subsurface geology of the lower Columbia and Willamette basins, Oregon,	
	1969: Newton.	2.50

The
Ore Bin

OREGON

GEOLOGY AND COPPER DEPOSITS OF THE HOMESTEAD AREA,
OREGON AND IDAHO

By

Tracy L. Vallier* and Howard C. Brooks**

Introduction

Deposits of copper, with some associated gold and silver, occur in many
parts of the Snake River Canyon north of the Oxbow Dam and also are wide-
spread in the southern foothills of the Wallowa Mountains of Oregon to the
west. and in the Seven Devils Mountains of Idaho to the east. During the
more than 90 years since the initial copper discoveries were made a large
number of deposits have been prospected and, particularly in recent years,
a variety of geologic mapping and exploration programs has been con-
ducted in parts of this region. Incomplete records indicate that copper pro-
duction probably has been about 19 million pounds, the bulk of which has
come from the Iron Dyke mine at Homestead, in Oregon. Published reports
which deal with copper mineralization in the region, including the area
described in this report, are by Lindgren (1901), Swartley (1914), Parks and
Swartley (1916), Gilluly (1932), Oregon Department of Geology and Min-
eral Industries (1939), Cook (1954), and Brooks and Ramp (1968).

　This report summarizes the stratigraphy and structure of a small area
near Homestead (figure 1) and briefly describes the geology of the Iron Dyke
mine and of several prospects in the vicinity. Homestead is located on the
Oregon side of the Snake River (figure 2), a few miles upstream from the
south end of the rugged and picturesque Hells Canyon and about 4 miles by
graveled road north of the Idaho Power Plant at Oxbow. A paved road
passes through the area along the Idaho side of the river. The area was
mapped geologically by Vallier in 1964-1965 as part of a larger project
(Vallier, 1967). Part of this information has been published (Brooks and
Vallier, 1967). In 1969 Brooks spent 5 days re-examining the copper de-
posits in this and nearby areas.

*　Indiana State University, Terre Haute, Indiana.
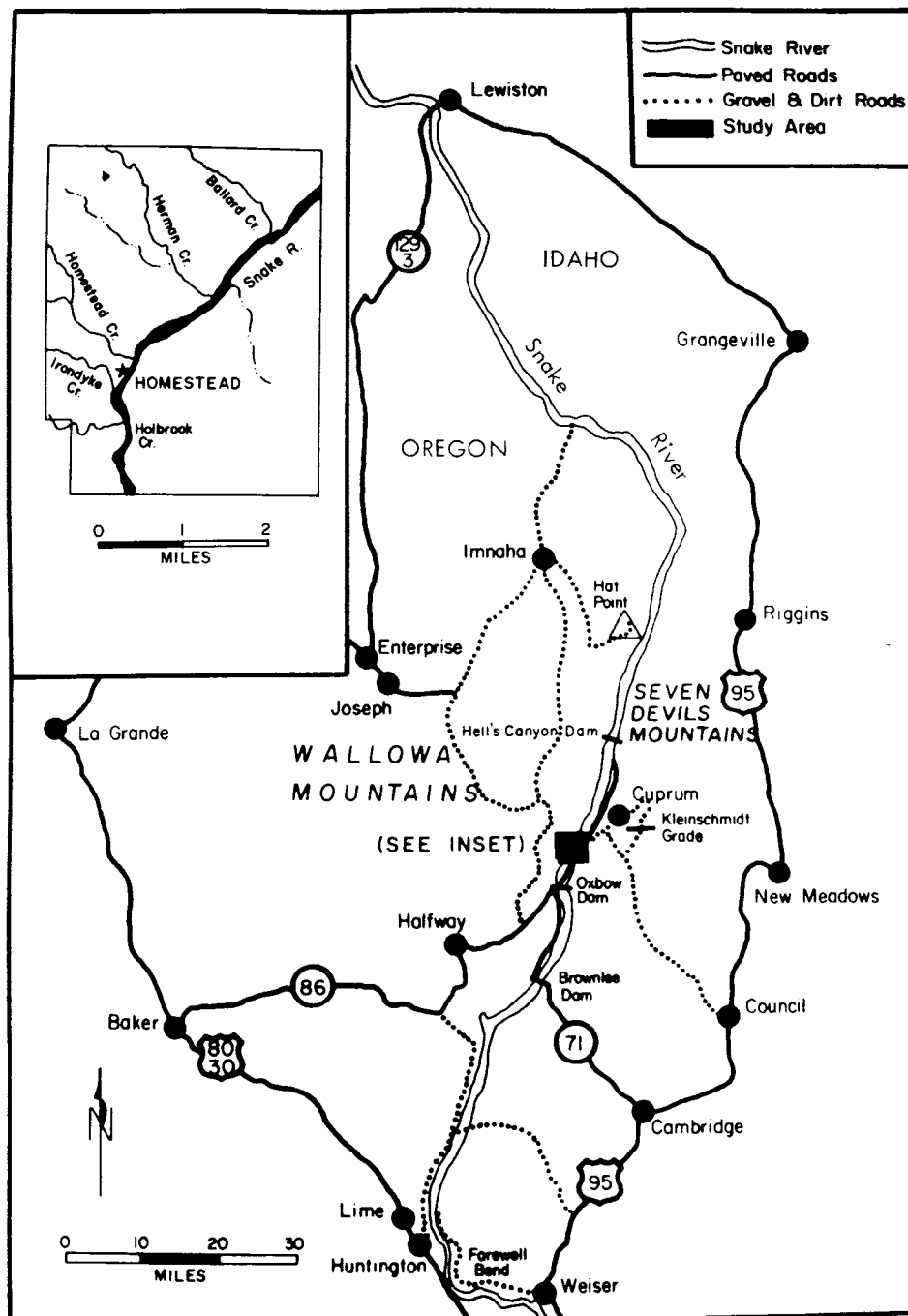** Geologist, State of Oregon Dept. of Geology and Mineral Industries.

Figure 1. Index map of the Snake River Canyon area, Oregon and Idaho, showing detail of the Homestead area.

Table 1. A simplified stratigraphic column of rocks in the Snake River Canyon north of Oxbow, Oregon. Asterisks mark rock units that are exposed in the Homestead area. Informal rock-unit names were assigned by Vallier (1967).

Geologic age	Name of rock unit	Thickness in feet	Description
Quaternary		?	Alluvium and landslide debris.
UNCONFORMITY			
Pliocene-Miocene	Columbia River Group*	2,000-3,000	Basalt flows and some volcaniclastic rocks.
UNCONFORMITY			
Late Triassic (Norian)	Martin Bridge Formation	1,750	Limestone and dolomite. Best exposures are near Big Bar, Idaho.
UNCONFORMITY (?)			
Late Triassic (Karnian) and Middle Triassic (Ladinian)	Doyle Creek formation and Grassy Ridge formation* (informal names)	10,000-15,000	Metamorphosed volcaniclastic and volcanic flow rocks with minor amounts of limestone, shale, and chert.
UNCONFORMITY			
Middle Permian (Leonardian and Guadalupian)	Hunsaker Creek formation* (informal name)	8,000-10,000	Metamorphosed volcaniclastic rocks, minor flows, shale, and limestone.
UNCONFORMITY (?)			
Paleozoic (Permian?)	Windy Ridge formation (informal name)	2,000-3,000	Metamorphosed volcanic flow rocks (keratophyres) and volcaniclastic rocks.

Stratigraphy

In the Homestead area, structurally deformed and metamorphosed Permian and Triassic rocks are overlain unconformably by nearly horizontal basaltic rocks of Miocene-Pliocene age. Plate 1 is a generalized geologic map of the area. The regional stratigraphic relationships are shown in table 1.

Permian rocks

Permian rocks, here informally called the Hunsaker Creek formation, mostly are stratified volcanic sediments and volcanic flow rocks. Some of the best outcrops of Permian rocks in northeastern Oregon and western Idaho are in or near the Homestead area. The most representative stratigraphic sections are in Hunsaker Creek and in Ballard Creek (figure 3). Good outcrops also occur in Homestead Creek (figure 4). Hypabyssal intrusives of gabbro, diabase, and keratophyre porphyry cut the stratified rocks and are, at least in part, of the same age.

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Rock types are characterized by heterogeneity. Volcanic sediments of both epiclastic and pyroclastic origins are breccia, conglomerate, sandstone, and fine-grained sediment. Volcanic flow rocks are spilite and keratophyre. Relative percentages of rock types in 3800 feet of section from Hunsaker and Ballard Creeks are as follows: 9 percent volcanic conglomerate, 21 percent volcanic breccia, 39 percent volcanic sandstone, 25 percent volcanic siltstone and other fine-grained sediments, 5 percent spilite flows, less than 1 percent keratophyre flows, and small amounts of limestone. Clast counts of conglomerates indicate that 85 percent are keratophyre and quartz keratophyre flow rocks and volcanic sediments. Plutonic rock clasts constitute less than 1 percent. Volcanic breccias generally grade upward into volcanic sandstone and volcanic siltstone in beds which range in thickness between 1 and 50 feet. Volcanic sandstones are graded. Silicified, fine-grained sediments resemble chert and can be differentiated only through thin-section studies. All rocks are metamorphosed to the greenschist facies of regional metamorphism. Notable mineralogic changes are albitization of feldspars and silicification of sediment matrices. Chlorite, calcite, and epidote also are common secondary minerals. During metamorphism, basalts were changed to spilites and andesites and dacites were changed to keratophyres and quartz keratophyres, respectively.

Fossils are quite abundant in the mapped area but occur less frequently elsewhere. From preliminary studies, F. Stehli of Case-Western Reserve University concluded that the rocks should be assigned to the Leonardian and Guadalupian series. Major fossils are brachiopods which include spiriferids, neospiriferids, rhynchonellids, lingulas, and productids. Other fossils are crinoid columnals, bryozoans, and clams.

No stratigraphic section exposes all of the Permian rocks, so the true thickness is not known. However, studies in the Snake River Canyon and in the foothills of the Wallowa Mountains suggest a thickness in the range of 8,000 to 10,000 feet.

The stratified rocks were deposited in a marine environment near volcanic landmasses. Erosion of rugged terrains and transportation, both by streams with steep gradients and by submarine turbidity currents, left heterogeneous deposits of immature volcanic sediments. Subaqueous pyroclastic flows similar to those described by Fiske (1963) probably contributed a large part of the volcanic sediments. The dominance of keratophyre and quartz keratophyre clasts in the conglomerates suggests that andesitic and dacitic volcanism was or had been prevalent in the source areas. Plutonic clasts of gabbro, quartz diorite, and diorite are similar to the Permian and Lower Triassic plutons of the Canyon Mountain magma series (Thayer and Brown, 1964). However, no plutons of known Permian age have been recognized in northeastern Oregon and western Idaho near the Snake River Canyon. Possibly, the old plutons are covered by Tertiary basalts. Sills and dikes of gabbro, diabase, and keratophyre porphyry intrude the Permian strata and may be in part contemporaneous with the deposition.

Figure 2. Looking west across the Snake River toward Homestead on the alluvial fan. Dumps of Iron Dyke mine occur west of the town. Dashed line marks unconformable contact between Permian rocks and overlying Tertiary basalts.

Figure 3. Permian strata in Ballard Creek where more than 1800 feet of volcaniclastic rocks are exposed.

Correlative rocks are the Clover Creek Greenstone (Gilluly, 1937) and part of the Seven Devils Volcanics (Anderson, 1930). Later work by Bostwick and Koch (1962) and by Vallier farther north in the Snake River Canyon indicates that the Permian rocks crop out over a much larger area than previously recorded.

Triassic rocks

Rocks of Middle and Late Triassic ages (Ladinian, Karnian, and Norian Epochs) are exposed in the Snake River Canyon (figure 5). In the Homestead area, Triassic rocks, informally named the Grassy Ridge formation, are preserved in a complex graben and are separated from the adjacent Permian strata structurally by steeply dipping boundary faults and stratigraphically by an unconformity. Fossils, identified by Dr. N. J. Silberling, are late Middle Triassic (latest Ladinian) and early Late Triassic (earliest Karnian) ages. Age assignments depended on the presence of the flat clam Daonella cf. D. indica and an ammonite Trachyceras (sensu stricto).
At least 500 feet of strata are exposed in the graben. Volcaniclastic rocks predominate but limestone, chert, limy shale, and conglomerate also occur.
Farther north in the Snake River Canyon equivalent rocks are well exposed, particularly along Squaw and Saddle Creeks, about 10 and 20 miles north, respectively, of the Homestead area. At these localities, thicknesses approach 3000 to 4000 feet and rocks include pillow lava, limestone, and graded beds of volcaniclastic sediments. These Triassic rocks also have been metamorphosed to the greenschist facies and major mineralogic changes are similar to those which occurred in the Permian rocks.
Provenance studies indicate that the contributing volcanic terranes were of basaltic composition. This is in stark contrast to the source areas for the Permian, which contained volcanic rocks of andesitic composition and also plutonic rocks. Apparently, the older Permian rocks had subsided before Middle Triassic volcanism began or perhaps they were covered by Triassic lava flows and did not contribute debris to the Middle Triassic basins.
The Middle Triassic rocks are of particular interest for any regional geologic interpretations because they are the only known strata of that age in the Cordilleran eugeosyncline of Oregon and Idaho.

Tertiary rocks

Overlying the pre-Tertiary rocks unconformably are the cliff-forming basalt flows of the Columbia River Group. West of Homestead these essentially flat-lying flows are more than 2000 feet thick and farther south thicknesses approach 3000 feet. The basalt flows poured out from fissures onto a terrain that had a minimum relief of 1500 to 2000 feet during Miocene-Pliocene time. Basalt dikes cut the older rocks near Homestead and in some

places the dikes follow pre-Tertiary faults. Widths of dikes range from 2 to 40 feet in the map area.

Intrusive Rocks

No major intrusives occur in the mapped area. A generalized review of plutonism in adjacent areas, however, might be important for future studies of the genesis of the copper deposits. The oldest known major intrusive event in northeastern Oregon was the emplacement of the Canyon Mountain magma series (Thayer and Brown, 1964), which occurred most probably during Late Permian to Middle Triassic time. White (1968) mapped 11 small intrusives in the nearby Seven Devils Mountains. He suggests that three kinds of plutonism are represented: Late Triassic-Middle Jurassic(?); Late Jurassic(?); and Late Jurassic-Early Cretaceous(?). The major intrusive emplacement in the Wallowa Mountains was during latest Jurassic (Taubeneck, 1963), whereas the major plutons of the Idaho batholith were intruded later, during the Middle Cretaceous-early Tertiary time interval (Larson and others, 1958).

Only small hypabyssal intrusives cut the rocks in the Homestead area. The Permian rocks are intruded by gabbro, diabase, and keratophyre porphyry which seem to be in part contemporaneous with the sedimentation. Diabase intrusives which cut the Triassic rocks seem unrelated to those in the Permian strata.

Structural Geology

Deformation is recorded by orogenic sediments, by faults and folds, and by unconformities. Orogenic deposits of conglomerate, breccia, and volcanic sandstone in thick, graded beds indicate that uplift and rapid erosion were common during the Permian and the Middle and Late Triassic. Broad folds are cut by steeply dipping faults. Northeast-striking strata dip mostly northwest and the strike of bedding parallels the trends of major faults. Displacements along faults are difficult to measure because the stratigraphic sequences are not well known. Vertical displacements may be several hundred feet but horizontal displacements may be even greater. Fault planes are rarely exposed.

Two major unconformities in the Homestead area are between the Permian and Middle Triassic strata and between the pre-Tertiary and the Miocene-Pliocene Columbia River Group. Both are angular unconformities, but the unconformity between Permian and Triassic rocks is difficult to find and trace because of a general absence of fossils in critical areas and because of the similarities between Permian and Triassic strata. Best exposures of the unconformity are along Homestead Creek at an elevation of about 2350 feet. The profound angular unconformity between the pre-Tertiary and Tertiary rocks is well exposed all along the Oregon side of the Snake River
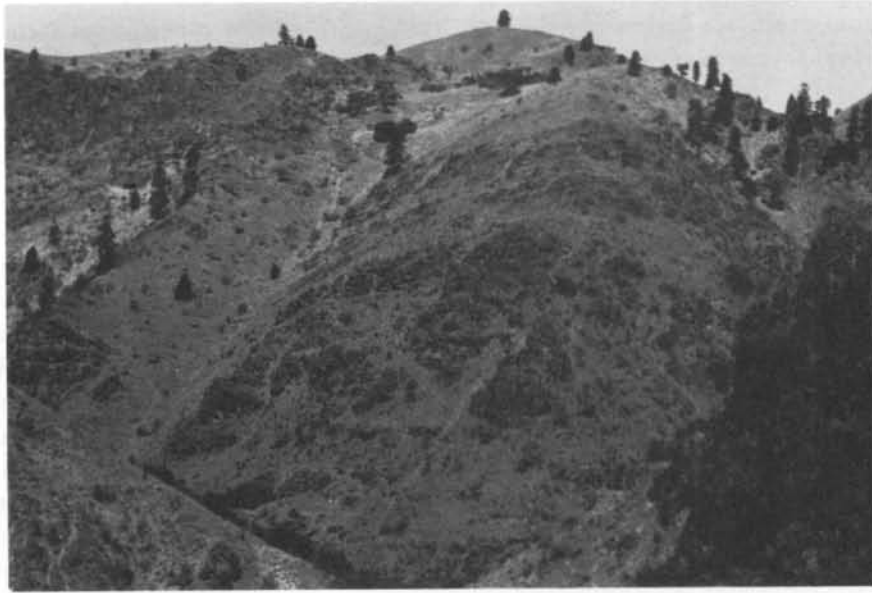
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Figure 4. Permian rocks exposed in Homestead Creek. The more
rugged and thicker outcrops are conglomerates and coarse breccias.

Figure 5. Middle Triassic rocks exposed along the ridge north of
Homestead Creek. Volcanic graywackes are interbedded with
thin bedded limestones which contain the flat clam Daonella.

Canyon. A major unconformity between Late Triassic and Middle or Late Jurassic strata occurs elsewhere in the Snake River Canyon (Morrison, 1961; Vallier, 1968).

The present rugged relief was formed by broad regional folding and uplift along normal faults which occurred during the Pliocene and Pleistocene epochs and which was contemporaneous with erosion by the Snake River that carved a deep gorge across the rising plateau.

Copper Deposits

A small "rush" to the Homestead area was instigated in the late 1890's by the promising early development of the Iron Dyke mine. Subsequent discovery and limited investigation of many prospects demonstrated widely scattered copper mineralization, but recorded output from deposits other than the Iron Dyke is very small. Production was mainly during World War I and the 1920's. In recent years parts of this and adjacent areas have been examined by a succession of mining companies; there has been little systematic areal coverage by modern surface-prospecting methods.

The copper deposits are associated with fault and shear zones. They occur in most of the many different kinds of rocks present in the pre-Tertiary assemblage including volcaniclastic conglomerates, breccias and sandstones, tuffs, lava flows, and keratophyric and diabasic intrusive rocks. The chief metallic ore minerals are pyrite and chalcopyrite and, in places, bornite, tetrahedrite, chalcocite, sphalerite, and galena. Malachite, azurite and, locally, chrysocolla and cuprite are present in near-surface exposures. Small amounts of gold and silver commonly occur in the ores in quantities that appear to be independent of the copper content. The metallic minerals generally are associated with quartz which has filled fractures and, in many places, has largely replaced the host rocks. Accessory gangue minerals include calcite, sericite, epidote, chlorite, and barite. Clays are present as wall-rock alteration products. Large alteration halos are not indicated at the surface.

In most of the deposits where evidence is available, extensive surface oxidation and leaching of ore minerals have been very shallow and there are no indications of appreciable supergene enrichment. Lindgren (1901, p. 633) stated, "The large sulfide mass of the Iron Dyke was covered by a brown shallow crust in which practically no copper was present. Immediately below this, pale and decomposed pyrite appeared, and the chalcopyrite began only a few feet below the pyrite." Silicified croppings of the McCarty prospect contain partly decomposed sulfides. Depth of oxidation and leaching may be somewhat greater at the Ballard and Rand-McCarthy prospects, where porosity of the metallized zones was enhanced by postmineral shearing. Near-surface exposures of these deposits show only traces of copper-oxide minerals; whether significant quantities of copper have been leached is unknown.

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Copper deposits in the Homestead area occur in both Permian and Upper Triassic rocks; none are known in the Miocene lavas. Mineralization postdated greenschist facies regional metamorphism, which probably occurred during Middle Jurassic time.

Origin of the deposits has not been fully established. Most of them are clearly epigenetic in their present relation to enclosing rocks, and their association with quartz veins and silicified and hydrothermally altered rocks along faults and shear zones implies deposition from heated solutions. The source of such solutions is unknown, but several possibilities should be considered. Although the deposits are several miles from the nearest exposures of plutonic rocks related to the Idaho batholith to the east and Wallowa batholith to the west, extensions of these plutons may exist at depth beneath the Homestead area and could have supplied the mineralizing fluids. This concept must take into account the fact, first noted by Lindgren (1901, p. 632), that the Homestead copper deposits and also those near Keating, Oregon are grossly different in form and mineralogy from the gold-quartz veins in and near the Wallowa batholith and other similar plutons in eastern Oregon. They also differ from the "contact" copper deposits in the nearby Seven Devils Mountains which Cook (1954, p. 9) regarded as Late Cretaceous or early Tertiary in age. Another possibility is that the ore minerals were derived from syngenetic sources in the surrounding volcanic rocks. Lindgren (1901, p. 632) suggested as the mechanism of redistribution "a sort of lateral secretion (involving) dilute, perhaps cold, solutions belonging to the general circulation of groundwater." It is suggested here that heated fluids orogenically derived from the country rocks may have been the mineralizing medium. The copper deposits probably are not related to the igneous activity responsible for the intrusion of the many small silicic bodies that are exposed in the Homestead area, such as the now pyritized keratophyre associated with the Iron Dyke deposit. The fact that most of these intrusives are of pre-Upper Triassic age conflicts with the evidence that copper deposits occur in Upper Triassic rock and that they postdate Middle Jurassic(?) regional metamorphism.

Iron Dyke mine

The Iron Dyke mine, on patented claims owned by Butler Ore Co., St. Paul, Minn., is on the south wall of Irondyke Creek about a third of a mile west of the Snake River at Homestead (figures 6-a and 6-b). Recorded production of the mine is summarized in table 2. Development began in 1897 and considerable ore was blocked out prior to 1916, when a 150-ton flotation plant became operative. A development program, including a large amount of diamond drilling, was conducted by the present owners in the early 1940's but there is no record of production after 1934.

According to old maps, development includes a glory hole and eight partly interconnected levels from four adits and a 650-foot vertical shaft,

Table 2. Production of gold, silver, and copper from the Iron Dyke mine, Homestead district, Baker County, Oregon 1910 to 1934 (Brooks and Ramp, 1968, p. 94).

Year	Ore smelted, tons	Ore milled, tons	Concentrates produced, tons	Gold, ounces	Silver, ounces	Copper, pounds
1910	68			1	535	13,861
1915	3,565			55	9,803	396,972
1916	23,225[1]			377	80,856	2,230,729
1916			1,673	58	8,337	290,971
1917		36,676	7,522	1,279	31,256	1,372,110
1918		33,583	6,734	3,794	24,212	1,602,145
1919		27,618	7,044	10,753	17,624	2,087,276
1920		34,804	7,910	8,322	18,890	2,353,276
1921		2,398	573	434	1,339	174,300
1922	2,047			513	4,167	198,320
1922		15,070	3,570	2,259	10,238	813,869
1923	369			26	862	57,345
1923		17,980	5,117	3,141	21,244	1,176,144
1924		14,746	3,418	1,879	12,039	757,440
1925		2,740	548	375	1,938	105,600
1926	27			81	97	6,519
1926		5,155	1,031	510	3,512	227,691
1927	185			7	729	43,356
1927		16,018	1,236	805	7,513	439,696
1928		2,800	223	148	1,283	70,300
1934		1[2]		150	15	-
	29,486	209,589	46,599	34,967	256,489	14,417,920

[1] Total ore milled and smelted.   [2] Bullion produced.

all within a vertical range of about 950 feet (plate 2). The lowest adit level, whose portal is near the mouth of Irondyke Creek and very few feet above the level of the Snake River, is 290 feet above the deepest shaft level. This adit, referred to as the 650 level, was driven during 1942-43 and has been maintained. Adit levels above the 650 level are caved; shaft levels below are flooded.

Stratigraphic relationships in the mine area are obscured by complex faulting and by landslide debris. Rocks visible at the surface and those cut by the 650 level are Permian in age. Stratified rocks are mainly volcaniclastic conglomerate, breccia, and tuff with minor interbedded sandstone, shale, and spilitic and keratophyric lava. A red keratophyre porphyry intrusive body for which the mine was named is well exposed in the gloryhole area (figure 6-b). This shattered body contains pyrite whose iron has been oxidized, thereby contributing the rusty red color.

In the mine area, movement along northeast-trending faults produced
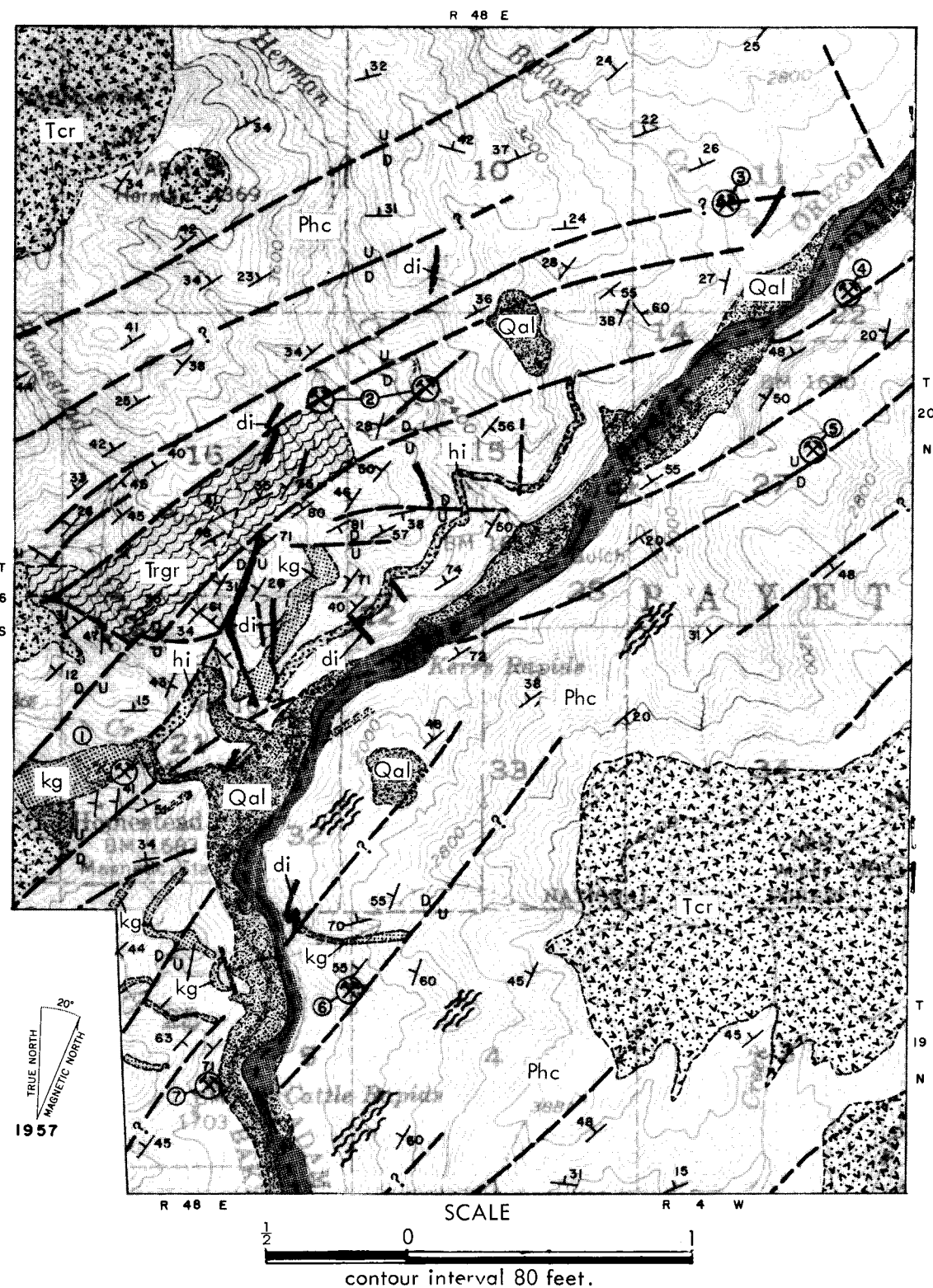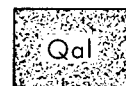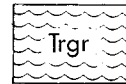
Explanation

Qal — Quaternary alluvium and landslide debris.
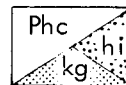
unconformity

Tcr; di — Miocene and Pliocene Columbia River Basalt; di, basalt dikes.

unconformity

Trgr — Middle and Upper (?) Triassic volcanics and volcanic sediments (Grassy Ridge formation*).

unconformity

Phc; hi; kg — Phc, Permian volcanic sediments (Hunsaker Creek formation*); hi, hypabyssal intrusives of diabase and gabbro; kg, keratophyre porphyry intrusives.

* Formation names are informal.

Fault, dashed where inferred.
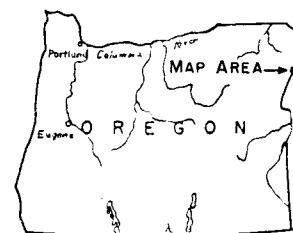Contact, dashed where inferred.
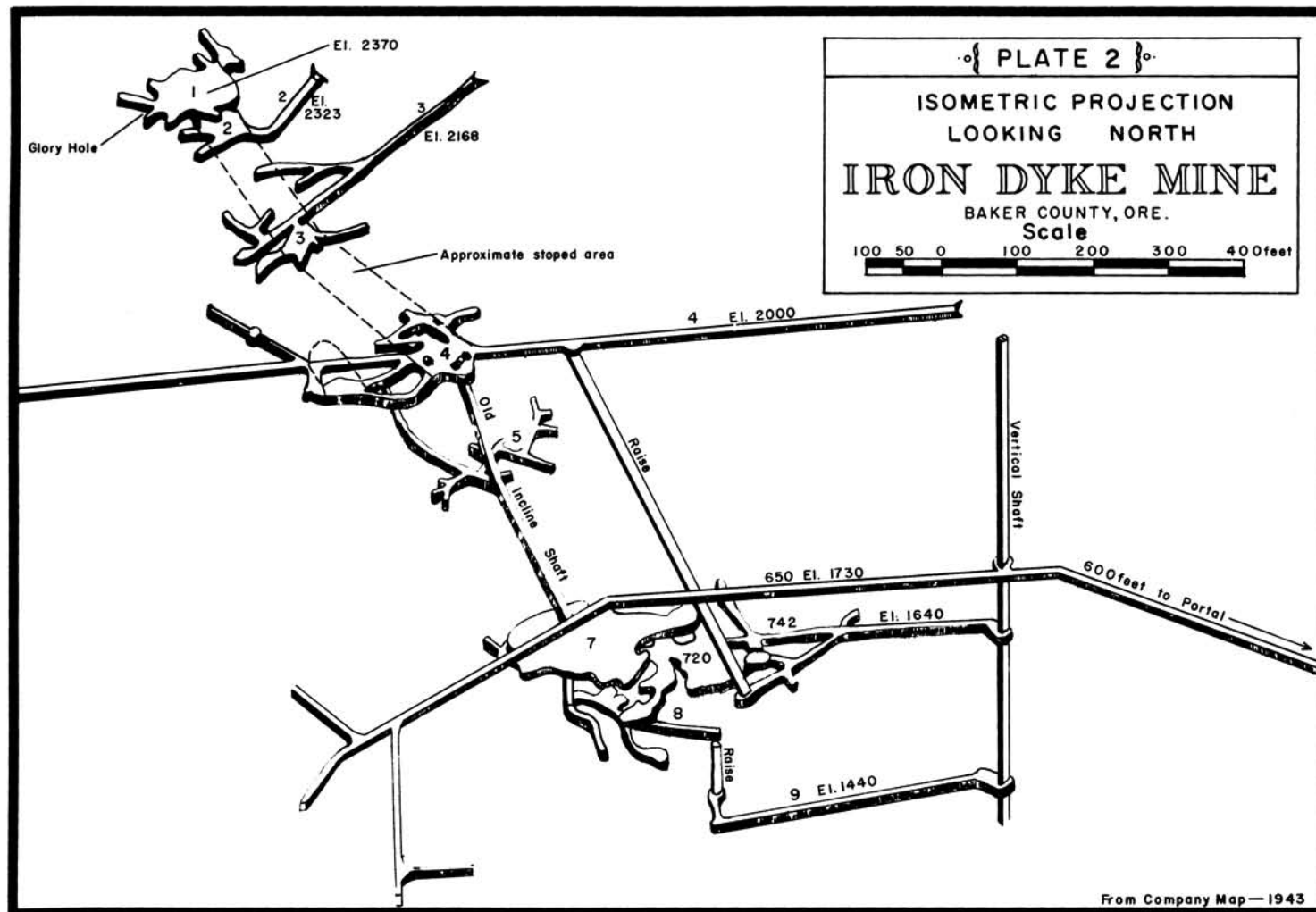
Strike and dip of bedding.

Shear zone.

Mines and prospects described in the text.

1. Iron Dyke mine
2. Rand–McCarthy prospect
3. Ballard prospect
4. River Queen prospect
5. Ants Creek prospect
6. McCarty prospect
7. Thorne Flat prospect

MAP AREA

OREGON

Topographic base from
USGS 15' Homestead quadrangle, 1957.

SCALE
½   0   1
contour interval 80 feet.

TRUE NORTH   MAGNETIC NORTH   20°
1957

R 48 E   R 4 W

PLATE 2

ISOMETRIC PROJECTION
LOOKING NORTH

IRON DYKE MINE

BAKER COUNTY, ORE.

Scale

100 50 0   100   200   300   400 feet

El. 2370

Glory Hole

El. 2323

El. 2168

Approximate stoped area

4   El. 2000

Old Incline Shaft

Raise

Vertical Shaft

650 El. 1730

742   El. 1640

720

600 feet to Portal

9   El. 1440

Raise

From Company Map—1943

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a maze of subsidiary faults, fractures, and crushed zones which later local-
ized the ore bodies.

According to available maps, the principal stope areas are within a
zone that pitches 50° in an easterly direction and has maximum horizontal
dimensions of about 250 feet and pitch length of about 1200 feet (plate 2).
Company reports indicate that most of the ore was in volcaniclastic rocks
and that the ore typically occurred in crudely lenticular masses or nodules
between which there was little apparent continuity, although stringers com-
monly extended short distances into the wall rocks. Because of their shape,
some of the ore masses in the lower levels were referred to as "boulders";
the "boulders" ranged in size from that of a man's fist to one yielding
150,000 tons of ore. Much of the ore was said to be almost completely
silicified, showing several stages of quartz. Before production had begun,
Swartley (1914, p. 109) reported: "The best ore in the lower tunnel (No.
4 level on plate 2) is massive chalcopyrite and pyrite with but little quartz
as a gangue in a lens-shaped body dipping 60° E. with a maximum width of
about 6 feet which is said to extend from the lower to the upper tunnel....
On either side of this high grade ore, which is said to average 15 to 20 per-
cent copper, is a much larger body of disseminated pyrite and chalcopyrite
in the chloritic greenstone, in which are abundant quartz seams, veinlets,
and nodules that contain pyrite....Statements are made that it contains
about $2.00 in gold, and 6 to 30 ounces in silver, regardless of the percent
of copper present. This deposit, both high and low grade, is in a zone of
crushing in which copper-bearing solutions have deposited their contents
largely by replacement." Oregon Department of Geology and Mineral In-
dustries Bulletin 14-A (1939, p. 62) states: "Since the above was written
...the mine was developed by shaft to levels below the lower crosscut. On
the lowest level the ore body was cut off by a nearly horizontal fault. The
ore body here was egg shaped, about 140 feet wide and 210 feet long, car-
rying good grades of copper and about $\frac{1}{4}$ ounce in gold." Upper portions of
stopes in this ore body are intersected by the 650-adit level.

A report on the mine by Wallace P. Butler, dated Jan. 3, 1944, states
that estimated reserves above the 650 level totaled 148,619 tons containing
1.16 percent copper and 0.038 oz. gold and 1.35 oz. silver per ton. In-
dications of additional ore reportedly were encountered at greater depths.

Rand-McCarthy prospects

The Rand-McCarthy prospects are near the forks of Herman Creek in
the NW$\frac{1}{4}$ sec. 15 and NE$\frac{1}{4}$ sec. 16, T. 6 S., R. 48 E., Oregon. There are
two groups of workings, one on each branch of the creek a short distance
above the forks. Much of this work was done before 1920.

Country rocks are mainly volcanic breccias and tuffs. Thin spilite
flows also are present.

Northeast-trending faults (plate 1) are expressed in the prospect areas

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Figure 6, a and b. Iron Dyke mine area. The letter X marks common
point on both photographs from different positions.
Figure 6-a (above): View east down Irondyke Creek;
shaft of No. 4 adit dump in middle ground. Snake River
in upper left.
Figure 6-b (right): View south across Irondyke Creek;
glory hole and "iron dyke" in upper middle ground;
No. 3 adit dump in foreground.

by zones of shearing wherein quartz and sulfide minerals were later intro-
duced locally. At the surface the sulfide minerals have been leached,
leaving some of the altered rocks richly iron stained; copper oxide miner-
als are rare.

On the south wall of the west branch of Herman Creek about half a
mile above the forks are four prospect adits which, judging from their dumps,
may have an aggregate length of between 700 and 1000 feet. According to
a 1919 private report by C. F. O. Merriam, the uppermost adit "prospects
a vein for a length of 225 feet and by a series of cross cuts exposes, in part,
a width of mineralization of about 40 feet." Reportedly, gold and silver
values and both sulfides and oxides of copper were encountered. No assay
results were presented. Rocks at the adit portal are bleached, limonitized,
and cut by west-trending fractures containing stringers and small bunches of
quartz. A small amount of highly pyritized quartz is present on the adit
dump.

Directly across the creek, croppings of a limonitized shear zone more
than 250 feet long and 10 to 25 feet wide have been prospected by a series
of cuts and short adits. Quartz stringers and shear fractures trend N. 45° E.
and dip steeply east.

Prospect development on the east fork of Herman Creek less than quar-
ter of a mile above the forks includes four adits and open cuts. Here,
quartz-filled fractures also strike N. 45° E. and dip steeply east. Very lit-
tle malachite was observed on the dumps. Some pyritized quartz occurs in
the dump of the lowest and longest adit.

Ballard group

Prospects located in 1899 by E. F. Ballard are on the north wall of
Ballard Creek canyon about a quarter of a mile west of Hells Canyon Reser-
voir in the SW¼ sec. 11, T. 6 S., R. 48 E., Oregon. Development includes
three short adits, all caved.

Host rocks are tuff with lesser amounts of volcanic breccia and sand-
stone. Much of the pale-green tuff includes dark-green elongated chlorite
clots that probably are relict pumice fragments.

In the prospect area sheared and brecciated rocks associated with a
northeast-trending fault have been silicified, bleached, and limonitized.
Limonitic pseudomorphs and voids after fine crystalline pyrite are abundant
locally. The former presence of a small amount of chalcopyrite also is in-
dicated, although no copper-oxide minerals were seen.

The brecciated character of the altered rocks indicates that silicifi-
cation and sulfide mineralization preceeded a final stage of brecciation and
subsequent leaching. The mineralized zone is poorly exposed and may be
discontinuous. Probably at the surface it does not much exceed 60 feet in
maximum width and 300 feet in length.

River Queen prospect

The River Queen prospect is about 100 yards east of the Hells Canyon highway in the S½ sec. 22, T. 20 N., R. 4 W., Idaho. Much of the following description is from Cook (1954, p. 15).

The mine has produced an estimated $20,000 in copper ore. Small production was recorded as early as 1912. The latest output was in 1936-40; about 200 tons of hand-sorted ore containing 15 to 17 percent copper was shipped. Development includes an open cut and several hundred feet of workings on two adit levels. Tuff, volcanic breccia, and sandstone are the principal host rocks. A small, poorly defined body of fine-grained rhyolite (keratophyre?) may be intrusive. A series of northeast-trending fractures and related breccia zones is irregularly filled with chalcopyrite and some bornite and chalcocite which, near the surface, have been partly oxidized to malachite, azurite, and a little cuprite. There is very little quartz gangue, although the host rocks have been silicified locally. Sericite and calcite are also present.

The rhyolite is impregnated with pyrite crystals and grains. Livingston and Laney (1920, p. 24) suggested genetic association of the rhyolite with copper mineralization.

Cook states, "A few thousand tons of low-grade ore, containing about three per cent copper, constitute the probable reserves. The complexity of the mineralized fractures makes exploration difficult and the irregularity of the mineralization within the fractures makes the future of the River Queen appear unpromising."

Ants Creek prospect

The Ants Creek prospect in the SW¼NE¼ sec. 27, T. 20 N., R. 4 W., Idaho, is on the north wall of Ants Creek canyon between 500 and 600 feet in elevation above the first switchback in the Kleinschmidt grade. Two accessible adits having a total length of about 200 feet are the principal workings.

The host rocks are intrusive (?) diabase and thin-bedded to massive tuffs with subordinate intercalated sandstone layers.

A drift about 40 feet long in the upper adit prospects narrow quartz lenses included in a fault zone several feet wide in which the host rocks have been sheared, partly altered to clays, and locally limonitized. The zone strikes east-northeast and dips 40° to 60° N. Tetrahedrite clots in the quartz are partly altered to malachite and azurite. Small amounts of pyrite and sericite are accessory minerals. Local prospectors report that sphalerite also is present, although none was observed by the writers. At the portal of the lower adit, about 50 yards to the west, badly fractured and altered rocks contain irregular quartz stringers. No sulfides or oxide copper minerals were observed here. Structural continuity of this altered zone

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with that in the upper adit has not been proven.

McCarty prospect

The McCarty prospect is about one mile south of Homestead in the NW$\frac{1}{4}$ sec. 4 and NE$\frac{1}{4}$ sec. 5, T. 19 N., R. 4 W., Idaho. The prospect is developed by four short adits totaling about 250 feet. The adits are open at the portals. Local prospectors report that a small amount of ore was shipped from this property in the early 1920's.

The host rocks are bedded, locally coarse-crystal tuffs that have been complexly faulted.

Cook (1954, p. 21) states, "Bornite, sphalerite, galena, pyrite, quartz, and calcite fill fractures and breccia zones in silicified and pyritized tuff. The maximum vein width is 24 inches, and all the veins are discontinuous. Comb structure and vugs in the quartz and cavity filling as the dominant process of emplacement indicate a low-temperature (epithermal) deposit. Considerable post-mineral faulting has displaced the veins and veinlets. Vein material contains 3 to 10 per cent zinc and up to 4 per cent copper, with a little lead, silver and gold."

The northernmost adit, at the base of a rock bluff, penetrates a zone of quartz and pyrite-impregnated tuff that at the surface is about 12 feet wide and 40 feet long in a northwesterly direction. Part of the fine-grained pyrite has been oxidized. A little chalcopyrite, malachite, and azurite were observed.

Thorne Flat prospect

The Thorne Flat prospect is in sec. 28, T. 6 S., R. 48 E., Oregon, about 0.8 mile south of Homestead. Several hundred feet of work has been done in two closely spaced adits about 100 yards west of the Oxbow-Homestead road. A shorter adit on the hillside to the southwest also is included in the property. According to information furnished by Doris Degitz, daughter of one of the original owners, the object of the work, done mostly during the early 1900's, was deeper exploration of a northeast-trending shear zone which is exposed on the hillside above. Reportedly several copper-sulfide-bearing fractures were crosscut but work ceased before the shear zone was intersected. A little pyrite and chalcopyrite is visible on the adit dumps.

Outlook

Available data do not warrant predictions regarding the possibilities of future copper production from the Homestead area. Prospecting has not been sufficiently extensive to nullify the changes of discovering either new high-grade deposits similar to the Iron Dyke or lower grade deposits amenable

to large-scale mining methods. With the exception of the work done at the Iron Dyke mine, there has been little prospecting to depths greater than 100 feet. In much of the area, bedrock is masked by soil or talus; thus the use of the more sophisticated prospecting tools available today might reveal the existence of buried deposits of economic importance.

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DRILLING RECORDS GET COMPUTER NUMBERS

The Department has assigned "unique numbers," based on the American Petroleum Institute system, to all the oil and gas drillings in Oregon. This was done as a service to the oil industry and other groups collecting information under the national system. Each drilling is given a 10-digit number which is different from any other number used for an oil or gas drilling in the United States. The 10-digit number consists of a state code, a county code, and five digits for the chronological order of drilling. By using the unique numbers, Oregon drilling records can be easily cross-referenced in the national data-retrieval system. New drill permits will hereafter be issued under the API number.

A list of API numbers for oil and gas drillings made thus far in Oregon is available through the Department at a cost of $1.00. The list also includes numbers for wells drilled on federal shelf lands.

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WORLD SUBSEA MINERAL RESOURCES OUTLINED

Four preliminary maps showing the world distribution of potential subsea mineral resources have been compiled by V.E. McKelvey and Frank F. H. Wang and issued by the U.S. Geological Survey as Map I-632. The four maps, accompanied by a 17-page explanatory pamphlet, can be purchased from the Survey's distribution office, Federal Center, Denver, Colorado, 80225, at $2.75 per set.

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WE MUST CONSUME, WE MUST CONSERVE

By Ralph S. Mason*

Although everybody agrees that the environment is being assaulted by man, very few are willing to assume the costs and efforts that are required to correct the devastation. Furthermore, man cannot live in a completely natural and untrammeled environment. Even if he could exist, he would not enjoy his life and his standard of living would be reduced to that of the primitive cave man, or lower. The trick is to maintain or even improve the world's standard of living while at the same time doing as little damage to the environment as possible.

Human existence depends upon the daily consumption of a wide variety of natural resources. Some of these materials are renewable, others are not. Some can be transplanted from place to place; others remain fixed. Some occur in vast abundance; others are in short supply. The wisest use of these natural resources, both from a short-term and a long-term standpoint, is called conservation. Conservation presents many problems, and all our resources have been damaged in some way. Mineral deposits are no exception. There are very real difficulties facing this segment of our environmental dilemma. Minerals, unlike all of the other natural resources, are not renewable and remain fixed as to location until mined. These two qualities impose severe handicaps to man in his struggle to improve his standard of living. Although in general we have a fair supply of minerals, the demands made upon them by a rapidly expanding economy have often exceeded man's ability (or desire) to extract them in the very best manner. In the past the availability of minerals at low cost has been the keystone for our economy. Today man is beginning to consider the environmental and conservation factors involved in the production of minerals.

A prime example of a mining endeavor that can complement an environment is to be found in our plain old sand and gravel industry. Every growing community requires large quantities of sand and gravel. Characteristically, these commodities are produced either within the city or not far beyond it. With proper planning, many communities can use the gravel and improve the land as well. After the gravel deposit has been mined out, the quarry can often serve as a solid-waste disposal site. Once it is filled in, it can be used for agricultural purposes, for a public park, or for any other purpose which does not require extensive subsurface excavation.

In addition to the environmental aspects of mineral production, everyday conservation factors are cause for considerable concern. Mineral deposits are being used up at an alarming rate, and some will be forever unavailable to man because of the lack of protective planning. Plants and animals are not the only "endangered species." Sand and gravel deposits, the essential materials for community growth and national development,

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* Mining Engineer, State of Oregon Dept. Geology & Mineral Industries.

will soon be a thing of the past in some areas owing to exhaustion of the resource. In some places good deposits are being removed permanently from production by zoning, urbanization, or other causes and these communities face a drying up of the resource prematurely. Other mineral deposits have much the same problem. When traced to its source, aluminum foil does not come from a grocery store, nor does gasoline come from service stations. Mines, quarries, and oil wells are the fountainhead from which much of our economic strength, personal comfort, and national wellbeing flow. No nation in history has flourished without adequate mineral resources and it is unlikely that any can.

Man is the product of his environment and he is completely dependent upon it even though he is doing his best to destroy it. Man can lessen the damage to all phases of the environment if and when he chooses. The cost will be high, and much of our present affluence will disappear as the price of raw materials soars and costly restrictions are imposed on waste disposal, water and air pollution, the use of fertilizers and pesticides, and heat-, noise-, and radiation-producing devices of all kinds.

The mineral industry, along with other industries, has learned to produce ever more efficiently. It is one thing to produce, however, and quite another to manage properly the waste products, the abandoned mining properties, and the myriad side effects created by the extractive effort. The solution lies partly in long-range, comprehensive, intelligent planning by agencies charged with the management of our natural resources. Little effective planning has been done by such instrumentalities. Many large-scale mining operations, on the other hand, are being conducted on a 25-year or longer program which involves so many variables that computers are required to determine the original program and make daily corrections as work progresses. Planning is possible and necessary, if our natural resources and environment are to be managed and protected properly. It is merely a matter of deciding when to start. The costs will be staggering but the benefits, in terms of man's living in his hereditary environment, will be enormous.

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COURSE IN ENVIRONMENT SCHEDULED

In response to growing pressure from concerned persons, a course in Environmental Survey is being offered at Portland State University this spring term. The program, sponsored by the Continuing Education Division of the State Board of Higher Education, will be taught by Ralph S. Mason, mining engineer with the Department. The course is designed primarily for engineers involved in work affecting the environment, but laymen wishing to learn more about the problems and possible solutions to them may enroll. The course is to be held Tuesday evenings, starting March 31st, at 6:45 p.m.

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THESES ON OREGON GEOLOGY RECEIVED IN 1968 AND 1969

The following unpublished master's theses and doctoral dissertations on the geology of the State of Oregon were added to the Department's library during 1968 and 1969:

Beeson, Marvin Howard, 1969, A trace element study of silicic volcanic rocks: Univ. Calif. at San Diego doctoral dissertation in Earth Sciences.

Carlton, Richard W., 1969, The structure and stratigraphy of a portion of the Trout Creek Mountain, Harney County, Oregon: Oregon State Univ. master's thesis.

Champ, John Gower, Jr., 1969, Geology of the northern part of the Dixonville quadrangle, Oregon: Univ. Oregon master's thesis.

Ellison, Bruce E., 1968, Stratigraphy of the Burns Junction-Rome area, Malheur County, Oregon: Oregon State Univ. master's thesis.

Elphic, Lance G., 1969, Geology of the southern one-third of the Glide quadrangle (Douglas County), Oregon: Univ. Oregon master's thesis.

Fouch, Thomas D., 1968, The geology of the northwest quarter of the Brogan quadrangle, Malheur County, Oregon: Univ. Oregon master's thesis.

Godchaux, Martha Miller, 1969, Petrology of the Greyback igneous complex and contact aureole, Klamath Mountains, southwestern Oregon: Univ. Oregon doctoral dissertation.

Haddock, Gerald H., 1967, The Dinner Creek Welded Ash-flow Tuff of the Malheur Gorge area, Malheur County, Oregon: Univ. Oregon doctoral dissertation.

Kim, Chong Kwan, 1968, Gravity and magnetic surveys of the Hole-in-the-Ground Crater, Lake County, central Oregon: Univ. Oregon master's thesis.

Lent, Robert L., 1969, Geology of the southern half of the Langlois quadrangle (Curry County), Oregon: Univ. Oregon doctoral dissertation.

MacLeod, Norman S., 1969, Geology and igneous petrology of the Saddleback area, central Oregon Coast Range: Univ. California Santa Barbara doctoral dissertation.

Muntzert, James K., 1969, Geology and mineral deposits of the Brattain district, Lake County, Oregon: Oregon State Univ. master's thesis.

Pungrassami, Thongchai, 1969, Geology of the western Detroit Reservoir area, Quartzville and Detroit quadrangles, Linn and Marion Counties, Oregon: Oregon State Univ. master's thesis.

Ramer, Alan R., 1967, Petrology of a portion of the Josephine peridotite sheet, Josephine County, Oregon: Univ. Oregon master's thesis.

Thiruvathukal, John V., 1968, Regional gravity of Oregon: Oregon State Univ. doctoral dissertation.

Wise, Joseph P., 1969, Geology and petrography of a portion of the Jurassic Galice Formation, Babyfoot Lake area, southwestern Oregon: Idaho State Univ. master's thesis.

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

2.	Progress report on Coos Bay coal field, 1938: Libbey	$ 0.15
8.	Feasibility of steel plant in lower Columbia River area, rev.1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev.1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole, editor	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor	2.00

GEOLOGIC MAPS

Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka	1.50
Geologic map of Oregon west of 121st meridian: (over the counter)	2.00
folded in envelope, $2.15; rolled in map tube, $2.50	
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat	2.00
folded in envelope, $2.25; rolled in map tube, $2.50	

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Available Publications, Continued:

SHORT PAPERS

2.	Industrial aluminum, a brief survey, 1940: Motz	.$ 0.10
18.	Radioactive minerals the prospectors should know (2nd rev.), 1955:	
	White and Schafer	0.30
19.	Brick and tile industry in Oregon, 1949: Allen and Mason	0.20
20.	Glazes from Oregon volcanic glass, 1950: Jacobs	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Mason	0.25
23.	Oregon King mine, Jefferson County, 1962: Libbey and Corcoran. . . .	1.00
24.	The Almeda mine, Josephine County, Oregon, 1967: Libbey	2.00

MISCELLANEOUS PAPERS

1.	Description of some Oregon rocks and minerals, 1950: Dole	0.40
2.	Key to Oregon mineral deposits map, 1951: Mason	0.15
	Oregon mineral deposits map (22" x 34"), rev. 1958 (see M.P.2 for key) . .	0.30
3.	Facts about fossils (reprints), 1953	0.35
4.	Rules and regulations for conservation of oil and natural gas (rev. 1962)	1.00
5.	Oregon's gold placers (reprints), 1954	0.25
6.	Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . .	1.50
7.	Bibliography of theses on Oregon geology, 1959: Schlicker	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . . .	0.50
8.	Available well records of oil & gas exploration in Oregon, rev.'63: Newton .	0.50
10.	Articles on Recent volcanism in Oregon, 1965: (reprints, The ORE BIN) . .	1.00
11.	A collection of articles on meteorites, 1968: (reprints, The ORE BIN) . .	1.00
12.	Index to published geologic mapping in Oregon, 1968: Corcoran	Free

MISCELLANEOUS PUBLICATIONS

Oregon quicksilver localities map (22" x 34"), 1946	0.30
Landforms of Oregon: a physiographic sketch (17" x 22"), 1941	0.25
Index to topographic mapping in Oregon, 1968	Free
Geologic time chart for Oregon, 1961	Free

OIL and GAS INVESTIGATIONS SERIES

1.	Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:	
	Newton and Corcoran	2.50
2.	Subsurface geology of the lower Columbia and Willamette basins, Oregon,	
	1969: Newton	2.50

The
Ore Bin

OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

VOLCANIC ERUPTIONS: THE PIONEERS' ATTITUDE
ON THE PACIFIC COAST FROM 1800 TO 1875

By Michael M. Folsom*

Volcanic eruptions, floods, earthquakes, and other hazards of nature can strongly influence the lives of people. Even the possible threat of such an event may alter the decisions people make. This paper is a short survey of the perception that American pioneers on the West Coast had of an environmental hazard: volcanic eruptions. The time interval to be investigated has been limited for reasons of practicality and coherence of treatment to the first 75 years of the 19th century.

Western Oregon and Washington, and much of northern California, are rather effectively walled off from the rest of the nation by the Cascade Range. Any overland routes of approach from the East would bring the traveler into close proximity to these steep and rugged mountains. Many of these high peaks are of volcanic origin and still exhibit on their flanks and foothills evidence of recent activity. The American pioneers migrating westward across these mountains cannot have escaped viewing this evidence and many must have considered its message. However, before any sort of conjectural sketch of historical ideas and attitudes can be developed the solid basis of fact must be attempted. Where and when were volcanic eruptions reported and how many of these reports represent real events?

From the earliest obscure story by the Indian, John Hiaton, in 1820 to the newspaper comment in the Washington Standard of Olympia in 1873 (Hopson and others, 1962, p. 635-637), there have been at least 40 reported volcanic events involving seven western mountains. Table 1 lists these mountains and the reported periods of activity. The locations of these mountains are shown in figure 1.

Mount Baker

The eruptions of Mount Baker, to start with the northernmost mountain, are generally only mentioned in the reports, and very little detailed information given. However, Professor Davidson's account of the eruptions of

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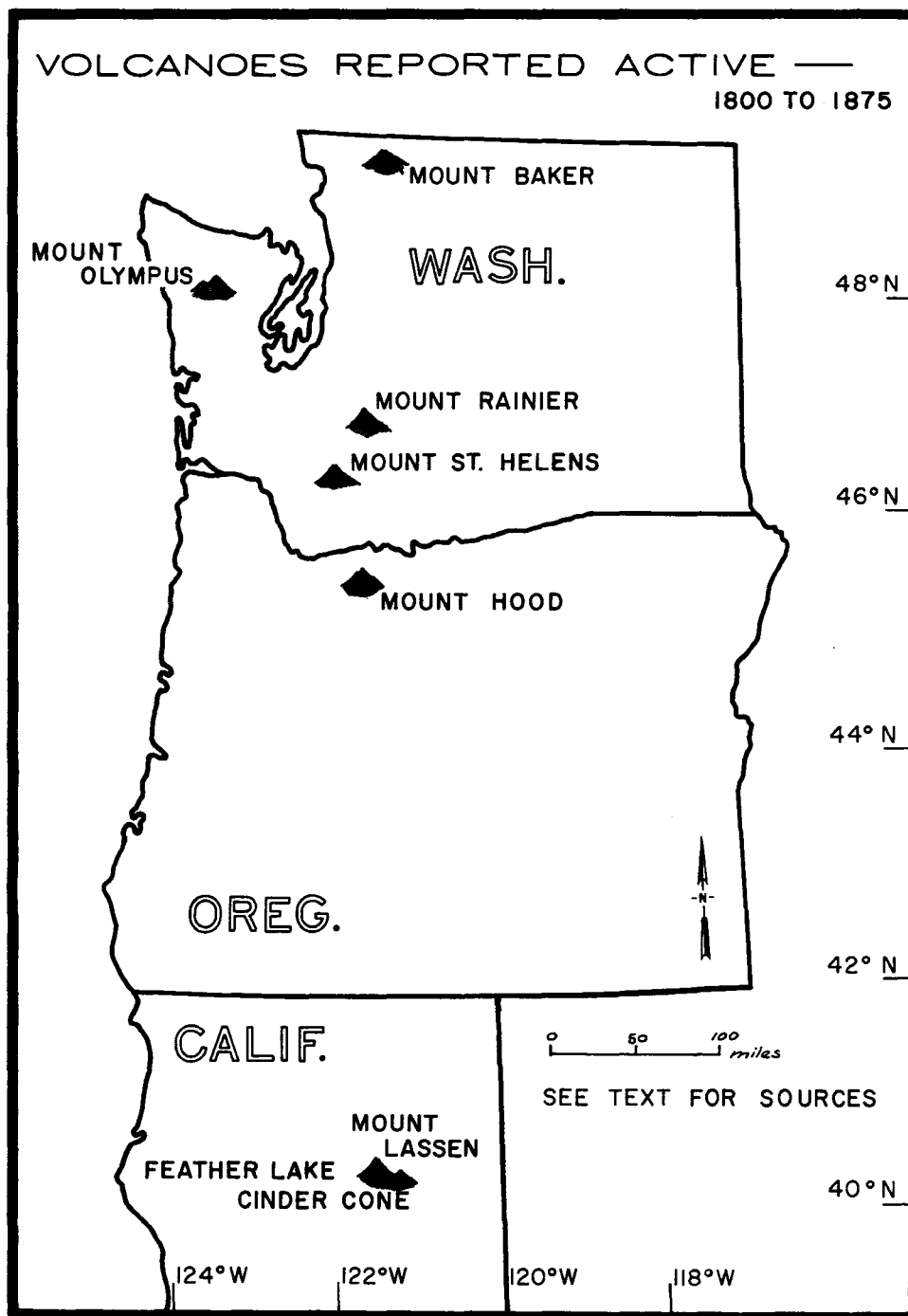
Figure 1. Sketch map showing location of reported active volcanoes during the period 1800 – 1875 in Oregon, Washington, and northern California.

Table 1. Reported volcanic events from 1800 to 1875.

Mount Baker	1842, 1843, 1846, 1847, 1853, 1854, 1858, 1859, 1860, 1870
Mount Olympus	1861
Mount Rainier	1820, 1841, 1843, 1846, 1854, 1858, 1870, 1873, plus an undetermined date between 1820 and 1854
Mount St. Helens	1802+, 1831, 1832, 1835, 1842 to 1848, 1852 to 1854, 1857
Mount Hood	1831, 1846, 1854, 1859, 1865
Feather Lake Cinder Cone	circa 1851
Mount Lassen	1857

Sources: Coombs and Howard (1960), Crandell (1969), Davidson (1885),
Diller (1899), Dutton (1885), Jillson (1915), Hopson (1962), and
Plummer (1898).

1854, 1858, and 1870 includes sufficient information, apparently based on
personal observation, to give it a distinct aspect of credibility (Davidson,
1885, p. 262). Professor Davidson of San Francisco was one of those prac-
tical, empirical scientists who, along with others like Powell, Gilbert, and
Richthofen, explored and measured much of the scope and detail of the nat-
ural world during the course of the 19th century. Davidson personally saw
Mount Baker in eruption on these three occasions while on surveying expe-
ditions along the north Pacific coastline. He mentions the shape, height,
and color of the smoke clouds, the amount of snowmelt, and the conditions
of the atmosphere through which he viewed the eruption. Concerning the
latter he professes distinct disappointment and frustration about the frequen-
cy of obscuring cloud cover.

Mount Olympus

The 1861 event on Mount Olympus is either pure fancy or a case of
incorrect conclusions from the available evidence (Plummer, 1898, p. 26-27).
This mountain is part of an eroded dome structure and does not owe any of
its relief to volcanism in historical time. Perhaps smoke from forest fires or
wind-blown dust from a landslide is what was really seen; in any case it
was not an eruption.

Mount Rainier

The probability of recent volcanic events on Mount Rainier was in-
vestigated prior to 1962 and it was suggested then that no significant

eruptions have happened for many thousands of years (Hopson and others, 1962, p. 635-637). More recently another researcher has concluded, on the basis of a fresh ash cover on glacial moraines of a known age, that Mount Rainier was mildly active sometime between 1820 and 1854 (Crandell, 1969, p. 22). The 1820 information (table 1) comes from an otherwise unidentified Indian John Hiaton, and mentions fire, noise, and shaking of the earth (Hopson and others, 1962, p. 635). The accounts of 1841 and 1843 come from a French chronicler of earthquakes, A. Perry, writing in the Memoirs de l'Academie de Dijon in 1851. Holden summarizes these comments with the phrase "violent eruptions of Mt. Raynier, Oregon (sic)" and simply appends a brief editorial question mark (Holden, 1898, p. 96). The early missionary Father De Smet provides the evidence for the 1846 event by saying that at that time Mount Baker, Mount St. Helens, and Mount Tacoma "became volcanoes" (Hopson and others, 1962, p. 636). This last mention of "Mount Tacoma" refers to an alternate appellation for this mountain which is still current in some parts of the Pacific Northwest. The 1873 report is from Plummer's list of 1898 and mentions an exact starting time and duration of seven days. This date exactly corresponds to that of a small earthquake felt in the Seattle area, and the reported "clouds of smoke pouring from the highest peak of Mt. Rainier" (Holden, 1898, p. 96) are quite possibly just wind-blown masses of dust billowing up from rockfalls from the oversteepened cirque headwalls on the north side of the peak.

Many of these early observations possibly suffer from some flaw; perhaps a confusion of the different high mountain peaks in the region, of which there are many; perhaps an ignorance of the basic geologic knowledge which could have helped to explain what was seen; or perhaps an odd sort of local boosterism and wishful thinking.

Based on the evidence provided by a dated ash layer near the mountain, at least one of these several reported events actually was volcanic. Even today Mount Rainier retains some relict form of its earlier extrusive activity. A climbing party on Mount Rainier in 1966 descended into the east summit crater and found active fumaroles and areas of hot rock which had caused melting of ice deep in the summit ice field (Crandell and Mullineaux, 1967, p. 18).

Mount St. Helens

Mount St. Helens has probably had more eruptions in historical time, and had them better recorded, than any of the other mountains ever reported as active. The eruption of 1831 ejected enough ash to leave a significant layer on the slopes of Mount Rainier 50 miles away (Hopson and others, 1962, p. 646). The 1832 event is from Plummer's list and no details are available (Plummer, 1898, p. 26). Perhaps the two dates have become confused and actually refer to the same eruption, but it is more probable that the mountain was in truth active for intermittent periods starting with

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Mount St. Helens erupting in 1847, by Paul Kane, Canadian artist, who sketched this scene from the mouth of the Lewis River in March 1847 and later painted it. Original in Ontario Museum of Archaeology, Toronto, Canada.

these two events, and finally became quiescent in 1857. The eruption of 1835 was witnessed by many people at Fort Vancouver, among them an Edinburgh physician and student of geology, Meredith Gairdner. He states in a letter that "we have recently had an eruption of Mount St. Helens, one of the snowy peaks ... about forty miles to the north of this place," and continues on to give details of ash fall, snow melted off the mountain, and streams of lava viewed "through the glass" (Holmes, 1955, p. 202). One of the quaint aspects of the literature concerning this subject is the frequent references to an anonymous "old French Canadian voyageur" who is supposed to have witnessed a huge explosion on the mountain during the winter of 1841-1842 (Diller, 1899, p. 640). Very probably he did, but if he let his memory move the date a year or so backward as some suspect (Holmes, 1955, p. 198), the substance of the old traveler's tale need not be doubted.

On November 23, 1842 Mount St. Helens burst into active eruption and scattered ash at least as far away as The Dalles in the Columbia River Gorge, where John C. Fremont later received a specimen of it (Jillson, 1917, p. 482). The mountain remained active for more than a year and many persons have recorded their observations of "immense and beautiful scrolls of steam" (Jillson, 1917, p. 482), "days memorable for the shower of sand (sic) supposed to come from Mt. St. Helens," and for "huge columns of black smoke" (Holmes, 1955, p. 204-205). The rest of the eruptions are equally well documented in diaries, letters, and newspapers. The eruption of March 26, 1847 was even sketched by an artist who eventually used the event as background in a painting (Holmes, 1955, p. 206) (see photograph).

Mount Hood

Mount Hood, the next possibly active peak to the south, is more poorly documented. The first three reported eruptions are in Plummer's list and are presented without comment of any sort (Plummer, 1898, p. 26-27). What was considered to be an eruption was witnessed by hundreds of people in Portland and was commented on in the Weekly Oregonian on August 17, 1859. This same event, or one very near it in time, was seen from the opposite side of the mountain by W. F. Courtney, who indicates that the activity was very short lived (Jillson, 1917, p. 482). In 1865 the night guard at Fort Vancouver reported seeing "Mt. Hood enveloped in smoke and flame," along with "rumbling noise not unlike distant thunder" (Jillson, 1917, p. 483). There are no additional reports of activity, but there are still active fumaroles and areas of hot rocks near the summit.

One of the most recent interpretations of the volcanic history of this mountain is that, except for the fumarole gas emissions, no extrusive activity has taken place for the past 2000 years (Wise, 1968, p. 85).

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Mount Lassen Area

Those five peaks just considered encompass most of the reported vol-
canic events on the Pacific Coast between 1800 and 1875; the only other
loci of activity during this 75-year period are a cinder cone in the wilder-
ness near Feather Lake, in the vicinity of Mount Lassen, California (Dutton,
1885, p. 46), and Mount Lassen itself, which had a steam emission in 1857
(Coombs and Howard, 1960). So far as is known, no one witnessed the erup-
tion on the smaller peak, but the accompanying lava flow was visited in
1854 by Dr. H. W. Harkness, who reported that there was evidence for
very recent activity, probably about 1851 (Harkness, 1893, p. 408-412).

Influence of Volcanic Hazard

With this information now established, it is possible to trim the list
of eruptions and mountains down to a size which is probably a better rep-
resentation of reality (table 2). This table lists "probable" eruptions and
was compiled from sources of varying reliability. The three most active
peaks are all in the Cascade Mountains of the old Oregon Territory; only
the Feather Lake Cinder Cone and Mount Lassen are not in this region. It
remains, then, to relate these relatively well-substantiated events to their
perception by the pioneers in the area.

The large number of reports, of both real and imagined eruptions, in-
dicates that the settlers were very much aware of volcanoes and what they
could do. Some of the reports give details of very mild activity like steam
emissions lasting just a matter of minutes. That such a minor event would
be noted indicates a distinct consciousness of the high snowy peaks to be
seen on the horizon whenever weather conditions permitted; and, if mod-
ern weather conditions are any guide, that might have been an infrequent
situation.

Table 2. Probable volcanic events from 1800 to 1875.

Mount Baker	1843, 1854, 1858, 1859, 1870
Mount Rainier	1843, 1854, 1858, 1870, and an undeter-mined date between 1820 and 1854
Mount St. Helens	1802+, 1831*, 1835*, 1842, 1844, 1845, 1847, 1854
Feather Lake Cinder Cone	circa 1851
Mount Lassen	1857

Sources: Coombs and Howard (1960), and Crandell (1969).
  * Other probable events not reported by Coombs and Howard or
    by Crandell.

The tone of this consciousness can best be indicated by short excerpts from contemporary accounts. William Fraser Tolmie, a doctor at Fort Vancouver, wrote to William Hooker in England in 1835 that "A proposal to climb Mt. St. Helens, then in volcanic eruption, had to be abandoned," because of the health of one of the participants (Holmes, 1955, p. 202). A Methodist missionary, John H. Frost, noted in 1843 that:

> I observed a column of smoke to ascend from the N.W. side of Mount St. Helens, towards the top; of which I thought at the time that it was a perfect resemblance of a volcanic eruption, but as I had no one but Indians with me, consequently no one with whom I could reason on the subject, I dismissed it from my mind (Holmes, 1955, p. 204).

When Professor Davidson's ship called at Vancouver, British Columbia, during the 1858 eruption of Mount Baker, he reported that the citizens were completely aware of the eruption and almost as completely unconcerned (Davidson, 1885, p. 262). And from the Weekly Oregonian of August 20, 1859:

> Eruption of Mt. Hood--On Wednesday last, the atmosphere suddenly became exceeding hot about midday. In the afternoon the heavens presented a singular appearance, dark, silvery, condensed clouds hung over the top of Mt. Hood. The next day several persons watched the appearance of Mt. Hood until evening. An occasional flash of fire could be distinctly seen rolling up. On Thursday night, the fire was plainly seen by everyone whose attention could be drawn to the subject. Yesterday, the mountain was closely examined by those who have recently returned from a visit to the summit, when, by the naked eye or a glass, it was seen that a large mass of the northwest side had disappeared, and that the quantity of snow which, two weeks since, covered the south side, had also disappeared. The dense clouds of steam and smoke constantly rising over and far above its summit, together with the entire change in its appearance heretofore, convinces us that Mt. Hood is now in a state of eruption, which has broken out within a few days. The curious will examine it and see for themselves.

This was tucked away in a general interest column on the second page along with an account of the great number of butterflies seen in the area lately, and a comment on the great lengths that newspapers often go to to dig up news to fill pages (Oregonian, August 20, 1859, p. 2) ! Even if this event may not be verified by present-day investigators, the observation of it by citizens in 1859 still yields valid indications of actual attitudes.

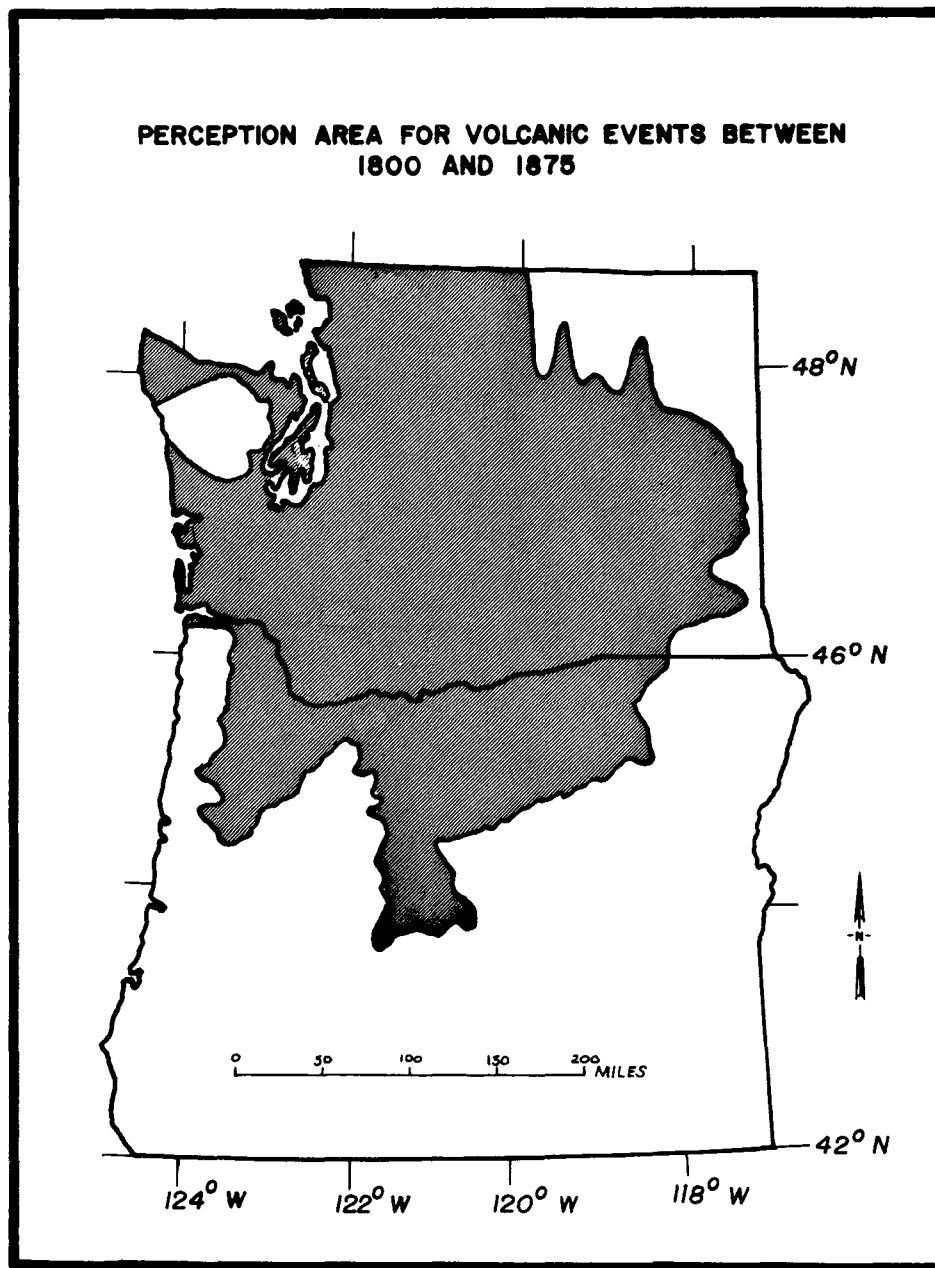PERCEPTION AREA FOR VOLCANIC EVENTS BETWEEN
1800 AND 1875

Figure 2. Sketch map of Oregon and Washington showing the region
from which early settlers might have witnessed volcanic events
between 1800 and 1875.

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The observers perceived this to be a real eruption.

The perception of volcanoes, then, was an amalgam of the intense curiosity shown by the educated man of science, the mild interest shown by the educated man of letters, and the general disinterest shown by the man on the street. No one, it seems, was alarmed.

That part of the old Oregon Country from which it was generally possible to view at least one of the three active volcanic peaks (figure 2) includes two sections of the Puget Depression: the Willamette Valley and the Puget Lowland. These two areas were the most densely populated, and were the areas of most active settlement in the Oregon Country between 1800 and 1875. This coincidence of volcanic visibility with relatively high population density should have maximized whatever effect the eruptions were to have on the pioneers in this region. Cinder Cone and Mount Lassen, in Lassen Volcanic National Park, however, are in a region that is even yet little used and of very low population density. Those eruptions could have had very little effect on the pioneers of 1800-1875.

The volcanoes of the Pacific Northwest, even though easily visible on clear days, were far distant from the inhabited valleys and presented no threat to the pioneers. The mountain peaks were often obscured by the low banks of strato-cumulus clouds that come inland with frontal systems from the Pacific Ocean, and so would have generally been out of mind during most of the long, wet winter. The eruptions when they did actually happen were on such a small scale that it was usually necessary to be looking at the mountain to be aware of them. We can probably attribute a higher awareness of natural phenomena to these pioneers than we could to urban men of the 1960's and 1970's, but it seems unlikely that settlers in a new and raw land would spend much time in idle contemplation of a mountain.

Through all of this 75-year period, during which there were possibly as many as 20 events of active eruption, there is only one account of an injury by volcanic activity, and this tells of an Indian hunting on Mount St. Helens who attempted to leap across a stream of lava but instead stepped into it and burned his foot (Holmes, 1955, p. 206). This kind of evidence indicates that the eruptions were, at their most important, just interesting but essentially immaterial occurrences that happened rarely, were more rarely observed, and affected almost nobody.

We have, then, an ambiguous situation. It can be shown that there was a distinct interest and awareness of events on the mountains and a high degree of scientific curiosity about them. It can also be shown that a calm, almost bland attitude of business-as-usual prevailed, and that no one was particularly excited or concerned about the eruptions. No doubt both attitudes existed contiguously, but the common aspect of both is that no one was afraid. No one was likely to move away and abandon a hard-won clearing or a newly started business just because of miniscule rumblings on a couple of remote mountain peaks. The converse of this is also true; no one is likely to move into a region just to be near the nice volcanoes. Even

Professor Davidson's observations were strictly an unexpected addition to what was essentially a surveying expedition (Davidson, 1885, p. 262).

If the many personal observations upon which the substance and conclusion of this paper are based are truly representative of the mood of the times, and we have no reason to assume that they are not, it is apparent that the decision of the pioneer families to settle or not to settle in any specific place in the Pacific Northwest was not materially influenced by their perception of volcanic hazard.

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OREGON GROUND WATER RESOURCE ESTIMATED

The U.S. Geological Survey in a recently issued publication (Professional Paper 600-A) reports that "Oregon is the first Pacific coast region State whose total ground water resource has been estimated. A compilation of all available data, supplemented by estimates, suggests that in its 18 major drainage-basin regions, Oregon is underlain by more than 250 million acre-feet of ground water at depths of less than 500 feet. Additional potential subsurface storage capacity is estimated to be between 55 and 60 million acre-feet, a significant part of which can be developed by artificial recharge if need arises.

"Ninety percent of ground water samples from the Willamette River basin in northwestern Oregon contained less than 500 mg/l of dissolved solids. This suggests that water of good quality is available throughout most of the basin, although local water-quality problems do exist. The dissolved-solids content consists primarily of calcium, sodium bicarbonate, and silica. Iron concentrations in many wells north of Salem are greater than 0.3 mg/l. Orthophosphate was found in varying concentrations throughout the basin, and high arsenic concentrations were reported from wells tapping the Fisher Formation near Eugene.

"Water containing more than 1000 mg/l of dissolved solids (predominantly sodium, calcium, and chloride) is found in deep aquifers underlying Portland, in parts of the Tualatin Valley, in the Willamette Valley north of Salem, and at Gladstone. "Salty" water, too highly mineralized for most uses, has been reported from bedrock wells in several parts of the Coast Range on the west side of the basin." (Oregon State Univ., Water in Oregon, no. 4, November 1969.)

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KLAMATH AND LAKE COUNTIES BULLETIN PUBLISHED

"The Reconnaissance Geology and Mineral Resources of Eastern Klamath County and Western Lake County, Oregon," by N. V. Peterson and J. R. McIntyre, has been issued by the State of Oregon Department of Geology and Mineral Industries as Bulletin 66. The 80-page bulletin describes a large region of continental Cenozoic volcanic rocks and sediments whose mineral resources are mainly uranium, mercury, copper, lead, zinc, silver, diatomite, pumice, perlite, and peat. The area is believed to have a potential for geothermal power development. A multicolored geologic map and a mineral-resource map at a scale of 1:250,000 accompany the abundantly illustrated text. Bulletin 66 can be purchased from the Department's offices in Portland, Baker, and Grants Pass. The price is $3.75.

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THE NAMING OF MINERALS

By Lloyd W. Staples*

The rules for the selection of names for newly discovered minerals are of
interest not only to the professional mineralogist but also to the much larger
group of hobbyists who are amateur mineral collectors and "rockhounds."
It has come as a matter of surprise to some members of the latter group that
there exists a formal code for the naming of minerals. It is necessary to
understand and follow carefully the rules of this code in order to prevent
confusion in mineralogical nomenclature. In the past, there has not always
been strict adherence to rules of mineral nomenclature, but progress is be-
ing made in enforcing better cooperation. It is probably true that nearly as
much time is now spent in correcting earlier errors and confusion, and in
discrediting improperly named or invalid species, as in describing and nam-
ing new valid species. Each issue of The American Mineralogist has a list
prepared by Michael Fleischer of new mineral names, new data, and dis-
credited minerals, and frequently the contributions in the latter two cate-
gories outnumber those in the first.

The gratitude and respect of mineralogists go to James Dwight Dana
for the part he played in the development of rules for mineral nomenclature.
In the first editions of the System of Mineralogy, Dana followed the sugges-
tions of Friedrich Mohs (Staples, 1964) and Linnaeus by adopting the bino-
mial latin nomenclature, using genus and species. Later, in the third edition
of the System of Mineralogy (1850), Dana broke away from Mohs' Natural
History Classification and adopted a classification based on chemical com-
position as recommended by Berzelius, with a single-word name for minerals.
For minerals, unlike organic materials, the binomial nomenclature was with-
out scientific basis and conservation of space and effort highly recommended
the change. As an example, such a difficult name as "barulus ponderosus"
was changed to "barite."

Although there was a simplification in the types of names used for
minerals, neither Dana nor anyone else attempted to limit the choice of
names to any particular category. This has led to a wide variety of name
types, which some people of orderly minds have decried as producing an
unacceptable potpourri, with names difficult to memorize, and in some
cases even more difficult to pronounce. Because mineral names are necessarily
international in origin, there will always be difficulty in pronunciation for
people of different nationalities. As an example, most English-speaking
people have difficulty in pronouncing the phosphate mineral, "przhevalskite,"
the sulfide, "dzhezkazganite," or the vanadate "tyuyamunite."

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Derivation of Mineral Names

The mineralogist who first describes a new mineral has almost complete freedom in the selection of a name. The practice of naming minerals after distinguished people of many different callings has been very common. This practice was initiated in 1783 by A. G. Werner, who named prehnite after the Dutch Colonel Prehn, who is reported to have obtained the mineral at the Cape of Good Hope. Other examples are "goethite" after Goethe the German poet; "wernerite" after the famous German mineralogist, A. G. Werner; "scheelite" after K. W. Scheele, a Swedish chemist; "uvarovite" after Count Uvarov of Russia, who was an amateur mineral collector; "alexandrite" after Alexander II, Emperor of Russia.

A problem has arisen when the discoverer of a new mineral has found that the surname of a person he wanted to honor is already in use for a mineral. In that case the given name may have to be used. As an example, the writer wished to name a new calcium zinc arsenate after Professor Austin Flint Rogers of Stanford University (Staples, 1935). The name "rogersite" was already in use, so the mineral was named "austinite." Recently (Gaines, 1969) a mineral was named "cliffordite," after Prof. Clifford Frondel of Harvard University, using his given name, because he previously (1949) had the mineral frondelite named after him. There are also examples of full names being used, as in the case of the mineral "tombarthite." The name "barthite" was already in the literature (1914). Using the given name, when it is as short as "Tom," would not have been satisfactory, and so mineralogists are happy to have the great Norwegian geologist, Tom F. W. Barth, honored by using his full name (Neumann and Nilssen, 1968).

It is also common practice to name minerals after the locality in which they are found. For example, countries have been honored, as in the name "brazilianite," states as in the case of "oregonite," counties as in "benitoite," and towns or localities as "franklinite" for Franklin Furnace, N.J. Physical properties were used frequently as illustrated by "azurite" for color; "amblygonite" for the Greek word indicating a blunt angle between the cleavages; and "scorodite" from the Greek word for "garlic," which is the odor given off when the mineral is heated. The mineral tetrahedrite was named after its crystal form (the converse is also true for pyrite where a crystal form, the pyritohedron, was named after the mineral). Several minerals have been named after the principal metal present, as in "zincite"; and as a special warning the name "sphalerite" meaning "treacherous" was given because of the difficulty in identification.

When Werner started the practice of naming minerals after people he was criticized as being guilty "of creating a paternity, and providing the childless with children to hand down their names to posterity" (Dana, 6th Ed., p. xli). To get away from the objection, and at the same time to provide a crutch for the student to use in remembering the chemical composition

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of a mineral, one can use a mnemonic name. An example of this is the new calcium vanadium silicate named by the writer "cavansite" from the first letters of the chemical constituents (Staples, Evans, and Lindsay, 1967).

Rules of Mineral Nomenclature

The rules of nomenclature which were used by J. D. Dana and later updated are stated in the introductory section of the System of Mineralogy, sixth edition, and a further discussion of them is given in volume one of the seventh edition by Palache, Berman, and Frondel. A Committee on Nomenclature and Classification of Minerals of the Mineralogical Society of America made several important recommendations (American Mineralogist, v. 8, 50 [1923]; v. 9, 60 [1924]; v. 21, 188 [1936]), most of which have been generally adopted by mineralogists. In 1933 considerable progress was made in obtaining agreement on usage by the American and British Mineralogical Societies. Later, international agreements on nomenclature have been delegated to the Commission on New Minerals and Mineral Names of the International Mineralogical Association. An index of new mineral names was compiled by Michael Fleischer in 1966, based on papers published in the American Mineralogist.

It has been generally agreed that new mineral names should end with the suffix "ite." In 1923, a minority of the Committee on Nomenclature made the suggestion that all mineral names be required to end in "ite," while the majority of the committee recommended changing only 43 mineral names. This resulted in names such as "cinnabarite" and "galenite." Some textbooks followed this suggestion, although not always consistently. For example, Moses and Parsons, Mineralogy, Crystallography, and Blowpipe Analysis (5th Edition), use "galenite" and "metacinnabarite" but retain "cinnabar." Most texts now have logically dropped the "ite" from metacinnabar, as well as from all those names of long historical standing which did not originally end in "ite."

Other less common endings for mineral names are "ine," as in "olivine," "ase" as in "dioptase," "ime" as in "analcime," "ole" as in "amphibole." There are advantages in the use of such a variety of suffixes in making the nomenclature less monotonous. The obvious advantage in using "ite" to indicate that the reference is to a mineral is lost, in part, because of the use of the ending on rock names, for example, "andesite." It has been recommended that all rock names end in "yte," as "trachyte," but this suggestion has not been generally adopted.

Priority in Nomenclature

In the naming of minerals, those names which have priority are generally accepted over names subsequently proposed for a mineral. Dana's System (6th edition, p. xliii) gives 11 rules for setting aside or revoking a

mineral name, even though it has priority. Most important of these are an inadequate or incorrect original description of the mineral, a description which gives a false impression of the physical properties, or the loss of the name of a mineral for more than 50 years.

Examples of the problems raised by the law of priority are numerous and two of them with which the writer has been involved will be briefly reviewed here. As mentioned above, the writer named the mineral "austinite" in 1935 (Staples, 1935). F. Ahlfeld had called attention in 1932 in the Neues Jahrbuch für Mineralogie to a mineral from Bolivia that he called "brickerite," which was a nomen nudum because he only indicated its general composition. In 1936, brickerite was analyzed chemically, but incorrectly, and it was not until 1938 that W. Brendler of Hamburg, Germany carefully analyzed the material and determined that "austinite" and "brickerite" were identical. He stated that priority should be given the name "austinite." To go back even further, the name "barthite" was proposed in 1914 for a mineral which later proved to be austinite, but as stated by Fleischer (1945) "the description of barthite, especially the chemical analysis, was so faulty that priority may be set aside and the name barthite (=cuprian austinite) should be dropped." The name "austinite" withstood these two challenges and it is now internationally accepted.

A priority problem that had a happy ending is illustrated by the case of erionite. This zeolite, first discovered by Eakle (1898) from Durkee, Oregon, had its occurrence, unit cell, and structure described in detail by Staples and Gard (1959), when the writer rediscovered the locality which had been "lost." As a result of the potential commercial use of erionite for "molecular sieves," and its occurrence in large quantities as a diagenetic mineral, the name became well established not only in mineralogy, but also in the literature of chemical and industrial minerals. In 1962, the British mineralogists, Hey and Fejer, in studying the little-known mineral offretite, found it to be identical with erionite. Because offretite was first described in 1890 by Gonnard, the name had priority and Hey and Fejer believed it should replace "erionite." On the other hand, offretite had been inadequately described, it had been lost sight of for more than 50 years, and the name "erionite" was so thoroughly entrenched in the literature that replacing it would cause great confusion. Many letters were written expressing strong viewpoints on the matter of replacing "erionite," and when the Commission on New Minerals and Mineral Names voted on the matter there was a split which seemed irreconcilable. At this time, good fortune entered the picture when it was determined by Bennett and Gard (1967) that the c cell dimension of offretite is half that of erionite. This indicated that offretite and erionite are distinct species, and both names should be retained, thus solving a problem in nomenclature that otherwise would have defied a happy solution.

The New-Mineral Dilemma

The above material has been written to underline the difficulties involved in naming a new mineral. The problem is really threefold: (1) determining if it is a new mineral; (2) adequately describing it; (3) naming it. As has frequently been pointed out by the writer (Staples, 1948 and 1962), to name a mineral without properly completing the first two steps can only lead to confusion. Fleischer (1966) has stated that during the period 1941-1960 about half the new mineral names proposed were considered unnecessary. This leads to listing more minerals as discredited minerals. According to Permingeat (1961) the ideal description of a new mineral requires a listing of macroscopic properties, crystallographic properties, physical properties, optical properties, chemical properties, physical-chemical properties, methods of synthesis, description of the deposit, nomenclature and classification, location of the depository of the material, and a bibliography. To provide this data it is necessary to have an adequate library and laboratory facilities which may include x-ray diffraction equipment, differential thermal apparatus, polarizing microscope, universal stage, x-ray fluorescence, analytical chemical apparatus, absorption spectrometer, and other equipment.

It is evident that only a professional mineralogist is capable today of determining whether a specimen is a new mineral, and then describing it properly. Consequently, any suspected new mineral material should be sent to a properly equipped laboratory or university for examination. If the material turns out to be a new mineral, the description of it may take several years, depending on the problems involved. Only after carefully determining the properties of the new mineral will a name be recommended for it and the mineralogist will then submit the name to the Commission on New Minerals and Mineral Names for approval before publication takes place. The amateur collector's role in this is the searching for and finding of new material, and his ability to advance the science of mineralogy in this way should be a great source of satisfaction. The chances of attaining success for the amateur are actually much greater than making contributions to other fields of science, such as physics and chemistry. Part of the thrill of mineral collecting for the amateur, as well as the professional mineralogist, is the chance that the next outcrop may yield a mineral which has never been found before.

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MINING LAW SUMMARY AVAILABLE

A "Mining Law Summary for Oregon Prospectors" has just been published
by the State of Oregon Department of Geology and Mineral Industries. The
4-page summary discusses the more pertinent aspects of the mining law as
it pertains to the location and filing of claims and to subsequent assessment
requirements. The information encompasses both Federal and State statutes
and is presented in a question and answer format. Copies are free upon re-
quest from the Department's Portland, Baker, and Grants Pass offices.

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WHAT TO DO WITH A HOLE IN THE GROUND

To much of the public, a mine is nothing more than a "hole in the ground," and an unsightly one at that. Few people realize that practically everything we use in our everyday lives originally comes from just such "holes." Automobiles, airplanes, and TV sets are made almost entirely of metal and glass; buildings are made from gravel, rock, limestone, and clay; and even the clothes we wear are woven from synthetic fibers made from petroleum products, which originally came out of a hole.

The sand and gravel industry in Oregon, being concentrated in the Willamette Valley near the population centers, is becoming hard pressed to provide the raw materials needed to build our highways, bridges, and airports. There is a potential shortage of this valuable product for the coming years, because many of the better deposits are being overrun by housing or other incompatible developments. What happens to a gravel pit after it is mined out? Can the land be reclaimed or put to other uses?

We are printing the following editorial which recently appeared in the Missouri Mineral Industry News, published by the Missouri Geological Survey. Even though the Missourians are primarily concerned with coal mining in their state, we believe that their comments and ideas could apply to the problems of our sand and gravel industry.

R.E.C.

MINE WHERE THE MINERALS ARE*

We need no crystal ball to see what will be written about us when this editorial appears. We'll be accused of siding with the miners in an unholy alliance to strip-mine coal within the city limits of Columbia ".... in calculating disregard for the well-being of the community." If there's one thing we don't need, it's adverse publicity at a time when operating funds for State agencies are woefully short, but we cannot stand idly by when principles are at stake; we must become involved.

Mineral deposits are where you find them; sometimes they're in convenient places, sometimes not, but wherever they are they can only be recovered by mining. Once highways, homes and industries are built over mineral deposits, they are lost and must be sought elsewhere. The Geological Survey has long advocated sequential use of lands underlain by mineral deposits. First, mine the minerals with a plan toward reclamation and reuse of the land. Second, reclaim the land so that it may well yield more than was gained from the mining. And third, reap the benefits in increased

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* Reprinted from: Missouri Mineral Industry News, Vol. 10, no. 3, March 1970.

tax revenues from land that might have been rendered worthless without forethought.

Is this practical? The city of Mexico, Mo. has schools built on land that once was a "worthless" clay pit; the clay that was once there financed the reclamation and part of the school construction and the upbringing of many of the kids who go there, while serving the nation in such capacities as boiler linings and launch pads for space vehicles. Last month the Nation's First Lady toured a reclaimed coal strip mine that will eventually bring its developers more money than the coal brought the mining company. Underground mines in Kansas City and Springfield provided cheap concrete aggregate and road stone for many years; now the mined space houses instrument factories, computer centers, warehouses and terminals that will provide profit for the owners and taxes for the cities far in excess of the value of minerals that were once there, and are now used.

The Columbia coal mining problem is an excellent example of how mining's poor public image and the public's uninformed outlook combine to saddle the citizens with higher utilities costs and lower tax revenues from unattractive developments. Some time ago, Peabody Coal Co. leased acreage outside Columbia for strip mining of coal. Subsequently the city annexed the area and immediately a hue and cry arose to stop the proposed stripping.

It happens that Peabody supplies Columbia City Utilities and the University with coal, and the beauty of this particular coal field lies in its proximity to the coal-fired electric generating plant. The savings in trucking costs can be passed on to the people of Columbia in the form of lower electric bills.

But this is not the only reason for advocating coal stripping in Columbia. The technology is already available for reclaiming mined lands; it is now possible to plan mining in a way that will give an end product of attractive landscape with recreational lakes, etc. that can be a part of the normal mining expenses. The great shovels that expose the coal need not be the monsters they've been portrayed as; people made them, people can control what the machines make.

We can think of no better way to have one's cake and eat it too. Why not work out a plan with the mining company for imaginative reclamation of the mined lands? While the mining is under way, the utilities have a supply of cheap coal. When it's used up, attractive lands with lakes and hills remain to be developed. Why be bound by whatever topography there is when you can design it yourself?

Surely, this is anything but "....calculating disregard for the well-being of the community"!

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AVAILABLE PUBLICATIONS

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BULLETINS

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OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

WESTERN CASCADES VOLCANIC SERIES,
SOUTH UMPQUA FALLS REGION, OREGON

By M. Allan Kays*

This report summarizes results of geologic mapping in the South Umpqua Falls
region of the Western Cascade Range in Douglas County, southwestern Ore-
gon (plate 1). Rocks of the Western Cascades range in age from late Eocene
to late Miocene and consist of deformed and partially altered flows, pyro-
clastic rocks, and interlayered sedimentary rocks (Peck and others, 1964).
In the area of this investigation, Tertiary units include the Colestin Forma-
tion of late Eocene age, the Little Butte Volcanic Series of Oligocene and
early Miocene age, and the Sardine Formation of possible middle and late
Miocene age. It is notable that older Tertiary rocks, present both to the
north and to the south, are absent beneath the rocks of the Colestin Forma-
tion in this region. In the vicinity of Tiller, west of the mapped area, pre-
Tertiary plutonic and metamorphic rocks form the basement and are overlain
with profound unconformity by strata of the Colestin Formation. Rocks of
the Western Cascade Range are capped to the east by younger volcanic rocks
of the High Cascade Range.

Location and Accessibility

Figure 1, on the following page, shows the location of the South Ump-
qua Falls region and some of the access roads and major features. Because
of increased timber cutting, access into the area improves with each year;
the number of roads has probably doubled since mapping was begun in 1966.
The major access to the area is a hard-surfaced road leading from Tiller,
Oregon; it is maintained throughout the year by the U.S. Forest Service.
This road parallels the South Umpqua River for a distance of about 21 miles,
ending about one mile west of South Umpqua Falls Guard Station. A grav-
eled road continues along the South Umpqua River and splits eventually into
two branches paralleling Castle Rock and Black Rock Forks of the South Ump-
qua; these roads make a complete loop beginning and ending near Camp

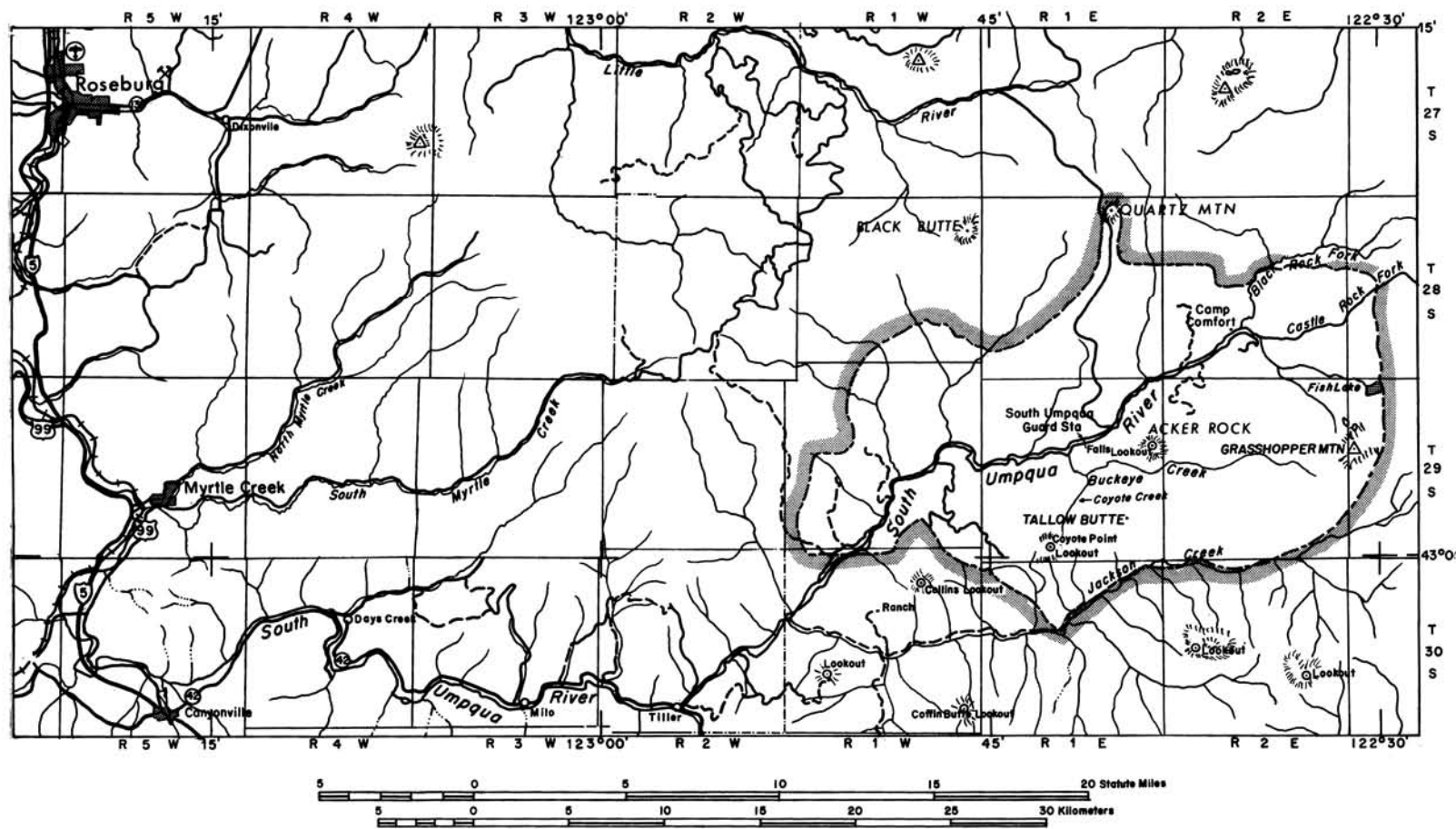* Department of Geology, University of Oregon, Eugene, Oregon.

Figure 1. Index map of the Umpqua Falls region showing outline of geologically mapped area of plate 1.

Comfort. Another graveled branch road follows Buckeye Creek to Acker Rock Lookout and beyond to Grasshopper Mountain. The other major access parallels Jackson Creek, which bounds the southern part of the mapped area. Less reliable roads provide access to logging units throughout the area.

Stratigraphy

General statement

The sequence of volcanic and interstratified sedimentary rocks is subdivided with some modifications according to the criteria of Peck and others (1964). Although deformed, the rocks occur in generally eastward-dipping and gently overlapping sequence trending north. The lowermost unit, the Colestin Formation, is largely andesitic in composition, and consists of flow breccias, conglomerates, and marine graywackes in the lower part, and volcanic flows and interstratified tuffs in the upper part. It has a total thickness which may exceed 2000 feet and is overlapped with some angular discordance by rocks of the Little Butte Volcanic Series. Rocks of the Little Butte consist of a basal welded tuff which grades upward to tuffs and tuff breccias and other alternating welded units. The ash-flow tuffs, generally rhyodacitic, are intruded in places by small, dome-like masses of similar composition which apparently broke the surface. The domes are considered, genetically at least, to form a part of the Little Butte Volcanic Series. The predominantly pyroclastic rocks of the Little Butte have a total thickness of about 5000 feet, and are overlain with only mild angular discordance by dacitic and andesitic flows of the Sardine Formation. In addition, andesitic flows become increasingly abundant upward in the column and the whole sequence thickens eastward; the platy dacitic and andesitic flows are overlain by a series of thick, highly porphyritic, vesicular to dense, black to dark gray andesites and basaltic andesites which constitute the upper part of the Sardine Formation in this report. The formation has a thickness of at least 2000 feet.

Colestin Formation

Of the three Tertiary units, the Colestin Formation was studied in least detail. Observations in this region, however, compare very favorably with descriptions in the type locality south of Ashland in that the lower part consists of predominantly bedded sedimentary units and stratified ash overlain by a thick series of massive ash-flow tuffs (Wells, 1956). Unlike the type locality, the contribution of pre-Tertiary metamorphic and plutonic detritus to the sediments in the basal part of the formation is locally quite high. Only the upper part of the section is present, however, in the mapped area of plate 1. The following discussion refers to the regional character of the Colestin Formation mainly to the west of the mapped area.

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GENERALIZED COMPOSITE SECTION

Sardine Formation

Upper

1000' +

Lower

1000'

Little Butte Volcanic Series

700'

5

1000'

4
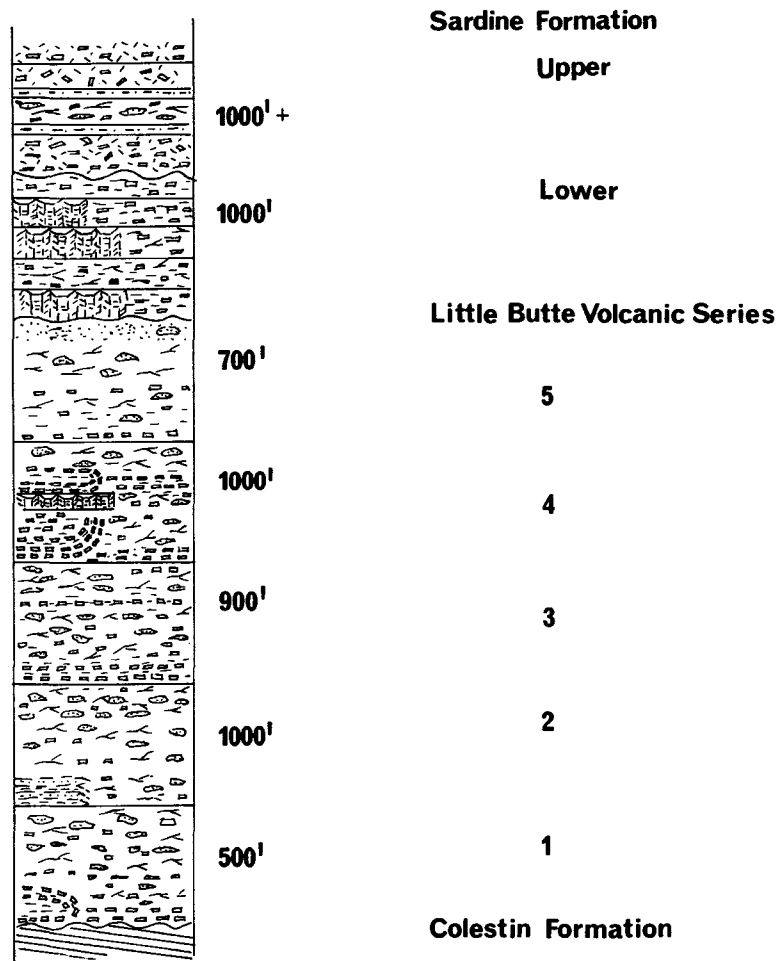
900'

3

1000'

2

500'

1

Colestin Formation

Figure 2. Generalized composite section of the major units in the
South Umpqua Falls region. See explanation opposite.

EXPLANATION

SARDINE FORMATION:

Upper, composed largely of black, glassy, highly porphyritic and locally vesicular hypersthene andesite. Contains vitric tuff units of indeterminate extent intercalated with the andesites.

Lower, consists largely of gray to reddish brown, flow-banded dacite. The rock is generally aphanitic but may be locally highly porphyritic. The dacite grades laterally to or interfingers with flows of blocky, dark gray andesite; intercalated tuff units occur locally. Blocky, black, aphanitic, columnar-jointed basalt occurs at the base of the section in some places.

LITTLE BUTTE VOLCANIC SERIES:

5, best exemplified by exposures on and in the vicinity of Quartz Mountain and continues down to an elevation of about 4300 feet. The basal part is purplish pink, platy rhyodacite-dacite welded tuff but could be in part a flow unit; contains elongate feldspar phenocrysts, 1 mm. or less, and is highly jointed with one set parallel to layering. Becomes increasingly silicified toward Quartz Mountain where the rock is a white, fine, sugary-textured "quartzite." Within the silicified mass find relict red tuff breccia as unaltered or partially altered fragments or patches. The degree of fracturing and brecciation also seems to increase toward Quartz Mountain.

4, begins with a rhyodacite flow or welded tuff which is highly silicified and locally sheared and brecciated. Throughout, the unit consists of alternating dense welded layers and nonwelded tuff breccia; the alternating types may also be gradational laterally. The sequence is cut by diabase sills and dikes. The welded tuffs are folded on a local scale due to viscous drag and contain abundant ramp structures.

3, sequence begins with basal welded rhyodacite unit and continues upward for 400 feet with alternating thin (6" to 8") welded layers and nonwelded layers. Welded units tend to be somewhat porphyritic with aligned feldspars and also contain flattened ash fragments. Less densely welded layers are coarser grained and somewhat vesicular. Densely welded layers may form prominent ridge cappings.

2, stratified tuff sequence; basal member is in part water-laid tuffaceous sandstone and siltstone, generally massive, but showing graded bedding; contains layers of mudstone 6" thick. The sequence grades laterally and upward to graded ash-fall tuff. Becomes massive, coarse, and poorly sorted ash flow with local welded layers near the top.

1, the basal unit is densely welded rhyodacite ash-flow tuff, approximately 250 feet thick. The rock is both flow banded and color banded; color banding is purplish gray to pink. Flattened pumice shards and glass shards occur wrapped around elongate feldspar phenocrysts. Ramp structures are observed near the top of the basal welded zone. The unit becomes less densely welded upward and contains coarse lithic and ash fragments in the upper 100 feet.

COLESTIN FORMATION:

See text discussion.

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In its lower part the Colestin Formation consists of massive to well-bedded tuffaceous sandstone and, locally, at its base consists of conglomeratic layers with fragmental pre-Tertiary material. The areal extent and lateral continuity of the conglomeratic layers is as yet undetermined. Upward in the section, greenish-gray massive lapilli tuff and agglomerates are interstratified with the sediments; coarse andesitic lithic fragments may be abundant in a matrix of altered ash. Carbonized wood fragments and logs are locally abundant in the tuffaceous rocks.

An erosional unconformity separates the lower, predominantly bedded sedimentary unit from the overlying thick series of massive ash-flow tuffs. Basaltic to dacitic flows are observed interbedded with the ash-flow tuffs and both rock types may be highly altered. Fractures in the highly brecciated flows are filled with zeolites, whereas ash fragments in the tuffs are altered to olive-green montmorillonite and/or celadonite (Peck and others, 1964). Bedded ash-flow tuffs and interbedded volcanic-lithic sandstones overlie the massive ash-flow tuffs and are in some cases distinguished with difficulty from parts of the overlying Little Butte Volcanic Series.

Little Butte Volcanic Series

The term Little Butte is restricted in this paper to the thick sequence of predominantly pyroclastic rhyodacites* and subordinate flows. This is a departure from the subdivision of stratigraphic units according to Peck and others (1964) and is justified on the basis of mapping in several critical areas. Mapping shows that the dacitic flows included in the upper part of the Little Butte Volcanic Series by Peck should be included within the basal part of the Sardine Formation. The basis for this subdivision is considered in greater detail in the next section.

Rhyodacitic pyroclastic rocks of the Little Butte Volcanic Series consist mainly of vitric lapilli ash flows. In this area, the series may be subdivided into five separate units (figure 2). Four consist of welded and nonwelded zones, and in all four the basal parts are densely welded, crystal-rich, ash-flow tuff. In the lowermost unit the extent of welding appears to diminish upward as grain size coarsens to reddish ash-flow tuff breccia (figure 3). In the other three, dense welded zones, 6 to 8 inches thick, alternate with less densely welded to vesicular ash flows (figures 4 and 5); the proportion of welded to nonwelded material appears to diminish upward in each. The lowermost welded to nonwelded unit is separated from the upper three by a thick, stratified to massive, nonwelded ash-flow sequence which is in part water-laid and contains tuffaceous sandstones, siltstones, and

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* Rhyodacite is used here as a field term for pale, reddish tuffs and tuff breccias which, on the basis of petrographic analysis, include dacite to quartz latite (Williams, Turner, and Gilbert, p. 126, 1954).

Figure 3.   Ash-flow tuff breccia with flattened ash fragments
in Little Butte Volcanic Series.   Locality is the third weir
site on Coyote Creek.

mudstones.   In addition basic, dacitic, and rhyodacitic flows and dome-
like features occur in the uppermost part of the series.

The welded units are usually pink to purplish in color and porphyritic,
with elongate feldspar crystals and flattened pumice fragments; pumice and
glass shards wrap around feldspar phenocrysts and impart a crude, wavy lin-
eation (figure 6).   Microfolds, probably resulting from viscous drag along
platy layering surfaces, and associated ramp structures (Walker and Swan-
son, 1968) are also present in the basal zones.   Welded tuff units above
the thick, lowermost welded zone grade laterally to nonwelded tuffs and
tuff breccias.   In some cases devitrification and silicification make it diffi-
cult to distinguish between welded and nonwelded zones.   Silicification,
especially evident where the rocks are faulted, may render alternating
welded and nonwelded zones indistinguishable and may result, in an ex-
treme case, in a nearly white, sugary "quartzite" as on Quartz Mountain.

Nonwelded ash-flow tuffs vary in their makeup from those rich in
crystals and ash to those rich in crystals and lithic fragments.   They are in
some cases interlayered with welded units but may, as mentioned above,
show gradational relationships.   They appear to be of the same composition
as the welded units, that is, predominantly rhyodacitic.   Internally, lithic
fragments are very fine grained, crystals are mainly plagioclase but quartz
may also be abundant; groundmass consists of very finely crystalline

Legend

Symbol	Description
▨	Sardine Formation — Upper
▦	Sardine Formation — Lower (flows/tuffs)
▩	Little Butte Volcanic Series
■	Colestin Formation
⬡	andesite basalt — Post-Colestin
⬡	andesite rhyodacite — Post-Colestin
⬡	zones of alteration
⋯	landslide
— · — · —	contact
— D/U —	fault
— + —	fold axis (synclinal)
/₁₂ /₁₂	strike & dip; joints - flow layering
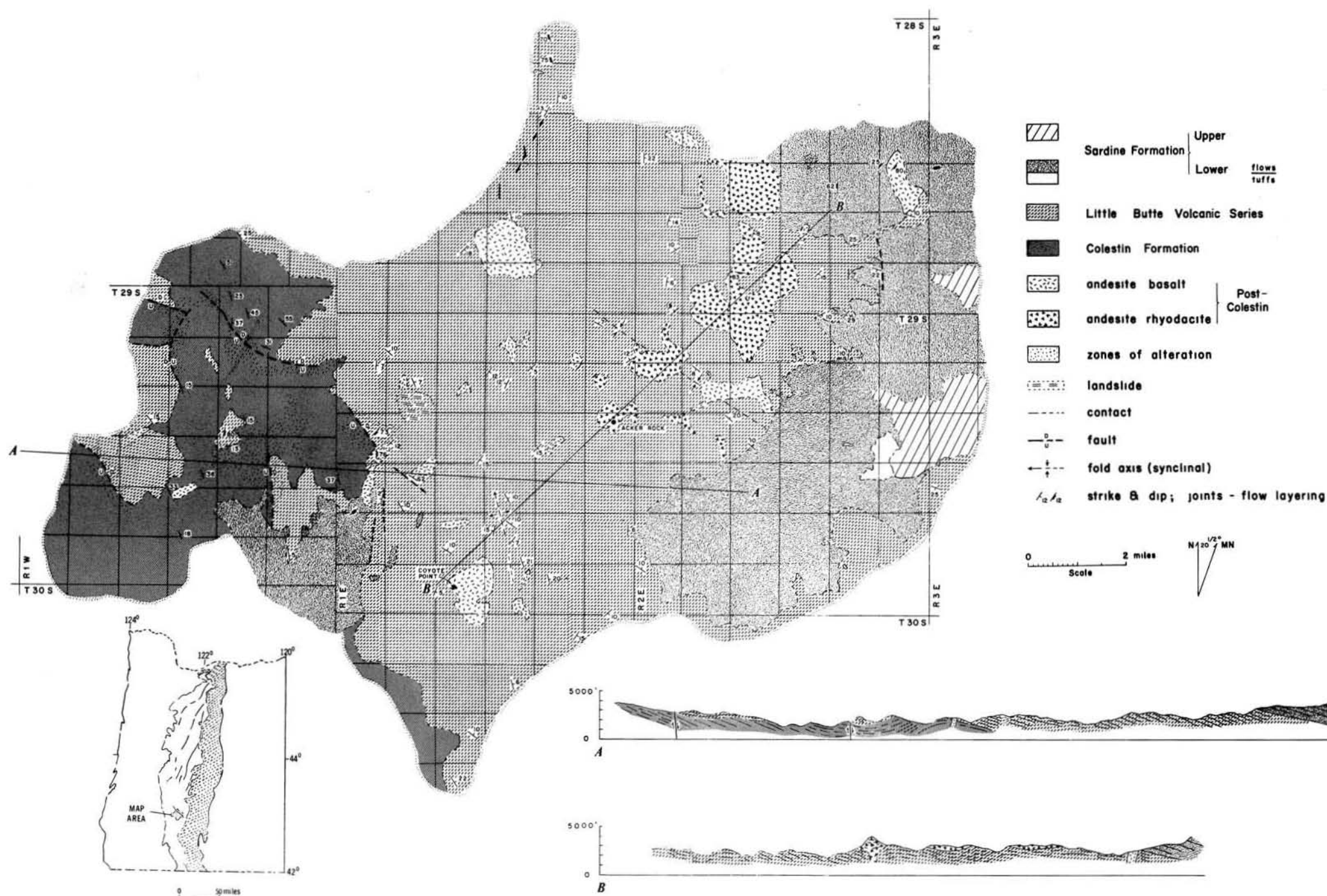
Plate 1. Geologic map of the South Umpqua Falls region, with index showing location of the map area. Shown also in the index are traces of axial planes of folds, taken in part from Peck and others (1964).

← ———— Figure 4.

Layering in alternating
welded and nonwelded
ash-flow tuff of Little
Butte Volcanic Series.
Locality is ridge crest
south of Quartz Moun-
tain at an elevation of
about 4400 feet.

Figure 5. ————→

Vesicular vitric ash-
flow tuff of the Little
Butte Volcanic Series;
outcrop width approx-
imately 2 feet.
Locality is along Buck-
eye Creek, just south
of Jade Camp.

quartz-feldspar (potash-rich) or the material from which it has devitrified, that is, glass shards and ash fragments with abundant, finely divided iron oxides.

A series of flows and domes is found to overlie and to intrude compositionally similar tuffaceous rocks in the vicinity of Acker Rock (plate 1). The flows consist of thin (up to about 2 inches), platy, crystal-rich layers which grade to or interfinger with crystal-vitric, lapilli ash-flow tuff. One dome-like feature which underlies Acker Rock Lookout appears horizontally layered with a prominent sag toward the center similar to a small laccolithic intrusion (figure 7).

Sardine Formation

As pointed out by Thayer (1936), andesitic lavas are abundant in the Sardine Formation; perhaps a dozen vents of these flows and associated pyroclastics have been identified by Peck and others (1964). Two vents marked by andesitic plugs have been identified by Peck, one on Hershberger Mountain and the other on Rabbit Ears to the south and east of the area of this investigation. Peck also envisages a belt of volcanoes forming a north-trending mountain chain along the eastern margin of the Western Cascade Range; that flows and pyroclastic debris erupted subaerially over a surface of considerable relief is well established.

In the area of this report, Sardine flows unconformably overlie pyroclastic rocks of the Little Butte Volcanic Series. Two subdivisions have been made: an upper series which consists of layered hypersthene andesites; a lower series which includes flows of basalt, dacite-andesite, and subordinate pyroclastic deposits. The upper series is uniformly layered and appears to have erupted over a surface of moderate relief. The lower series is lithologically variable and erupted over a surface of considerable relief, filling great topographic irregularities cut in Little Butte and Colestin terrain. Mapping shows that dacitic flows of the lower series, nearly conformable with underlying rhyodacite tuffs of the Little Butte in certain areas, also overlap units of the Colestin Formation in the upper reaches of Zinc Creek in the southwesternmost part of the area. Although these dacitic flows may be compositionally similar to underlying ash-flow tuffs and tuff breccias of the Little Butte, they are interlayered with andesitic flows mapped by Peck and others (1964) as Sardine Formation. These same andesitic flows become increasingly abundant upward in the column and the whole sequence thickens eastward. For this reason, dacitic flows at the base of the sequence are considered Sardine Formation in this paper (see figure 2).

Unlike older units, volcanic features are, in some places, readily recognizable within the Sardine Formation; glassy fissure flows can be traced to denser, finely crystalline plug-like masses of the vent phase. Locally, knobby, globular, and rubbly mound-shaped accumulations of dacitic and andesitic rocks are suggestive of spatter cones. Dacitic flows are observed
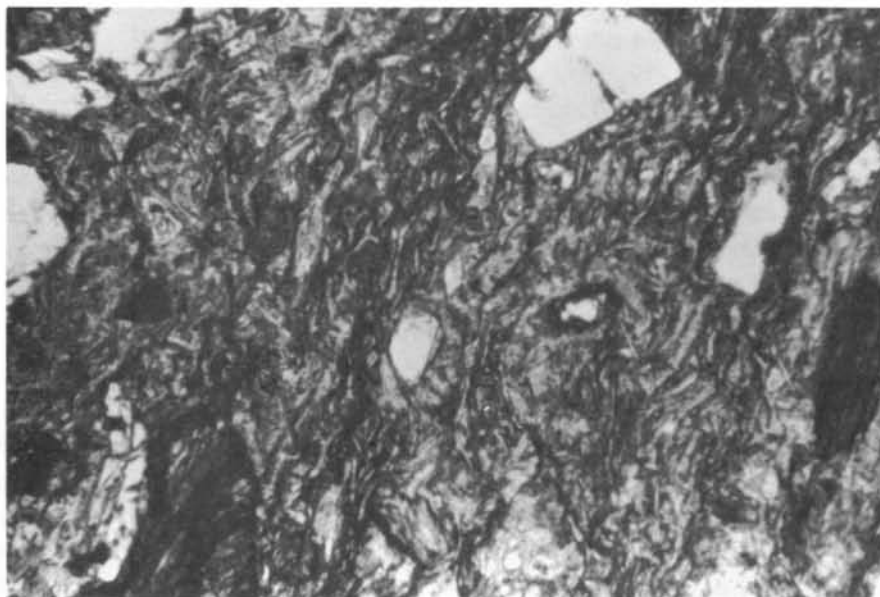
91

Figure 6. Photomicrograph, crystal–welded–tuff with flattened glass shards in Little Butte Volcanic Series. Short field diameter is 2 mm.; plain light.
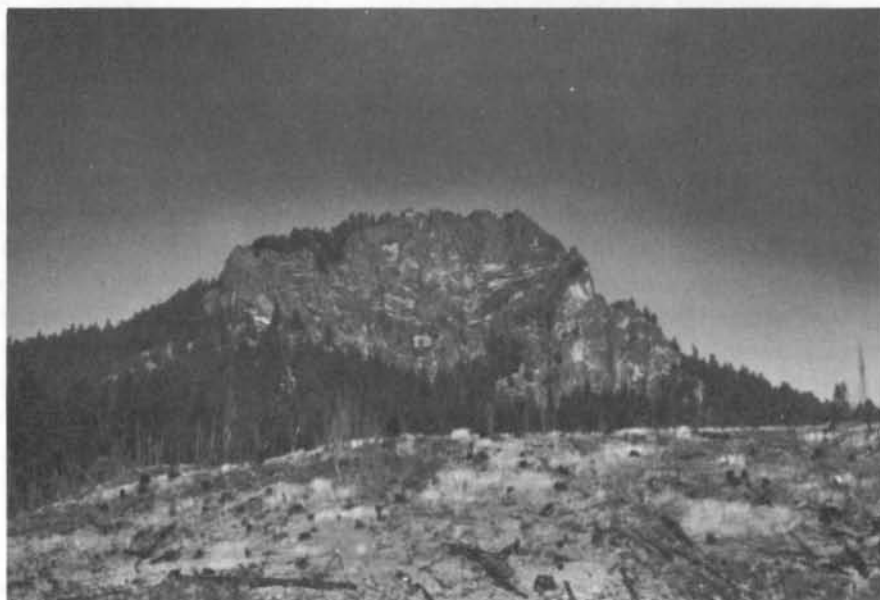

Figure 7. Acker Rock dome as viewed from the south. Note the apparent flow layering and its inward dip or sag.

to become rubbly and grade laterally to breccia which may in certain places be laharic. Basaltic to andesitic dikes and sills are in some places traceable to flows; other isolated intrusions within the underlying Little Butte may may represent fissures of eroded Sardine flows.

Structure

Structural data obtained during mapping indicate that the degree of angular discordance between eastward-dipping, north-trending Tertiary formations decreases upward. Rocks of the Colestin Formation rest with profound angular unconformity upon pre-Tertiary plutonic and metamorphic rocks. Pyroclastic rocks of the Little Butte Volcanic Series rest with angular discordance of as much as 20° upon rocks of the Colestin Formation near their mutual contact in the western part of the area. Between Dumont and Boulder Creeks, for example, rocks of the Colestin Formation dip 35° eastward, whereas the immediately overlapping strata of the Little Butte dip only 15° in the same direction. There are certain cases, however, where the discordance is only apparent and is caused by post-Little Butte faulting. Although flows of the Sardine Formation cover extensive topographic irregularities cut in Little Butte and Colestin rocks, elsewhere their angular discordance with Little Butte rocks probably does not exceed 5°.

Structurally, the area of this investigation is situated just to the south of the hinge-area where predominantly northeast-trending regional fold-axes and faults swing north and northwest (plate 1). Structure contours on top of rocks of Eocene age (Peck and others, fig. 27, p. 42, 1964) show similar trends but with the reversal shifted south and passing through the mapped area. Folds and faults of strong northwest trend predominate in this area and appear to be superimposed on the general north-to-northeast trend of the range. One broad synclinal fold of strong northwest trend is traceable for a distance of at least 5 miles in Little Butte strata and may continue for another 4 miles, buried in part beneath relatively undeformed dacitic and andesitic lavas of the overlying Sardine Formation. Note as well that in the western part of the area folds and faults are generally of the same trend; there is a suggestion that vertical movement along steeply dipping northwest-trending fault planes and development of folds were complementary. Note too, that the Colestin-Little Butte contact is in several places a fault contact. Minor folds and faults in relatively incompetent sedimentary and volcaniclastic strata of the Little Butte may have developed, in part, because of differential compaction; such folds and faults may simply reflect topographic irregularities in the more competent strata of the underlying Colestin Formation.

Acknowledgments

investigation. Of special mention is the financial support of the U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station. The Oregon Department of Geology and Mineral Industries also contributed toward field expenses. The writer's wife, Dorothy, served as chief cook and bottle washer while the field work was in progress and his sons, David and Timothy, proved to be able field companions on numerous occasions.

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GEOLOGIC TIME CHART REVISED

A new, up-dated version of the Department's Geologic Time Scale is just off the press and is available free of charge. It incorporates new radiocarbon and potassium-argon dating for the stratigraphic divisions.

The old version of the time chart, prepared in 1961, has been reprinted so many times that we have lost count. Probably 10 or 15 thousand copies have been given out in letters and over the counter.

Like the old chart, the new version is printed on both sides of an $8\frac{1}{2}$-by 11-inch sheet. On one side is the Geologic Time Chart for the United States, listing the stratigraphic divisions, estimated ages of time boundaries, and dominant life through the ages. On the reverse side is a Generalized Time Chart for Oregon, outlining the principal geologic events from Devonian time to the present. Also delineated on the chart is the most recent information on what are the oldest rocks in Oregon, in North America, and in the world, as well as the age of the oldest known fossil. Information for the time charts has been adapted from the U.S. Geological Survey and from other sources.

*   *   *   *   *

CENTRAL OREGON GEOLOGIC MAP PUBLISHED

"Reconnaissance geologic map of the east half of the Bend quadrangle, Crook, Wheeler, Jefferson, Wasco, and Deschutes Counties, Oregon," has been published by the U.S. Geological Survey as Misc. Invest. Map I-568. The author is Donald A. Swanson.

First issued in 1968 as an open-file report, this map is now in revised form and in full color, at a scale of 1 inch equalling about 4 miles. The map, cross sections, explanation, and other data are printed on a sheet 30 by 40 inches. The area covered by this map extends from 44° to 45° lat. and 120° to 121° long., encompassing sixteen 15-minute quadrangles and including the towns of Prineville, Mitchell, Fossil, and Antelope. In this broad, anticlinal region are exposed Cretaceous and pre-Cretaceous rocks, Clarno and John Day Formations, Columbia River Basalt, and younger Cenozoic volcanic and sedimentary rocks. Over the years, a number of geologists have mapped portions of the region, and some of their work was used by the author in preparing the present map.

Map I-568 is for sale by the U.S. Geological Survey, Federal Center, Denver, Colo. 80225. The price is $1.00.

* * * * *

QUADRANGLE MAPS WITHOUT CONTOURS AVAILABLE

The U.S. Geological Survey is running a special printing of certain of the topographic quadrangle maps without the contours and woodland areas shown. Such a map is particularly useful in situations where only the roads, towns, and other planimetric features are needed. In order to know which of the Oregon quadrangles are issued in this form, request a free copy of the latest "Index to Topographic Maps of Oregon" from U.S. Geological Survey, Federal Center, Denver, Colo. 80225. Maps without the contours are indicated on the index by a special symbol.

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ARCHAEOLOGY BIBLIOGRAPHY COMPILED

"A bibliographic guide to the archaeology of Oregon and adjacent regions," by LeRoy Johnson, Jr., and David L. Cole, has been published by the Museum of Natural History, University of Oregon, Eugene 97403. The bibliography has been issued as a Special Publication and is available from the Museum for $2.00. It contains a list of 447 references which are keyed to a subject guide and area map.

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IT'S NOW OR NEVER FOR SOME DEPARTMENT BULLETINS

The Department's bulletins go out of print all too quickly, mainly because only a limited number (1 to 2 thousand) can be issued. Many of these out-of-print items are in great demand. Although the Department would like to be able to reprint them, the process is too much of a drain on its meager publications budget, which is allocated instead for the publishing of current investigations on geology and mineral resources in the State.

Some of the bulletins that will soon be out of print are listed below. In most instances the supply is quite low, and so persons wishing copies should place their orders as soon as possible before the stock is exhausted.

Bulletin 26: Soil - its origin, destruction, and preservation; by
    W. H. Twenhofel (1944), 47 p., 30 photos _ _ _ _ _ Price 45 cents
Bulletin 35 (revised edition): Geology of the Dallas and Valsetz
    quadrangles, Oregon; by E. M. Baldwin (1963) (includes
    colored geologic map) 56 p., illus._ _ _ _ _ _ _ _ _ _ _Price $3.00
Bulletin 36: Papers on foraminifera of the Tertiary of western Wash-
    ington and Oregon; by Cushman, Stewart, and Stewart
    Vol. I. (1946) (includes photographic plates) 119 p. _ Price $1.00
    Vol. II. (1949) (includes photographic plates) 208 p._ _ _Price $1.25
Bulletin 37: Geology of the Albany quadrangle, Oregon; by
    I.S. Allison (includes colored geologic map) (1953) 18 p. Price $.75
Bulletin 46: Ferruginous bauxite deposits in the Salem Hills,
    Marion County, Oregon; by R. E. Corcoran and F. W. Libbey
    (1956) 53 p., photo, geologic map - - - - - - - - - - - Price $1.25
Bulletin 49: Lode mines of the central part of the Granite Mining
    District, Grant County, Oregon; by G.S. Koch, Jr.
    (1959) 49 p., photos, mine maps_ - - - - - - - - - - - - _Price $1.00
Bulletin 52: Chromite in southwestern Oregon; by Len Ramp (1961)
    169 p., photos, mine maps, geologic maps_ _ _ _ _ _ _ Price $3.50
Bulletin 58: Geology of the Suplee-Izee area, Crook, Grant, and
    Harney Counties, Oregon; by W. R. Dickinson and L. W.
    Vigrass (1965) (includes colored geologic maps) 109 p.,
    photos, checklists of fossils_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _Price $5.00

Two supplements to the Bibliography of Oregon Geology and Mineral Re-
sources are still in print:

Bulletin 33: Supplement for the period 1936-1945 _ _ _ _ _ _ _ Price $1.00
Bulletin 53: Supplement for the period 1951-1955_ _ _ _ _ _ _ _Price $1.50

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AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

2.	Progress report on Coos Bay coal field, 1938: Libbey	$ 0.15
8.	Feasibility of steel plant in lower Columbia River area, rev.1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole, editor	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor	2.00
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75

GEOLOGIC MAPS

Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka	1.50
Geologic map of Oregon west of 121st meridian: (over the counter) folded in envelope, $2.15; rolled in map tube, $2.50	2.00
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat folded in envelope, $2.25; rolled in map tube, $2.50	2.00

The Ore Bin

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Available Publications, Continued:

SHORT PAPERS

2.	Industrial aluminum, a brief survey, 1940: Motz	.$ 0.10
18.	Radioactive minerals the prospectors should know (2nd rev.), 1955:	
	White and Schafer.	0.30
19.	Brick and tile industry in Oregon, 1949: Allen and Mason	0.20
20.	Glazes from Oregon volcanic glass, 1950: Jacobs.	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Mason.	0.25
23.	Oregon King mine, Jefferson County, 1962: Libbey and Corcoran.	1.00
24.	The Almeda mine, Josephine County, Oregon, 1967: Libbey	2.00

MISCELLANEOUS PAPERS

1.	Description of some Oregon rocks and minerals, 1950: Dole	0.40
2.	Key to Oregon mineral deposits map, 1951: Mason	0.15
	Oregon mineral deposits map (22" x 34"), rev. 1958 (see M.P.2 for key).	0.30
3.	Facts about fossils (reprints), 1953	0.35
4.	Rules and regulations for conservation of oil and natural gas (rev. 1962)	1.00
5.	Oregon's gold placers (reprints), 1954.	0.25
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7.	Bibliography of theses on Oregon geology, 1959: Schlicker	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts	0.50
8.	Available well records of oil & gas exploration in Oregon, rev.'63: Newton.	0.50
11.	A collection of articles on meteorites, 1968: (reprints, The ORE BIN)	1.00
12.	Index to published geologic mapping in Oregon, 1968: Corcoran.	Free

MISCELLANEOUS PUBLICATIONS

Oregon quicksilver localities map (22" x 34"), 1946	0.30
Landforms of Oregon: a physiographic sketch (17" x 22"), 1941	0.25
Index to topographic mapping in Oregon, 1968	Free
Geologic time chart for Oregon, 1961.	Free

OIL and GAS INVESTIGATIONS SERIES

1.	Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:	
	Newton and Corcoran.	2.50
2.	Subsurface geology of the lower Columbia and Willamette basins, Oregon,	
	1969: Newton.	2.50

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CENOZOIC ASH-FLOW TUFFS OF OREGON*

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ABSTRACT

Periodic violent eruptions from many different centers during Cenozoic time deposited vast quantities of pyroclastic material as ash-flow tuffs over most of Oregon, although the Coast Ranges and isolated patches elsewhere in the state appear to have been spared these recurring inundations. Eruptions occurred at different times throughout the Cenozoic, and for purposes of description, they can be separated into three age groups: an older one of Eocene, Oligocene, and Miocene age, an intermediate one of early and middle Pliocene age, and a young group of late Pliocene, Pleistocene, and Holocene age.

Some of these ash-flow tuffs are of small volume, less than a cubic mile, and are related to fissure vents, small domal complexes, or calderas from which several kinds of volcanic products were erupted. A few cover thousands of square miles, have volumes of tens of cubic miles, and apparently are related to a large-scale basinal collapse structure and associated calderas.

Most ash-flow tuffs are rhyolite or dacite; a few are peralkaline soda rhyolite. Older ash-flow tuffs are commonly diagenetically altered to a variety of secondary minerals; of the younger tuffs, only those that erupted into shallow lakes exhibit comparable alteration.

Introduction

Periodic violent eruptions during nearly all of Cenozoic time deposited vast quantities of silicic pyroclastic material over nearly all of Oregon, although the Coast Ranges and some small, isolated patches in other parts of the State do not appear to have been inundated. Much of this pyroclastic material was erupted high into the air, where it cooled, fell, and was incorporated as volcanic ash or pumice and crystal fragments in tuffs and tuffaceous sediments. A large part of this material, however, was erupted as hot, high-density suspensions of pyroclastic material in volcanic gas. These suspensions retained much of their inherent volcanic heat as they flowed as turbulent mixtures down broad slopes of volcanic cones, and laterally from large craters

* Publication authorized by the Director, U.S. Geological Survey.

or calderas over vast, nearly flat areas. At times they devastated thousands of square miles in a matter of a few hours or a few days. Some of these flow mixtures filled valleys locally to considerable depth, whereas others spread out as very thin (less than 10 feet thick) sheets over peneplained surfaces. The turbulent, hot mixture of gas and pyroclastic material has been variously labelled nuée ardente, tuff flow, incandescent tuff flow, glowing avalanche, and ash flow, to mention a few names, and the material deposited from the mixture labelled as ignimbrite, eutaxite, or ash-flow tuff. Following the usage of Ross and Smith (1961), most geologists in the United States now refer to these incandescent mixtures of gas and pyroclastic material as ash flows and the deposits as ash-flow tuffs, and they will be so termed here.

After emplacement, the ash-flow tuffs were modified by several processes, including compaction and welding of the still hot and plastic pyroclastic material to form welded or sintered tuffs, by secondary flowage to form laminated rock similar in some ways to flow-banded rhyolite, by crystallization of the glassy constituents, and by several kinds of alteration.

Manifestations of this type of volcanic activity are well preserved in the Cenozoic stratigraphic record of Oregon and, although structural complications, erosion, and deep burial of the older ash-flow tuffs hinder comprehensive studies of some of them, several of the younger ash-flow tuffs are well exposed over very large areas, and they afford an excellent opportunity for investigation.

Some of the data obtained over the past few decades on distribution, age, and character of Oregon ash-flow tuffs are summarized in this paper. For those interested in more detailed information on the development of ash-flow tuff terminology, postulated mechanisms of flowage and emplacement, and detailed characteristics of these volcanic products as they occur in Oregon and in other parts of the world, reference should be made to the excellent and comprehensive summaries by Smith (1960a, 1960b) and Ross and Smith (1961).

Historically, these extensive ash-flow tuff sheets in Oregon, as well as elsewhere, were interpreted as rhyolite or dacite with unusual textures that originated from fissures now concealed, inasmuch as centers of eruption seemed to be lacking and the individual flow units covered areas of such immense size. The presence of these extensive sheets of rhyolitic rock in different parts of Oregon was recognized for many years, but the fact that most, though by no means all, of these sheets are deposits from Tertiary and early Quaternary ash flows has been established only within the past few decades, and the origin of a few small rhyolitic sheets is still in doubt.

As early as 1882, Russell (1884, p. 437) recognized the volcanic character and rhyolitic composition of some of these layered rocks. Diller (in Diller and Patton, 1902) identified a distinctive ash-flow deposit (the Quaternary Wineglass Welded Tuff of Williams, 1942) on the northeast wall of Crater Lake caldera as a tuffaceous dacite that appeared to him to be transitional between a flow and a tuff. An early description of the Pliocene Rattlesnake Formation of central Oregon by Merriam, Stock, and Moody (1925, p. 54) indicates that the formation contains a widespread, massive rhyolite flow with tuffaceous phases. Fuller (1931), in discussing the geology of the Steens Mountain area, describes rocks occurring stratigraphically above the Steens Basalt as "acidic lavas" and as well-indurated stratified tuffs, some of which are "... remarkably high in lithophysae and in irregular gas cavities." He (Fuller, 1935) recognized flow features in some tuffs in southeast Oregon and also that parts of these rocks were compacted and vitreous through collapse of pumice fragments. Wells and Waters (1934) identified a glassy dacite tuff south of Cottage Grove that appeared to them to be about the same stratigraphic horizon as

"... a single flow of glassy dacite (vitrophyre) ...." a few miles away. Moore (1937, p. 3) indicates that the Pliocene Rattlesnake Formation contains a "pumiceous rhyolite flow," now recognized as a welded tuff.

The foregoing brief descriptions of rhyolitic volcanic rocks exposed in different parts of Oregon include data on texture, structure, and induration indicating close resemblance to both flows and pyroclastic materials. These features were first attributed to the eruption and welding of pyroclastic materials in Oregon ash-flow tuffs by Ross (1941), who considered that a tuff in the John Day Formation, of middle Oligocene to early Miocene age, resulted from complete welding of a glassy, hot, and plastic air-fall ash. Shortly thereafter, Williams (1942) described in considerable detail the development of Crater Lake caldera and the ash-flow tuffs related to this spectacular volcanic center. Allen and Nichols (1945) recognized welded tuff south of Cottage Grove in the Calapooya Formation of Eocene age, during a study of high-alumina clays near Hobart Butte. Several years later, the "rhyolite" of the Rattlesnake Formation was identified as an ignimbrite or welded tuff by Wilkinson (1950), and welded tuffs in eastern Jefferson County, near the Horse Heaven mercury mine, were attributed by Waters and others (1951) to nuées ardentes or glowing avalanches. Since then, welded tuffs or ash-flow tuffs have been reported from many different localities in Oregon (Hausen, 1954; Dole and Corcoran, 1954; Williams, 1957; Lund, 1962, 1966; Hay, 1963; Bowen, Gray, and Gregory, 1963; Dickinson and Vigrass, 1965; Peck, 1964; Peck and others, 1964; Prostka, 1962, 1967; Haddock, 1965; Hampton, 1964; Fisher, 1966; Walker and Repenning, 1965, 1966; Walker, Peterson, and Greene, 1967; Swanson, 1969), although locations of the eruptive centers for many of these sheets are still in considerable doubt.

Age and Distribution

Within the vast region of Cenozoic volcanic rocks that extends essentially from the Willamette Valley to the eastern border of Oregon, ash-flow tuffs have been identified in nearly all parts of the stratigraphic column, the oldest of Eocene or early Oligocene age and the youngest of Holocene age. For purposes of this report these tuffs have been separated arbitrarily into three age groups: an older one that includes Eocene, Oligocene, and Miocene ash-flow tuffs, an intermediate group of early and middle Pliocene age, and a younger group of late Pliocene, Pleistocene, and Holocene age. Outlines of the areas underlain by ash-flow tuffs of these different age groups are shown in figures 1, 2, and 3; the boundaries of these areas are only approximate because of inadequate data on the extent of some ash-flow tuffs beneath younger volcanic and sedimentary cover and because the continuity of some units has been destroyed by structural deformation and erosion. Lack of continuity is particularly evident in the older group of ash-flow tuffs shown on figure 1.

Eocene-Oligocene-Miocene ash-flow tuffs

Some of the older stratigraphic units that contain ash-flow tuffs are the Clarno Formation (Swanson, 1969) of Eocene and early Oligocene age, the middle Oligocene to early Miocene John Day Formation of central and eastern Oregon (Coleman, 1949; Waters, 1954, 1966; Hay, 1963; Peck, 1964; Fisher, 1966; Brown and Thayer, 1966; Walker, Peterson, and Greene, 1967; Swanson, 1969; Swanson and Robinson, 1969), and the Oligocene and early Miocene Little Butte Volcanic Series (Peck and others, 1964; Hausen, 1954) of the western Cascade Range. The Dooley
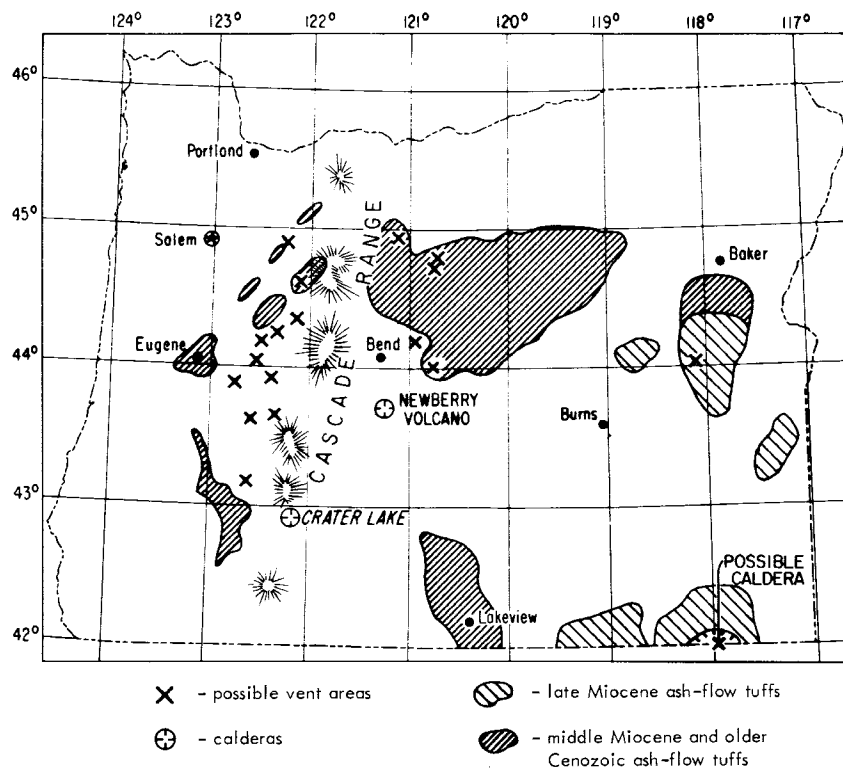
Figure 1. Approximate outcrop areas of Miocene and older Cenozoic
ash-flow tuffs in Oregon.

Rhyolite Breccia of Miocene(?) age (Gilluly, 1937), in the area south of Baker,
contains ash-flow tuffs as do units of about the same age near Ironside Mountain in
east-central Oregon and in several areas near Lakeview. Somewhat younger Miocene
ash-flow tuffs are present in several parts of east-central and southeast Oregon: in-
cluded are the Dinner Creek Welded Ash-flow Tuff (Haddock, 1965; Kittleman and
others, 1965); Leslie Gulch Ash-flow Tuff Member of the Sucker Creek Formation
(Kittleman and others, 1965); ash-flow tuffs in the Strawberry Volcanics (Thayer,
1957); and several unnamed units in the Trout Creek Mountains (southern Harney
and Malheur Counties) and in areas westward to Guano Valley along the southeast
border of the State (fig. 1).

Early to middle Pliocene ash-flow tuffs

Early and middle Pliocene ash-flow tuffs (fig. 2) are almost continuously ex-
posed in the area of Harney Basin and are represented by very extensive but scattered
outcrops in areas to the north in Paulina Basin, in John Day, Bear, and Burnt River
Valleys, and in parts of the Powder River drainage basin east of Baker. Scattered
outcrops of Pliocene ash-flow tuffs also are present near Durkee (Prostka, 1967), in
areas northwest of Westfall (northern Malheur County), Juntura Basin (Bowen, Gray,
and Gregory, 1963), near Crowley (west-central Malheur County), south of Frenchglen,
on the back (west) slope of Steens Mountain, and in areas southwest of Harney Basin

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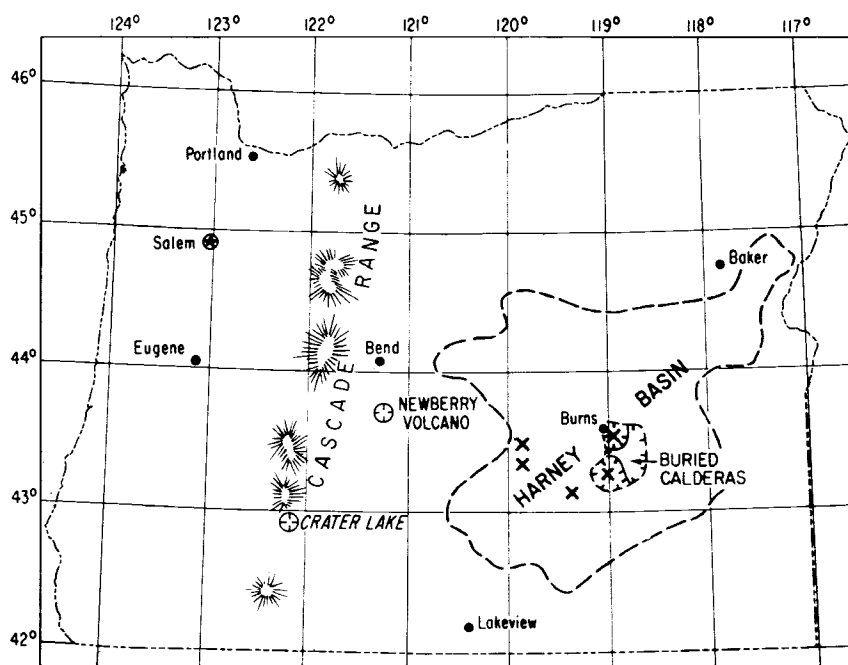
Figure 2. Approximate outcrop area of early and middle Pliocene
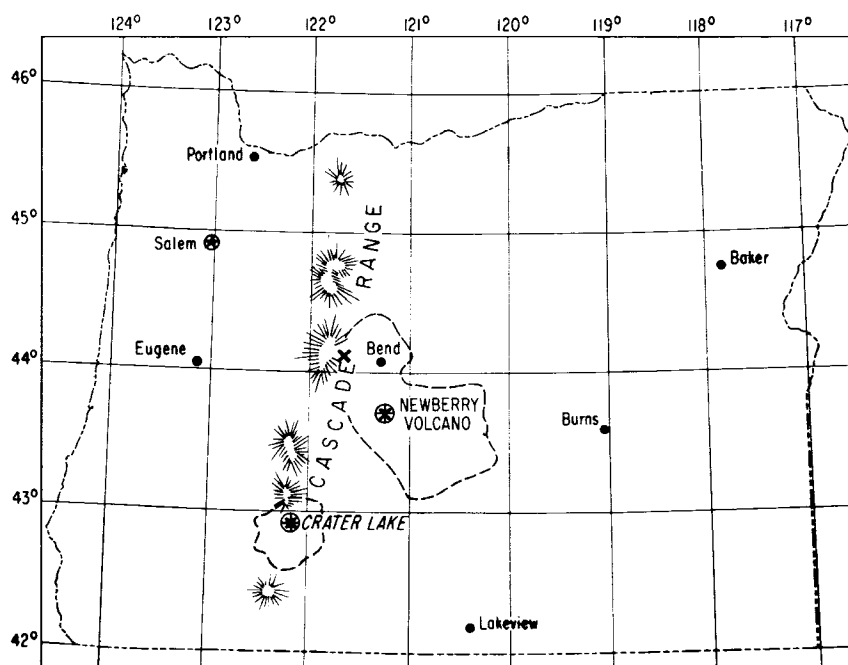ash-flow tuffs in Oregon. X's denote possible vent areas.

Figure 3. Approximate outcrop areas of late Pliocene, Pleistocene,
and Holocene ash-flow tuffs in Oregon. X's denote vent
areas.

near Poker Jim Ridge, Abert Rim, and Summer Lake Valley.

Several of the ash-flow tuffs are thickest and most continuous in the Harney Basin, particularly the three units beautifully exposed in stream and road cuts along U.S. Highway 395 from about 3 miles to 20 miles north of Burns. They represent parts of what was originally mapped as Danforth Formation by Piper, Robinson, and Park (1939), who regarded the upper part of the pumiceous ash-flow tuff highest in this section and exposed closest to Burns as a tuff breccia member. This highest unit has been briefly described by Lund (1962; 1966) and its possible correlation with other ash-flow tuffs to the north by Campbell and others (1958). The thin distal ends of some of these units that are more extensively exposed in Harney Basin are recognizable many tens of miles to the northwest, north, and northeast of Burns where they can be traced into units of ash-flow tuff originally included in the Rattlesnake Formation, the marginal facies of the Columbia River Group, and the Strawberry Volcanics of Brown and Thayer (1966), the Drewsey Formation of Bowen, Gray, and Gregory (1963), and possibly the Wildcat Creek Welded Ash-flow Tuff of Kittleman and others (1965).

Late Pliocene-Pleistocene-Holocene ash-flow tuffs

A comparatively small volume of ash-flow tuffs of either late Pliocene or Quaternary age is present in two separate areas in and just east of the Cascade Range (figure 3). A widespread, thin ash-flow tuff of late Pliocene or Pleistocene age was erupted "... from a parasitic vent high on the northeast flank of the Broken Top volcano" (Williams, 1957); it is exposed in several parts of the Deschutes River drainage north of Bend. Pumiceous ash-flow tuffs, considered by Williams (1957) to be of Holocene age, also are exposed in canyon walls of the Deschutes River and Tumalo Creek a few miles north of Bend. Many small-volume ash flows of late Pleistocene or Holocene age were erupted from the caldera now occupied by Crater Lake. Some of the more extensive ones are found in the canyons of Rogue River, Annie, Sand, and Sun Creeks, on the margins of Klamath Marsh, and in Pumice Desert. Except for the Wineglass Welded Tuff on the northeast wall of the caldera, most of the ash-flow deposits are either unwelded or show evidence of only slight compaction and welding. Young ash-flow tuffs also have been recognized in the east wall of Newberry Caldera (Higgins and Waters, 1967) and in several areas on the eastern margins of Newberry Volcano; presumably all of these are Pleistocene or Holocene in age. A thin, pumiceous ash-flow tuff that crops out extensively west of Hampton Butte (Walker, Peterson, and Greene, 1967), along the Crook-Deschutes County line has been dated at 3.6 million years (late Pliocene)* (R. F. Marvin, written communication, 1965).

Volume

Although the aggregate volume of ash-flow tuffs in Oregon is prodigious, the volume of most individual tuffs appears to be small to moderate, commonly on the order of a few cubic miles or less, although a few contain about 10 cubic miles; at least two that cover several thousand square miles in southeast Oregon are of considerably larger magnitude. Insofar as volumes of ash-flow units have been studied, those of Eocene-Oligocene-Miocene age appear to be small to moderate;

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* Analysts: R. F. Marvin, H. H. Mehnert, J. Obradovich, W. M. Mountjoy, U.S. Geological Survey, Denver, Colorado.

several of those of Pliocene age are large; and those of Pleistocene-Holocene age are very small.

From distribution and thickness data presented by Fisher (1966) and Swanson and Robinson (1968), several of the largest individual ash-flow tuffs of the middle Oligocene to early Miocene John Day Formation total perhaps slightly more than 10 cubic miles ($\approx$40 km^3) in volume. The volume of Miocene ash-flow tuffs on the Oregon-Nevada border, in the Trout Creek and Pueblo Mountains area, is unknown but it probably is greater than 10 cubic miles. Most of this pyroclastic material occurs south of the state line in Humboldt County; the volume in Oregon probably totals less than 4 cubic miles. Haddock (1965; 1967) describes a late Miocene ash-flow tuff having a volume of more than 10 cubic miles in the northwestern part of Malheur County. Most of the Miocene and older ash-flow tuffs in the Lakeview area (Lake County) and in the Sucker Creek area (Malheur County) appear to be of small volume, and several near Lakeview appear to be small, linear bodies that filled valleys to a depth of about 50 feet.

Ash-flow tuffs of very large volume -- on the order of 40 to 50 cubic miles ($\approx$ 150 to 200 km^3) or more -- are known to occur in Oregon only in and adjacent to Harney Basin. A pumiceous ash-flow tuff of middle Pliocene age -- that includes the tuff-breccia member of the Danforth Formation of Piper, Robinson, and Park (1939) -- covers more than 4000 square miles mostly northwest, west, and southwest of central Harney Basin and has an average thickness estimated at about 60 feet, giving a total volume in excess of 45 cubic miles. An older, early Pliocene, crystal-rich ash-flow tuff covers more than 7000 square miles to an average depth of about 35 feet, mostly south, north, and east of the central part of Harney Basin; the total volume is probably in excess of 45 cubic miles. A Pliocene ash-flow tuff of soda rhyolitic composition that covers about 20 square miles on the south slope of Wagontire Mountain contains only a fraction of a cubic mile (less than 1 km^3) and appears to be related to local vents (Walker and Swanson, 1968).

The total volume of young ash-flow -- or glowing avalanche -- deposits that emerged from the caldera now occupied by Crater Lake is in the range of 6 to 8 cubic miles (Williams and Goles, 1968, p. 40), although individual flows represent only a small fraction of this figure. Likewise, individual ash flows associated with New-berry caldera appear to be of comparable small volume.

Data on distribution, continuity, and thickness of most other ash-flow tuffs in Oregon are far too sketchy for volume estimates.

General Features of Ash-flow Tuffs of Oregon

The emplacement of hot particulate mixtures composed of different amounts of frothed and fragmented volcanic glass, crystals and crystal fragments, rock particles, and gas on either flat or irregular eroded surfaces has produced ash-flow tuffs of extremely diverse character. Some of the resultant ash-flow tuffs show evidence of having formed from a single outburst of pyroclastic material and are composed of a single more-or-less uniform tapering sheet, generally referred to as a single flow unit. In contrast, others are characterized by horizontal partings, thin interbeds of airfall tuff, or other evidence of having formed from successive outbursts that, in places, built up sequences several hundred feet thick; these are commonly referred to as compound or composite ash-flow tuff sheets. Both single and composite units have been recognized in Oregon, although single units seem to be more abundant.

A few of the ash flows seem to have been little modified after their

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Figure 4. Typical outcrops of Pliocene ash-flow tuff that overlie
light-colored, vertebrate-bearing late Miocene (Barstovian)
tuffaceous sedimentary beds on south margin of Harney Ba-
sin, Harney County. The ash-flow tuff is part of a large-
volume, crystal-rich, single cooling unit that forms many
upland surfaces in the Harney Basin.

Figure 5. Well-columned late Miocene ash-flow tuff on lower Trout
Creek, north base of Trout Creek Mountains, Harney County.
In this area, ash-flow tuff occurs in tilted fault blocks.

emplacement. They are thick (commonly tens of feet), nonbedded, poorly indurated units, most of which are poorly sorted and consist of small to moderate amounts of pumice fragments, up to 15 or 20 cm. in size, in a matrix of vitric dust and glass shards. Rock fragments and crystals rarely total more than a few percent. Because these poorly indurated ash-flow tuffs are subject to erosion, they are characterized by gentle slopes and are commonly recognizable only where stream banks or road cuts expose them. Hence their distribution, thickness, and lithologic features are not well known in Oregon or elsewhere.

Because of the inherent heat and gas, most ash flows have been slightly to greatly modified during and shortly after emplacement. Most changes resulted from compaction and partial or complete welding of the plastic glassy fragments and crystallization of the glass to form less porous and more coherent rock. The more resistant parts of ash-flow tuffs commonly form prominent ledges (figures 4 and 5) and, in eastern Oregon, some rim rocks; it is mainly these resistant zones that have been recognized and mapped.

Typically, welded ash-flow tuffs are characterized by lithologically distinct zones that result partly from different degrees of welding during cooling and partly from crystallization of the glassy constituents. Essentially all of the varied characteristics of individual zones described by Smith (1960b) have been recognized in ash-flow tuffs of Oregon; only a very brief summary of these features is presented here, primarily in diagramatic form (figure 6). Individual zones (figures 7 and 8) are nearly always gradational into adjoining zones, although the gradation commonly occurs over a short distance, in places through a few centimeters. The zones vary considerably in thickness within individual flows and from one flow to another. In some ash flows, particularly ones less than 20 feet thick, the zone of dense welding is only a foot or two thick, generally occurring at or near the base of the unit. A few thin ash-flow tuffs are mostly densely welded and probably represent flows with either higher than normal initial heat or very rapid emplacement resulting in high heat retention. In some large-volume ash-flow tuffs that are more than 200 feet thick, the zone of dense welding is 10 to 20 feet thick, in places with dense glass low in the zone and rare to abundant spherulites suspended in glass high in the zone. Above the densely welded zone in thick welded tuffs is a zone of vapor-phase crystallization, commonly 100 to 180 feet thick and characterized by abundant lithophysae (figure 9) or spherulites which in places reach a foot or more in diameter but are mostly less than an inch in size. In many ash-flow tuffs these spherulitic masses are completely or partly filled with chalcedony or quartz; they commonly are referred to as thunder eggs, the official state rock of Oregon. The original vitroclastic texture normally evident in the zone of dense welding is partly or completely destroyed in the vapor-phase zone characterized by abundant lithophysae. Several of the thick ash-flow tuffs also have a zone as much as 15 feet thick of vapor-phase crystallization, above the thick lithophysal zone, that is dense, stony, and highly resistant to erosion (zone 2, fig. 6); characteristically, the groundmass glass has been thoroughly crystallized, and large lumps of pumice, although partly compressed, show no or only slight evidence of crystallization. Material above this zone is mostly not welded or only very slightly welded and, in many places, it has been stripped by erosion down to the resistant stony zone; many ledges and upland surfaces in southeast Oregon are composed of this resistant zone. In the nonwelded zone, fumarolic activity has locally crystallized the glass or introduced cementing mineral substances along pipelike passageways in parts of some ash flows. Differential erosion of the less resistant ash-flow tuff and the cemented material on the pipelike conduits has resulted

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A. Zones of welding

NO WELDING

PARTIAL WELDING

DENSE WELDING

ASH-FLOW TUFF

B. Superimposed zones of crystalization

Distribution and relative abundance of lithophysae and spherulites indicated by stars.
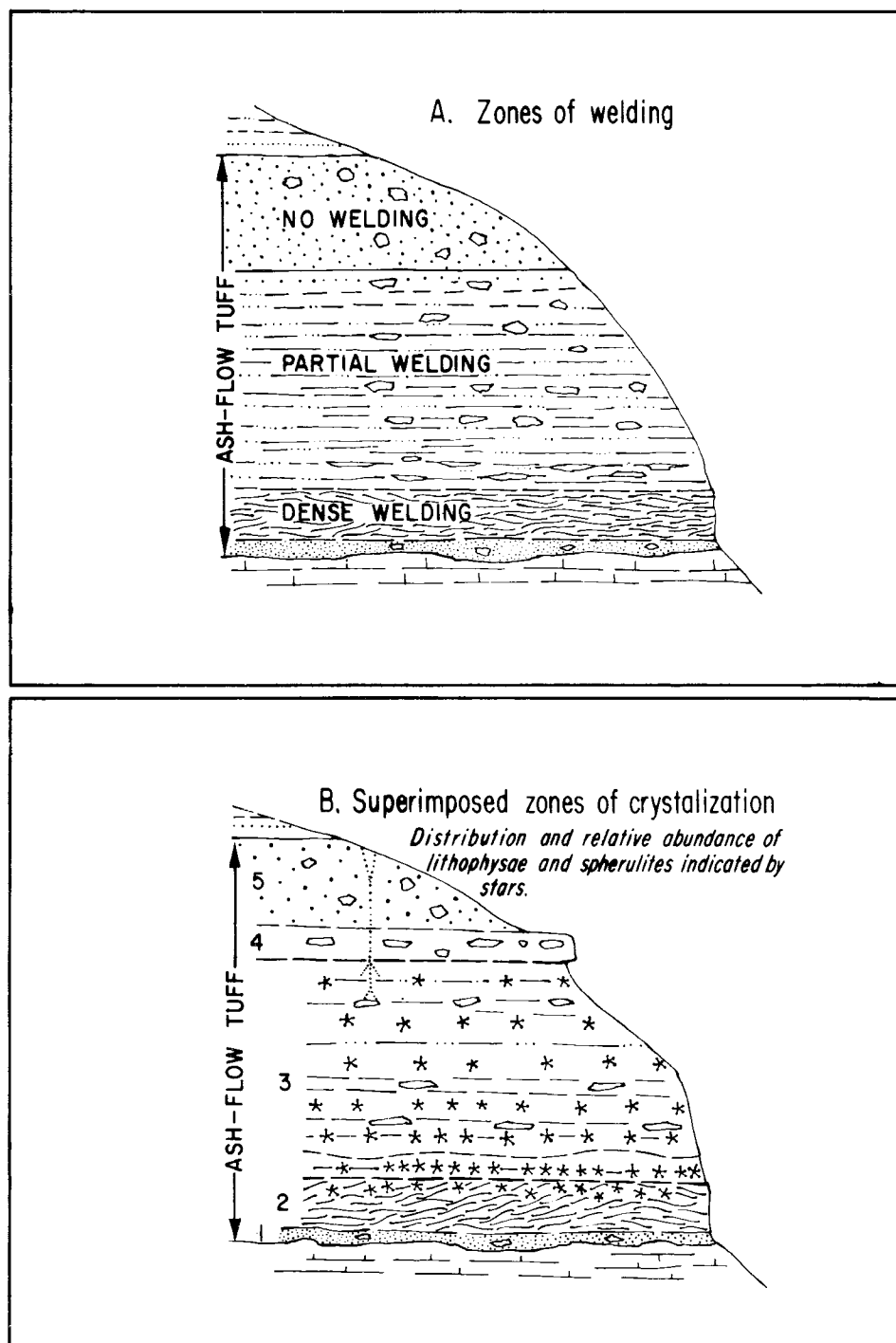
5

4

3

2

1

ASH-FLOW TUFF

Figure 6. See explanation on page 107.

Figure 6. Sketch sections, showing typical zonal patterns of ash-flow tuffs.
The individual zones vary in thickness, in position within flows, and
in degree of compaction of plastic glassy fragments and crystallization.

A
- -

Sketch A shows typical zones resulting from compaction and welding.
Densely welded zone commonly mostly glass but in a few flows that
erupted with an initial high content of crystals the crystals are con-
centrated in this zone and, locally, constitute up to about 35 percent
of zone.

B
- -

Sketch B shows general position and character of zones resulting from
crystallization of vitroclastic material.

Zone 1, commonly a thin zone of nonwelded or poorly welded
tuff; little or no compaction or crystallization of glass fragments.

Zone 2, normally a comparatively thin zone of moderately to
densely welded gray to black glass that commonly shows evidence of
crystallization by rare to abundant spherulites, particularly near top
of zone. In older ash-flow tuffs glass partly or completely devitrified
and hydrated.

Zone 3, zone of vapor-phase crystallization, where present,
generally manifest by partial to complete crystallization of glass and
by common to abundant lithophysae that give rocks a porous, sponge-
like character. Evidence of dense to moderate welding where original
texture not destroyed by crystallization. In some flows zone 3 shows
strong foliation and local lineation denoting laminar flowage (see
Walker and Swanson, 1968); in some flows zone 3 shows prominent
columnar jointing.

Zone 4, some ash-flow tuffs exhibit moderately to poorly
welded nonporous zone at top of vapor-phase zone that is highly re-
sistant to erosion as a result of crystallization of glass.

Zone 5, top zone of nonwelded material is poorly indurated
and commonly has been stripped from ash-flow tuffs. In places, fu-
marolic activity has crystallized and cemented tuff along nearly ver-
tical channelways.

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Figure 7. Well-developed columnar jointing with strong foliation and
sheet jointing at 90° to columns in vapor-phase zone of
Pliocene ash-flow tuff. Outcrops on south flank of Wagon-
tire Mountain near line between Lake and Harney Counties.

in some unusual erosion features, such as the Pinnacles on Sand Creek at Crater Lake
National Park (see Williams, 1942, Plate 16, or McBirney, 1968, fig. 1).

Composition

Comparisons of some chemical aspects of ash-flow tuffs of Oregon show that
all are of rhyolitic to dacitic composition, except the welded basaltic tuff described
by Taylor (1969) that presumably has an origin quite different from those described
here; some of the rhyolitic to dacitic tuffs are silicic alkalic types. Chemical vari-
ations are related partly to geographic distribution of the tuffs and generally not to
their age, although there are some distinct petrochemical types within the different
age groups.

Most of the ash-flow tuffs contain more than 70 percent SiO_2, commonly about
73 to 74 percent, although the range is from about 67 to nearly 77 percent. Differ-
ences in total alkalies, alkali ratios (figure 10), and silica content are related in

Figure 8. Single cooling unit of Pliocene ash-flow tuff exposed on Buzzard Creek, southwest of Harney Lake. Unit extends from light-colored airfall tuff at base through vertical wall composed of zone of vitrophyre (lower dark band) and upper zone of vapor-phase crystallization; slopes above vertical wall underlain by zone of crystallized tuff containing very abundant lithophysae.
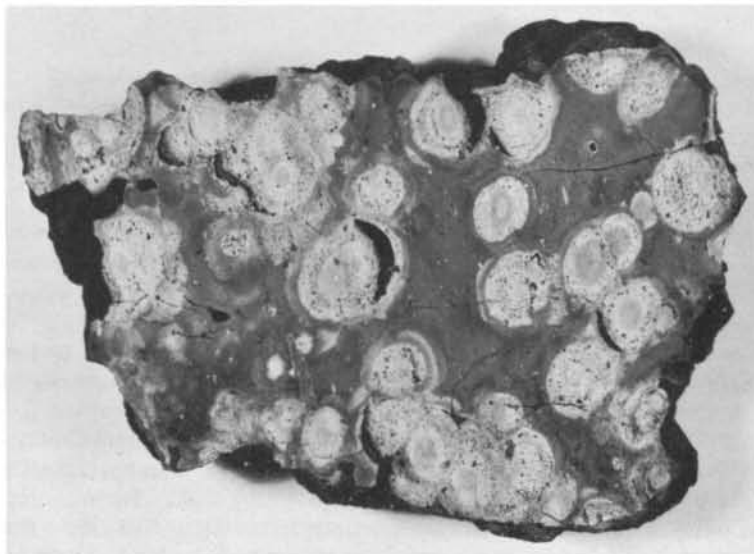
Figure 9. Concentrically banded lithophysae in crystallized ash-flow tuff of Pliocene age. Largest lithophysa about 1.5 inches in diameter.
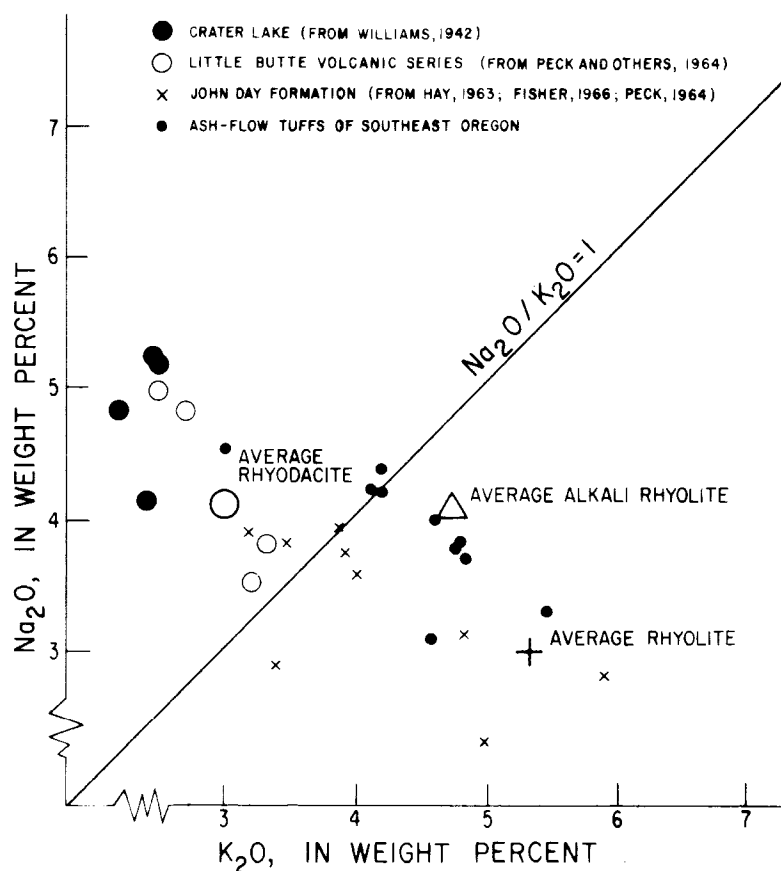
Figure 10. Diagram showing relation of alkalies in Oregon ash-flow
tuffs. Averages for rhyolite, alkali rhyolite, and rhyodacite
are from Nockolds, 1954.

part to geographic distribution. Less silicic and more sodic types are present in the Cascade Range and westward to the Willamette Valley. Included are the ash-flow tuffs at Crater Lake (Williams, 1942) that belong to the youngest age group, and those in the Little Butte Volcanic Series (Peck and others, 1964) of the oldest age group. More silicic and more potassic types are present in central and eastern Oregon, although even there some alkalic silicic ash-flow tuffs are abnormally high in soda, low in alumina, and are of soda rhyolite (comenditic) composition (Dickinson and Vigrass, 1965; Walker and Swanson, 1968; Noble, McKee, and Creasy, 1969). Included in the more silicic and more potassic tuffs are some from the John Day Formation of middle Oligocene to early Miocene age (Hay, 1963; Fisher, 1966; Peck, 1964), and a few are from unnamed Pliocene units in southeast Oregon. Rather sparse analytical data indicate that most of the soda rhyolite ash-flow tuffs of eastern Oregon are either of late Miocene or early Pliocene age.

Furthermore, as found elsewhere, some of these ash-flow tuffs show distinct

differences in alkali ratios between the glassy vitrophyric parts and the devitrified parts, apparently indicating alkali transfer during hydration and crystallization of the metastable glass.

Some of the soda rhyolitic tuffs contain acmite both in the norm and in the mode; the mode also is characterized by blue sodic amphibole, sodic sanidine or anorthoclase, quartz, basaltic hornblende, magnetite, iron-rich clinopyroxene, and minor accessory minerals. Less sodic, rhyolitic and rhyodacitic ash-flow tuffs generally appear to contain more glass and fewer crystals than the soda rhyolite ash-flow tuffs although there are exceptions, particularly in several tuffs showing evidence of laminar flowage (Walker and Swanson, 1968); the crystals, where present, include sanidine containing small to moderate amounts of soda, sodic plagioclase, quartz, and rarely hornblende, biotite, iron-rich clinopyroxene, magnetite, and minor accessories, including apatite and zircon.

Diagenesis of the vitric material in Miocene and older ash-flow tuffs has resulted in the formation of zeolites, principally clinoptilolite, clay minerals, secondary silica minerals, potassium feldspar, and celadonite. Small to moderate amounts of mordenite and phillipsite also have been recognized in some of these tuffs. Younger, Pliocene ash-flow tuffs have undergone similar types of alteration but apparently only where they erupted into shallow, probably slightly alkaline lakes. In some basins of southeast Oregon, subaerial parts of ash-flow tuffs can be traced laterally into lacustrine sequences; distinct differences are evident in degree of compaction and welding, and in these waterlogged ash-flow tuffs the vitric constituents are converted to erionite, heulandite, clinoptilolite, opal, clay minerals, and other alteration products.

Source Areas

Although a variety of ash-flow tuffs have been identified in many parts of the Cenozoic section of Oregon, only in a few places have individual flows been traced to the vents from which they erupted. Some source or vent areas have been clearly identified, a few other source areas are suspected but need further substantiation by detailed mapping or geophysical surveys, and still others are much in the realm of speculation.

Data on a number of potential local sources for Oligocene and early Miocene ash-flow tuffs of unknown, but apparently rather small, volume in the Little Butte Volcanic Series of the Western Cascades have been compiled by Peck and others (1964, fig. 15), although the relation of individual ash flows to vents has not been established. Potential vents for small- to moderate-volume ash-flow tuffs in the middle Oligocene to early Miocene John Day Formation of central Oregon were identified in the Burnt Ranch, Eagle Rock, and Miller Creek areas by Waters (1954, 1966) and in the Ashwood area by Peck (1964). Other possible vents for small volume ash-flow tuffs of the John Day Formation may be obscured by silicic volcanic piles such as those at Powell Buttes, Bear Creek Buttes, and Mutton Mountains. Sources for Miocene and older ash-flow tuffs in the Goose Lake area near Lakeview are not specifically known, although a number of silicic domes and volcanic necks, such as those at Slide, Round, and Dead Indian Mountains and at Fitzwater Point, may bury and obscure the original vents. A late Miocene ash-flow tuff having a volume of more than 10 cubic miles apparently vented from fissure zones now occupied by rhyolite dikes in the Castle Rock area of northern Malheur and southeastern Grant Counties (Haddock, 1965). The late Miocene ash-flow tuffs that straddle the Oregon-Nevada border in the Trout

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Creek Mountains area are related to an arcuate structure, possibly a caldera (Walker and Repenning, 1965).

In the Harney Basin area, distribution of the several Pliocene ash-flow tuffs of very large volume -- totaling more than 100 cubic miles of pyroclastic material -- indicates they are related to the structural collapse centered in the area between Burns, Harney Lake, and Malheur Lake. Presumably beneath the Quaternary cover of sediments and basalt flows in this central area are several closely grouped calderas whose precise positions and character can be determined only by investigations of the subsurface, probably by geophysical means. The Pliocene ash-flow tuffs far to the north and east of Harney Basin near John Day and Baker are, in part, related to the calderas in the Harney Basin, although it is likely that some erupted from fissure vents nearer at hand. Several fissure vents have been postulated for Pliocene ash-flow tuffs in the western part of Harney Basin at Wagontire Mountain (Walker and Swanson, 1968) and near Buzzard Creek (Walker, 1969).

Spectacular, little-modified calderas at Crater Lake (Williams, 1942) and at Newberry Volcano (Higgins and Waters, 1967, 1968) mark the most obvious vents for comparatively small ash-flow tuffs there. Ash flows from these calderas are of late Quaternary age -- some less than 10 or 15 thousand years old -- and are associated with large volumes of other volcanic materials, including lava flows and pyroclastic debris not of ash-flow origin.

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GOLD FOUND IN WATER, PLANTS, AND ANIMALS

A recent circular issued by the U.S. Geological Survey summarizes the amounts of
gold in ocean water, streams, ground water, plants, and animals. Sea water con-
tains from 0.001 to 44 parts per billion (ppb) gold, and the total amount of gold in
sea water, world wide, is estimated to be nearly 27.5 million tons. Ground waters
and river waters contain gold in amounts similar to sea water. A few analyses of wa-
ter from hot springs show gold ranging from 0.01 to 2.2 ppb, averaging about 0.5 ppb.

    Varying amounts of gold are contained in the ash of algae, fungi, lichens,
mosses, herbs, shrubs, and trees, according to the report. The maximum amount of
gold detected in plant ash is 36 ppm (parts per million) and the average is about 7 ppm.

    Gold has been looked for in only a few animals. Values range from as little
as 0.0012 ppb gold in the dry matter of fish muscle to as much as 430 ppb in human
hair. Human teeth show 10 to 30 ppb gold. Marine animals contain the least amount
of gold, and terrestrial animals the most.

    The report, "Gold Content of Water, Plants, and Animals," by Robert S.
Jones, is published as U.S. Geological Survey Circular 625; it may be obtained free
upon request from the U.S. Geological Survey, Washington, D.C. 20242.

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GEOCHEMICAL ANALYSES AVAILABLE

The results of all analyses of stream sediments on more than 3000 streams in south-
western Oregon are available for public inspection at the State of Oregon Depart-
ment of Geology and Mineral Industries offices in Portland, Baker, and Grants Pass.
The information consists of semiquantitative chemical analyses for copper, zinc,
molybdenum, and mercury, all made in the Department's laboratory in Portland. In
addition, semiquantitative spectrographic analyses for 30 elements were made on
these samples by the U.S. Geological Survey at its Denver laboratory.

    In addition to being available for inspection at the Department's offices,
these data, tabulated on approximately 400 pages, will be duplicated upon request
for $25. A set of 36 quadrangle maps showing the location of the sample sites and
some of the chemical data is available for an additional $25.

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INTERIOR'S BUREAU OF MINES REORGANIZED

Reorganization of the Interior Department's Bureau of Mines--designed to strengthen and facilitate both its law enforcement activities and its mineral research and development functions--has been announced by Secretary Walter J. Hickel.

The reorganization, first to encompass the entire Bureau of Mines since 1963, is being put into effect immediately, Secretary Hickel said. Among its major objectives are:

--Assurance that the Bureau's responsibilities for administering tough new mine health and safety laws will be carried out;

--Assurance that Bureau research and development on mineral supply and environmental problems move rapidly forward to make the Bureau more responsive to current needs on the environmental front. Two new units have been created especially to deal with pollution and waste problems;

--Closer and more productive relationships with State and local governments;

--Improved efficiency and economy in the collection and dissemination of economic and statistical information on mineral development;

--Greater emphasis on mineral and energy supply problems and improvements of the Bureau's ability to detect, define, and help solve them.

Secretary Hickel said that a key feature of the reorganization is the establishment of two Deputy Director positions, immediately beneath the Bureau's Director in management responsibility. One Deputy will have direct charge of the Bureau's law enforcement activities in mine health and safety; the other will administer all Bureau research and environmental development functions.

Other aspects of the reorganization, the Secretary said, are aimed at achieving greater emphasis on environmental problems associated with the mining and processing of minerals and fuels; at better coordination of fact-finding functions with research and development activities; and at more effective concentration of the Bureau's field staff.

Commenting further on the reorganization, Secretary Hickel said it stemmed from a recognition of three relatively recent developments on the national scene: (1) the growing concern over waste and pollution and the need to attack them constructively through research; (2) new legislation that has given Interior greater enforcement powers in the field of mine health and safety; and (3) increasing variety and complexity in mineral and energy supply problems, all of which demand greater Federal involvement.

"The reorganization is expressly designed to strengthen the Bureau's capabilities in responding to each of these major developments," Secretary Hickel said. (Alaska Division of Mines and Geology Mines Bulletin, May 1970, page 2.)

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The center of the earth lies nearly 4,000 miles beneath our feet. To date, man has drilled about 5 miles into the earth.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev.1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon,	
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35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev.1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947:	
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52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
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OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

PRELIMINARY REPORT ON FOSSIL FRUITS AND SEEDS
FROM THE MAMMAL QUARRY
OF THE CLARNO FORMATION, OREGON

By Thomas M. McKee*

The Department encourages students of geology and paleontol-
ogy to submit original articles of scientific merit for publication in
The ORE BIN. This paper by Thomas M. McKee on the fossil fruits
and seeds from the Mammal Quarry site in the Clarno Formation is a
noteworthy example of what a young person with aptitude, motiva-
tion, and guidance can achieve.

Tom McKee, a recent graduate of Jefferson High School in
Portland, has been keenly interested in paleobotany since elemen-
tary school days. He is a member of the Oregon Museum of Science
and Industry Student Research Center and is on the paleontology re-
search team at Camp Hancock. His work on fossil fruits and seeds
from the Mammal Quarry won him a number of state and national
awards, including one in the Westinghouse National Science Talent
Search. This report, originally printed in mimeograph form by the
OMSI Student Research Center, is published here with only slight
alterations.   --- Ed.

Introduction

During the summer of 1969 the author was a
member of the Vertebrate Paleontology Re-
search Team of the Oregon Museum of Sci-
ence and Industry. This team consisted of
eight high school students and a field direc-
tor. The team's objective was to recover
vertebrate fossils from the Clarno Formation
Mammal Quarry near Clarno, Oregon. It
was evident from previous excavations that abundant fossil plant material
was located in the middle and lower units of the quarry. Therefore it was
decided to collect and study the fossil fruits and seeds associated with the

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   Portland, Oregon

vertebrate fossils, allowing a more complete reconstruction of the paleo-
ecology of the Clarno Mammal Quarry site and a detailed analysis of the
depositional environment.

This paper is a preliminary report on the fossil seeds and nuts so far
collected and studied by the author. He expects to continue his research
on plant material at the Clarno Mammal Quarry site and extend his studies
to adjacent areas.

Geologic Occurrence

The Clarno Mammal Quarry (OMSI Loc. No. ONT-1) is located
about 2 miles east of Clarno, Oregon, in the NE$\frac{1}{4}$ sec. 27, T. 7 S., R. 9
E., in the Clarno quadrangle, Wheeler County. The quarry is in the Clar-
no Formation, which is widely exposed throughout central Oregon. R. L.
Hay (1963, p. 201) states that "The Clarno Formation consists largely of
lava flows and volcanic breccias, but volcanic conglomerates and sand-
stone, claystones and vitric tuffs are common in some places. The various
lithologic units interfinger laterally and no units have been found which are
sufficiently widespread to subdivide the formation over a distance of more
than ten miles. The full thickness of the formation is about 5000 feet...."

In the area of the Clarno Mammal Quarry, the Clarno Formation con-
sists of interbedded mudflows and tuffs and andesitic lavas that have been
altered both hydrothermally and by weathering. The upper limit of the
Clarno Formation is a subject of debate, but it is usually accepted that the
lower member of the overlying John Day Formation (upper Oligocene) was
deposited on the surface of the eroded Clarno Formation. Well-core data
from the vicinity of the Clarno Mammal Quarry show that the Clarno Forma-
tion rests unconformably on Cretaceous marine sediments (figure 1).

Previous Work

The Clarno Formation was considered to be upper Eocene by Merriam
(1901) in his original description of the formation. This age determination
was based on the analysis of fossil leaf remains from the Clarno Formation
by Knowlton, who published his findings in 1902. Chaney (1952) consid-
ered the Clarno Formation as middle and upper Eocene, also based on fossil
leaf remains. Scott (1954) described the fossil flora of the Nut Beds of the
Clarno Formation and stated that "The affinities of the fruits and seeds sub-
stantiate the Eocene age of the Clarno Formation and suggest, but do not
confirm, that it is older than upper Eocene." Mellett (1969) describes a
partial skull of Hemipsalodon grandis, a large Pterodon-like hyaenodontid
from the Clarno Mammal Quarry. Mellett states that Hemipsalodon is
stratigraphically limited to the early Oligocene. Bruce Hansen of the
University of California, Berkeley, who is working on the Clarno vertebrate
fauna, states (oral communication, 1969) that the two prepared brontothere

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ERA	Period	Epoch	Millions of years ago	Series	Formation
CENOZOIC	Quaternary	Pleistocene			Alluvium
					Erosion
			2 - 3		Rattlesnake Fm.
	Tertiary	Pliocene		upper	
				middle	Erosion
			12	lower	Mascall Fm.
		Miocene		upper	Columbia River Basalt
				middle	Erosion
			26	lower	John Day Fm.
		Oligocene		upper	
				middle	Erosion
			38	lower	Clarno Fm.
		Eocene		upper	
				middle	Erosion
			54	lower	
MESOZOIC	Cretaceous				Undifferentiated marine sediments
			136		

Figure 1. Generalized geologic time chart showing age relationship of the Clarno Formation.
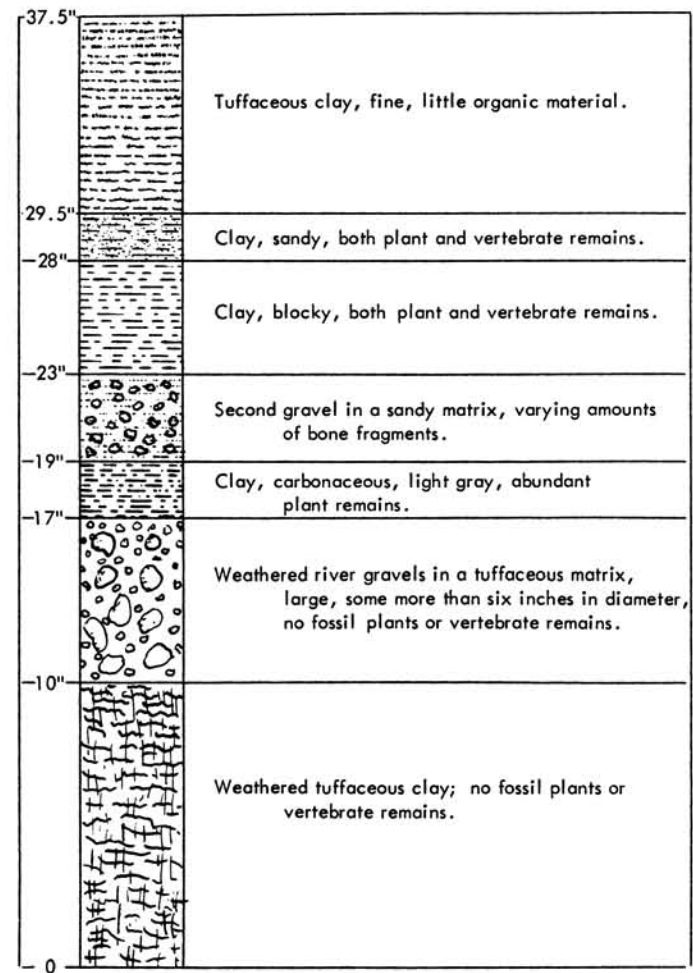
Figure 2. Measured section of the Clarno Mammal Quarry.

Tuffaceous clay, fine, little organic material. (37.5" – 29.5")

Clay, sandy, both plant and vertebrate remains. (29.5" – 28")

Clay, blocky, both plant and vertebrate remains. (28" – 23")

Second gravel in a sandy matrix, varying amounts of bone fragments. (23" – 19")

Clay, carbonaceous, light gray, abundant plant remains. (19" – 17")

Weathered river gravels in a tuffaceous matrix, large, some more than six inches in diameter, no fossil plants or vertebrate remains. (17" – 10")

Weathered tuffaceous clay; no fossil plants or vertebrate remains. (10" – 0)

mandibles collected from the Clarno Mammal Quarry during 1969 seem to be of species limited to the Oligocene (figure 1).

Stratigraphic Relationships

An occurrence of fossil plant remains known as the Clarno Nut Beds (Scott, 1954) is found approximately half a mile southwest of the Clarno Mammal Quarry. Stratigraphically above the Nut Beds is a deposit known locally as Red Hill. This deposit consists of a clay soil weathered from tuffaceous sand and volcanic dust (Taylor, 1960).

Taylor ran a series of tests on the red tuffs at Red Hill and on the tuff that occurs at the Clarno Mammal Quarry. He found that the two tuffs are texturally similar. The Clarno ignimbrite caps both the Red Hill and the Clarno Mammal Quarry tuffs. This seems to place the Clarno Mammal Quarry in the same clay stratum as the red tuff which occurs at Red Hill. Based on the textural similarity and the fact that the Clarno ignimbrite caps both deposits, the author assumes that the Clarno Mammal Quarry was deposited at the same time as the tuffs of Red Hill. Therefore, the Clarno Nut Beds, which occur stratigraphically below Red Hill, are older in age than the Clarno Mammal Quarry, although the difference may be very slight.

Age

A potassium-argon date of 34.5 million years was determined for the Clarno Nut Beds by Evernden, Curtis, and James (1964). The assumption then can be made that the Clarno Mammal Quarry is younger than 34.5 million years. Placement of the quarry in the early Oligocene agrees with the suggested assignments to early Oligocene age based on vertebrate remains from the Clarno Mammal Quarry by both Mellett (1969) and Hansen (oral communication, 1969).

Stratigraphy at the Clarno Mammal Quarry

The Clarno Mammal Quarry occurs in a large slump block of tuffaceous clays that appears to have moved down slope about 40 feet from its original position. Capping the clays is the Clarno ignimbrite which is used as the marker bed for the displaced sediments. To the east of the main quarry and about 40 feet above the fossil-bearing level of the main quarry is a smaller mammal deposit. The beds at this second deposit probably represent part of the main quarry beds not displaced by slumping.

On the basis of limited excavation, the general stratigraphy of the deposit shows distinctly stratified sediments dipping 12° northwest and striking N. 30° E. (figure 2). The sediments at the bottom of the excavation appear to be a highly weathered tuffaceous clay. Resting on this clay is a deposit consisting of highly weathered river gravels composed of chert

and tuffaceous cobbles in a tuffaceous matrix. The larger cobbles in this unit are more than 6 inches in diameter. Lying on the river gravels is a carbonaceous unit of very fine, light-gray clay containing abundant plant remains. Directly above this carbonaceous unit is a second gravel in a sandy matrix which contains varying amounts of bone fragments. Resting on the second gravel is a deposit of blocky clay containing both vertebrate and plant remains. The blocky clay underlies a thin unit of sandy clay containing both plant and vertebrate remains. The top unit in the excavation consists of a fine tuffaceous clay containing little organic material.

Floral Composition

Of the 204 specimens of fossil fruits and seeds recovered from the Clarno Mammal Quarry, 39 have been identified. The unidentified material is so poorly preserved that identification is either unreliable or impossible. All identified specimens belong to the Phylum SPERMATOPHYTA, Class ANGIOSPERMAE, Subclass DICOTYLEDONAE. Four families and six genera are represented in the identified flora, with three identified to the species level.

Systematic List

Phylum: SPERMATOPHYTA
    Class: ANGIOSPERMAE
        Subclass: DICOTYLEDONAE
            Family: JUGLANDACEAE
                Genus: JUGLANS Linnaeus
                    Juglans clarnensis Scott
            Family: MENISPERMACEAE
                Section: TINOSPOREAE Diels
                    Genus: ODONTOCARYOIDEA Scott
                        Odontocaryoidea nodulosa Scott
                Subsection: COCULINAE
                    Genus: DIPLOCLISIA
                        Diploclisia sp.
            Family: ICACINACEAE
                Section: PHYTOCRENEAE Engler
                    Genus: PALAEOPHYTOCRENE
                        Palaeophytocrene cf. P. foveolata
                            (Reid & Chandler)
            Family: VITACEAE
                Genus: VITIS (THURNBERG) Linnaeus
                    Vitis sp.
                Genus: TETRASTIGMA Planchon
                    Tetrastigma sp.

The genus DIPLOCLISIA is the most abundant plant represented in the Clarno Mammal Quarry flora with 31 specimens having been recovered. Second in abundance is the species <u>Odontocaryoidea nodulosa</u> with three specimens (figure 3).

Species	No. of specimens
<u>Juglans clarnensis</u>	1
Odontocaryoidea nodulosa	3
Diploclisia sp.	31
Palaeophytocrene cf. P. foveolata	2
Vitis sp.	1
Tetrastigma sp.	1
Total	39

Figure 3. Numerical data.

Systematic Relationships

Phylum: SPERMATOPHYTA

Class: ANGIOSPERMAE

Subclass: DICOTYLEDONAE

Family: JUGLANDACEAE

Genus: JUGLANS Linnaeus

<u>Juglans clarnensis</u> Scott

(Plate 1, figures 1-2)

Specimen: OMSI No. PB-1.

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Discussion: One specimen of this species was found, consisting of a lateral half of the cotyledon. The specimen is a cast that is slightly compressed, distorting the two lateral halves of the primary embryo lobes. The surface of the lobes is smooth. Length: 11 mm.; width in the plane of dehiscence is distorted; thickness (at right angles to plane of dehiscence) 11 mm.

Family: MENISPERMACEAE

Section: TINOSPOREAE Diels

Genus: ODONTOCARYOIDEA Scott

Odontocaryoidea nodulosa Scott

(Plate 1, figures 5-6)

Specimen: OMSI No. PB-31.

Discussion: Three specimens of this species were recovered. All are locule casts with a carbonaceous cover which appears to have been the exocarp. The specimens have been slightly compressed. The locule cast is elongate, length: 22-28 mm.; width: 5 mm.; thickness: undeterminable owing to compression; and deeply boat shaped. The apical end is pointed, the shoulder region slopes, and the basal end is blunt with a small median projection. The dorsal side is smooth, with a slight median ridge marking the suture. The ventral side is concave.

Family: MENISPERMACEAE

Section: TINOSPOREAE Diels

Subsection: COCULINAE

Genus: DIPLOCLISIA Miers

Diploclisia sp.

(Plate 1, figures 3-4)

Specimen: OMSI No. PB-6.

Discussion: This genus has the largest representation in the Clarno Mammal Quarry flora, with 31 specimens consisting of both locule casts and

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impressions. Most of the specimens show the flattened interface of one valve of the endocarp in the plane of dehiscence. This view shows the horseshoe-shaped ring of about 22 large tubercles with corresponding hollows between them, surrounding a slightly elevated flat surface. The walls of the specimen appear to consist of radially directed coarse fibers and are thick with a pronounced ridge extending completely around the horseshoe-shaped ring. Length: 9-11 mm.; width in plane of dehiscence: 5-7 mm.; thickness: undeterminable owing to compression.

Family: ICACINACEAE

Section: PHYTOCRENEAE Engler

Genus: PALAEOPHYTOCRENE Reid & Chandler

Palaeophytocrene cf. P. foveolata Reid & Chandler

(Plate 2, figures 3, 4, 4a)

Specimen: OMSI No. PB-37.

Discussion: Two incomplete locule casts of this species were recovered from the Clarno Mammal Quarry. Their estimated length is 14-16 mm.; width 7-9 mm.; and the thickness indeterminable. There are approximately 7-8 surface pits lengthwise and 5-6 pits across the width. These incomplete specimens compare favorably with the species Palaeophytocrene foveolata.

Family: VITACEAE

Genus: VITIS (Thurnberg) Linnaeus

Vitus sp.

(Plate 2, figures 5-6)

Specimen: OMSI No. PB-39.

Discussion: One complete seed of this genus was recovered from the Clarno Mammal Quarry. The seed is split into two parts along the raphe ridge and is distorted by compression. It is obovoid with smooth contours sharply pointed at the apex and rounded at the base. Length of seed: 3 mm.; width 2.3 mm.; thickness: undeterminable. The specimen has been compared at the Oregon Museum of Science and Industry to No. 984 of the

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Hancock collection from the Clarno Nut Beds.

The Clarno Mammal Quarry specimen does not appear to represent the London Clay species Vitis pygmaea. The London Clay species, Vitis pygmaea, differs from this specimen in the appearance of the apex, which is highly stipitate in Vitis pygmaea but smooth in the Clarno specimen. Moreover, the raphe ridge of the Clarno specimen extends onto the apex, but not in the London Clay species; and the ventral infolds are much narrower in the London Clay species.

Family: VITACEAE

Genus: TETRASTIGMA Planchon

Tetrastigma sp.

(Plate 2, figures 7, 8, 8a)

Specimen: OMSI No. PB-40.

Discussion: One complete seed of this genus was recovered. The seed is ovate and is ornamented with prominent radial lobes separated by deep furrows. The raphe ridge extends the length of the ventral face. Length: 5 mm.; width: 3.5 mm.; thickness: undeterminable.

ANGIOSPERM

INCERTAE SEDIS

(Plate 2, figures 1-2)

Specimen: OMSI No. PB-34.

The specimens consist of three much compressed fruiting heads which are only partially intact, preventing identification. Diameter of globular fruiting heads is 18-22 mm.

Relation of Living and Fossil Floras

Present-day distributions of the modern equivalent genera of the fossil plant remains so far identified in the Clarno Mammal Quarry flora have habitats ranging from cool-temperate to exclusively tropical (see figure 4). However, the majority of the identified fossil genera (4 of 6) have modern equivalents living in subtropical to tropical habitats.

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Fossil Genus	Nearest modern equivalent	Habitat
Juglans	Juglans	Tropical to cool temperate
Odontocaryoidea	Odontocarya	Lowland tropical
Diploclisia	Diploclisia	Tropical to sub-tropical
Palaeophytocrene	Phytocrene	Lowland tropical
Vitis	Vitis	Tropical to cool temperate
Tetrastigma	Tetrastigma	Subtropical and lowland tropical

Figure 4. Present-day distribution of the
nearest modern equivalent genera.

The nearest modern equivalents to identified fossil genera of the Clarno Mammal Quarry have a wide geographical distribution ranging from Canada to many tropical areas in the Old World. A majority of the modern equivalents (5 of 6) are found in India and Ceylon (figure 5).

The Clarno Mammal Quarry fruit and seed genera are found in several other Tertiary floras in the New and Old Worlds. The Clarno Nut Beds correlate best with the Clarno Mammal Quarry by having all six genera present. The lower Eocene London Clay Flora of England comes next, with four out of six genera represented (figure 6).

Summary

This report is preliminary to further collecting and study at both the Clarno Mammal Quarry and the Clarno Nut Beds.

Based on the information previously discussed, the author concludes that the Clarno Mammal Quarry is younger than the Clarno Nut Beds, and probably early Oligocene in age. This assignment agrees with age determinations of vertebrate remains from the Clarno Mammal Quarry.

The 39 identified specimens indicate the presence of a tropical to subtropical climate at the site of the Clarno Mammal Quarry during early Oligocene time. Based on the limited flora identified, the composition of the Clarno Mammal Quarry flora appears to be essentially the same as the flora found in the Clarno Nut Beds.

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EXPLANATION OF PLATE I

Juglans clarnensis Scott - Page 122

Fig. 1. OMSI No. PB-1. The lateral half of the cotyledon.
The specimen has been compressed, distorting the two lateral halves of the primary embryo lobes. 3 X
Fig. 2. Drawing showing the lateral half of the cotyledon and the correct position of the two lateral halves of the primary embryo lobes. 3 X

Diploclisia sp. - Page 123

Fig. 3. Drawing showing the horseshoe-shaped furrow enclosing the plug. 3 X
Fig. 4. OMSI No. PB-6. The flattened interface of one valve of the endocarp showing the horseshoe-shaped ring of tubercles and corresponding hollows. 7.5 X

Odontocaryoidea nodulosa Scott - Page 123

Fig. 5. OMSI No. PB-31. Dorsal side showing a slight median ridge marking the suture. 3 X
Fig. 6. Same, ventral side concave, showing the pointed apical end, blunt basal end with a small median projection, and the sloping shoulder region. 3 X

EXPLANATION OF PLATE II

Incertae sedis - Page 125

Fig. 1. OMSI No. PB-36. Fruiting head partially intact, showing awns. 3 X
Fig. 2. OMSI No. PB-34, the same. 3 X

Palaeophytocrene cf. P. foveolata - Page 124

Fig. 3. OMSI No. PB-37. Incomplete locule cast, showing surface pits. 3 X
Fig. 4. OMSI No. PB-38, the same. 6 X
Fig. 4a. Drawing showing external shape of complete locule cast in relationship to fig. 4. 3 X

Vitis sp. - Page 124

Fig. 5. OMSI No. PB-39. One-half of the obovoid seed, split down the raphe ridge. 3 X
Fig. 6. The same. Other half of the seed in matrix. 9 X

Tetrastigma sp. - Page 125

Fig. 7. OMSI No. PB-40. Impression of seed in matrix. 6 X
Fig. 8. The same. Obovate seed showing its ornamentation with prominent radial lobes separated by deep furrows and the raphe ridge which extends the length of the ventral face. 6 X
Fig. 8a. Drawing of fig. 8, emphasizing the radial lobes and deep furrows and the prominent raphe ridge. 3 X

PLATE I
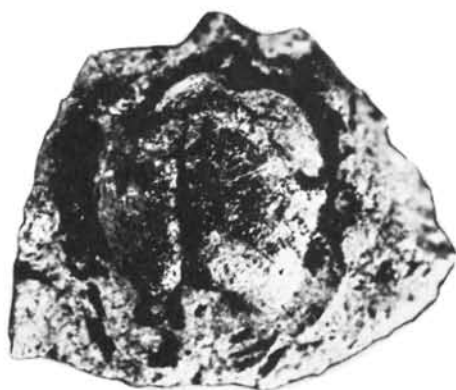
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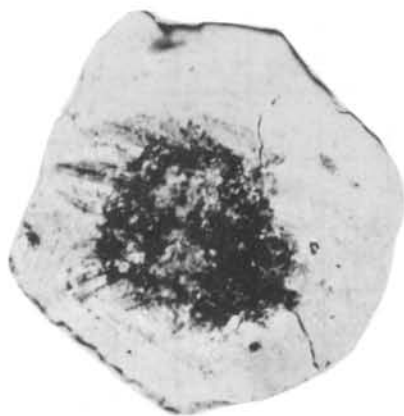
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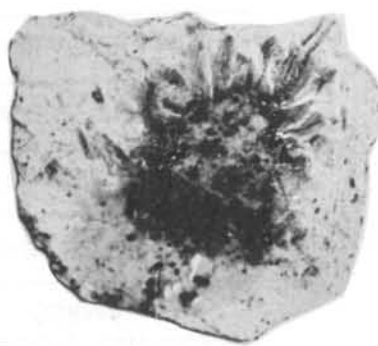
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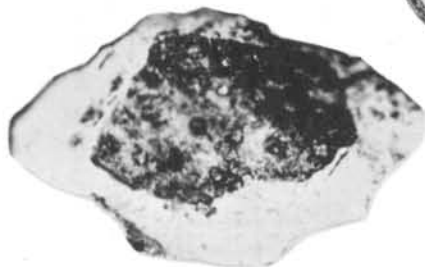
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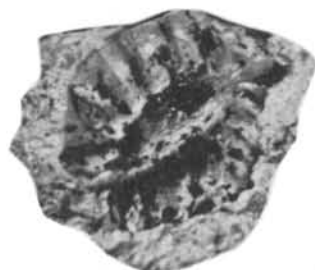
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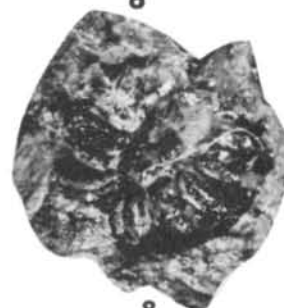
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Fossil genus	Nearest modern equivalent	CANADA	UNITED STATES	MEXICO AND CENTRAL AMERICA	HIMALAYAS	JAPAN AND NORTH CHINA	SOUTH CHINA AND BURMA	INDIA AND CEYLON	FURTHER INDIA	MALAY PENINSULA	MALAY ISLANDS	TROPICAL AFRICA	PHILIPPINES
Juglans	Juglans	X	X	X	X	X		X					
Odontocaryoidea	Odontocarya			X									
Diploclisia	Diploclisia						X	X		X	X		
Palaeophytocrene	Phytocrene							X	X	X			X
Vitis	Vitis		X	X	X	X	X	X	X	X	X	X	X
Tetrastigma	Tetrastigma				X		X	X	X	X	X		X

Figure 5. Geographical distribution of the nearest modern equivalents of the Clarno Mammal Quarry fruit and seed genera.

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Genera	Clarno Nut Beds	Chalk bluffs	London Clay	Lower Bagshot	Bournemouth
Juglans	X				
Odontocaryoidea	X		X		
Diploclisia	X				
Palaeophytocrene	X	X	X		
Vitis	X		X	X	X
Tetrastigma	X		X		

Figure 6. Occurrence of Clarno Mammal Quarry
fruit and seed genera in other Tertiary floras.

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OREGON TERTIARY PHYTOPLANKTON

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ABSTRACT

Silicoflagellates have only recently been studied in the Pacific Northwest. Specimens of this bizarre group of planktonic plant microfossils, examined from late Tertiary sediments in the Bandon, Oregon area, demonstrate their usefulness as a biostratigraphic tool.

Introduction

A study of fossiliferous strata in western Oregon (Orr and Ehlen, 1970) has revealed microfossil groups previously unreported from the Pacific Northwest. Subsequent studies (Orr and Zaitzeff, 1970) have indicated that one of these groups of microfossils known as silicoflagellates may be of substantial biostratigraphic value where it occurs in the Tertiary sediments of Oregon and Washington as well as in submarine rock exposures off this coast.

Within Oregon, silicoflagellates have been successfully recovered from localities south of Bandon as well as from submarine exposures off the Oregon coast (see figure 1).
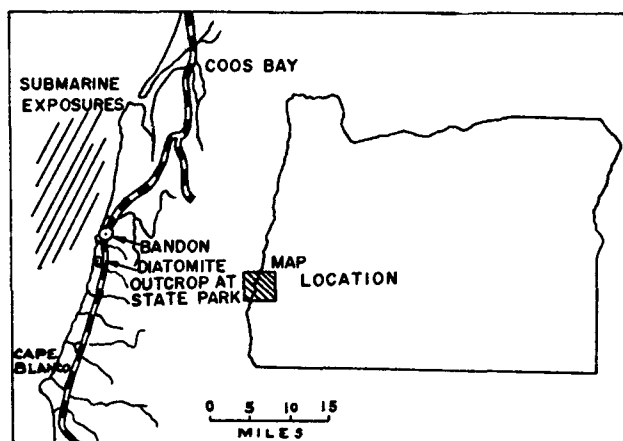
Figure 1. Map of the Bandon area of western Oregon showing location of silicoflagellate-bearing sediments studied. Submarine exposures are generalized (cross-shaded).

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Silicoflagellates have been described from numerous localities in California (Hanna, 1928; Mandra, 1968, and others), but much of the important and original literature on this fossil group appears in German and French journals. Previously, silicoflagellates have been variously classified with the diatoms because they are autotrophic, or with the radiolaria because of their skeletal morphology. However, present evidence indicates that these small fossils are the skeletal remains of a group of solitary marine planktonic algae of the Order Chrysomonadina, Class Flagellata. They are a common component of modern marine plankton, and, although they are technically pelagic or drifting with the marine currents, locomotion is effected by a single whiplike flagellum on each organism (see figure 2). The average size of the silicoflagellate skeleton is around 30 μ * and, like many planktonic organisms, they most frequently display a radial symmetry.

Of particular significance here is the siliceous composition of the skeletal framework of the silicoflagellates. The tubular opaline silica skeleton is able to withstand the action of the various acids (nitric, hydrochloric, acetic) used to concentrate and extract the fossils from the rock matrix retaining them. This resistance to strong acids makes the silicoflagellates an attractive fossil group in a geologic terrain such as the Pacific
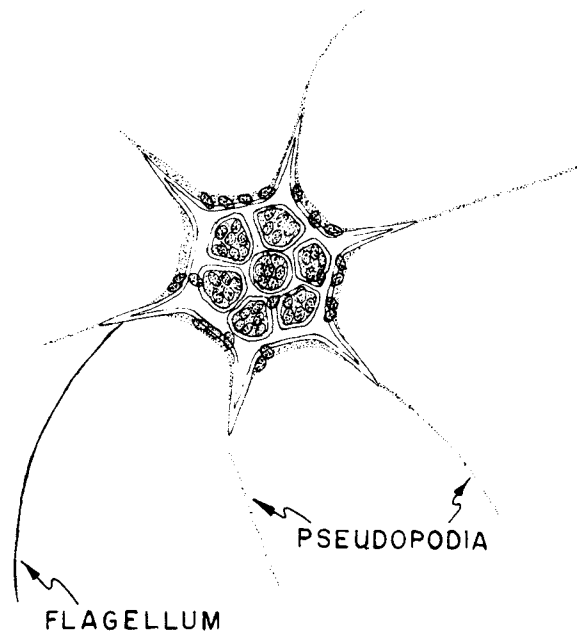
Figure 2.
Distephanus speculum, living specimen illustrating protoplasm, chromatophores, pseudopodia and the flagellum. Redrawn after Loeblich (Marshall, 1934).
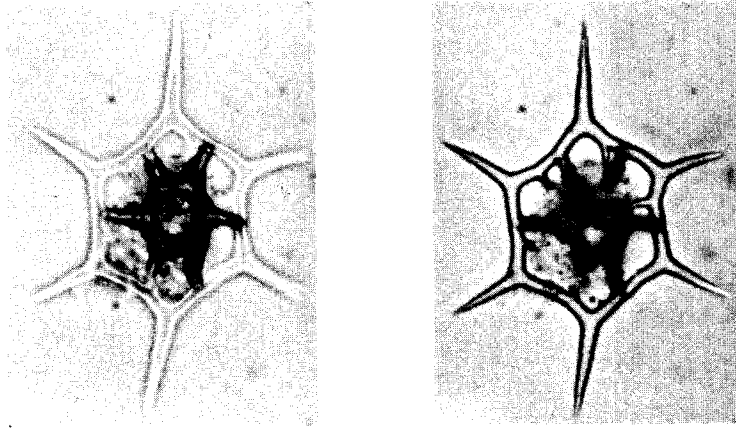
PSEUDOPODIA

FLAGELLUM

* 1 μ = ~ $^4/10,000$ inch.

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Figure 3. Microphotographs of the same specimen of Distephanus speculum focused on the basal ring and apical ring, respectively. Basal accessory spines are visible in the basal ring focus, and the tubular nature of the skeleton may be seen in the apical ring focus.
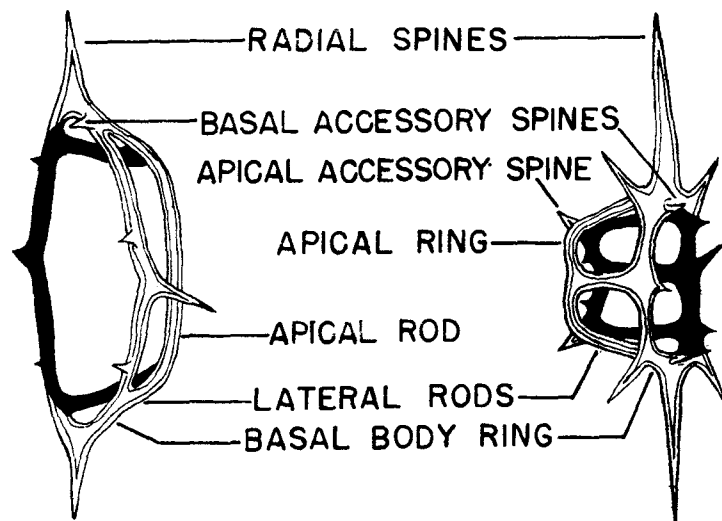

Figure 4. Nomenclature of the silicoflagellate skeleton (modified after Tynan and Deflandre).
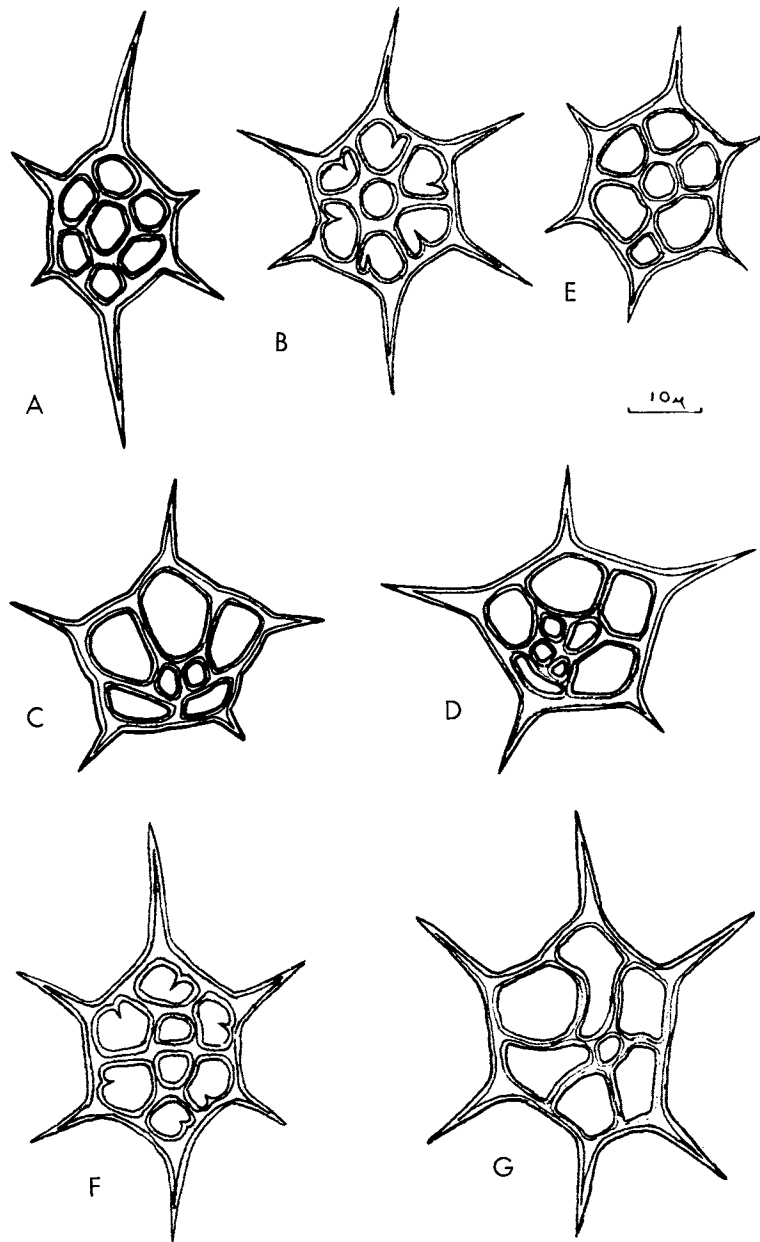
Figure 5. Representative Oregon silicoflagellates:
  a. Distephanus speculum (Ehrenberg)
  b. Distephanus speculum var. regularis Lemmermann
  c,d. Distephanus speculum var. pentagonus Lemmermann
  e,f,g. Distephanus speculum var.
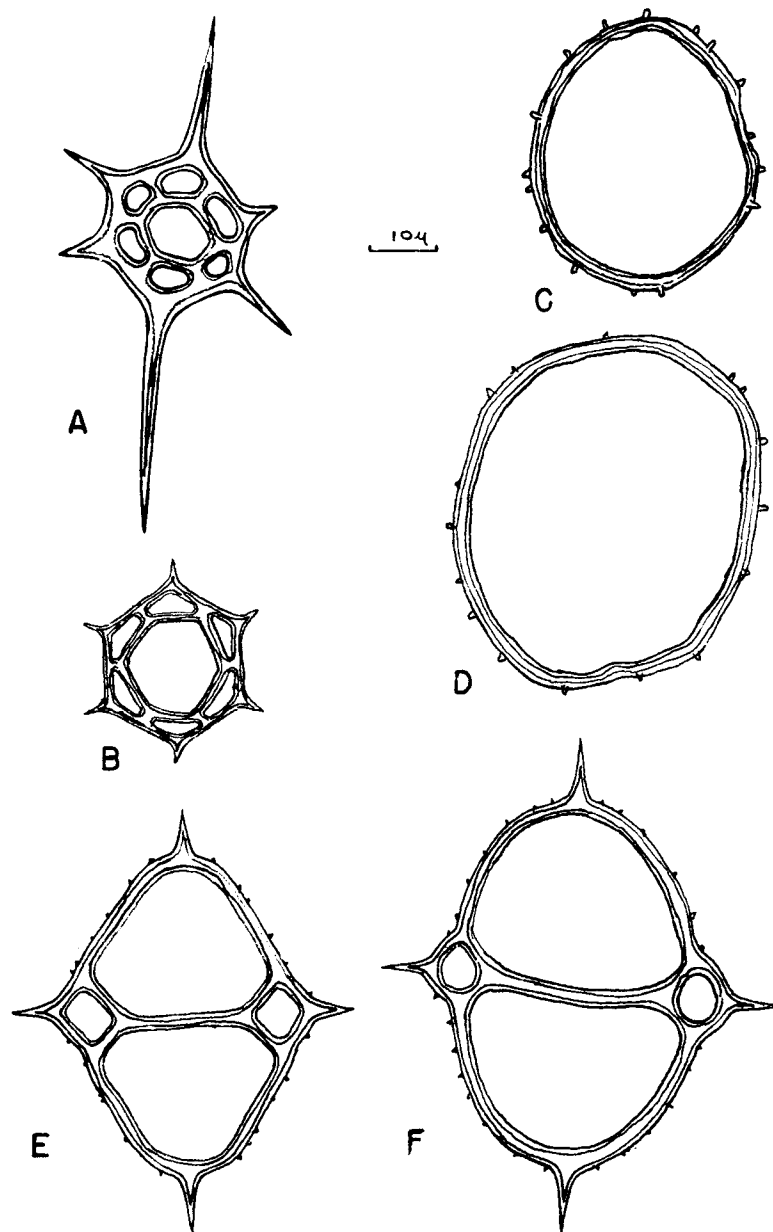
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Figure 6.   Representative Oregon silicoflagellates:
          a.   Distephanus ornamentus (Ehrenberg)
          b.   Distephanus speculum var. brevispinatus Lemmermann
       c,d.   Paradictyocha polyactis (Ehrenberg)
       e,f.   Dictyocha mutabilis Deflandre

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Northwest where many of the Tertiary sedimentary rocks have undergone substantial induration, and standard techniques of removing fossils fail to produce satisfactory results. An additional feature enhancing the silico-flagellates as a biostratigraphic tool in this area is their apparent abundance in certain of the later Tertiary rocks of the Pacific Northwest. Silicoflag-ellates are known from contemporary oceans as well as from rocks as old as Lower Cretaceous. The greatest frequencies of their skeletal remains are found in Tertiary-age rocks which have substantial amounts of biologically precipitated silica such as marine diatomites and radiolarian oozes.

Morphology

Typically the silicoflagellate skeleton consists of a single or double ring of opaline silica (figures 3 and 4). Spines projecting from these rings are frequently of two succinct types: the larger radial spines, and the much smaller accessory spines projecting from either the basal body ring or the smaller apical ring or apical rod. The skeleton itself is tubular in structure (indicated here by double lines). The apical ring, if present, is oriented in the same plane as the basal ring and is supported by lateral rods.

Utility in Oregon

All of the silicoflagellate-bearing sediments collected from the Ban-don localities (figure 1) are very rich in diatom frustules with lesser amounts of radiolaria and other nonsiliceous microfossils including plant spores and pollen, foraminifera, discoasters, and coccoliths. Examination of the sil-iceous phytoplanktonic microfossils from these localities (diatoms, silico-flagellates) indicates that the sediments bearing these microfossils range in age from the late Miocene to the early Pliocene (Delmontian Stage to Re-pettian Stage) and may be correlative with the lower part of the Empire Formation. Further studies of samples from offshore submarine exposures (see Kulm and Fowler, 1970) as well as from a number of late Tertiary for-mations in western Oregon are presently underway. It is expected that these current studies will permit the eventual establishment of a standard chro-nology for the fossil phytoplankton of the late Tertiary in the Pacific North-west. Because of their mobility and relative freedom from limitation to particular rock facies, pelagic organisms have for some time been recog-nized as being ideal as index microfossils. The subsequent cosmopolitan distribution of silicoflagellates combined with their abundance, small size, and resistant opaline skeleton greatly enhances their value as correlative means for later Tertiary sediments of the Pacific Northwest.

Representative late Tertiary silicoflagellates of Oregon are illustrated in figures 5 and 6. These genera and species are from various localities near Bandon and offshore submarine exposures of diatom-rich sediments.

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MAPS OF JOHN DAY UPLIFT ON OPEN FILE

Predominantly marine sediments, ranging in age from Devonian to Cretaceous, unmetamorphosed and not intruded by large igneous bodies, are exposed in the John Day uplift of central Oregon. Detailed mapping of these beds and their structural features in the southwestern part of the uplift by H. J. Buddenhagen has provided important clues to the pre-Tertiary geological history of the vast lava-covered plateau region east of the Cascade Mountains.

Because of the recent interest in the geology of this complex area by the oil industry, the Department is placing on open file all the maps and cross sections prepared by Buddenhagen. These maps are drafted on dimensionally stable mylar sheets and can be easily reproduced. This material is available for inspection at the Department's Portland office.

*   *   *   *   *

"ONE THIRD OF THE NATION'S LAND"
REPORT OF THE PUBLIC LAND LAW REVIEW COMMISSION

"One Third of the Nation's Land," the report of the Public Land Law Review Commission that was presented to the President and Congress on June 23, is now available for distribution. The 342-page book contains a total of 400 recommendations for revision of public land policies. Recommendations regarding mineral resources appear on pages 121-138.

The report is for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402. The price is $4.50.

*   *   *   *   *

REYNOLDS TO BEGIN LOCAL BAUXITE PROGRAM

Reynolds Mining Corp., a subsidiary of Reynolds Metals Co., reports that it will soon begin a small-scale mining program in Columbia, Washington, and Marion Counties, Oregon, and in Cowlitz County, Washington, to obtain laterite (bauxite) for research purposes. For the past 10 years the company has been drilling laterite samples from the four counties and making small-scale processing tests. With this phase of the research completed, the company is now ready to run larger-scale tests. Approximately 50,000 tons of the laterite will be taken from sites totaling about 12 acres. Local contractors will be employed to mine the ore, and trucks will transport it to outloading points for rail or water shipment to a Reynolds plant in another part of the country. The company will continue to follow good conservation practices, and once the work is completed it will restore the area and seed the surface.

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35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
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Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . .	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37) .	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker . . .	1.00
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GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
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Geologic map of Oregon west of 121st meridian: (over the counter)	2.00
folded in envelope, $2.15; rolled in map tube, $2.50 . . .	
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat .	2.00
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MISCELLANEOUS PAPERS

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	Oregon mineral deposits map (22" x 34"), rev. 1958 (see M.P.2 for key).	0.30
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 OREGON

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GEOLOGIC TOUR OF COVE PALISADES STATE PARK
NEAR MADRAS, OREGON

By N. V. Peterson* and E. A. Groh**

Introduction

When you drive through the Madras region on U.S. Highway 97, you see a
gently rolling plain dotted with low hills and flat-topped buttes. Since the
plain appears to extend westward uninterruptedly to the foothills of the Cas-
cade Range, little would you imagine that between you and the mountains
lurk three awesome canyons, totally invisible until you nearly reach the
brink. Three rivers -- the Deschutes, the Crooked, and the Metolius --
have cut these gashes into the plain and have laid open for observation a
sequence of remarkable geologic events. The place where the three rivers
join to make one canyon marks the general location of the Cove Palisades
State Park (figure 1).
    Cove Palisades State Park encompasses Round Butte Dam and its reser-
voir, Lake Billy Chinook. The 7,000-acre park features picknicking, camp-
ing, and boating facilities on the shore of the lake and scenic viewpoints
on the canyon rims. The park is an excellent place to see 10 million years
of geologic history.
    The purpose of this report is to present the geologic background of the
park area in a nontechnical way (assisted by a short glossary of terms), and
then to outline a geologic motor tour of the park by means of descriptive
text, photographs, cross sections, and maps. The self-conducted tour starts
at Madras, makes 12 designated stops, and ends on the far side of the park
in the canyon of the Deschutes River, a total distance of about 25 miles.

Location and Access

    Cove Palisades State Park lies about 10 miles west of Madras (figure 2),
the seat of Jefferson County. Madras, with a population of about 2,000, is
the main commercial and distribution center for the surrounding agricultural
area. Two U.S. Highways intersect at Madras. U.S. 26 leads northwest-
ward toward Mount Hood and on to Portland. In the opposite direction, this

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highway goes southeastward to Prineville and on to eastern Oregon. U.S. 97 crosses the state north and south from Washington to California. The park is easily accessible by good paved roads from Madras and other junctions along U.S. Highway 97 south of Madras. Inside the park, road signs direct the traveler to the various recreation sites and viewpoints.

History and Development of the Park

The Madras area of Jefferson County began to be settled about a century ago, and favored fishing locations and places for relaxation were soon discovered in the deep canyons to the west. One of these places was on the banks of the Crooked River about 2 miles above its junction with the Deschutes. This secluded spot, sheltered by canyon walls, came to be known as "The Cove."

Public and private development through the years improved the accessibility of The Cove, first with roads from Madras and Culver, on the east side, and later with bridges across the Crooked and Deschutes Rivers and a road connecting with Grandview and Sisters on the west. A small hydroelectric plant was built at The Cove in 1912 and was enlarged in 1923 to provide power for the communities of Madras, Prineville, and Redmond. Even a peach orchard was cultivated at The Cove, because the climate is quite mild at the bottom of the canyon.

In the late 1930's and early 1940's, the Oregon State Highway Commission, which had recognized the recreational potential of the area, acquired through purchase and lease agreements from public and private holders some 7,000 acres of this canyon region. After World War II, trails and camping facilities were built and the area was officially named "Cove Palisades State Park."

All of this was to change, though, for in 1960 construction of Round Butte Dam began on the Deschutes River just below the mouth of the Metolius. This rock-fill dam has raised the water level nearly 400 feet above the bottom of the canyon. The old Cove Palisades State Park and the adjacent hydroelectric plant are now under 200 feet of water. Through agreement with the State Parks and Recreation Division, the Portland General Electric Co., owner of the dam, provided for a move of the park facilities to a location about a mile to the southwest on the Deschutes River side of the Peninsula. After the dam was completed, the reservoir created a three-armed body of water which is named Lake Billy Chinook for a Warm Springs Indian guide who accompanied Captain John Fremont in early-day explorations of Oregon. The geologic map (plate 1) and also figures 1 and 2 show most of the over-all extent of Lake Billy Chinook.

Once the lake was available, other additions were made, and the park now has an overnight camp area offering 87 trailer sites and 94 campsites with utility facilities. Three day-use areas provide parking, boat launching, picnicking, swimming, and other recreational accommodations.

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Figure 1. Aerial view looking south toward Lake Billy Chinook and Cove Palisades State Park. Round Butte Dam is in the foreground. At the left, the Crooked River and Deschutes River arms of the lake stretch southward. Metolius River arm branches to the right.

A marina concession extends services of boat rental, a restaurant, and sundry supplies. The outstanding fishing, boating, and other accommodations, together with its scenic attractions, make Cove Palisades State Park one of the most desirable of all the Oregon parks.

Within the park area a viewpoint observatory and museum, built by Portland General Electric Co., perches on a cliff overlooking the Round Butte Dam and Lake Billy Chinook. It offers downstream vistas of the imposing Deschutes Canyon and presents information on central Oregon wildlife, Indian artifacts, and construction of the dam. Picnicking facilities are also provided. The observatory is open daily during the summer vacation months and on weekends during the spring and fall. The hours are from 10:30 a.m. to 7:30 p.m. Should the observatory be closed, a short walk to the cliff edge will give you an excellent view of the canyon and dam.

The summit of Round Butte is also a part of Cove Palisades State Park. A paved road to the top of this shield volcano connects with the road from Madras to the Round Butte Dam viewpoint. It has the highest elevation within the area and its summit offers a magnificent panorama of the Deschutes basin, High Cascades, and surrounding country.

Geologic History

The geologic history so dramatically displayed in the walls of the canyons at Cove Palisades State Park tells the story of the past 10 million years. But if you drive to the top of Round Butte, you will see in the surrounding mountains a record of events going back as much as 50 million years.

Early history

Beginning in the Eocene Epoch (about 50 million years ago), numerous volcanic eruptions covered the region with predominantly andesite* lavas and tuffs*, and in some places sediments were washed into shallow basins. These rocks, named the Clarno Formation*, compose the distant Ochoco Mountains on the eastern skyline and also make up part of the Mutton Mountains to the north of the park.

In middle Oligocene time (about 30 million years ago) a new episode of volcanism began to emit tremendously explosive eruptions which continued into early Miocene time (about 25 million years ago). These eruptions threw dacite* and rhyolite* ash and pumice fragments high into the air to fall out over the terrain in thick deposits which later consolidated* into the red, green, and buff-colored tuffs of the John Day Formation. Some of the highlands visible from Round Butte, such as Gray Butte,

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* Words followed by an asterisk are defined in the Glossary of Geologic Terms on page 168.

Juniper Butte, Grizzly Mountain, and part of the Mutton Mountains, were at this time active volcanoes that contributed to the John Day Formation.

In middle and late Miocene time (20 to 15 million years ago) great floods of basaltic lava poured over the eroded surface of Clarno and John Day rocks. These basalts*, named the Columbia River Group, are exposed at the Pelton damsite a few miles down the Deschutes canyon from Cove Palisades State Park.

All three formations -- the Clarno lavas, John Day tuffs, and Columbia River basalts -- are probably "basement rocks" beneath the rocks exposed in Cove Palisades State Park (see cross sections, plate 2, page 162)

Pliocene Epoch

The story of Cove Palisades State Park as revealed in its canyon walls begins in the Pliocene Epoch, which dates back about 10 to 12 million years. At this time, volcanism began building the Cascade Range from north to south across Oregon. Basalt and basaltic andesite lavas erupted from vents to form a series of shield volcanoes. Volcanoes of this type receive their name from the similarity in shape to a warrior's shield lying with the rounded, or convex, side up. Round Butte, situated in the park area, is typical of a small shield volcano. The shield volcanoes of the Cascade Range were much larger, however, and were fed by more vigorous sources of magma*. Numerous lava flows radiating from central vents, and from parasitic vents on the flanks, resulted in huge volcanic piles which coalesced and overlapped, forming the base for the present High Cascades.

Westward-flowing streams were forced to seek north or south courses in order to reach the sea. Thus the ancestral Deschutes River and its tributaries became established. While the Cascades were building, earth movements were causing a slow sinking of the land surface in what is now the middle Deschutes basin, including the area of Cove Palisades State Park. Erosion, the ever-present process of wearing away the rocks, was providing the detritus from the Cascade shield volcanoes for fill in the basin. Airborne volcanic material, such as ash and cinders, carried by the prevailing winds, contributed also. This debris, with minor amounts eroded from the John Day highlands, and many thin lava flows, accumulated over the basement rocks to a thickness of 1000 feet or more. These rocks are called the Dalles Formation. They are exposed in the canyons of Cove State Park and are designated as QTd on the geologic map, plate 1.

Dalles Formation

The Dalles Formation in the Madras region was named for similar deposits at the lower end of the Deschutes River and along the Columbia River near The Dalles.

Most of the sedimentary beds in the Dalles Formation were laid down

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in either a river floodplain or a shallow lake environment. They are composed of light- and dark-gray layers of siltstone, sandstone, and conglomerate*. In many places cross bedding is revealed by finer laminations at various angles to the main layering. Crossbedding is characteristic of stream sediments deposited by torrential flood waters.

Numerous basaltic lava flows are interbedded in the Dalles Formation. These lavas came from vents within the basin, and some may have streamed in from the flanks of the growing Cascades. The lava flows undoubtedly dammed and/or diverted the ancestral Deschutes River, developing small, temporary lakes where fine silt and clay were deposited in quiet waters, forming lenses of thinly laminated beds; many examples of these lake-bed deposits are now exposed in the river-canyon walls. The lavas can also be recognized in the canyon walls as more resistant dark-brown layers with prominent columnar jointing*.

Eruptions in some of the Cascade volcanic centers became more explosive during the latter part of the Pliocene Epoch. Andesitic, dacitic, and rhyolitic ash and pumice were blown into the air, falling out over the basin. Much of the fragmental product also accumulated around the vents and, mixed with periodic lava flows, built the type of volcanoes known as composite cones.

These huge Pliocene volcanoes probably discharged some of the ash-flow tuffs found interbedded in the Dalles Formation in the park area. Ash flows occur when gas-charged magma erupts so rapidly from a volcanic vent that it flows out with great mobility as a suspended mixture of ash, pumice fragments, and gas. Ash flows are estimated to travel at speeds as high as 100 miles an hour, and some spread over hundreds or even thousands of square miles of terrain. The mixture, on coming to rest, tends to fuse or weld together from retained heat and action of the gases. The resulting rock is called an ash-flow tuff, or sometimes a welded tuff. In thick ash flows the inner portion may fuse so completely that it resembles a lava flow. These devastating eruptions occurred numerous times throughout the deposition of the Dalles Formation.

The growth of the High Cascades eventually raised a barrier across Oregon which prevented warm, moist coastal air from moving eastward. The climate of the Pliocene became drier, although not to the degree it is now. The forests took on a modern aspect (Chaney, 1956). The most abundant tree, according to fossil evidence north of the park, was the aspen, but willow, cherry, cottonwood, and box elder were also present.

We probably would feel at home with the vegetation of the Pliocene were we to be transported back by "time machine" to the ancestral Deschutes basin. Perhaps not so with the animals of the time. Although no fossil bones have been found in the park area, fossils found elsewhere in the Dalles Formation indicate that animals such as rhinoceroses, giraffe-camels, hippopotami, elephants, bear-dogs, giant beavers, and pony-sized horses lived in the central Oregon countryside.

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Figure 2. Index Map of Cove Palisades State Park.

Scale in Miles
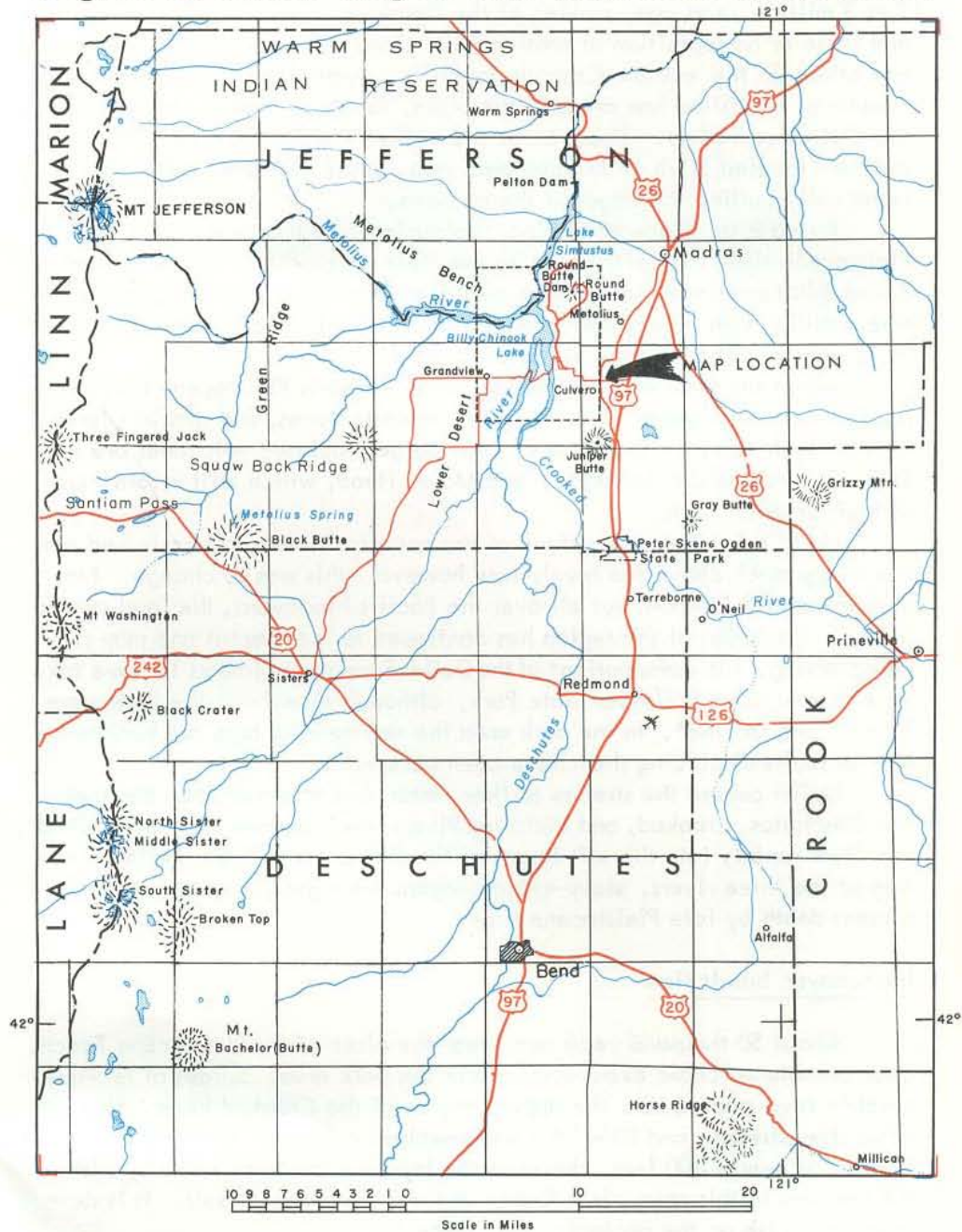
Pleistocene Epoch

At the end of the Pliocene Epoch or the beginning of the Pleistocene, 2 or 3 million years ago, sinking of the Deschutes basin gradually ceased, and little or no deposition or erosion took place. Then local volcanic vents, and others in the eastern Cascade foothills, erupted basaltic lavas which coalesced and filled low areas in the plain, forming a basalt capping over the Dalles sediments. These lavas are called the Rimrock basalt in this article (labeled QTrb on the geologic map, plate 1), since they characteristically outline the edges of the canyons.

Round Butte is one of the local volcanic vents that was active in early Pleistocene time; it contributed to the Rimrock basalt in the park area. Round Butte continued to build its shield, eventually culminating in explosive activity with the formation of two small summit cinder cones (indicated by pattern on QTrb of geologic map, plate 1).

Along the crest of the Cascade Range, in early Pleistocene time, explosive volcanism began to build lofty composite cones, and glaciers formed high on their flanks. Examples of these large glaciated volcanoes are the Three Sisters, Mount Jefferson, and Mount Hood, which still retain much of their original form.

Up to this time, the surface of the ancestral Deschutes basin had not been very much above sea level; now however, this was to change. Not only in central Oregon, but all over the Pacific Northwest, the land started to rise. Elevation of the region has continued to the present and may still be occurring. No deformation* of the Dalles Formation appears to have taken place in Cove Palisades State Park, although elsewhere the beds were folded* and faulted*. In the park area the sedimentary beds are horizontal and no faults displacing them have been observed.

Uplift caused the streams to flow faster and to erode deep channels. The Deschutes, Crooked, and Metolius Rivers, their courses now entrenched*, cut down rapidly into the soft layers of the Dalles Formation. At the junction of the three rivers, steep-sided canyons were gouged nearly to their present depth by late Pleistocene time.

Intracanyon basalt flow

About 50 thousand years ago, near the close of the Pleistocene Epoch, a remarkable volcanic event occurred in the park area. Surges of red-hot basaltic lava poured into the upper canyon of the Crooked River, flowed miles downstream, and filled the steep-walled valleys in the park area to a depth of nearly 800 feet. Because the lava was contained wholly within the canyons in this area, it is known as the Intracanyon basalt. It is designated as Qib on the geologic map, plate 1.

By the time the lava reached Cove Palisades State Park it was beginning to cool, and in the narrow canyon of the Deschutes, about 4 miles

Figure 3. View to the west taken from Round Butte summit. Mount
Jefferson to the left and Olallie Butte to the right.

Figure 4. View to the southwest from the summit of Round Butte.
Peaks are, from right to left, Mount Washington, Black Butte be-
hind Squaw Back Ridge, Black Crater, North and Middle Sister,
South Sister, and Broken Top. The canyons of Crooked, Des-
chutes, and Metolius Rivers are in the middle distance.

below the mouth of the Metolius, the sluggish end of the flow piled up to form a dam. As the river of molten rock continued to be fed from its source, its level rose behind the lava dam and backflowed 8 miles up the Deschutes and at least 4 miles up the Metolius canyon. Here, too, a damming took place and, with continued supply, a great pool of lava rose and flooded the canyon area to within 200 feet of the rims. The volume of lava filling the canyons is approximately one cubic mile.

From where did all this lava come? Surprisingly, the source was far to the south of Cove Palisades State Park. From its terminus, the Intracanyon flow can be traced up the Crooked River for 27 miles to the point where it entered the canyon 1.5 miles west of O'Neil (shown on figure 2). And yet, the probable source lies another 32 to 35 miles south in the vicinity of Horse Ridge, about 16 miles southeast of Bend, making the total distance traveled by this amazing lava flow come to more than 60 miles!

The erosive force of running water is not easily thwarted, and after the emplacement and cooling of the Intracanyon lava flow, the rivers proceeded to wear it away. The Deschutes and Metolius Rivers cut new gorges through it. Even the Crooked River, whose canyon contained the greatest obstruction, succeeded in carving its way completely through the Intracanyon basalt, reaching its original depth.

In Cove Palisades State Park, wedge-shaped remnants of the Intracanyon lava lie against the walls of the former canyon. The brownish-black, columnar-jointed basalt is in sharp contrast to the lighter colored Dalles beds. At the Island, also a remnant of the Intracanyon lava, the sheer basalt cliffs rising 450 feet above the lake give some idea as to the tremendous volume of lava that once filled the valleys and the powerful forces of erosion that have cut steadily through it.

Landslides

Most recent of the geologic processes at work in the canyons of the park has been landsliding -- the downward movement of large masses of earth and rock under the influence of gravity. Oversteepening of the canyon walls through downcutting by the rivers triggered these movements in the park area. The landslides (indicated by Qls on the geologic map, plate 1) occurred long before Round Butte Dam was built to form Lake Billy Chinook, which in effect has stopped river erosion. These masses of earth and rock now slope gradually out toward the center of the lake and represent fairly stabilized areas where the park facilities have been developed.

A Geologic Tour of the Park

Forearmed with the general geology given in the preceding section, the area should now be visited in its natural setting. The 12-stop tour will start at the top of Round Butte for an over-all view of the surrounding

geology; then proceed to points on the canyon rim; and, finally, move down into the canyons themselves.

As previously mentioned, the park and its several viewpoints can be reached from road junctions south of Madras, but it is preferable to start from Madras in order to take in the whole tour.

Whether you come into Madras from the north or the south, you will see a large green Highway Department sign pointing west toward Round Butte Dam and Cove Palisades State Park. Follow the sign and, in about 0.8 mile, turn right and follow Belmont Lane. A little more than 2 miles farther, the road dips into Dry Canyon. Where it climbs out on the other side of this valley there is a good exposure of cross-bedded, gray sandstone of the Dalles Formation. A short distance farther west, a road cut exposes the basaltic lava flows of Round Butte; you are now on the gently sloping flanks of this volcano whose summit, slightly to the left, is the immediate objective; coming abreast of the north side, you can see exposed in a quarry the dark-red cinders composing the cone.

About 7.5 miles from the starting point in Madras, the road descends a long grade. A power line crossing the road ahead warns of an approaching junction; turn left, as the signs indicate, and proceed south another 1.7 miles. Here is the entrance to the Round Butte Dam viewpoint, which will be by-passed for the moment to continue straight ahead for nearly a mile. At this spot turn left and drive up to the top of Round Butte.

STOP 1: At the top of Round Butte, 700 feet above the surrounding plain, the view is truly magnificent. More than 100 miles of the Cascade Range with its snow-capped volcanoes is spread along the western skyline. Mount Jefferson is closest and due west (figure 3). To the left, Three Fingered Jack, ravaged by glaciation, appears on the horizon, followed by Mount Washington with its pointed spire. The symmetrical cone, Black Butte (figure 4), shows only its apex, being obscured by Squaw Back Ridge. Next to be seen are Black Crater and the imposing peaks of the Three Sisters. Finally, in the distance is the glaciated cone of Broken Top, and to the left the summit of Mount Bachelor. All of these volcanoes were built during Pleistocene time and those showing the best conical form have been the most recently active.

By turning due south you can see Juniper Butte which, along with Gray Butte and Grizzly Mountain still farther to the left, is made up of John Day tuffs and flows. These buttes and mountains are erosional remnants that mark the main centers of volcanism in the area at that time. The original volcanoes were probably much larger than they are now. In spite of all the workings of erosion, they are still prominent highlands today.

The view from southeast to northeast shows the distant hills and ridges making up the western part of the Ochoco Mountains that continue far to the east to merge into the Blue Mountains of eastern Oregon. The visible mountains are composed mainly of John Day and Clarno Formations.

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Figure 5. Looking over Round Butte Dam from the viewpoint observatory.
Deschutes canyon and Lake Simtustus are beyond.

Figure 6. Crooked River and Deschutes River arms of Lake Billy
Chinook, separated by the Island on the left as seen
from the first, or northern, rim viewpoint.

Directly to the north is the large highland of the Mutton Mountains, composed also of John Day Formation rocks along with some of the Clarno Formation. The Mutton Mountains probably represent a large eruptive center which spread a great variety of volcanic products onto the area during John Day time. Mount Adams in Washington is visible, on a clear day, between the Mutton Mountains and Mount Hood.

To the northwest, in solitary splendor, is Oregon's highest peak -- that magnificent volcano, Mount Hood. Typical of the other peaks in the Cascade Range, its lofty cone was formed by the products of explosive eruptions and lava flows from a central vent.

Finally, in completing the circular view of the prominent features from Round Butte, there remains Olallie Butte (figure 3) several miles north of Mount Jefferson. This eroded volcano is capped by a knob called a plug dome, which resulted from the accumulation of viscous lava over the vent in the last stages of eruptive activity.
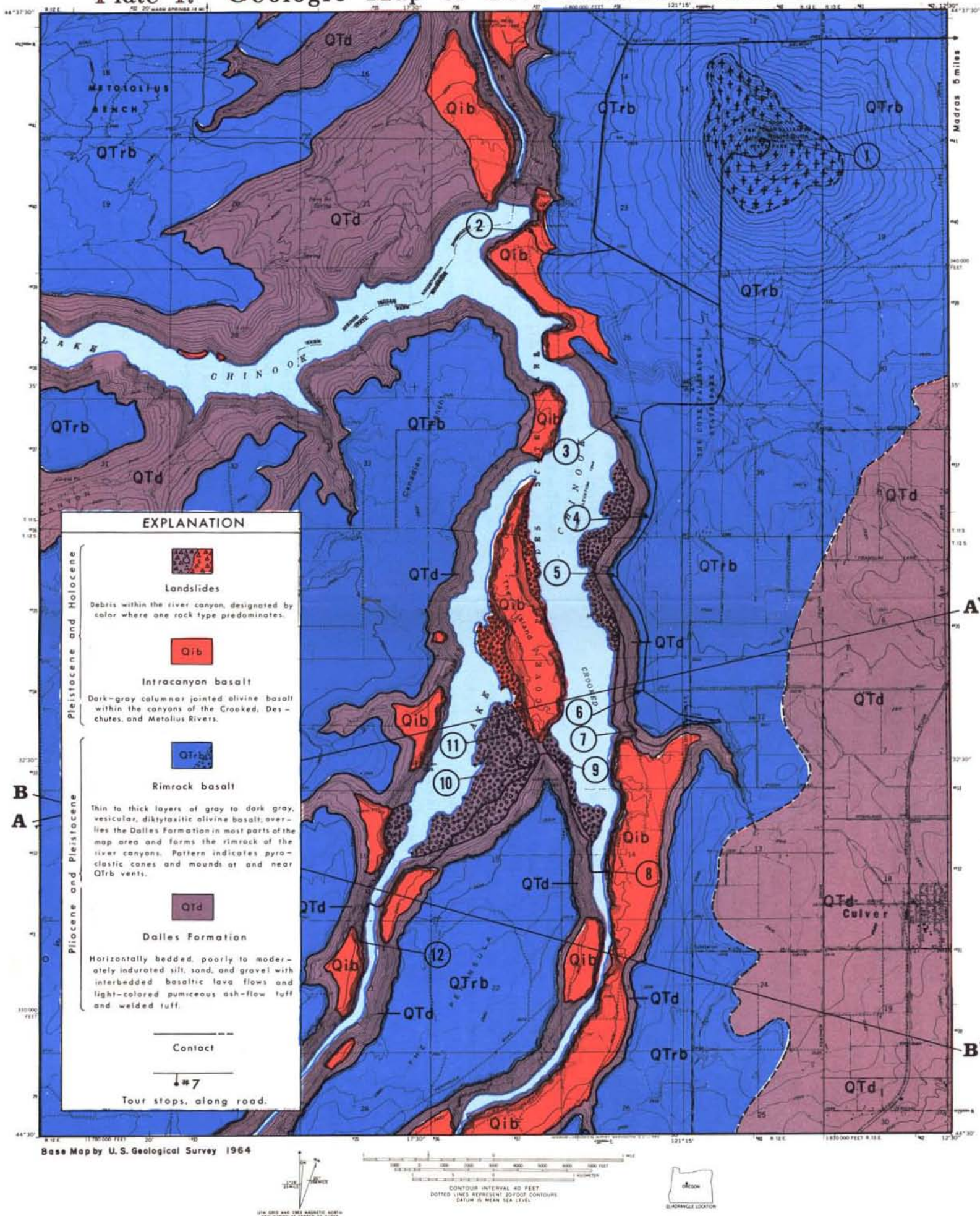
Below, and surrounding Round Butte for miles in all directions, is the plain of the middle Deschutes River basin. Basaltic lavas of Pleistocene age floor most of the basin and, although not well revealed from this vantage point, are cut through by the great canyons of the Crooked, Deschutes, and Metolius Rivers. The dark rims of these lavas sharply outline the excavations in the plain. From this over-all view of the surrounding country, the tour now leads down to the level of the plains and into the canyons below.

STOP 2: After coming down from the summit of Round Butte, turn right at the road junction and return to the Round Butte Dam viewpoint junction, a distance of about a mile, and continue on to the observatory overlooking the dam. Below is the first good view of the Deschutes canyon and the Metolius canyon to the left, now partially filled by the reservoir waters of Lake Billy Chinook. Downstream beyond Round Butte Dam are the still waters of Lake Simtustus backed up by Pelton Dam. A road leading down the right canyon wall to the base of the Round Butte Dam has cut through numerous beds of the Dalles Formation (figure 5). Halfway up, two brownish-weathering interbedded basalt flows are exposed.

Above the west end of the dam there is a wedge-shaped remnant of columnar-jointed basalt of the Intracanyon flow. Its top surface is on a level with the observatory, which also rests on a remnant of the Intracanyon flow. This bench-like surface extends around to a position above the east end of the dam and provides the footing for the powerline towers (figure 5).

STOP 3: The next objective after leaving the observatory is the first of four viewpoints located on the rim of the Crooked River canyon. Proceed again towards the Round Butte junction, turn right, and continue on the paved road for a total distance of 3 miles from the observatory. A small sign pointing to the right directs the way into the low-walled parking area. About 650 feet below is the wide Crooked River arm of Lake Billy Chinook,

Plate 1. Geologic Map of Cove Palisades State Park

EXPLANATION

Pleistocene and Holocene

Landslides

Debris within the river canyon, designated by color where one rock type predominates.

Qib

Intracanyon basalt

Dark-gray columnar jointed olivine basalt within the canyons of the Crooked, Deschutes, and Metolius Rivers.

Pliocene and Pleistocene

QTrb

Rimrock basalt

Thin to thick layers of gray to dark gray, vesicular, diktytaxitic olivine basalt; overlies the Dalles Formation in most parts of the map area and forms the rimrock of the river canyons. Pattern indicates pyroclastic cones and mounds at and near QTrb vents.

QTd

Dalles Formation

Horizontally bedded, poorly to moderately indurated silt, sand, and gravel with interbedded basaltic lava flows and light-colored pumiceous ash-flow tuff and welded tuff.

Contact

#7

Tour stops, along road.

Base Map by U.S. Geological Survey 1964

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

OREGON

QUADRANGLE LOCATION

(see page 162 for cross sections)

and to the left (figure 6) the first glimpse of the Island, a large remnant of Intracanyon basalt that separates the Crooked and Deschutes River arms of Lake Billy Chinook. This observation point is perched on the Rimrock basalt at an elevation of nearly 2,600 feet, while the surface of the Island, composed of Intracanyon lava, is 200 feet lower. Upstream in Crooked River canyon small peninsulas jut out into the water (figure 7); these are the tops of several of the landslides previously described under the Geologic History heading. Even the Island has not escaped this type of massive erosion, as shown by a large landslide visible at its center.

STOP 4: The second rim viewpoint is about 0.9 miles farther south on the Crooked River canyon rim. To the northwest, you can see the shore of the Metolius arm of Lake Billy Chinook framed by the Intracanyon basalt (figure 8). To the right, several interbedded columnar-jointed lava flows within the Dalles Formation are well exposed. Also in view is the capping Rimrock basalt, which probably had its source in Round Butte. To the left, across the lake, the landslide of the Island breaks the continuity of the vertical palisade* cliffs (figure 9). Below you is the hummocky landslide mass on which marina parking facilities are situated.

STOP 5: The third rim-rock viewpoint, about half a mile farther south, provides a view upstream into the Crooked River canyon. At this point you can see the vertical walls of the inner gorge cut into the Intracanyon basalt flow that filled the older outer canyon of the Crooked River (figure 10). The top of the Intracanyon flow in the Crooked River canyon matches that of the Island to the right, both having an elevation of about 2,400 feet. Also, from this vantage point can be seen the park entry road grading down to a hairpin turn and then following the level of the reservoir southward.

STOP 6: The most impressive view from this observation point is that overlooking the saddle between the Peninsula on the left and the Island on the right (figure 11). Light- and dark-colored sedimentary beds of the Dalles Formation, including at least two ash-flow tuffs, are exposed at the end of the Peninsula. A rock pinnacle called "The Ship," about halfway down the ridge, is an erosional remnant of an ash-flow tuff layer that caps dark-gray sandstones made of basaltic fragments. Visible through the saddle are the Deschutes canyon and Deschutes arm of Lake Billy Chinook. Benches formed by the Intracanyon flow are seen along the canyon. The lava that poured down the Crooked River pooled at the junction of the two rivers, and backed up into the Deschutes River Canyon.

While at this observation point, look up the Crooked River at the benches of Intracanyon lava; then sweep your view to those in the Deschutes canyon, over to the Island, and down the Crooked River as far as possible. When you mentally connect these features, you can imagine the

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Figure 7. Looking up the Crooked River canyon from the first rim
viewpoint. The basaltic lava mass of the Island is on
the right.

Figure 8. From the second rim viewpoint the shoreline and canyon
wall of the Metolius arm can be seen in the distance.
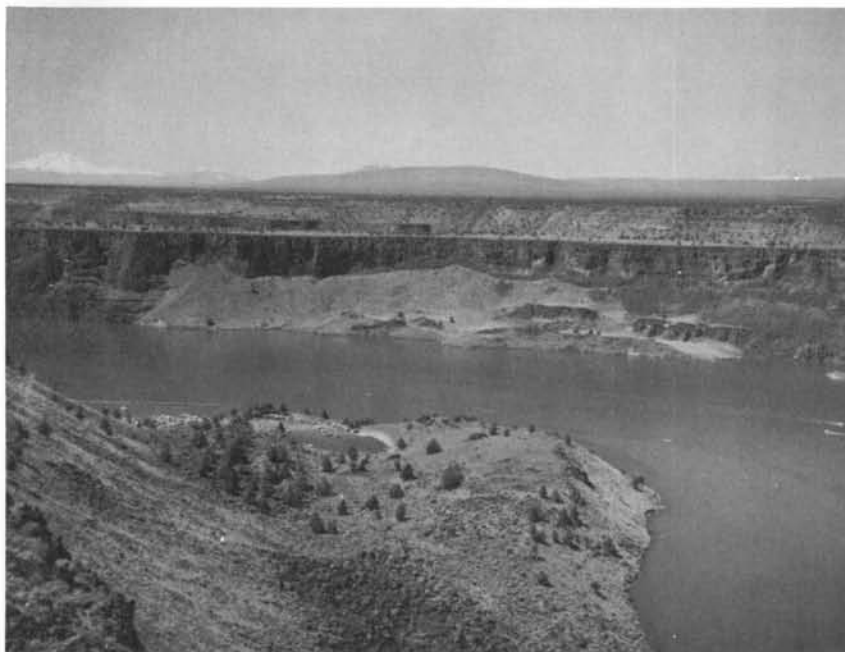The Island is on the left.

Figure 9. Landslide on the Island as observed from the second rim
viewpoint. Marina parking area in foreground.

Figure 10. View south up the Crooked River canyon from the third rim
viewpoint. Park entrance road is on the left.

Figure 11. Looking across the saddle between the Peninsula, left, and the Island, right, into the Deschutes River canyon from the fourth, or southern, rim viewpoint.

Figure 12. Contact between Intracanyon basalt on the right and Dalles Formation strata on the left, as seen from upper end of park entrance road.

immense lake of lava which once filled the ancestral Crooked and Deschutes River canyons. This black-crusted lake probably gave off fumes and steam for many years, since such a large volume and thickness of lava must have cooled slowly.

Also, directly below this viewpoint is the location of the former Cove Palisades State Park and the old hydroelectric plant, now drowned beneath some 200 feet of water.

STOP 7: After leaving the last of the rim viewpoints, the road winds about three-quarters of a mile to the junction with the park entrance road into the canyon. Turn right and travel slowly down the grade. On the left are the cultivated and irrigated benchlands on the surface of the Crooked River Intracanyon basalt flow. Various exposures of the Rimrock basalt are on the right. A sharp right turn opens to view the expanse of the canyon and reservoir.

As you descend the main park road into the canyon, you pass the layers of the Dalles Formation, which are well exposed in the road cuts. The top, or youngest, layer is a very light-gray, pumiceous sandstone probably deposited by wind. Next, a small, interbedded basaltic lava flow shows excellent columnar jointing; a buff-colored skin coats the weathered surfaces, but the fresh rock is dark gray to black. Typical of the Dalles Formation is the next lower bed, which is a thick, brown to dark-gray sandstone and conglomerate showing cross bedding.

At this point there is a space for parking to the left. Here, overlooking the nearby canyon wall, there is an excellent exposure of the contact between Dalles beds to the left and Intracanyon basalt to the right (figure 12). The sharp divergence between two types of rock resembles a fault, but is actually a line of contact where the younger lava flow rests against an older erosional surface (an unconformity*). The Dalles beds are freshly exposed along the road cuts to the left. A pinkish-tan ash-flow tuff layer contains lumps of pumice and crops out conspicuously in many places along the canyon walls of the Deschutes and Crooked Rivers.

Continue down the entrance road to the next rock unit beneath the pinkish-tan ash-flow tuff. It is a dark-gray sandstone derived from volcanic detritus. Beneath it there is another ash-flow tuff. It is about 30 feet thick, light gray in color, and contains large lumps of pumice. Next is a pebble-and-cobble conglomerate bed of dark gray color overlying a light-gray volcanic ash layer. Beneath this is another dark-gray pebble-and-cobble conglomerate. From here to the hairpin turn at the bottom of the slope the Dalles beds are obscured by rubble and slope debris of the landslide on which the park facilities are built.

STOP 8: After rounding the hairpin turn, the road follows along the shoreline of Lake Billy Chinook. Roadcuts show sandstones, conglomerates, and ash-flow tuffs comparable to those in the upper section. This is

approximately in the middle of the Dalles Formation, and the age of the rocks is estimated to be about 6 million years. The sheer cliffs of the Intra-canyon basalt rise above, and its contact with the layered sediments can be seen in numerous places.

About a mile and a half beyond the hairpin turn, a hill-like mass across the canyon can be seen protruding into the lake (figure 13). This is another landslide which has broken from the walls of the Peninsula behind it. The tilted beds show movement typical of a landslide block.

Just before crossing the bridge over the Crooked River arm of Lake Billy Chinook, the roadway offers an excellent view of the inner gorge of the Crooked River (figure 14). Thick remnants of the Intracanyon basalt stand above the water line on each side, attesting to the river's power to cut directly through this resistant rock in order to maintain its course.

STOP 9: After crossing the bridge, proceed up the road over the back of the landslide previously mentioned toward the saddle between the Penin-sula and the Island. Park at the convenient spot available for the first close view of the thick Intracanyon basalts of the Island (figure 15). The pali-sade cliffs, some 450 feet high, are a good example of a complex cooling pattern in basalt. The curved pattern is due to the ponding, back-flowing, and intertonguing of the lava as it congealed, and the columnar jointing is a result of cooling and contraction of each flow unit.

As you continue over the crest of the saddle, there is an interesting rock on the left side of the road. It is a large basalt boulder displaying petroglyphs which were carved into its surface by prehistoric Indians.

STOP 10: About 500 feet farther along the route, a side road enters from the right. Stop here for a view back toward "The Ship" and a section of the Dalles Formation (figure 16). This is part of the same series of rock layers encountered on the park entrance road. Beginning with the pinnacle of "The Ship," there is a remnant of the pinkish-tan ash-flow tuff; below it is the dark-gray sandstone and, in descending order, the thick, light-gray ash-flow tuff; the dark, sandy conglomerate beds; and, at the bottom, a thin, light-gray volcanic ash layer. The pinkish-tan ash-flow tuff pro-vides us with an excellent "marker" bed for our correlation.

The terrain on this side of the saddle is part of an immense landslide in the Deschutes canyon. This landslide, with the help of a smaller one on the Crooked River side, has produced the gap or saddle between the Island and the Peninsula. The slide is about 2 miles wide, as shown on the geo-logic map (plate 1). Even though the surface is hummocky, it provides suf-ficient level land for development of the overnight campground, parking, boat launching, and other recreational conveniences.

STOP 11: Drive northward a short distance down the side road to a parking spot at a pumice pit on the left for the best view of the north end

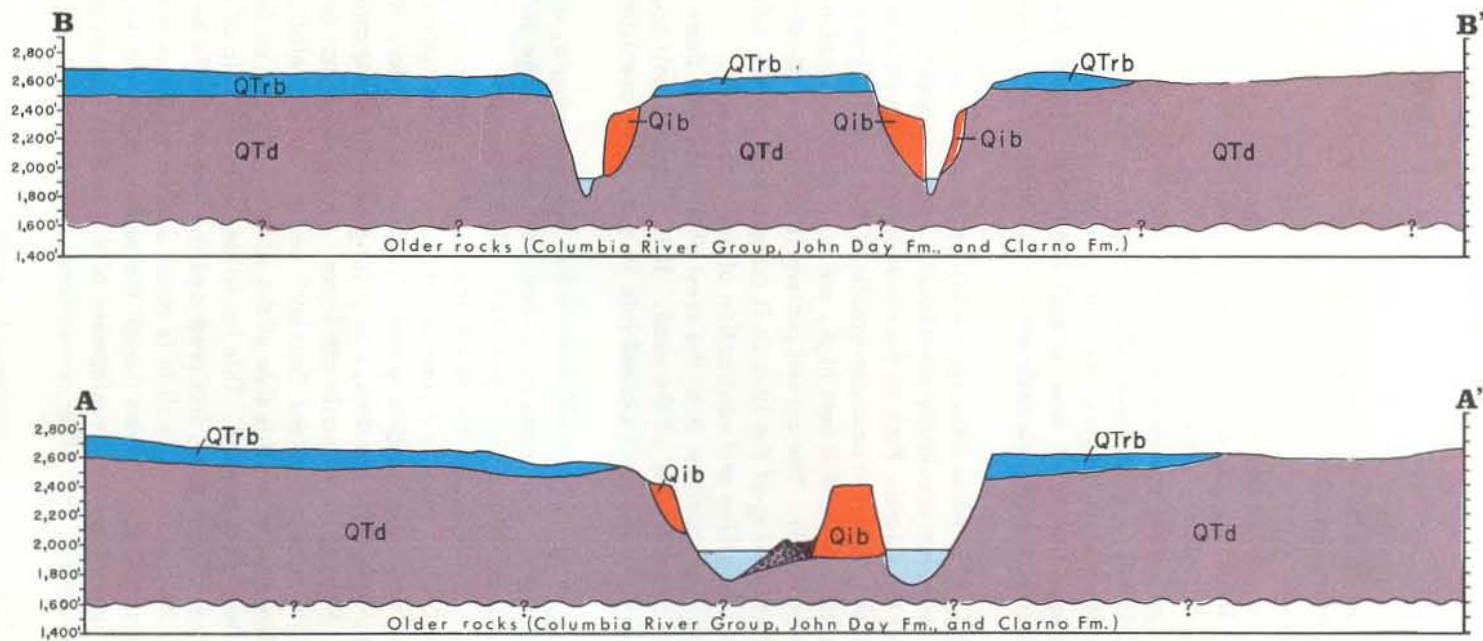# Plate 2. Geologic cross sections for Cove Palisades State Park

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Figure 13. Tilted beds in a landslide seen across the Crooked River arm. The Peninsula is in the background.

Figure 14. The Crooked River gorge from the bridge crossing.

Figure 15. Palisade cliffs of the Island as seen from below the saddle.

Figure 16. "The Ship" stands as a prominence to the left at the end of the Peninsula. The thick, light-gray layer is ash-flow tuff.
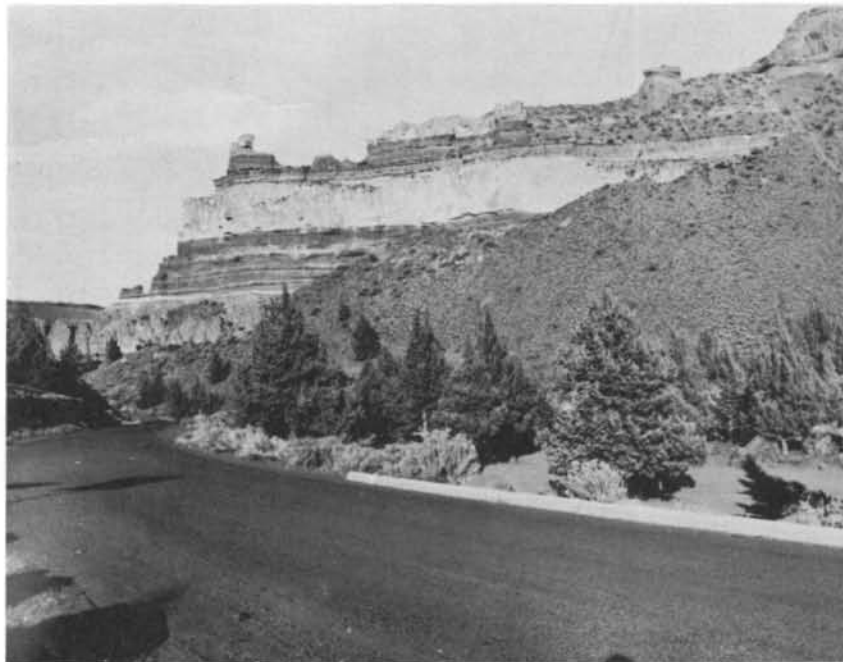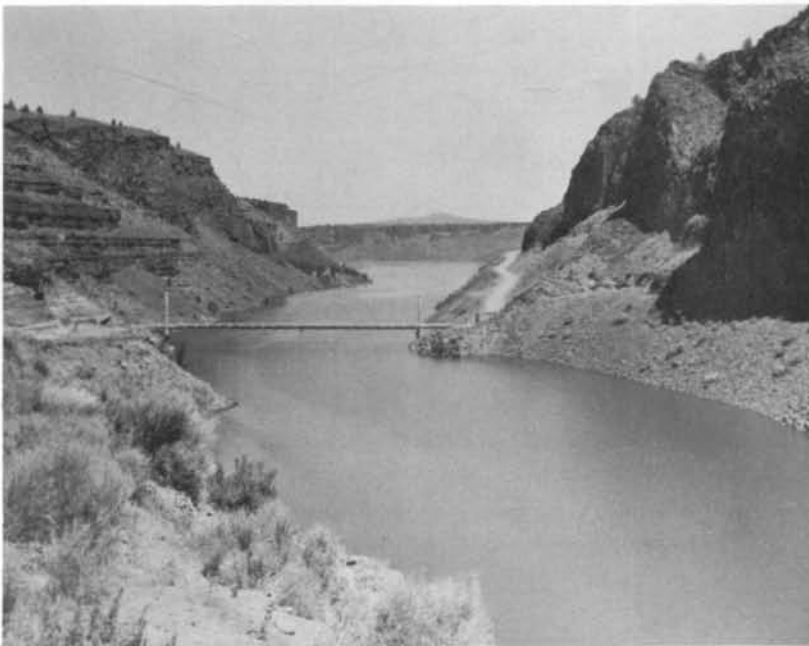
Figure 17. Looking at the northern end of the big landslide in the
Deschutes River canyon. On the right is the Island.

Figure 18. The view is northerly down the Deschutes canyon from the
first hairpin turn above the bridge. Round Butte is visible
in the background.

of the big landslide (figure 17). Here a large section of the thick basalt lavas of the Island has slumped down from the canyon wall, reducing itself to a huge pile of rubble. It is a fine example of the geologic process called mass wasting, a gradual downhill movement of material under the force of gravity, aided by the oversteepening of the canyon wall by the past erosive action of the river.

Return to the main road, turn right, and after reaching the end of the pavement continue over the well-graded gravel road into the steep-walled Deschutes canyon. On the opposite canyon wall sedimentary layers of the Dalles Formation are well exposed. Many beds which are better consolidated and more resistant to weathering than others stand out as ledges. Visible again are the perched wedge-like remnants of the Intracanyon basalt and their unconformable contacts with the underlying Dalles beds.

STOP 12: Cross the bridge over the Deschutes River arm of Lake Billy Chinook, and notice the typical sandy and conglomeratic beds of the Dalles Formation in road cuts. On reaching the first switchback, about a third of

Figure 19. Dalles Formation beds in contact with Intracanyon basalt to the left, seen from the same location as that of figure 18. Light-colored bed slightly above center is ash-flow tuff.

a mile south and above the bridge, stop at a roadside parking strip for a view to the north down the narrowed canyon of the Deschutes (figure 18). On the right and left are massive columnar-jointed remnants of the Intracanyon basalt.

Directly east across from this position there is an excellent view of the contact between the Intracanyon basalt and layered rocks of the Dalles Formation (figure 19). A pinkish-tan ash-flow tuff layer is visible nearly halfway down the canyon wall. It appears to be our favored "marker" bed seen before at "The Ship" and on the park entrance road.

Another unconformable contact of the Intracanyon basalt is visible just above this parking spot. Basalt is lying against gravelly slope wash, which was present on the canyon wall at the time the lava flowed over it. A reddish baked zone at the contact shows the influence of heat from the lava flow.

This ends the geological tour of the Cove Palisades State Park; but we hope that you will follow the tour in reverse on your return trip to the canyon rim and Madras in order to review and remember better the sequence of events that formed this unique geological area.

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reconnaissance geologic map of the central portion of the High Cas-
cade Mountains: Oregon Dept. Geology and Mineral Ind. map and
text.

Glossary of Geologic Terms

Andesite-Medium- to light-gray igneous rock usually extruded as lava flows
but also occurring as fragmental products from release of gases during
explosive volcanic activity.
Basalt- Black to gray igneous rock generally extruded as lava flows. Often
shows blowholes and is then called vesicular basalt.
Columnar jointing-Shrinkage cracks produced by cooling of a basalt flow,
forming a hexagonal pattern on the surface and columns in side view.
Conglomerate-Rounded, water-worn rock fragments, such as pebbles, ce-
mented together.
Consolidated-Compacted or cemented to form solid rock; for example, con-
solidated sand is sandstone.
Dacite-Light-colored igneous rock found as thick lava flows but more com-
monly as fragmental products such as ash and pumice.
Deformation-Any change in the original form of a rock mass, such as a
movement along a break (fault) or a bend (fold).
Entrench- To erode downward, as a stream cutting a gully or canyon in its
former valley.
Fault- A break in rock where one side has moved in relation to the other.
The amount of displacement can vary from a few inches to miles.
Fold-A bending of rock as a result of earth pressures. Best seen in layered
rock.
Formation-A large and persistent stratum of one kind of rock that can be
mapped as a geologic unit.
Magma-The mixture of molten rock constituents and dissolved gases existing
at depth. On erupting at the surface, it forms lava flows and frag-
mental products such as ash, cinders, pumice, scoria, and bombs.
Palisades-A line of bold cliffs, generally composed of basalt and showing
columnar structure.
Rhyolite-An igneous rock of light color similar to dacite. Forms very thick
lava flows encrusted with the volcanic glass called obsidian. Most
often, it is erupted in the form of ash and pumice.
Tuff-Deposits of ash and pumice that have become compacted into rock.
Some tuffs are very resistant to erosion. Others are soft and wear
down easily.
Unconformity-A surface of erosion, representing a lapse of time, separating
younger rocks from older ones. Usually seen as a line in cross section.

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AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev.1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev.1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch . .	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass .	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole, editor	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor . . .	2.00
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre .	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00

GEOLOGIC MAPS

Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . .	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37) .	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker . . .	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts . . .	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams . .	1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka . .	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka . .	1.50
Geologic map of Oregon west of 121st meridian: (over the counter) . . . . folded in envelope, $2.15; rolled in map tube, $2.50	2.00
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat . folded in envelope, $2.25; rolled in map tube, $2.50	2.00

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Available Publications, Continued:

SHORT PAPERS

2.	Industrial aluminum, a brief survey, 1940: Motz	.$ 0.10
18.	Radioactive minerals the prospectors should know (2nd rev.), 1955:	
	White and Schafer.	0.30
19.	Brick and tile industry in Oregon, 1949: Allen and Mason	0.20
20.	Glazes from Oregon volcanic glass, 1950: Jacobs	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Mason	0.25
23.	Oregon King mine, Jefferson County, 1962: Libbey and Corcoran. . . .	1.00
24.	The Almeda mine, Josephine County, Oregon, 1967: Libbey	2.00

MISCELLANEOUS PAPERS

1.	Description of some Oregon rocks and minerals, 1950: Dole	0.40
2.	Key to Oregon mineral deposits map, 1951: Mason	0.15
	Oregon mineral deposits map (22" x 34"), rev.1958 (see M.P.2 for key). .	0.30
3.	Facts about fossils (reprints), 1953	0.35
4.	Rules and regulations for conservation of oil and natural gas (rev. 1962)	1.00
5.	Oregon's gold placers (reprints), 1954.	0.25
6.	Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . .	1.50
7.	Bibliography of theses on Oregon geology, 1959: Schlicker	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . . .	0.50
8.	Available well records of oil & gas exploration in Oregon, rev.'63: Newton .	0.50
11.	A collection of articles on meteorites, 1968: (reprints, The ORE BIN) . .	1.00
12.	Index to published geologic mapping in Oregon, 1968: Corcoran	Free

MISCELLANEOUS PUBLICATIONS

Oregon quicksilver localities map (22" x 34"), 1946	0.30
Landforms of Oregon: a physiographic sketch (17" x 22"), 1941	0.25
Index to topographic mapping in Oregon, 1968	Free
Geologic time chart for Oregon, 1961	Free

OIL and GAS INVESTIGATIONS SERIES

1.	Petroleum geology of the western Snake River basin, Oregon–Idaho, 1963:	
	Newton and Corcoran.	2.50
2.	Subsurface geology of the lower Columbia and Willamette basins, Oregon,	
	1969: Newton	2.50

The
Ore Bin

OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

MINERAL RESOURCE INDUSTRY -- A NATIONAL DILEMMA

Everyone involved with the mining and petroleum industries, either
directly or indirectly, is aware of the mounting concern by the gener-
al public with the possibly deleterious effects of mineral exploration
and development on the environment. Oftentimes the outcry about
"desecration of the land" is not based on actual knowledge of a spe-
cific mining activity.

The mineral resource companies are faced with a true dilemma;
they are being subjected to increasing governmental restraints and
regulations because of the nature of the work they perform while, at
the same time, people continue to want more and more manufactured
goods which originate in a "hole in the ground." These companies
are trying to develop a greater awareness on the part of the public of
the problems faced by the industry in providing the necessary raw ma-
terial required by our technological society.

Three magazine articles received by the Department during the
past few months discuss different aspects of mineral resource devel-
opment. Excerpts from them are printed below. These articles are
by men who are involved with various phases of mineral conservation
and who show that they have given thoughtful attention to this com-
mon area of concern. The first report is taken from a news release
by Hollis M. Dole, Assistant Secretary of the Interior for Mineral
Resources. The second item appeared in an article by George Mow-
bray, who is Director and principal of Stevenson & Kellogg, Ltd.
of Canada. The last article is part of a report written by Samuel S.
Johnson, President of Jefferson Plywood Co., Redmond, Oregon.
Mr. Johnson served on the Advisory Council of the Public Land Law
Review Commission. The full report of the Commission was published
in June 1970 and contains 18 recommendations of basic principles
to guide future policy concerning the public lands.

These three articles deserve thoughtful and serious attention.
The points brought out in them will eventually have to be recognized
by all of us -- the general public, the governmental agencies, and
the mineral resource industries -- if we are ever to develop a bet-
ter understanding of our mutual problems.

R.E.C.

MINERAL RESOURCE DEVELOPMENT*
by Hollis M. Dole

Among all the peoples of the world, we in the United States enjoy the high-
est average standard of living. That standard is based on our consumption
of an extraordinary volume and variety of minerals and mineral products.
If we expect to maintain and improve that standard, we must first insure
that our essential mineral needs are met. And they must be met at costs
that are in line with other material and service costs.

Even the most conservative projections of mineral consumption and
requirements indicate that assuring future supply will require new discover-
ies and far more efficient extractive and processing technologies than we
have today. Our own population is expected to total about 320 million by
the beginning of the next century and that of the world should reach the $6\frac{1}{2}$
billion mark by then. Right now, we have only 6 percent of the world's
population but consume nearly a third of the world's minerals. If the esti-
mates prove correct we will have only about 5 percent of the world's popu-
lation in the year 2000, but the total number of people in this country will
have increased by one third and the world total will be almost twice what
it is today.

Two conclusions are inescapable. First, our requirements for raw ma-
terials and energy in this country will mount rapidly over the next three
'decades. Second, throughout the world, competition for the resources that
supply these basic necessities will increase enormously.

Already the gap is widening between the percentage of our mineral
requirements that we are able to supply domestically and that which we
must obtain from sources outside our boundaries. "Able" and "must" are
highly significant words in this context. They represent the consequences
of a choice that we have made.

During World War II our economy began to expand very rapidly and
it has been zooming right ahead ever since. This rapid growth demanded
a correspondingly large increase in mineral supply. But two world wars and
the tremendous industrial development that made us a major world power
had already skimmed much of the cream from our domestic mineral crop. It
became clear that our burgeoning requirements would have to be satisfied
either from our own domestic resources, which were diminishing in grade,
or from richer foreign sources which, at that time, were eager to attract
American capital.

The rapid industrialization that has occurred outside the United States
in the past two decades has stimulated increased per-capita demands for
minerals abroad. Although these per-capital rates are still far below the
levels here at home, they are rising more rapidly than ours. And, as

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* Excerpts from U.S. Dept. of the Interior news release, March 9, 1970.

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industrialization gains momentum elsewhere in the world, the terms of trade for the United States are worsening. We no longer get the kind of deals we used to. Take, for example, the rise in host-government revenues from oil.

Moreover, the number of domestic mineral producers with the financial resources needed in shifting to foreign sources -- or, for that matter, in conducting research on the necessary scale -- is limited. As a result, many of our smaller producers have found themselves captive to a declining resource base and a relatively static technology.

This problem is compounded by the fact that it confronts us at a time when we are becoming acutely aware of the necessity for assuring optimum use of our land surface. The projected growth of our population will generate increased demands on the fixed quantity of land that we have. More land will be needed for growing food, more for living space, and more for recreation. The pressures already are intense enough in some parts of the country that the prices being asked for the land, in themselves, are so high as to preclude the profitable development of any minerals it might contain. Those pressures can only increase.

Not only do we need a technology that will enable industry to extract and process lower grade resources at reasonable monetary costs; we also need -- and need desperately -- mining and processing systems that are low cost in terms of insult to the environment in which we all must live.

President Nixon has launched an intensive Federal effort to rescue our environment from the menace of pollution. It is "now or never," he has said. Clearly, we must begin the rescue within this decade or it will be too late. Time will run out on us. The President, accordingly, has begun the process of reordering our national priorities. Under his leadership the government this year will spend more on human resources and the improvement of our environment than on national defense. This is the first time that has been done in two full decades.

The national determination to have a quality environment carries grave implications for the industries that supply us with essential minerals and fuels. The technology utilized by these industries was originally designed to provide large volumes of raw material at low and stable prices over long periods. This it has done and done well. But that same technology has been predicated too often on the mistaken belief that costs could be avoided by using the air, the water, and the land as giant sinks for the dispoal of mining and processing wastes. The costs weren't really avoided after all. They were merely deferred. As Secretary Hickel has put it: "We carelessly assumed that Nature could absorb unlimited punishment. Now, we have to pay the bill."

We have a lot of expensive cleaning up to do. But the real challenge lies ahead of us. Developing a mining and processing technology that is wholly compatible with our growing demands for environmental quality and at the same time capable of supplying an adequate share of our mineral

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requirements from resources that are diminishing in grade will present a monumental task. It has been considered more or less axiomatic, for example, that the lower the grade of the material being mined the more waste will be generated in the process. And the average grade of our domestic mineral deposits is diminishing. If we hope to get more out of less -- as we clearly must -- without further punishing our environment, we urgently need new and better extractive and processing methods ... methods that drastically reduce waste......

An adequate and dependable supply of minerals and fuels is essential to our economy, our security, and our industrial and social advancement. And we must assume further that a substantial share of that supply should be derived from the development of our own domestic resources.

The global nature of mineral supply and demand precludes the advocation of a complete self-sufficiency policy. Such a policy would serve neither our own interest nor that of the world trading system of which we are such an important part. And even if it would, we simply could not adopt it. We are not that affluent in all the materials that we must have. Already we depend on imports for many vital commodites and if we are to be realistic we must expect that dependency to grow.

Conversely, we produce surpluses of certain mineral commodities which, in our own interest, must compete successfully in world markets. Clearly then, we must continue to seek -- on mutually favorable terms -- access to foreign sources of minerals and fuels that are not available from domestic deposits at costs that we can afford.

The laws relating to mineral development on public lands are in many respects antiquated and are currently under review and in that process the need for being able to anticipate developments well ahead of time has become abundantly apparent. Every scrap of information that bears on the problem of obtaining the maximum beneficial use of our public lands in the public interest has been eagerly sought and carefully studied by the Public Land Law Review Commission. Even so, the Commission has encountered many difficulties in achieving the kind of long-range review it must have in making its recommendations. Here again, we can glimpse the future only as "through a glass darkly," because we have not yet developed the capabilities the Government must have if it is to play its role well.

Minerals represent the basic material strength of the United States, and every one of us has an immense stake in assuring that we have them in adequate quantity and variety. Each of us also shares to some degree the responsibility for guaranteeing that stake. The Federal responsibility as I have defined it incorporates anticipation of need and planning to meet it, encouragement and provision of information to State and local governments and to industry, and, when absolutely necessary, regulation in the public interest.

State and local governments have similar responsibilities and similar roles to play, though on a more limited scale. Industry has a responsibility

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to supply the goods and services the public needs and to do so in a fashion and at a cost the public can afford. Financial institutions have a responsibility to invest the monies entrusted to them by their clients in activities that are compatible with the public and the National good. It is time now for a reinvestment in America's future.

President Nixon has said that one of the central themes of his New Federalism is "a willingness to return power to the people and dignity to the individual, through financial help to State and local governments and renewed reliance on private, voluntary action."

For many decades now power has been flowing from the people to the Federal Government and with that power has gone responsibility. If the flow of power is now to be reversed, so also must be the flow of responsibility. State and local governments, private industry, and private citizens must be ready and willing to accept greater responsibility if ours is to remain a free society, fully capable of self determination.

MINING INDUSTRY -- PROSPECTS AND CHALLENGES*
by George Mowbray

My opportunity to reflect on the long-term future of mining implies the need for prophetic vision more akin to the mysticism of theology than the science of man. This suggests the desirability of my having a text for this sermon. To find a text I turned to the bible of mining, Georgius Agricola's famous De Re Metallica. Published in the 1550's, this work stood for nearly 200 years as the basic reference book. Let me quote from the first lines in the first chapter -- the genesis as it were, of the mining scripture. Agricola began with these words: "Many persons hold the opinion that the metal industries are fortuitous and that the occupation is one of sordid toil, and altogether a business requiring not so much skill as labour. But as for myself, when I reflect on its special points one by one, it appears to be far otherwise."

Far otherwise indeed. The major problems challenging the industry seem to me to be no longer financial, geophysical or technological but social -- problems of the human environment to which the industry must adapt or perish as a free enterprise system. On the resource side, and in technology, prospects are bright indeed. But the ability of the mining industry to capitalize on these prospects can be summed up, I think, in very basic human, social terms.

The society is calling for new forms of leadership in mining. My belief is that if these are not forthcoming from within the industry, they will be imposed from without. And the greater the outside injection of directives on resource allocation, the smaller will be the opportunities and

* Western Miner, July 1969.

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rewards to the industry as a private business operation. The trend, in short, now appears to be towards the gradual extinction of mining as a private sector of the provincial and national economy of this country.

We have witnessed the growing worldwide pressure for industrial development to fulfill the long-frustrated aspirations of the poor nations. The more mature economies have great and expanding resource needs, too. This will ensure a steadily rising long-term demand for all minerals, whether for energy or direct industrial use. The earth's crust will have increasing difficulty meeting these needs. As a result, real prices for most minerals will rise. Marginal producers will make marginal or standard profits, but the rewards for the occasional rich strike will become even greater. This is a heady vision. It is one worth pursuing far more skillfully and more subtly than the way the mining industry's leaders are now going about it.

Because of growth in the oil industry and in building materials -- which are unfortunately included in our present statistical definitions of the mining industry -- Canadian mineral production has been rising in relation to over-all national output since the war. It is still not as large, relatively, as it was in 1937. However, if we take metallics and nonmetallics only, these core sectors of the industry are even now barely holding their own in relation to expansion in other industrial sectors. The 1968 value of mineral production in these two major categories was about $2.7 billion, or equivalent to about 4 percent of Canada's Gross National Product. This figure has not changed since 1950, and in 1937 it was 7 percent, almost twice as great.

Even now, close to a million and a half people are employed in manufacturing. If we exclude coal mining, employment in the metallics and nonmetallics is only about a hundred thousand. The voices and votes of the urban centres, the city people as distinct from the mining people, are clearly stronger. They will tend to become even more so in the future. The ways in which mining supports the other sectors such as transportation and manufacturing are not well known. Indeed, a substantial portion of Canadians profess to know very little about the mining industry -- even the people who live in mining communities.

What I am trying to say without going into a long disquisition on the economic history of the western world is rather simple: mining in Canada is likely to become less important economically, socially and politically in the next generation than it is now -- despite a huge absolute growth. This is an extremely important point. If we couple it with the changing climate for business in general, then I believe we can see some real challenges for the industry to overcome. Let's begin by touching briefly on some of the sources of actual or potential public hostility to the industry as it now appears to operate.

Since most mining operations are a long way from the major centres of population and influence, it's a case of "out of sight, out of mind." The industry also seems to be made up of several quite distinct groups of

people -- the prospectors, the miners, and mine managers, scientists of
various kinds who operate in the field, and shadowy figures at head offices
in Toronto or New York who watch over things and make the important de-
cisions. The public could be forgiven for thinking that the industry has
many faces, not all of them scrubbed and wholesome. This set of conditions
poses an enormous communications challenge.

To many people, mining may well appear to be a not particularly
creative business -- risky mainly in the early stages of exploration and de-
velopment and when established requiring little real entrepreneurial skill.
The fact that some mining companies make very handsome profits does not
do anything to dilute such impressions. Then too, the resources are in the
ground; it's not for nothing that the Mexican government calls its depart-
ment of mines the "department of the national patrimony." There is always
a latent pressure, because of these and other factors, for greater social
control, more taxation, and so on -- so the people will get back something
of "their" resources via the coffers of their governments. When the mining
company is American, British, Japanese, etc., the rationalization becomes
even easier. Of course, the resources are useless if they are not discovered,
mined, processed and sold, but this point is easy to overlook. Development
of mining investment may well be inhibited by future emotionalists of a
nationalistic type. You are thus challenged to explain and rationalize
the structure of the industry or lose control over the way it operates.

The moral and ethical issue remains to haunt the senior leaders of the
mining community. You cannot just ignore the situation and take your own
little fliers now and then. The challenge is to get behind stock exchange
reform and effective disclosure rules -- despite the fact that it means sup-
porting further government intervention in business. There is also the ques-
tion of the professionals who turn out geological reports for penny stock
promoters. Should we not be controlling such people through social pres-
sures, through professional engineering and other associations?

In recent years, the mining industry has paid much attention to pollu-
tion. I do not wish to say whether or not it has paid enough attention. My
point is that I believe that public will more and more demand that business-
men return nature to the people, unspoiled. Socially and politically, more
than in terms of health or economics, the challenge is to go the extra half-
mile on this issue, and to tell the public that you are doing so. In this
connection, we might also note that the concept of "health" is becoming
narrower every day. Scientific research is always finding new ills and new
causes of illness. We need not expect to escape these tentacles of science
-- pollution will become defined as being more and more dangerous to
health every year regardless of the level of pollutants.

Attacks on the mining industry by public figures and journalists are
not, I am afraid, just the random thoughts of isolated individuals. Behind
these speakers and writers is a rising class of influential intellectuals who
are basically hostile to mining. They include economists, sociologists,

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political scientists, resource development planners -- all educated and in-
spired to help us find new and better formulas for operating our industrial so-
ciety. The old slogans about capitalism and socialism are no longer rele-
vant. The new approach is for closer integration of government and busi-
ness in the achievement of recognized social goals. Planning has become
a key word. The French equivalent, planification, often appears in the
studies leading to the establishment of Quebec's new instrument of govern-
ment participation in mineral exploration and development in that province.
Behind such concepts are ambitious theorists from the latest generation of
crusading university graduates in the social sciences.

Exploitation is being revived as a witch word in the North American
economy. Instead of being bandied about by street corner orators it is be-
ing brandished by mobs. The student radicals of this country and the United
States can be expected to move off campus and start attacking other estab-
lished institutions. You do not have to think very hard to see that the
mining industry is an ideal target because of its isolated manifestations
and the conditions of some of its northern communities.

In the past, the mining industry has not hesitated to ask for the support
and financial assistance of provincial and federal governments. Often this
has been forthcoming. The general economic and legal climate is still quite
favourable. But it seems to me that the revolution in the concept of plan-
ning for economic development is going to change this situation. We
must expect that over the next generation our governments will feel not only
morally entitled but intellectually qualified to tell the mining industry what
it must do. The end of the road of failure to deal with this changing intel-
lectual climate is some form of nationalization and loss of control over both
exploration and investment decisions. The ultimate challenge, therefore,
is to survive. The best method now appears to be involvement rather than
combat. Perhaps we can stake out some strategies for the industry in this
forthcoming adagio dance with our new partners.

The main step required is perhaps the most difficult one for the tra-
ditional leaders of an individualistic product-oriented industry. It is just
this: We have to decide to recognize the fact that mining is part and par-
cel of the social structure of the provinces and the nation. A key role of
the future mining executive will thus be a social one, fully as important as
his business role. In fact, these two roles will be combined, as we shall see.

FOOD FOR THOUGHT IN LAND LAW REPORT: MINERALS*
by Samuel S. Johnson

In its general discussion of mineral resources on public land, the [Public
Land Law Review] Commission notes that our standard of living and our
national defense are wholly dependent on the availability of fuel and nonfuel
* NAM Reports, July 20, 1970

minerals. National requirements for these products are an essential factor in the development of a national policy for mineral development on our public lands. Our industrial dependence on the production of fuel and non-fuel minerals is more significant than the monetary value they contribute. Many factors we take for granted in our standard of living would be impossible without reliable and economic supplies of minerals. Likewise, our survival as a leading nation depends on our mineral supplies.

"As our demands for minerals have grown, we have become more dependent on foreign sources of supply. Over one-third of our mineral supplies are imported. This reliance on foreign sources may well increase according to current indications. Experiences in Peru, the Middle East, and elsewhere demonstrate that total reliance on foreign sources would be a hazardous economic and political policy. We strongly favor, therefore, an overriding national policy that encourages and supports discovery and development of domestic sources of supply."

The report asserts that public land mineral policy should encourage exploration, development and production of minerals on the public lands. Over 64 million acres of Federal land were under lease for oil and gas in 1968. Substantial deposits of coal, phosphate and sodium compounds are also known to exist in public land areas and some are under lease. In 1965, the western public lands states in which over 90 percent of the public lands lie produced over 90 percent of the nation's domestic copper, 95 percent of the mercury and silver, 100 percent of the nickel, molybdenum potash, and about 50 percent of the lead. In fact, most of the known domestic resources of metallic minerals other than iron are situated in the West.

Present knowledge about the geology of mineralization in the United States, combined with the geographic pattern of established mining districts, indicates a strong probability that the public land areas of the West generally hold greater promise for future mineral discoveries than any other region.

"Consequently, we have concluded that it is in the public interest to acknowledge and recognize the importance of mineral exploration and development in public land legislation. Also, a decision to exclude mineral activity for any public land area should never be made casually or without ádequate information concerning the mineral potential. Mineral exploration and development should have a preference over some or all other uses on much of our public lands."

To justify this conclusion, the commission points out that, as a land use, mineral production has several distinctive characteristics. Mineral deposits of economic value are relatively rare, and, therefore, there is little opportunity to choose between available sites for mineral production, as there often is in allocating land for other types of use. Also, development of a productive mineral deposit is ordinarily the highest economic use of land.

Mineral production requires less surface area than most other land uses.

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For example, in 1966 Arizona was the western state in which mining was conducted over the largest area. Nevertheless, only 0.13 of one percent of the state's area was actually used for this purpose. Therefore, a use preference is warranted by nature's sparse and random distribution of valuable mineral deposits and the vital relationship between our national welfare and uncertain supplies of minerals. Furthermore, a worthwhile mineral deposit is usually concealed and becomes available to meet our national needs only as a result of an expensive, long-term and high risk search effort.

"The Federal Government generally should rely on the private sector for mineral exploration, development, and production by maintaining a continuing invitation to explore for and develop minerals on the public lands. We are satisfied that private enterprise has succeeded well in meeting our national mineral needs, and we see no reason to change this traditional policy." The commission goes on to say that existing Federal programs to develop nationwide geological information should be continued and strengthened, and that these Federal programs should serve to identify general areas favorable to mineral occurrence with detailed exploration and development left to private enterprise.

The report states that the commission does not favor opening national parks and monuments to mineral development. However, it does recommend that, in connection with consideration of statutory exclusion of mineral activity from designated public land areas, Federal agencies should make mineral examinations which will provide reliable information concerning their mineralization. Too often in the past exclusions have been accomplished with little or no knowledge of mineral values.

The report also urges the establishment of a program to determine the extent of mineralization of public lands where mineral activities are presently excluded, but mineralization appears to be likely. "Even though we oppose opening these areas to development, the resulting information would be of substantial value for the identification of standby reserves that might be needed in national emergencies."

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MAP OUTLINES FEDERAL LANDS

A new map prepared by the U.S. Geological Survey shows the distribution of federally owned lands in the United States. The 19 x 28-inch multicolored map outlines 17 different categories of lands administered or held in trust by the U.S. Government. As of June 30, 1968, 33 percent of the United States was owned by the Federal Government. This included about 95 percent of Alaska and more than 50 percent each of Nevada, Utah, Idaho, and Oregon. Atlas sheet No. 272, "Federal Lands," may be obtained from the Federal Center, Denver, Colorado 80225 for $1.50 per copy.

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NEW MERCURY RECOVERY PROCESS DEVELOPED

A new mercury recovery process developed by the U.S. Bureau of Mines, Reno Metallurgy Research Center, is described in Technical Progress Report 26, "Electrolytic Oxidation of Cinnabar Ores for Mercury Recovery," by B. J. Scheiner, R. E. Lindstrom, D. E. Shanks, and T. A. Henrie. The abstract is as follows:

Electrooxidation of cinnabar mercury ores (HgS) was investigated as a means of providing an effective and economical hydrometallurgical technique for extraction of mercury from its ores, particularly those too low in grade to allow economical metal recovery by retorting or furnacing techniques. Oxidation was accomplished by electrolysis of ore slurried with brine. Cinnabar was dissolved by oxidation of the insoluble sulfide to soluble mercuric salts. The mercury ion in a brine solution forms a stable tetrachloro complex. Typical laboratory experiments required 1 to 7 hours of electrolysis at 35-percent pulp density in a brine solution that contained 4 to 20 weight-percent sodium chlroride (NaCl). Power consumption ranged from 10 to 50 kwhr/ton of dry ore. Mercury extraction values between 90 and 99 percent were obtained with all of the ores investigated. Subsequent mercury recovery from leach solutions was readily accomplished by precipitation on zinc.

Pilot mill experiments in a 100- to 200-lb/hr extraction plant are in progress to quantify power and reagent requirements, and extraction and recovery data obtained to date closely parallel those obtained in the laboratory.

* * * * *

NEW BIBLIOGRAPHY SUPPLEMENT PUBLISHED

The fourth supplement to the "Bibliography of the Geology and Mineral Resources of Oregon" has just been issued by the State of Oregon Department of Geology and Mineral Industries. The publication, designated as Bulletin 67, was compiled by Miriam Roberts. It covers all published and unpublished reports on Oregon geology and minerals issued during the 5-year period of January 1, 1956 through December 31, 1960. About 40 pages of the 88-page bulletin are devoted to a subject index. The bulletin can be purchased from the Department's offices in Portland, Baker, and Grants Pass. The price is $2.00. The first and third supplements to the bibliography are still available, at a fee of $1.00 and $1.50 respectively.

* * * * *

PRECIOUS METALS*

Charles R. Stahl, president of Economic News Agency, Inc. and publisher of Green's Commodity Market, predicted that "between 1975 and 1977, the demonetization or near demonetization of gold should be completed" which should coincide with Americans' being legally permitted to own gold bullion which will be traded on the commodity exchanges in the United States in the same manner as silver and platinum. He said that the free market would then fluctuate between $50 and $75 per ounce. "However, it should be kept in mind that this upside move in the price of gold will be based strictly on commercial demand and will not be caused by monetary crises. Before the end of this decade, the industrial demand for gold will be so strong that central bankers will sell their gold to the industry to alleviate the predictable shortage of the yellow metal in the late 1970's."

Mr. Stahl, in turning to silver, predicted that "the commercial use of silver in this country will exceed 200 million ounces per annum within the next few years and the yearly gap between production and consumption will widen by about 50 percent from the current 110 million to over 160 million ounces. I expect private mints to become the largest users of silver in the United States. This nation has become so coin conscious that the minting of commemorative medals is now a growth industry. For example, the Franklin Mint alone will have a capacity to process 50 million ounces of silver by September of this year. Once this capacity is fully utilized, Franklin Mint's yearly consumption of silver will exceed by 20 percent the consumption of the entire photographic industry which is currently the largest user of silver in this country." Discussing the alleged large supply of silver above ground, particularly in India, Stahl remarked, "Unquestionably, there is a lot of silver in India but no one has ever counted that silver and all figures are simply uneducated guesses. However, silver owned by the people of India will never close the gap between world consumption and production. Some silver will trickle from India, but the amount will be insignificant. No one in India is going to scrap the roofs of Pagodas or religious objects made out of silver to please the silver users. Further, in India, women wear silver bracelets to show their wealth. To expect that all those bracelets will be melted is like expecting American women to scrap their diamonds to recover coal from diamonds' impurities." As to U.S. silver coinage, Stahl estimated "the potential supply to be around 400 million ounces of silver contained in quarters and dimes held by the public but only 10 percent to 20 percent of this total will ever be melted. The majority of the silver coinage is not in the hands of large holders but spread around the country reposing in junior's cookie jar and mother's sugar pot. Most of the people won't part with their silver coins because they remind them of better times; others because of the coins' numismatic value. Every time silver

coins are melted, the numismatic value of the remaining coins increases. Obviously, few will be in a hurry to melt their coins first. In the last 10 years, the deficit between production and consumption was covered by the sale of 2 billion ounces of U.S. Treasury silver. The silver hoard is now being exhausted and the Treasury has conceded that it will be out of the silver market by November of this year. If no substitutes are found for some industrial uses within less than a decade, silver prices could go as high as $10 per ounce."

*   *   *   *   *

PLACER GOLD IN SIXES RIVER AREA EVALUATED

"Distribution of Placer Gold in the Sixes River, Southwestern Oregon -- a Preliminary Report," by Sam Boggs, Jr. and Ewart M. Baldwin, has been published by the U.S. Geological Survey as Bulletin 1312-I. The study is part of the Survey's Heavy Metals program designed to evaluate domestic resources of metals and minerals in short supply. For the Sixes River study, 183 samples of alluvium were collected from various parts of the river and analyzed for gold content. The richest concentrations were found in the upper branches, particularly in the South Fork, and appear to have had their source in areas of Galice argillite intruded by small diorite bodies.

Bulletin 1312-I can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for 25 cents.

*   *   *   *   *

DEPARTMENT HIRES STRATIGRAPHER

The State of Oregon Department of Geology and Mineral Industries recently hired John D. Beaulieu as the new State stratigrapher. The new staff member, who was born at Hanford, Washington in 1944, was raised in nearby Richland, where he graduated from Columbia High School in 1962. He received his Bachelor's degree in geology in 1966 from the University of Washington, where he was a member of Phi Beta Kappa. Subsequently, he spent 3 years conducting research on the San Andreas Fault as a National Science Foundation Fellow at Stanford University. He expects to complete work towards a doctoral degree this autumn.

Mr. Beaulieu's previous professional experience includes employment as a geologist with Battelle-Northwest in Richland and a year of teaching at the University of Oregon. He is presently familiarizing himself with the geology of the State through a series of field trips. His work with the Department will be primarily to coordinate geologic mapping and research projects in the State.

*   *   *   *   *

GEOTHERMAL ENERGY FOR GREENHOUSE HEATING

The uses of geothermal energy are expanding with the increasing awareness that this clean, low-cost heat can be made to perform many of the tasks normally done by fossil fuels and electricity. One of the applications for geothermal energy is in greenhouse and soil heating, and is used in Iceland, Hungary, Russia, New Zealand, Alaska, and Oregon. A new greenhouse in Lakeview, Oregon, demonstrates the ingenuity of the American agronomist by combining geothermal energy with hydroponics. The following article by Jon Head of Medford, Pacific Power & Light Co., describing the Lakeview operation, is reprinted from the Lake County Examiner of August 20, 1970.

Geoponically speaking, it's mostly a matter of partial hydroponics and an interesting fact of geotectonics -- all of which means Oregon Desert Farms Inc. of Lakeview is making a success of growing tomatoes using natural hot water from the ground in a specially equipped greenhouse. A 26,000 square foot steel-framed fiberglass building, located 2 miles north of mile-high Lakeview on highway 395 is the setting for Lake County's latest agricultural enterprise.

Inside the enormous greenhouse, temperature is kept at a carefully watched 70° mark. It is this temperature control combined with special nursing techniques that now are producing tomatoes of remarkable size and quality. Indeed, the entire tomato-raising operation depends solely on keeping temperatures within a range of 60° (night) and 75° (day).

How is this done? Lakeview's high altitude and short growing season is not conducive to tomato growing. Commercial success depends on year-round warmth. And the only sure thing that remains warm year-round in Lakeview is the many geysers, perpetual tea kettles of bubbling hot water.

Recognizing this fact, four Lakeview men -- Bob Utley, Jim Lynch, Chuck Kelley and Andy Parker -- got together in 1969 and formed Oregon Desert Farms Inc. with the idea of building a greenhouse that would never cool off by using the readily available thermal heat. First step in the program called for extensive experimentation with the technique of warming by underground heat and, perhaps most important, the selection of varieties of tomatoes that would thrive in the special environment that would be provided for them. This was accomplished in a small greenhouse adjacent to the main building.

Andy Parker, together with his associates, selected a variety of tomato best suited to their needs to be marketed under the trade name designation, "Desert Gems."

"We picked two varieties for our initial needs after tests involving eight other varieties of tomato. Our special growing conditions, in which water enriched with nutrients would be used on growing beds composed of vermiculite and peat moss, had to be considered and not all tomatoes thrive under these conditions," Parker notes. A further nursing element is to maintain 75° in the growing soil with the warm water.

Satisfied that the technique was sound, construction was started on the primary building. First planting of Desert Gem tomatoes was made in March 1970 even before the building was entirely completed. This initial group of tomatoes is now being harvested and the whole of the interior appears as one giant tomato plant jungle with neat 7-foot-high rows of vines laden with plump tomatoes filling the interior. The plantings are sectionalized so when the growing potential of one set of vines is expended, a new block of vines bearing fruit is ready and the old vines may be removed and the area replanted.

The complete story of Lakeview's newest pollution-free and economically promising business actually begins 440 feet beneath the tough clay soil of Lake County. At that level, the natural heat of the earth in the form of intensely hot water comes in contact with a "v" shaped coil approximately 4 inches in diameter which is filled with cold water. A heat transfer occurs; the cold water is heated and pumped into 16 heat exchangers which are placed along the upper north wall of the hothouse. A radiator-like effect occurs and heat -- pushed by fans -- is forced along overhead in building-length filmy polyethylene tubes pierced with holes that distribute the heat evenly over the interior. This approach is designed to provide 70° temperatures with an outside temperature of zero with a 10-mile-per hour wind.

During the summer, the temperature problem becomes one of lowering instead of raising. Ten exhaust fans located along the north wall of the building can be turned on to produce a moderate lack of pressure in the building. As windows located the length of the south wall are opened, a flow of air is drawn across the building. Located on the outside of the south wall is a "swamp cooler" system. Large mats of semi-porous material are situated here and when filled with water, the draw of air through them produces cool air by evaporation. Lakeview's naturally low humidity is an asset to this type of cooling.

What about control -- who or what actually keeps tab on the critical temperature? All temperature control devices including exhaust fans, heat exchangers, the opening and closing of windows and operation of the swamp cooler are tied into a custom built environmental control system. When it gets a few degrees from normal, say too warm, exhaust fans automatically start -- and just enough fans turn on to reduce the temperature and no more.

"It's a clever system," Parker says, "and absolutely essential."

Presently, Desert Gem tomatoes are being marketed locally in the Lakeview, Bend and Klamath Falls areas. As production smooths out the market area will be extended to include the entire Pacific Coast.

"The idea of supplying the Pacific Coast year-round with Oregon grown tomatoes is exciting. Normally, during the winter months, tomatoes must be trucked in from as far away as Mexico, and needless to say, local vine-ripe tomatoes will have better quality than those picked green and shipped thousands of miles," Parker stated.

*   *   *   *   *

OIL TEST CORES AGE-DATED

Radiological age dating of cores of igneous rock by the Mobil Oil Co. research laboratory in Dallas, Texas* has provided important clues to the geologic history of south-central Oregon. The age of the cores from one of Humble Oil & Refining Co.'s two Lake County oil tests shows that Cretaceous seas probably did not extend this far east.

Both drillings were made in 1960 by Humble to explore for marine rocks believed to underlie Tertiary volcanics. Humble "Leavitt No. 1" was drilled near the town of Lakeview and the Humble "Thomas Creek Unit No. 1" was drilled at Grasshopper Flat in the Fremont Mountains 25 miles northwest of Lakeview. A summary of data is tabulated below:

Humble Oil & Refining Co. "Leavitt No. 1"

Sec. 2, T. 40 S., R. 20 E.,	Core 9576-9579 – Andesite
Lake County	79.8 ± 4 m.y.
Total depth, 9579 feet	83.4 ± 2 m.y.

Humble Oil & Refining Co. "Thomas Creek No. 1"

Sec. 18, T. 36 S., R. 18 E.,	Cuttings 11840-11850 – Basalt
Lake County	29.7 ± 1.8 m.y.
Total depth, 12,093 feet	30.3 ± 1.4 m.y.

Core 9576-9579 from the bottom of the Humble Leavitt No. 1 consists of an upper section of fine-grained andesite and a lower section of a coarser grained porphyritic andesite. The K-Ar dating places the rock in about the middle of the Cretaceous Period.

The dated samples from the 11840-50 interval of the Humble Thomas Creek No. 1 indicate that the basalts were extruded near the middle of Oligocene time. Rock alteration may have reduced the K-Ar age somewhat, but in the opinion of the Mobil scientists the rock cannot be any older than late Eocene.

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* R.E. Denison, Mobil Research and Development Corp., Field Research Laboratory, Dallas, Texas.

CONDON LECTURE BOOKLETS AVAILABLE

"The Geological Revolution," by Charles L. Drake, and "Planetary Exploration," by Carl Sagan, both delivered as Condon Lectures, were recently published by the Oregon State System of Higher Education. Address orders to: University of Oregon Books, 107 Friendly Hall, University of Oregon, Eugene, Oregon 97403. Each booklet sells for $2.00.

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AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

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8.	Feasibility of steel plant in lower Columbia River area, rev.1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
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37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch . .	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
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63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
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66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre .	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00

GEOLOGIC MAPS

Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . .	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37) .	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker . . .	1.00
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Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams . .	1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka . .	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka . .	1.50
Geologic map of Oregon west of 121st meridian: (over the counter) . . . . folded in envelope, $2.15; rolled in map tube, $2.50	2.00
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat . folded in envelope, $2.25; rolled in map tube, $2.50	2.00

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18.	Radioactive minerals the prospectors should know (2nd rev.), 1955:	
	White and Schafer	0.30
19.	Brick and tile industry in Oregon, 1949: Allen and Mason	0.20
20.	Glazes from Oregon volcanic glass, 1950: Jacobs	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Mason	0.25
23.	Oregon King mine, Jefferson County, 1962: Libbey and Corcoran. . . .	1.00
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MISCELLANEOUS PAPERS

1.	Description of some Oregon rocks and minerals, 1950: Dole	0.40
2.	Key to Oregon mineral deposits map, 1951: Mason	0.15
	Oregon mineral deposits map (22" x 34"), rev. 1958 (see M.P.2 for key). .	0.30
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6.	Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . .	1.50
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7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . . .	0.50
8.	Available well records of oil & gas exploration in Oregon, rev.'63: Newton .	0.50
11.	A collection of articles on meteorites, 1968: (reprints, The ORE BIN) . .	1.00
12.	Index to published geologic mapping in Oregon, 1968: Corcoran	Free

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Geologic time chart for Oregon, 1961.	Free

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1.	Petroleum geology of the western Snake River basin, Oregon–Idaho, 1963:	
	Newton and Corcoran.	2.50
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	1969: Newton	2.50

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OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

GEOLOGY OF THE STACKS AND REEFS
OFF THE SOUTHERN OREGON COAST*

By Ralph E. Hunter, H. Edward Clifton, and R. Lawrence Phillips
U.S. Geological Survey, Menlo Park, California

Introduction

It is sometimes difficult to relate the results of onshore and offshore geologic studies, partly because of information gaps in nearshore waters where ships cannot operate. Offshore sea stacks and shoal areas with numerous stacks, locally called "reefs" (figure 1), can be useful in bridging the gap between onshore and offshore bedrock geology. This is especially true in areas like southern Oregon, where the geology is complex and structural features trend at low angles to the shore (figure 2). One cannot always assume that stacks are similar to rocks immediately onshore.

The stacks off the southern Oregon coast have been studied very little because of difficulties of access (see, for example, Weissenborn and Snavely, 1968). Work described herein was helicopter-supported; skillful piloting by Earl Lady permitted landings on or close approaches to many stacks. To help delineate the structure, field work was supplemented by high-altitude aerial photographs, which revealed the outlines of kelp beds associated with shallow outcrops on the sea floor.

Study of the geology of the stacks of this coastal area adds to our knowledge of the distribution, character, and structure of Upper Jurassic, Lower Cretaceous, and Upper Cretaceous sedimentary rocks.

Stratigraphy

Otter Point Formation

General character: The Otter Point Formation and probably equivalent rocks crop out along parts of the coast from Whalehead Island north to Blacklock Point and beyond (figure 2). Among the more important offshore occurrences of the Otter Point are Mack Reef, part of Rogue River Reef, Island Rock, Redfish Rocks, Orford Reef, and part of Blanco Reef (figures 2-10). The formation was named for its type section at Otter Point (figure 7) and dated by Koch (1966) as latest Jurassic (late Tithonian or late Portlandian and Purbeckian). It is a eugeosynclinal assemblage of mudstone, sandstone (largely graywacke), volcanic rock, conglomerate, and bedded chert. Medium- to coarse-grained igneous rocks are commonly associated with the volcanic rocks in the stacks and are probably hypabyssal equivalents of the extrusive rocks.

The Otter Point Formation commonly is intensely folded and faulted. Although

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* Publication authorized by the Director, U.S. Geological Survey.

most of the Otter Point Formation in the stacks appears unmetamorphosed in outcrop and has no metamorphic fabric; microscopic and X-ray diffraction studies show that low-grade metamorphism is common. Bodies of ultramafic rock, largely altered to serpentinite, and glaucophane-bearing schist and phyllite are commonly associated with the Otter Point Formation onshore (Koch, 1966; Boggs and Baldwin, 1970; Lent, 1969) but were not found offshore.

Sandstones: Sandstones are widely distributed in the Otter Point Formation of the offshore stacks. Most of the sandstones that form stacks are thick bedded; inter-bedded mudstone is uncommon. Thin graded sandstone beds separated by mudstone layers are more typical of the Otter Point Formation onshore (Koch, 1966, p. 39) but compose only minor parts of some stacks. Most of the sandstones of the stacks contain a very high proportion, commonly about 75 percent, of rock fragments, the majority of which are volcanic. Quartz, polycrystalline quartz, and chert fragments make up less than 20 percent of the volcanic lithic sandstones of the stacks. Plagio-clase is common but the potash feldspar content of the volcanic lithic sandstone is less than 1 percent.

Volcanic lithic sandstones occur in the Otter Point Formation onshore as well as offshore, but onshore they are subordinate or subequal to arkosic and chert-dom-inated lithic sandstones (Koch, 1966, p. 39-40, and Lent, 1969, p. 111). Sand-stones of the types dominant onshore are rare in the stacks except in the Orford Reef, where massive coarse-grained sandstone containing only 50 percent rock fragments is common.

Most of the volcanic lithic sandstones were classified as graywacke in the field. The detrital matrix content is very difficult to estimate in thin section, how-ever, because it is mineralogically similar to the rock fragments, because the rock fragments have been deformed by pressure from the more competent grains, and be-cause textures have undergone incipient modification during metamorphism. Some of the sandstones may have a low matrix content and therefore may be subgraywackes rather than lithic graywackes according to the classification of Pettijohn (1957, p. 290-293).

The assemblage of sedimentary structures in Otter Point sandstones onshore suggests deposition by turbidity currents (Koch, 1966). The Otter Point sandstones in the stacks also probably are turbidites.

Volcanic rocks: Volcanic rocks are subordinate to sedimentary rocks in the Otter Point Formation onshore but are abundant in the stacks (figures 2-10), probab-ly because of their resistance to erosion. Massive flows, pillowed flows, and breccias are the most common types. Yellow Rock (figure 4) is composed at least partly of bedded tuff. Most of the volcanic rocks are andesitic in composition, but some are basaltic. A few contain quartz. Most have been metamorphosed, as described in a following section.

Medium- to coarse-grained rocks of dioritic composition are associated with the extrusive rocks in Mack Reef and on Island Rock. They occur also as clasts in many of the breccias. Some of the breccias containing dioritic clasts have a red hematite-rich matrix. The dioritic rocks probably are hypabyssal, and the breccias containing dioritic clasts may be vent breccias.

Conglomerates: Conglomerates are fairly common in the Otter Point Forma-tion of the offshore stacks. Conglomerate composed largely of pebbles of volcanic
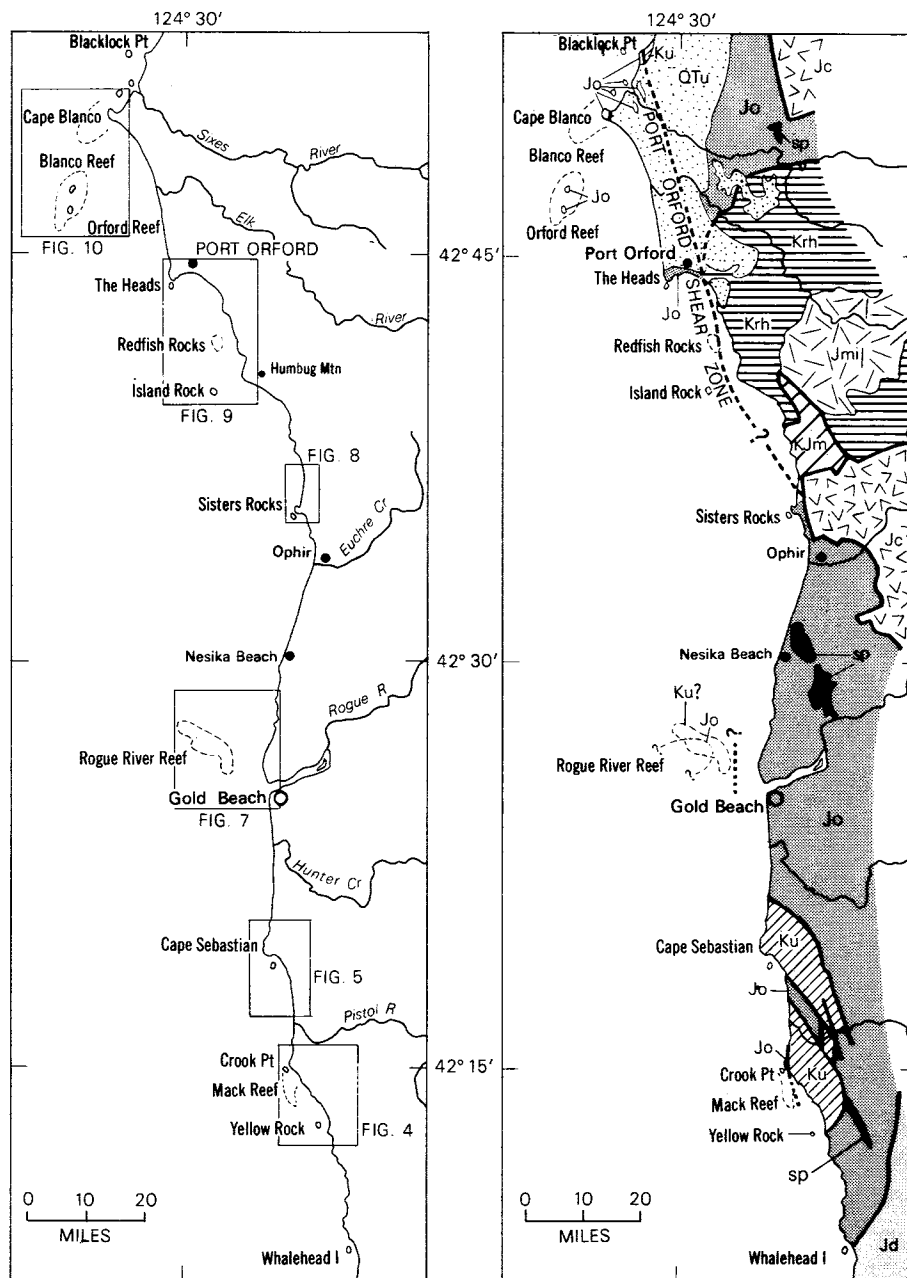
Figure 1.   Index map of southern Oregon coast. (Left)

Figure 2.   Geology of southern Oregon coastal region. Onland mapping from
            sources listed in figures 4-10 and from Lent (1969) and Janda
            (personal communication). (Right)

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rocks is a common type. Such volcaniclastic conglomerates are subordinate to con-
glomerates composed of chert clasts in the Otter Point Formation onshore (Koch,
1966, p. 40) but are common in the Whalehead Formation of Widmier (1963), which
crops out along the coast from Yellow Rock to Whalehead Island (figure 2) and is
considered to be correlative with the Otter Point Formation (Koch, 1966, p. 36-38).

Bedded cherts: Bedded chert unaccompanied by other rocks forms few stacks
in the area studied. However, chert lenses are commonly associated with volcanic
rocks in the stacks. Most of the chert is of reddish color. It is veined by quartz and
probably is partly recrystallized.

Metamorphism of the Otter Point Formation: Most of the offshore volcanic
rocks, sandstones, and conglomerates of the Otter Point Formation have undergone
low-grade metamorphism. They are largely unaltered texturally except very near
shear surfaces and are thus in textural zone 1 of Blake, Irwin, and Coleman (1967).
The degree to which the rocks approached metamorphic equilibrium varies greatly,
but only the very sheared rocks have completely recrystallized. The relation between
alteration and shearing indicates that the changes are truly metamorphic and occurred
during deformation of the rocks.
    The most widespread mineralogic change has been the alteration of relatively
calcic plagioclase to albite. The altered nature of the plagioclase is indicated by
its abundant inclusions of chlorite and colorless to pale-green mica and by the oc-
currence of relict calcic plagioclase in rocks that were not completely albitized. In
the incompletely albitized rocks, grains of clear, commonly zoned plagioclase rang-
ing in composition from oligoclase to labradorite have been partly replaced by cloudy
albite along veinlets and in irregular patches.
    Of the four offshore clastic sedimentary rocks thin-sectioned, only the mas-
sive sandstone from Best Rock in the Orford Reef (figure 10) contained largely un-
altered plagioclase. Of the 12 offshore volcanic and dioritic rocks thin-sectioned,
only the andesite tuff on Yellow Rock (figure 4) contained largely unaltered plagio-
clase. Onshore, Koch (1966, p. 40-41) classified half of the andesitic flow rocks
as altered; and most of the volcanic rocks examined by Lent (1969, p. 43-55) were
altered and contained sodic plagioclase. The albitized volcanic rocks are here clas-
sified as keratophyres (andesites with albitized plagioclase) and spilites (basalts with
albitized plagioclase).
    Most of the albitized igneous rocks contain nearly unaltered hornblende and/or
clinopyroxene. In patches or along sheared surfaces, the ferromagnesian minerals of
some rocks have been partially or completely altered to chlorite. Chlorite commonly
also occurs as patches interstitial to the feldspar and ferromagnesian minerals of the
volcanic rocks; the interstitial chlorite may be an alteration product of glass. Chlo-
rite is a common alteration product of the volcanic rock fragments in the sandstones
and conglomerates, but some of these rocks contain unaltered detrital grains of py-
roxene and hornblende.
    Other metamorphic minerals occurring in veinlets and as disseminated grains
in the Otter Point Formation offshore include prehnite, found in 7 of the 12 volcanic
rocks thin-sectioned, and pumpellyite, found in 3 of the volcanic rocks and in 2
metagraywackes. Optical identifications of the two minerals were checked by X-ray
diffraction powder patterns. Actinolite was found on Island Rock and occurs with
pumpellyite in the metavolcanic or metadioritic rock forming Sea Rock in the Orford
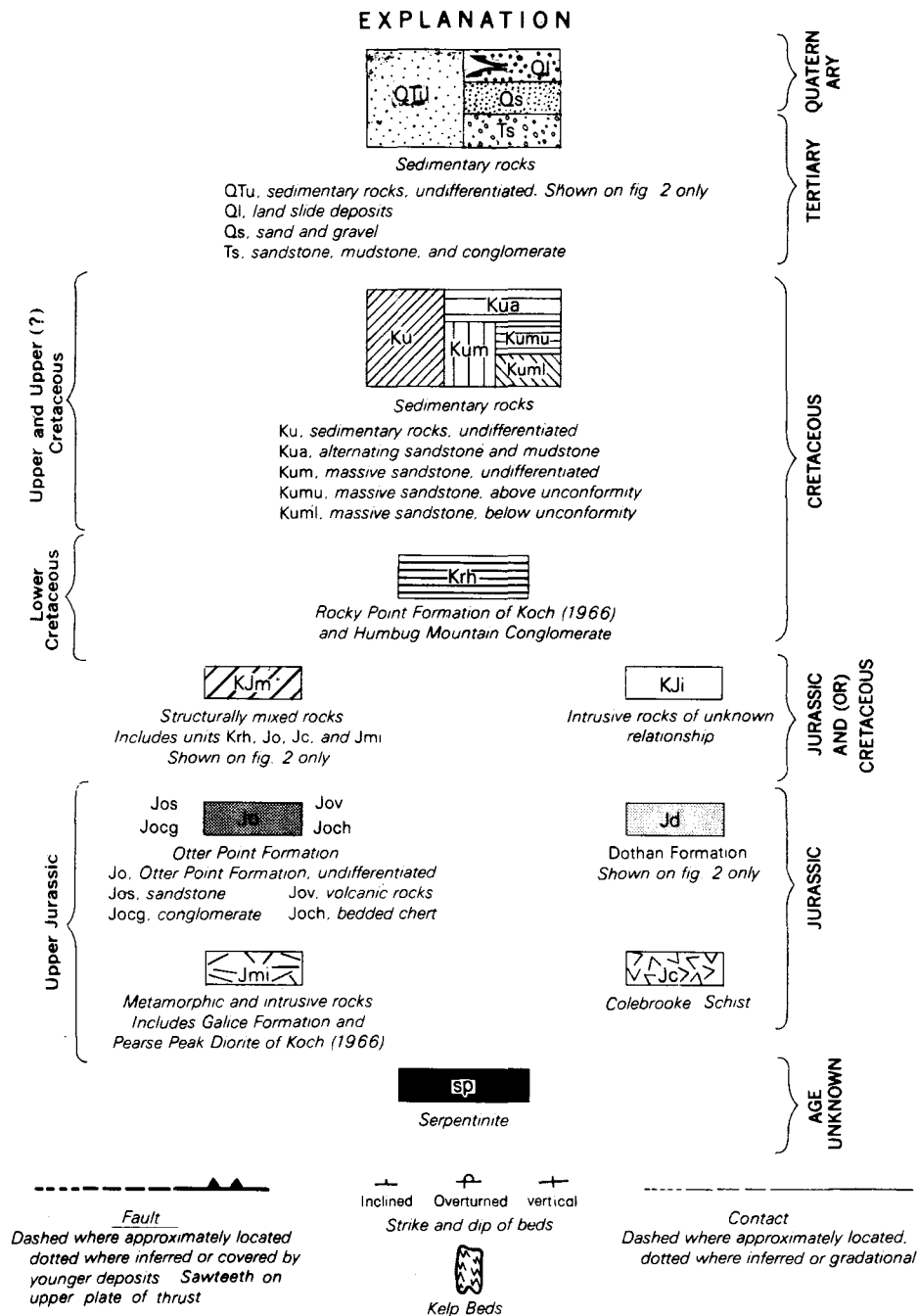Reef (figure 10); this is the only rock observed in which all the original minerals

EXPLANATION

Sedimentary rocks

QTu, sedimentary rocks, undifferentiated. Shown on fig 2 only
Ql, land slide deposits
Qs, sand and gravel
Ts, sandstone, mudstone, and conglomerate

Sedimentary rocks

Ku, sedimentary rocks, undifferentiated
Kua, alternating sandstone and mudstone
Kum, massive sandstone, undifferentiated
Kumu, massive sandstone, above unconformity
Kuml, massive sandstone, below unconformity

Rocky Point Formation of Koch (1966)
and Humbug Mountain Conglomerate

Structurally mixed rocks
Includes units Krh, Jo, Jc, and Jmi
Shown on fig 2 only

KJi
Intrusive rocks of unknown
relationship

Jos   Jov
Jocg   Joch

Otter Point Formation
Jo, Otter Point Formation, undifferentiated
Jos, sandstone   Jov, volcanic rocks
Jocg, conglomerate   Joch, bedded chert

Jd
Dothan Formation
Shown on fig 2 only

Metamorphic and intrusive rocks
Includes Galice Formation and
Pearse Peak Diorite of Koch (1966)

Colebrooke Schist

sp
Serpentinite

Fault
Dashed where approximately located
dotted where inferred or covered by
younger deposits   Sawteeth on
upper plate of thrust

Inclined   Overturned   vertical
Strike and dip of beds

Kelp Beds

Contact
Dashed where approximately located.
dotted where inferred or gradational

QUATERNARY
TERTIARY
Upper and Upper (?) Cretaceous
Lower Cretaceous
CRETACEOUS
JURASSIC AND (OR) CRETACEOUS
Upper Jurassic
JURASSIC
AGE UNKNOWN

Figure 3. Explanation of figures 2, 4, 5, 7, 8, 9, and 10.

have been destroyed and a metamorphic fabric has been acquired. Calcite is the only carbonate alteration product found in the rocks.

The occurrence of pumpellyite is especially significant in placing the rocks in a metamorphic facies. The assemblage quartz-albite-chlorite-muscovite-pumpelly-ite in some of the metagraywackes is indicative of the pumpellyite zone of Blake, Irwin, and Coleman (1967) or the prehnite-pumpellyite metagraywacke facies of Coombs (1960, 1961); see also Hawkins, 1967). The albite-chlorite-prehnite and albite-chlorite-pumpellyite assemblages found in the metavolcanic rocks are less definitive but suggest that the metamorphism reached at least the zeolitic facies of Turner and Verhoogen (1960, p. 532) or the equivalent laumontite-prehnite-quartz facies of Winkler (1965, p. 137-141). Lent (1969, p. 52-55) specifically refers certain Otter Point metavolcanic rocks onshore to the laumontite-prehnite-quartz facies, and Coleman (personal communication, 1969) has found laumontite in the Otter Point onshore.

Humbug Mountain Conglomerate and Rocky Point Formation of Koch (1966)

The Humbug Mountain Conglomerate and the conformably overlying Rocky Point Formation of Koch (1966) form most of the coast from Port Orford to near Sisters Rocks (figure 2). Both formations were defined and dated as Early Cretaceous (Val-anginian) by Koch (1966). Koch's Rocky Point Formation, whose name unfortunately is preempted for Pennsylvanian rocks in Oklahoma and Tertiary rocks in Oregon, is composed of sandstone, largely of graywacke type and occurring in graded beds, and mudstone. Stacks formed of Lower Cretaceous rocks seem not to occur offshore more than a few tenths of a mile. Although the petrologic differences between some Otter Point and Lower Cretaceous sandstones are subtle (Koch, 1966, and Lent, 1969), the close association of volcanic rocks and sandstones in the reefs excludes the pos-sibility of these rocks being either the Humbug Mountain or Rocky Point rather than the Otter Point Formation.

Upper Cretaceous and probable Upper Cretaceous rocks

Several areas of known and probable Upper Cretaceous rocks are found along the southern coast of Oregon (figure 2). The largest is in the vicinity of Cape Se-bastian; the rocks in this area have been described and dated by Howard and Dott (1961) but have not been named. Small areas of probable Upper Cretaceous rocks occur at Blacklock Point (Dott, 1962, p. 130) and near Bandon (Baldwin, 1966, p. 190). During the present study, sandstone and subordinate conglomerate very similar to the Upper Cretaceous rocks at Cape Sebastian were found in the Rogue River Reef (figure 7). Pelecypod molds were found but not collected on Pyramid Rock. Sand-stone and subordinate conglomerate similar to rocks at Cape Sebastian were found in part of the Blanco Reef (figure 10) but cannot be as certainly correlated because ex-posures are too limited for lithologic comparison and fossils have not been found.

Petrographic analyses show that the probable Upper Cretaceous sandstones in the Rogue River and Blanco Reefs are similar in composition to the Upper Cretaceous sandstones in the Cape Sebastian area (table 1). Dott (1965, p. 4692) has shown that Upper Cretaceous sandstones in southwest Oregon are characterized by their higher content of quartz and potash feldspar and lower content of chert fragments, rock fragments, and detrital matrix than other sandstones of southwest Oregon ranging in age from Jurassic to Eocene. Although the petrographic analyses presented here

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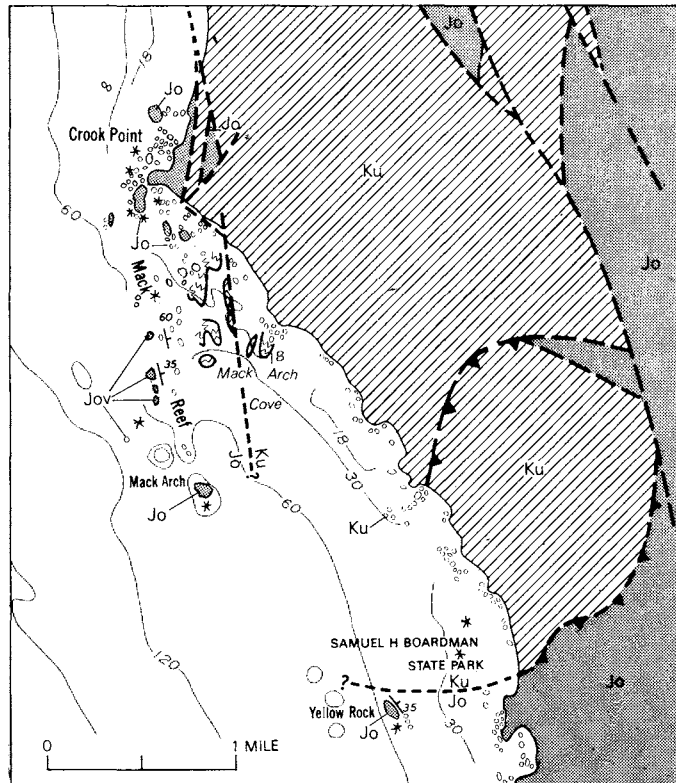
Figure 4. Geology of Mack Reef and vicinity. Onland mapping modified slightly from Howard and Dott (1961) and Widmier (1963).
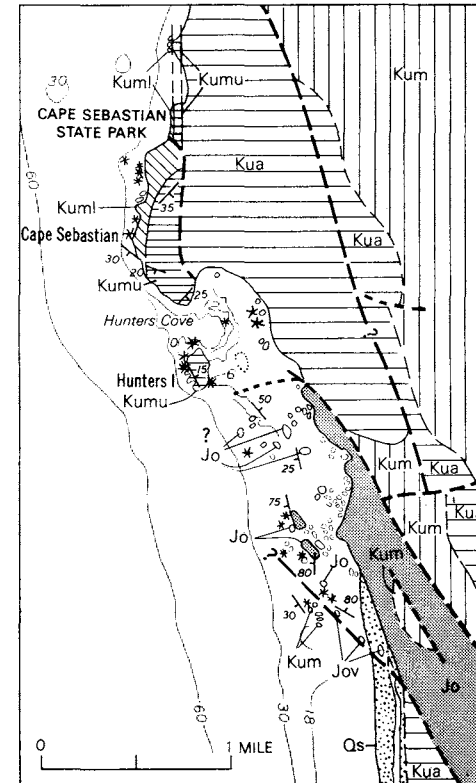
Figure 5. Geology of stacks near Cape Sebastian and vicinity. Onland mapping modified slightly from Howard and Dott (1961).

Table 1. Petrographic compositions of Upper Cretaceous and
probable Upper Cretaceous sandstones

Component	Cape Sebastian area (ave. of 2 samples)	Rogue River Reef (ave. of 3 samples)	Blanco Reef [1] (ave. of 3 samples)
Quartz	25	27	16
Polycrystalline quartz	6	6	5
Chert [2]	2	2	2
Rock fragments	27	26	28
Plagioclase	16	14	21
Potash feldspar	8	7	8
Flaky minerals [3]	3	1	4
Heavy minerals [4]	4		1
Carbonate cement		14	5
Detrital matrix [5]	9	3	10

[1] Pebble fraction excluded from analysis of one sample.

[2] Some silicic volcanic rock fragments may have been misidentified as chert, and
some impure chert may have been misidentified as rock fragments.

[3] The flaky minerals include biotite, muscovite, and chlorite; biotite is the most
common.

[4] The heavy minerals include, in approximate order of abundance, epidote, black
opaque minerals, sphene, and apatite.

[5] Some squeezed rock fragments may have been misidentified as matrix.

differ in detail from those of Dott, the low matrix content and relatively high miner-
alogic maturity of the Upper Cretaceous sandstones in the Cape Sebastian area and
their probable correlatives in the Rogue River and Blanco Reefs are easily recogniz-
able in hand specimen by the light color of the sandstones.

In addition to petrographic similarity, the correlation of the light-colored
sandstones in the Rogue River Reef with the Upper Cretaceous sandstones at Cape
Sebastian is suggested by the similarity in sedimentary structures and stratigraphic se-
quence. The Upper Cretaceous rocks in the Cape Sebastian area have been divided
into a massive sandstone unit and an overlying sandstone-shale unit (Howard and
Dott, 1961). Outcrops in the cliffs at Cape Sebastian, which are nearly inacces-
sible by land but were visited by helicopter, reveal a further subdivision of the
massive sandstone unit. An angular unconformity having a discordance of 16° at one
point divides the massive sandstone into two units (figure 5). No fossils have been
found in the lower sandstone unit, but its similarity in composition to the upper unit
suggests that it is not much older.

Both units are composed largely of sandstone, but a boulder-bearing con-
glomerate forms the base of the upper sandstone unit, and pebbly sandstone and con-
glomerate are subordinate rock types throughout the lower sandstone unit and the
lower half of the upper sandstone unit. The lower sandstone unit is characterized
by common graded bedding; a few beds are made up of unlaminated but graded ba-
sal parts, middle parts that have parallel lamination, and upper parts that have
current-ripple lamination. This assemblage of sedimentary structures strongly suggests

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Figure 6. Aerial photograph of Rogue River Reef.
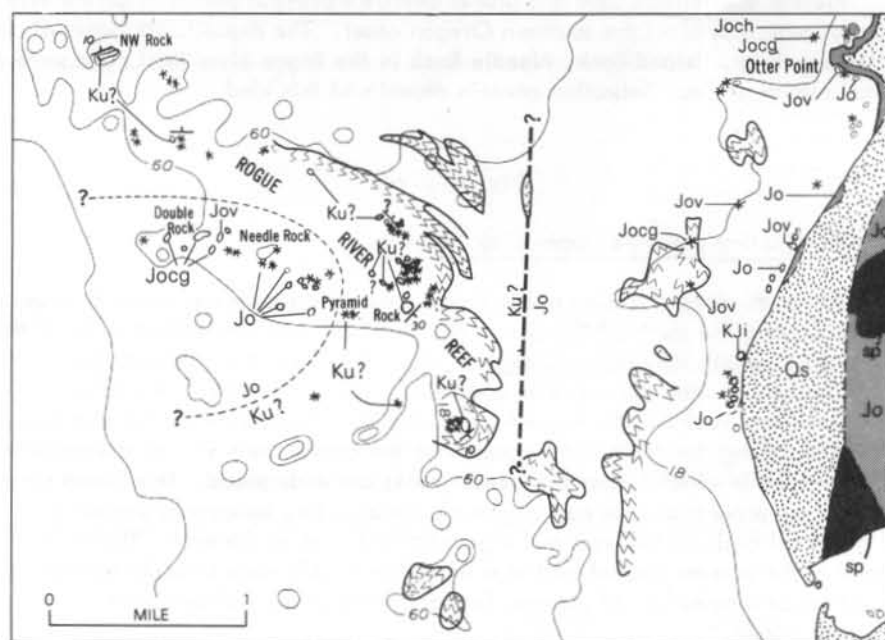
Figure 7. Geology of Rogue River Reef and vicinity. Onland
mapping modified slightly from Koch (1966).

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deposition by turbidity currents (Bouma, 1962). The upper sandstone unit, on the other hand, is characterized by cross-laminated beds 6 inches to more than 1 foot thick and a few symmetrical ripple marks. A shallow marine origin is probable.

On Pyramid Rock, the best exposure of probable Upper Cretaceous rocks in the Rogue River Reef (figure 7), both the graded, probable turbidite facies and the crossbedded, probable shallow-marine facies are present. The crossbedded facies apparently overlies the graded facies, but the contact itself is inaccessible. Other exposures of probable Upper Cretaceous sandstones in the Rogue River and Blanco Reefs are not large enough for identification of the sedimentary facies.

Tertiary rocks

Eocene rocks crop out along the Oregon coastline south of the Cape Arago area only at Cape Blanco (Dott, 1962), where they are mainly mudstones and do not form stacks. Miocene and Pliocene rocks crop out along portions of the Oregon coast from Coos Bay south to the Port Orford area (Baldwin, 1945, 1966; Dott, 1962; Koch, 1966). They are not present onshore from the Port Orford area south to northern California, where they again occur onshore (Moore and Silver, 1968), but beds of presumed younger Tertiary age are present on much of the continental shelf (Mackay and Kulm, 1968; Moore and Silver, 1968; Bales and Kulm, 1969). Miocene sandstone forms one stack on the beach at Cape Blanco, but Miocene or Pliocene rocks were not recognized on any of the offshore stacks.

Quaternary deposits

Pleistocene terrace sand and gravel overlie wave-cut platforms on the tops or sides of some stacks off the southern Oregon coast. The deposits are generally less than 10 feet thick. Island Rock, Needle Rock in the Rogue River Reef, and some of the stacks south of Cape Sebastian contain deposits of this kind.

Structure

Structures affecting probable Upper Cretaceous rocks

Although rocks of known and probable Late Cretaceous age occur in several small areas along the southern Oregon coast, they are very rare inland as far as the Medford area, where they occur along the edge of the Tertiary volcanic mass making up the Cascade Mountains (Wells and Peck, 1961). The discovery of probable Upper Cretaceous rocks in the Rogue River and Blanco Reefs extends the distribution of such rocks along the coast and suggests that the coastal belt may be the eastern edge of an area in which Upper Cretaceous rocks are widespread. In a broad sense, therefore, the present coastal belt may mark the boundary between a depositional or later structural basin to the west and a geanticlinal area to the east. The same importance of the present coastal belt at a later date is still more strongly suggested by the widespread distribution of younger Tertiary rocks on the continental shelf and their rarity inland.

The distribution of probable Upper Cretaceous rocks can be extended locally beyond the stacks by the bathymetric pattern and by the pattern of kelp beds rooted on sea-floor outcrops. In the Rogue River Reef, for example, a linear pattern of

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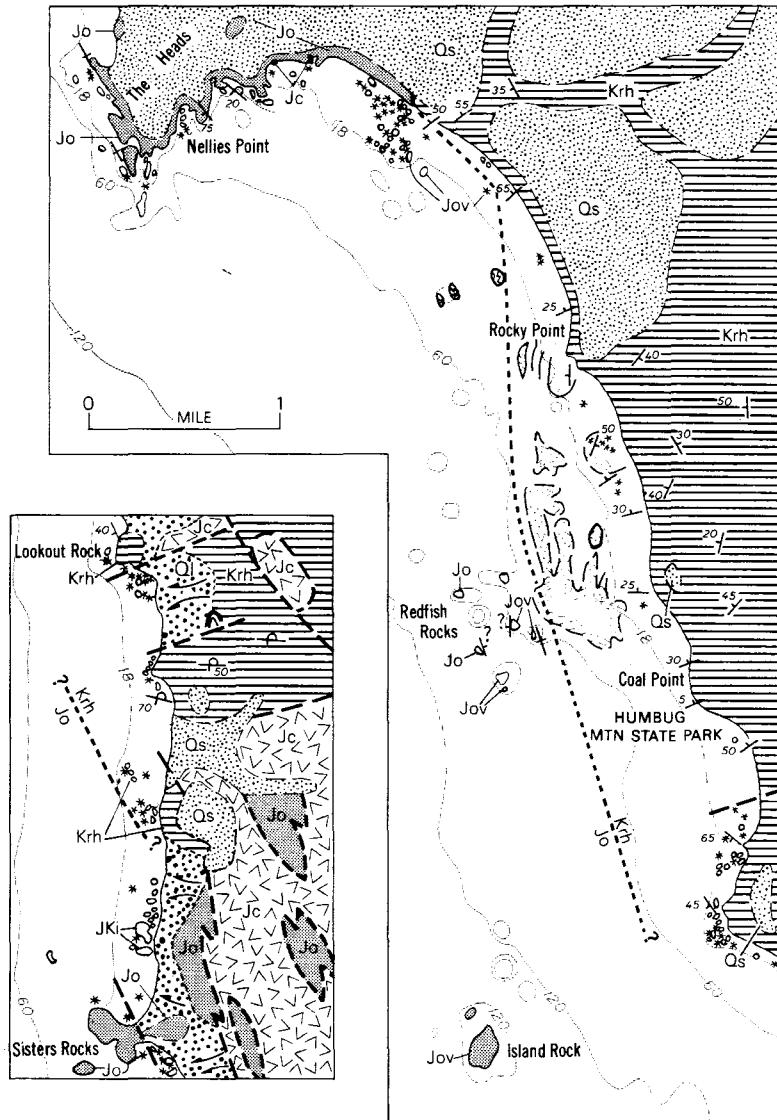
Figure 8. Geology of Sisters Rocks and vicinity. Onland mapping
modified slightly from Koch (1966). (Lower left)

Figure 9. Geology of Redfish Rocks, Island Rock, and vicinity.
Onland mapping slightly modified from Koch (1966).
(Right)

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kelp beds northeast of the reef parallels the strike of bedding in the probable Upper Cretaceous sandstones exposed in the stacks and appears to outline resistant sandstone beds that crop out on the sea floor (figures 6 and 7). Similarly, the submarine ridge extending southwest from the southeastern part of the Rogue River Reef is parallel to the strike of bedding in the stacks and is evidently formed by probable Upper Cretaceous rocks. The linear pattern of kelp beds northeast of the reef does not extend past a fairly well-defined north-south line. East of this line, presumably a fault, is an irregular pimple-like pattern of kelp beds typical of areas known to be underlain by the Otter Point Formation. Another linear pattern of kelp beds that may outline Upper Cretaceous rocks occurs south of the Blanco Reef, between the Orford Reef and the shore (figure 10). For these rocks, however, a Tertiary age is perhaps equally possible.

Although Upper Cretaceous rocks may occur widely on the continental shelf, it is doubtful that they underlie any large continuous area, for onshore they are cut by numerous faults. The probable Upper Cretaceous rocks in the Rogue River and Blanco Reefs also are apparently cut by numerous faults (figures 7 and 10). As the major faults cutting Upper Cretaceous rocks in the Cape Sebastian area strike northwest (Howard and Dott, 1961), the probable Upper Cretaceous rocks in the Rogue River Reef probably occur along this same fault system. Most of the faults in the Cape Sebastian area apparently dip at high angles, but at the south end of the area the Otter Point Formation (Whalehead Formation of Widmier, 1963) is mapped as thrust over Upper Cretaceous rocks (Howard and Dott, 1961).

The Upper Cretaceous beds overlie older (Otter Point) rocks with marked angular unconformity in the Cape Sebastian area (Howard and Dott, 1961). The same relation is suggested in the Rogue River Reef, where the probable Upper Cretaceous beds strike in an arc around a core of the highly deformed Otter Point Formation and dip gently away from the core (figure 7).

Although the Upper Cretaceous beds in the Cape Sebastian area are cut by numerous faults, the beds commonly dip less than 30°. The probable Upper Cretaceous rocks in the Rogue River and Blanco Reefs dip almost entirely at angles of 30° or less (figures 7 and 10). The low dips are useful, though not definitive, in distinguishing these rocks from older rocks in the area. Some of the folding took place during the period in which the rocks were deposited, as indicated by the angular unconformity within the massive sandstone at Cape Sebastian.

Structures affecting Jurassic and Lower Cretaceous rocks

The Jurassic and Lower Cretaceous terranes are characterized by numerous differences in general lithology, types of associated rocks, style of deformation, and metamorphism (table 2). Koch's structural interpretation (1966, p. 63-65) offers a possible explanation for these differences. Koch suggests that the eugeosynclinal Otter Point Formation was deformed during the "Diablan orogeny" near the end of Jurassic time, and that when sedimentation resumed during Early Cretaceous time, a miogeosynclinal facies was deposited.

Several problems arise from Koch's interpretation, which implies that both the Jurassic Otter Point and the Lower Cretaceous terranes are autochthonous. Wherever the base of the Lower Cretaceous beds is exposed in the coastal area, the beds unconformably overlie a pre-Otter Point metamorphic-plutonic complex. According to the autochthonous interpretation, this basement complex was a local positive area in which Late Jurassic rocks were never deposited, were deposited as a

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Figure 10. Geology of Orford Reef, Blanco Reef, and vicinity.
Onland mapping slightly modified from Dott (1962).

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Table 2. Comparison of typical terranes underlain by
Jurassic Otter Point Formation and Lower Cretaceous rocks

	Terrane underlain by Jurassic Otter Point Formation	Terrane underlain by Lower Cretaceous rocks [includes Humbug Mountain Conglomerate and Rocky Point Formation of Koch (1966)]
Lithology:	Eugeosynclinal; volcanic rocks and bedded chert present.	Miogeosynclinal; volcanic rocks and bedded chert present.
Associated rocks:		
Underlying rocks	Unknown	Pre-Otter Point plutonic and metamorphic rocks where known.
Serpentinite	Many small to large tectonically emplaced bodies	Typically absent in coastal area
Blueschist and related metamorphic rocks	Many small tectonically emplaced bodies	None known
Colebrooke Schist	Many small to large, tectonically emplaced, superjacent bodies	Few small bodies of uncertain relationship
Style of deformation:	Much faulting and steep folding; parallelism of structures common, producing linear structural grain	Broad folds and domal uplifts; structural grain not pronounced
Metamorphism:	Commonly in the zeolite or prehnite-pumpellyite facies	Not known to be metamorphosed

thin onlapping wedge (Dott, 1966), or were stripped off by erosion during the Diablan orogeny. The existence of such a laterally restricted, but evidently extremely upthrown, area seems somewhat improbable but not impossible. A more perplexing problem is that the Lower Cretaceous beds are preserved on what must have been a profound uplift during Late Jurassic time but have been removed from, or were never deposited on, the surrounding Otter Point terrane, which was a deep basinal area during Late Jurassic time. The implied reversal of positive and negative areas is conceivable but seems unlikely.

Because of the problems associated with an autochthonous interpretation of the Otter Point and Lower Cretaceous terranes, an allochthonous interpretation should be considered. Many of the differences between the two terranes are indeed

consistent with, and suggestive of, tectonic transport on a regional scale. Such tectonic transport could have been accomplished by either thrust faulting or strike-slip faulting. In either case, of course, the present contacts of the two terranes may be later faults than those along which the major tectonic transport took place. All these possibilities should be kept in mind.

The contact between the Otter Point Formation and Lower Cretaceous rocks occurs offshore from Port Orford to the vicinity of Sisters Rocks (figures 2, 8, and 9). It must be located between the onshore Lower Cretaceous rocks and the Otter Point Formation on Island Rock and Redfish Rocks, but its precise position is unknown. The contact in the offshore area apparently coincides in a general sense with the Port Orford shear zone.

The Port Orford shear zone is thought to be a wide, north-northwest-trending major fault zone; it is characterized by intensely brecciated, granulated, folded, altered rocks (Koch, 1966, p. 58-59; Dott, 1962, p. 131-132). The shear zone is presumed to extend offshore south-southeast from Port Orford (Koch and others, 1961; Dott, 1965; Koch, 1966) and probably touches shore again in the vicinity of Sisters Rocks (Dott, 1962 and 1965). The Brush Creek shear zone, which is in the coastal area between Humbug Mountain and Sisters Rocks, is probably related to the Port Orford shear zone (Koch, 1966, p. 58). North of Port Orford, faults striking north-northwest to the Cape Blanco area are thought to be part of the Port Orford shear zone (Dott, 1962).

The nature of the faulting in the Port Orford shear zone is poorly known. Koch (1966, p. 58-60) reported several features suggestive of strike slip but did not rule out the possibility of other types of faulting. Even the dips of the dominant faults are not certainly known because exposures are poor and there are many shear surfaces having various attitudes. Some of the faults offsetting Tertiary rocks in the Cape Blanco area are definitely high-angle faults (Dott, 1962), but the relation of these faults to the complex deformation within the Otter Point Formation in the area is unknown.

Evidence suggesting that the Otter Point-Lower Cretaceous contact in the offshore area may be a low-angle thrust fault is the presence of several prominent low-angle faults on both sides of the contact. A low-angle fault is the most prominent discontinuity in the Otter Point volcanic rocks forming Island Rock, just west of the shear zone (figure 9). A nearly horizontal fault was traced by helicopter for a distance of about 3,000 feet along sea cliffs formed by Lower Cretaceous rocks between the Port Orford and Brush Creek shear zones, about 2 miles southeast of Humbug Mountain in the $S\frac{1}{2}$ sec. 6 and $N\frac{1}{2}$ sec. 7, T. 34 S., R. 14 W. Drag along the fault indicates relative westward movement of the upper plate. A recent landslide origin of the fault is unlikely because the fault is offset vertically for distances of a few feet by several steeply dipping faults. The occurrence of calcite veinlets and intense granulation in a zone 1 to 3 feet wide along the fault are further evidence refuting a recent landslide origin. A few other prominent gently dipping faults occur in the sea cliffs between Humbug Mountain and Ophir.

None of the faults mentioned is a major fault separating rocks of greatly differing age, and the inference that these faults are part of a system in which low-angle thrusting was the dominant type of movement must be considered suggestive only. Moreover, the existence of low-angle thrust faults in the Mesozoic rocks does not rule out the possibility of younger faults of different type.

Other features suggestive of a low-angle Otter Point-Lower Cretaceous contact include the apparent bends in the contact in the offshore area (figures 2 and 9)

and the occurrence of outliers of the Otter Point Formation in the predominantly Lower Cretaceous terrane between Humbug Mountain and Sisters Rocks (Koch, 1966). These features can be easily explained by original waviness, folding, and vertical offsetting of a low-angle fault contact, but, as noted by Koch (1966, p. 59), a sinuous pattern can also be produced by braided wrench faults. On the other hand, the divergence of the Otter Point-Lower Cretaceous contact from a north-northwest trend in the area north of Port Orford (figure 2) certainly is so extreme that the juxtaposition of the two terranes cannot be explained solely by strike-slip tectonic transport along the Port Orford shear zone as it has been mapped. If a high-angle strike-slip interpretation of the Port Orford shear zone is retained, a complex system of other faults must be inferred to explain fully the juxtaposition of Otter Point and Lower Cretaceous rocks.

The hypothesis that the Lower Cretaceous rocks have been brought into juxtaposition with the Otter Point Formation by low-angle thrust faulting is supported by evidence from the sea stacks and coastal cliffs, but the evidence is far from conclusive. Much additional field work will be required to test this hypothesis against other interpretations.

Regional tectonic transport of Mesozoic rocks in southwestern Oregon and northern California by low-angle thrust faulting has been postulated by many other workers. Irwin (1964) originally suggested that the Upper Jurassic and Lower Cretaceous rocks, later named the Otter Point Formation, Humbug Mountain Conglomerate, and Rocky Point Formation by Koch (1966), formed part of an upper plate above a regional overthrust. This interpretation was followed by Blank (1966) and by Blake, Irwin, and Coleman (1967). However, later detailed studies (Bailey and Jones, 1966; Coleman, 1969; and Lent, 1969) show conclusively that in Oregon the regional thrust occurs above the Otter Point Formation. Moreover, Coleman (1969) and Dott (1966) interpret the thrust as passing over the Rocky Point Formation and the Humbug Mountain Conglomerate. The hypothesis presented here differs from earlier interpretations in suggesting that the Upper Jurassic and Lower Cretaceous rocks are themselves separated by a low-angle thrust fault along which regional tectonic transport has taken place.

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HOW LONG? HOW LONG?

By Richard G. Bowen*

The possibility of developing geothermal power has been delayed again because legislation to allow leasing and production of geothermal resources on Federal lands has not been enacted. The delay was not from a lack of effort by its proponents in Congress, but from a disagreement between the Executive and Legislative branches as to the details of the leasing law. This has been the story of this legislation since the first bill was introduced by Senator Alan Bible of Nevada in 1962.

Two bills allowing the leasing of Federal lands for the development of geothermal resources passed both the Senate and the House of Representatives during this session, but, because of the delay in acting on them, there has not been time for a joint conference of members of the House and Senate to consider and reconcile the differences in the two bills. The chances of performing the necessary conference work for passing the final bill during the special session, to be held in November and December, are rated as slim by Washington observers.

Since its introduction, the geothermal leasing bill has been plagued by controversy which has centered around two points, the so-called "grandfather" clause and the amount of rents and royalties to be charged. The grandfather provision recognizes that the pioneers in the industry who, prior to 1965, had either filed claims or applied for leases on Federal land for geothermal resources and had done a significant amount of work on the claims, should have a preferential right to these lands. The other dispute has centered around the revenue aspects of the bill.

The Senate bills have followed the pattern established for the leasing of oil and gas on Federal lands; that is, competitive bidding for leases on lands known to have geothermal resources and on a first-come-first-served basis for so-called "wildcat" acreage. The royalty payment would be a fixed percentage based on the amount of production. This system has served very well during the development of the oil and gas industry and has helped make the domestic oil industry the strongest in the world and prices in the United States the lowest.

The Interior Department has taken the position that, because geothermal energy was not specifically mentioned as a claimable or leasable mineral in any of the mining laws, it could not be developed on Federal lands and those who were exploring for it under any other type of claim were guilty of trespass and had no valid claim. The Senate committee has repeatedly rejected this thesis and pointed out that the development of the mineral resources in the United States has been by the prospector and the developer who entered the public domain and risked their own capital with the expectation of financial reward for their efforts. In the committee's words: "Pioneers have made enormous contributions to the development of the Nation's natural resources. And the geothermal pioneers are no exception. Through their efforts -- their courage, their initiative, their willingness to risk substantial investment, their foresight -- they have demonstrated the great potential value of this little-known resource."

In Senator Bible's bill a compromise was struck in which this right was recognized, but the amount of acreage that could be claimed under the grandfather clause was limited to a total of two leases in any one state and a maximum nationwide of 10,240 acres. Industry representatives at the hearing felt that this amount was only

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a token of what they had worked on and filed claims for, but that it was satisfactory
if it would enable passage of the bill.

Establishment of a rate of return from the production of geothermal resources
has been the other source of contention between the Interior Department and the
Senate committee. The Interior Department recommended that a royalty of not less
than 10 percent be charged and that the rates could be increased by regulation if the
Secretary of Interior felt the field could support higher rates. This, of course, is an
open escalation clause. The objection to this clause came from industry representa-
tives who pointed out that, in order to develop geothermal power, large capital com-
mitments had to be made to build the electrical power plants on the site where the
steam is produced and that these capital commitments could amount to hundreds of
millions of dollars. For example, Pacific Gas & Electric Co. has already spent more
than ten million dollars and is committed to another fifty million over the next five
years at the Geysers area in California.

If the amounts of royalties were not determinable within a limited range, the
financing, based on the amortization of the plants, would be impossible to arrange,
because lenders have a habit of wanting to know when and how they will be repaid.
The committee's recommendation was that royalties would not be readjusted for the
first 35 years, but after that would be readjusted every 20 years to a maximum of
$22\frac{1}{2}$ percent. This would allow for the initial amortization of the plants. A succinct
statement by the Senate Committee gives its philosophy on the matter:

"Further, the committee seriously questions the wisdom of placing undue em-
phasis at this time on rentals and royalties from geothermal leases as a source of
Federal revenue. The emphasis now must be to establish a climate favorable for
development of the resource. Looking to the future, the tax revenue return to the
Government from a vigorous, prosperous geothermal power industry producing low-
cost, pollution-free energy will far exceed any present return from lease rentals
and royalties."

Both bills are similar to the one passed by both the Senate and House in 1968,
but vetoed by President Johnson on the recommendation of the Interior Department.
It appears that even if the bill were approved by Congress during the special session
it would again be vetoed because of the objections of the Secretary of Interior, who
has the job of implementing the bill. If this is the outcome, geothermal develop-
ment will again be shelved for at least two more years while the nation is facing a
power shortage.

The western United States, with its vast areas of recent volcanism, is believed
to contain a large amount of the world's geothermal resources. The abundance of sub-
surface heat is manifested by more than 1200 hot springs and fumaroles. Oregon alone
has nearly 200 hot-spring areas, and drilled wells reveal temperatures as high as 295°F.
Thermal manifestations and studies of heat flow indicate that many areas are probably
underlain by very hot rocks (temperatures as high as 2000°F. have been measured in
lava flows) that are proven in places to be capable of producing dry superheated
steam.

Where this source of low-cost power has been developed, capital costs are
only two-thirds to three-quarters those of comparable fossil fuel plants and less than
half those of a nuclear plant. Not only are costs lower but, perhaps more importantly,
the plant produces a minimum of air and water pollution and has no radioactive
emissions.

Geothermal energy may not be able to provide all the power that Oregon and
the other western states need, but in some regions it could be an equal partner to the

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nuclear and fossil fuel plants now under development. Geothermal energy is a proven method of power production that, on a world-wide basis, has an installed capacity of nearly 1,000,000 kilowatts. It needs no funds for research. The technology for its utilization has been perfected and industry is ready to start its development, but unless some action is taken to pass the legislation that has been before the Congress for the last eight years, there will be no chance for an appraisal of its potential.

*   *   *   *   *

DEPARTMENT GEOLOGIST ATTENDS GEOTHERMAL CONFERENCE

R. G. Bowen, Economic Geologist for the Department, attended the United Nations Symposium on the Development and Utilization of Geothermal Resources held in Pisa, Italy, from September 22 to October 1. This conference, the first that had been held since 1961, was a review of the progress that had taken place since that time. The sessions included the following:

1. Geothermal Systems; a discussion of the geology and physical characteristics of the known geothermal systems.
2. The Status of Geothermal Development; exploration, development, and production activities in the geothermal fields throughout the world.
3. The Geologic Environment of Geothermal Fields as a Guide to Exploration; the geologic factors to consider on an exploration program.
4. Geophysical Techniques in Geothermal Exploration; methods of detection of the geothermal reservoir based on physical measurements.
5. Geochemistry Applied to the Discovery, Evaluation, and Exploitation of Geothermal Energy Resources; chemical analysis as a tool for predicting location and temperatures in geothermal reservoirs.
6. Drilling Technology; recent improvements in drilling and blow-out prevention techniques.
7. Reservoir Physics and Production Management; methods of extracting a maximum amount of energy to the surface for exploitation.
8. Collection and Transmission of Geothermal Fluids; handling of geothermal fluids with emphasis on corrosion prevention and fluid disposal.
9. Utilization of Steam and High Enthalpy Water; mainly electrical power production.
10. Utilization of Low Enthalpy Water; space heating, industrial, agricultural, and other uses.
11. The Economics of Geothermal Power; costs and cost comparison of geothermal with other forms of energy.

Special sessions were devoted to United Nations programs for utilizing the geothermal resources in the under-developed nations. A one-day tour was made of the Larderello Geothermal Field, the world's oldest and presently the largest.

The participants at the conference represented nearly all the countries in the world where geothermal studies are taking place. Since the 1961 conference, production had been increased in every geothermal field that was under development at that time, which included Italy, New Zealand, the United States, and Mexico. New countries that have joined the ranks of geothermal electric-power production are Japan, Iceland, and Russia.

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AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev.1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev.1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch . .	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass .	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole, editor	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor . . .	2.00
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre .	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00

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Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . .	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37) .	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker . . .	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts . . .	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams . .	1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka . .	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka . .	1.50
Geologic map of Oregon west of 121st meridian: (over the counter)	2.00
folded in envelope, $2.15; rolled in map tube, $2.50	
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat .	2.00
folded in envelope, $2.25; rolled in map tube, $2.50	

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Available Publications, Continued:

SHORT PAPERS

2.	Industrial aluminum, a brief survey, 1940: Motz	.$ 0.10
18.	Radioactive minerals the prospectors should know (2nd rev.), 1955:	
	White and Schafer.	0.30
19.	Brick and tile industry in Oregon, 1949: Allen and Mason	0.20
20.	Glazes from Oregon volcanic glass, 1950: Jacobs	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Mason.	0.25
23.	Oregon King mine, Jefferson County, 1962: Libbey and Corcoran. . . .	1.00
24.	The Almeda mine, Josephine County, Oregon, 1967: Libbey	2.00

MISCELLANEOUS PAPERS

1.	Description of some Oregon rocks and minerals, 1950: Dole	0.40
2.	Key to Oregon mineral deposits map, 1951: Mason	0.15
	Oregon mineral deposits map (22" x 34"), rev. 1958 (see M.P.2 for key). .	0.30
3.	Facts about fossils (reprints), 1953	0.35
4.	Rules and regulations for conservation of oil and natural gas (rev. 1962)	1.00
5.	Oregon's gold placers (reprints), 1954.	0.25
6.	Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . .	1.50
7.	Bibliography of theses on Oregon geology, 1959: Schlicker	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . . .	0.50
8.	Available well records of oil & gas exploration in Oregon, rev.'63: Newton .	0.50
11.	A collection of articles on meteorites, 1968: (reprints, The ORE BIN) . .	1.00
12.	Index to published geologic mapping in Oregon, 1968: Corcoran	Free

MISCELLANEOUS PUBLICATIONS

Oregon quicksilver localities map (22" x 34"), 1946	0.30
Landforms of Oregon: a physiographic sketch (17" x 22"), 1941	0.25
Index to topographic mapping in Oregon, 1968	Free
Geologic time chart for Oregon, 1961.	Free

OIL and GAS INVESTIGATIONS SERIES

1.	Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:	
	Newton and Corcoran.	2.50
2.	Subsurface geology of the lower Columbia and Willamette basins, Oregon,	
	1969: Newton	2.50

The
Ore Bin

OREGON

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AN ANCIENT ACACIA WOOD FROM OREGON

By Irene Gregory*

A small, localized outcrop of tuff in central Crook County, Oregon, mapped
as Clarno Formation of late Eocene to early Oligocene age by Waters (1968),
has yielded fossil wood of both stem and roots of the genus Acacia. The pale-
obotanical occurrence is unusual in that fossil stem wood and root wood of
the same species are rarely found together.

The occurrence consists of what is believed to be the remnants of a
single tree. It lies horizontally in a matrix of fine-grained tuff in an out-
crop area of about 200 square feet at the summit of a low hill. Although
the leaves, twigs, and small branches are missing, limbs and roots 10 to 12
feet long (but segmented by earth pressures) and trunk sections are present.
The prime condition of the wood, which shows no fungus rot, insect infesta-
tion, or distortion from drying, indicates that the tree was literally buried
alive.

Conditions of burial and preservation can only be surmised. Possibly
in Clarno time the acacia grew near a stream in the vicinity of an active
volcano. Torrential flood waters undermined the tree, tore it loose, swept
it along stripping it of its leaves and small branches, and finally left it
stranded. Before the wood could deteriorate, it was buried by showers of
volcanic ash and silicified. Erosion has now removed the volcanic cover
and has exposed the fossilized tree, much of it still in place.

Photomicrographs of thin sections cut from the fossil wood (figures 1,
2, and 3) show structural details to be so well preserved that the diagnostic
features necessary for identification are as definitive as in living wood.

Acacias in the Fossil Record

Reports of fossil acacias are few. Leaves are recorded chiefly from
Eocene deposits of Alaska and Texas and from the Oligocene Florissant flora
of Colorado. A well-preserved seed pod compared with Acacia farnesia
(a tidal swamp species) is included in the Eocene Lower Bagshot flora of
England -- a tropical lowland assemblage (Chandler, 1964). Deporta (1961)

* Mrs. James M. Gregory is a fossil wood anatomist, Hillsboro, Oregon.
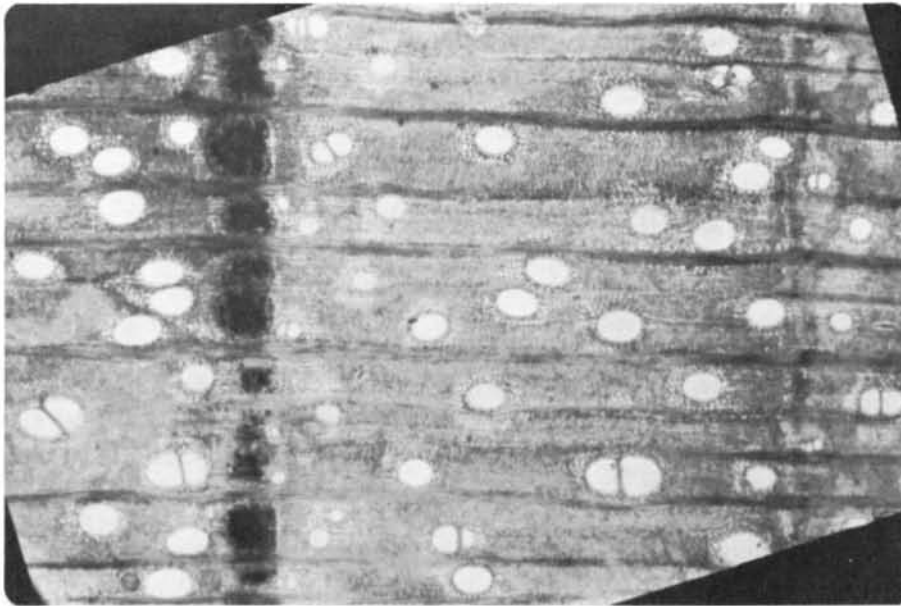
↑ Figure 1. Transverse (cross section) view of stem wood of the acacia. Magnification approximately X 30. Photograph by Thomas J. Bones.

↓ Figure 2. Radial view of stem wood of the acacia. Magnification approximately X 30. Photograph by Thomas J. Bones.
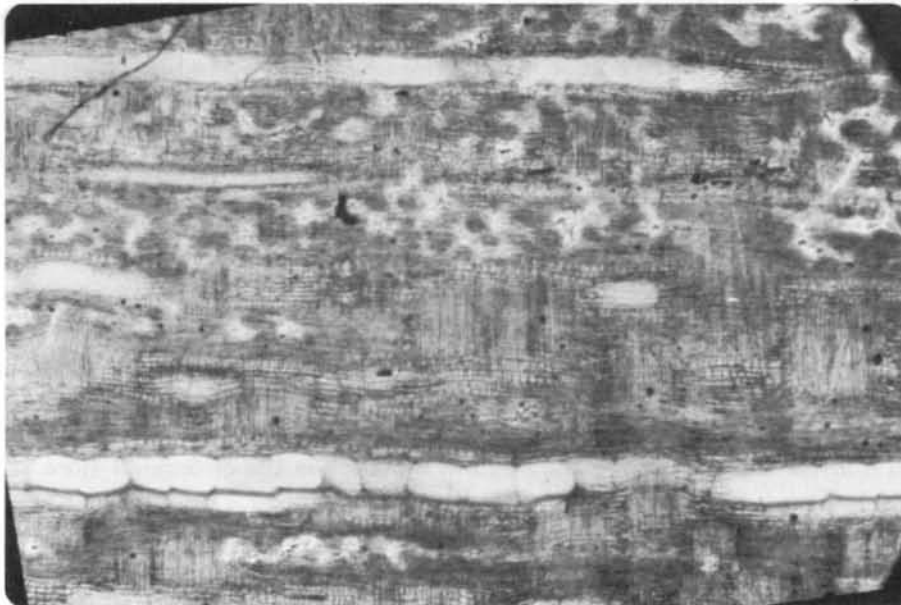
found Acacia sp. in an Oligocene-Miocene pollen flora of Colombia which includes palms and members of several subtropical angiosperm families such as Malvaceae, Bombaceae, and Sapotaceae.

Knowlton (1902) listed Acacia oregoniana Lesq., consisting of a nearly perfect complete seed pod, from the upper Miocene Mascall beds in Grant County, Oregon. But on the basis of additional collections of similar seed pods from the same locality, Chaney and Axelrod (1959, p. 207) have assigned Knowlton's specimen to Albizzia oregoniana.

As far as the author is aware, only one other specimen of fossil wood from the Pacific Northwest has been considered to be a possible Acacia. Prakash and Barghoorn (1961) report on a specimen they catalog as Leguminoxylon occidentale, as follows: "The nearest approach to the structure of the fossil which we have been able to establish is the genus Acacia and within this genus, the species A. ferruginea. One aspect of the fossil which renders its identification more difficult is the tangential compression failure which preceded mineralization, thus exaggerating the ellipticity of the vessels as seen in transverse section. In view of these facts, it seems more desirable to designate the fossil to family rather than to genus."
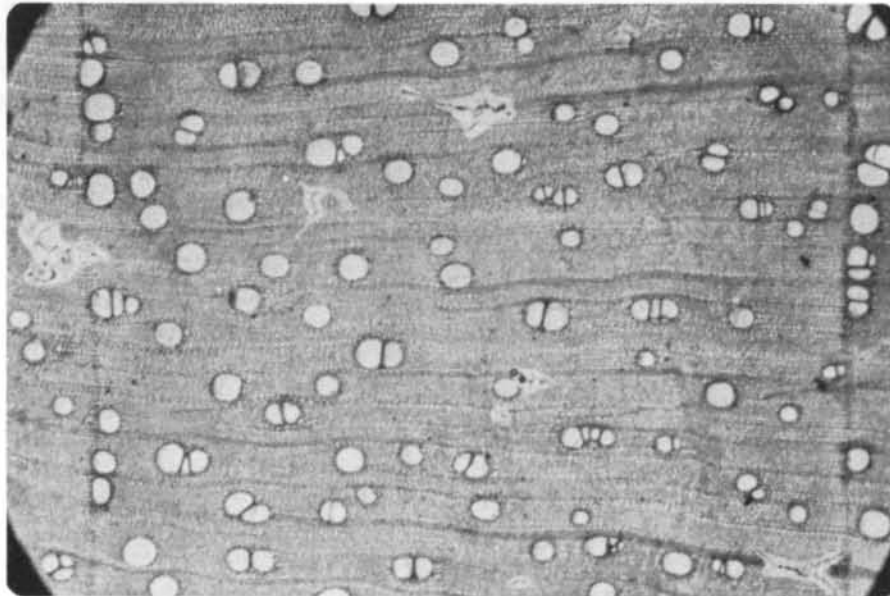
Figure 3. Transverse (cross section) view of root wood of the acacia. Magnification approximately X 30. Photograph by Thomas J. Bones.

Anatomical Description

Genus: Acacia
Sub-family: Mimosoideae
Family: Leguminosae

Growth rings: Indistinct and inconspicuous. Delimited by a fine line of
sporadic terminal parenchyma with infrequent small vessels embedded
in it. Rings vary greatly in width.

Vessels: Medium. Visible without lens. Diffuse-porous. In widest rings,
those in center one-third of ring are largest. Some rings exhibit (at
beginning and end of ring) a distinct zone of vessels smaller than
those in rest of ring and embedded in the terminal parenchyma. Ev-
enly distributed. 5 to 15 per sq. mm. Mostly solitary with a few
radial rows of two (and less frequently) three cells. Occasionally,
two cells are contiguous in the tangential plane. Also scattered ir-
regular clusters or nests of mixed small and large pores (not present
in every ring). Perforation plates simple; somewhat oblique. Vessel
segments are short (0.2 - 0.4 mm.). Rather thick walled and form-
ing conspicuous vermiform lines along the grain. Deposits of gum are
frequently observed in the vessels. (In the fossil specimen these hap-
pen to be the same red-brown color as in the living wood.)

Parenchyma: Abundant vasicentric several cells wide forming a narrow halo
around vessels or vessel groups. Also aliform with short wings.
Sometimes confluent between two or three pores. Terminal paren-
chyma rather sporadic in a 3- to 4-seriate somewhat discontinuous
line including or associated with a zone of small pores.

Fibers: Libriform. Rounded in transverse section. Thick walled. Not
aligned radially but arranged in wide tracts between rays.

Rays: Medium. Visible without lens on cross-section. Approximately 5
per mm. Conspicuous on radial forming a cherry-like fleck. Slightly
undulate around larger vessels. Homogeneous. Mostly 4 to 6 cells
wide. 30 to 40 cells high. Also sparse 1- to 2-seriate rays a few
cells high.

Intercellular canals: Vertical traumatic gum ducts arranged in tangential
rows. Fairly frequent.

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Affinities and Discussion

The genus <u>Acacia</u> today includes more than 400 species of trees and shrubs widely distributed over the tropics and subtropics of both hemispheres. Of these, more than 300 are native to Australia and the South Pacific islands. Native acacias nearest to the Crook County collecting area are those in the southwestern United States and Mexico.

While the fossil <u>Acacia</u> described here reflects closely the typical structural details of the living woods of this genus, to which it clearly belongs, assignment to a particular species is more difficult to establish -- particularly in the absence of such helpful diagnostic plant parts as leaves or seed-pods. Among the species of live woods available for comparison, its structure most closely approximates that of <u>A</u>. <u>arabica</u>, with which it is virtually identical in all major features. Minor differences include: fewer pores in the fossil wood (4 to 12 per sq. mm. in the fossil species and 5 to 15 per sq. mm. in <u>A</u>. <u>arabica</u>); somewhat smaller pore size in the fossil species; and fewer vessels containing gum deposits in the fossil species. (Obscuring by mineral stains as well as abnormalities of preservation might account for this apparent difference to some degree.)

<u>A</u>. <u>arabica</u> is indigenous to India, Arabia, and North Africa. It cannot withstand freezing temperatures but can adapt to a variety of environments, including lake and river banks as well as flood plains with repeated and prolonged periods of inundation.

New Fossil Species?

Further comparisons with additional specimens of living <u>Acacia</u> may prove beyond doubt that the Clarno fossil species has its closest affinity with <u>A</u>. <u>arabica</u>. The minor anatomical differences noted could then provide the basis for separating the fossil species from the closely similar living <u>A</u>. <u>arabica</u> and for the establishment of a new fossil species of the genus <u>Acacia</u>.

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GEOTHERMAL STEAM FOUND IN NEW MEXICO

What appears to be commercial-quality natural steam has been struck by a
wildcat drilling rig in the Valles Caldera near Los Alamos, New Mexico,
according to the Los Alamos Monitor, October 22, 1970. Previous explo-
ration in this region had found mixtures of steam and hot water, but this well
has apparently encountered a new zone containing dry steam. Numerous
exploration wells in the West have tapped hot water at high temperatures
and pressures, but up to now Yellowstone Park and the "Geysers" in north-
ern California were the only known dry-steam fields in the United States.

    The significance of the New Mexico discovery to Oregonians is that
steam reservoirs are more widespread in the western states than previously
supposed and that it is possible to find this source of energy through appli-
cation of geologic knowledge and modern exploration techniques. Explo-
ration for geothermal energy is not yet possible in most of Oregon, however,
because all Federal land has been withdrawn from this type of prospecting.
Consequently, there will be no opportunity to appraise the geothermal po-
tential of this state, or of any other western state where a large share of
the land is under Federal jurisdiction, until a Federal leasing law is passed.

*   *   *   *   *

TWENTY-YEAR INDEX TO ORE BIN PRINTED

The Department has just printed a 20-year index to The ORE BIN. The in-
dex is limited to articles signed by authors and is intended as a handy aid
to finding the major reports published in The ORE BIN during the period of
1950 through 1969. The index can be obtained for 30 cents from the De-
partment's offices in Portland, Baker, and Grants Pass.

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K-AR AGES OF LAUREL HILL PLUTON AND DIKE, OREGON

By Michael Bikerman*

Introduction

The Laurel Hill-Still Creek intrusions are situated on the lower reaches of
the southwest part of Mount Hood in T. 3S., R.8 E.W.M., Oregon. Wise
(1969), in a comprehensive discussion of the geology of the Mount Hood
area, suggests that both intrusions are actually parts of one much larger plu-
ton, which has been locally unroofed to give the two exposures. Accord-
ing to Wise (1969), the Laurel Hill-Still Creek body is a shallow pluton of
quartz diorite intruded into late Miocene Rhododendron Formation (7-12
m.y. old) and early Pliocene lavas (4-7 m.y. old). An anomalous age of
11.6 m.y. was obtained for a whole-rock specimen of the Laurel Hill intru-
sion (Wise, 1969).
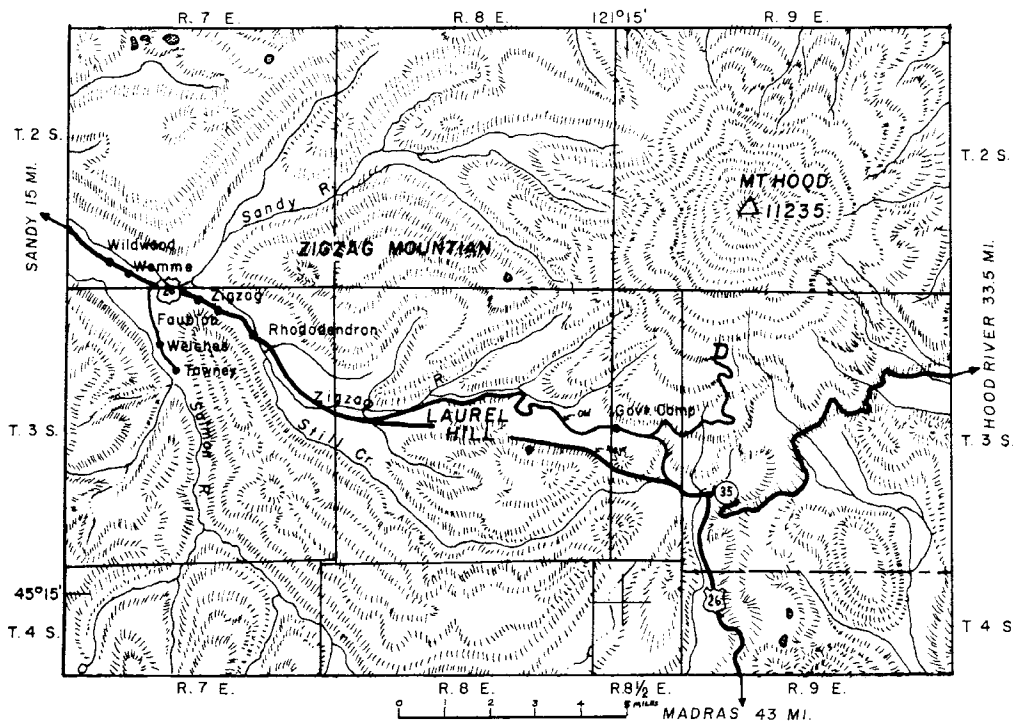
Sketch map of the Laurel Hill area.

* University of Pittsburgh Department of Earth and Planetary Sciences.

This paper reports two new K-Ar mineral ages from the Laurel Hill portion of the intrusion and a whole rock K-Ar date of one of a pair of andesite dikes cutting through the intrusion. These new dates are interpreted in light of the dates given in Wise (1969) on the Laurel Hill and associated volcanic rocks.

Sampling

The collection of the pluton samples was made by H. Ito of the University of Pittsburgh as part of a paleomagnetic study of the Laurel Hill intrusive (Ito and Fuller, 1970). The dike was sampled by the author at a later date. The three samples were collected from fresh outcrops exposed along U.S. Highway 26 between Rhododendron and Government Camp.

Age Determination Methods

The two pluton samples (Ito No. 509 and No. 512) were separated and analyzed at the U.S. Geological Survey in Menlo Park, Cal., in G.B. Dalrymple's laboratory prior to the completion of the author's laboratory. The techniques used in the U.S. Geological Survey laboratory for both argon and potassium analyses are discussed by Dalrymple and Lanphere (1969).

The technique used for argon analysis at the University of Pittsburgh is similar in many ways. The main differences are that we use a less sensitive MS-10 mass spectrometer which is run dynamically, and that our calibration is with known mineral separates rather than air. The argon spike is Ar^{38} from the University of Zurich. Sample fusion is by RF in a glass vacuum system. Clean up of gas from the fusion is accomplished by adsorption of water on zeolite, through reaction with hot (650°C) CuO, and with Ti foil.

Potassium analysis on the dike sample was done by John Anania using atomic absorption spectrophotometry. Duplicate analyses agree to within 1 percent of the amount reported.

Results

The two plutonic samples Ito No. 509 and No. 512 were split into hornblende and plagioclase samples, each of which was processed independently. The results (see table 1) indicate that the hornblende ages agree within experimental error at 8.2 m.y. The plagioclase separates both gave off much gas in fusion and contained more than 99 percent atmospheric argon and no useful age could be calculated from them. The hornblendes also contained a high atmospheric argon content -- a significant point for further discussion on the pluton.

The dike gives an age of approximately 5 m.y. (within the possible range of 4 m.y. to 5.5 m.y.). The uncertainty here is a function of a very

Table 1. K-Ar ages of the Laurel Hill pluton and associated dike.

Sample No.	Material	K%	Ar^{40*}	Atmos. Ar %	Apparent Age
Ito 509	hornblende	.26	$3.885 \times 10^{-12} m/g$	86.4	$8.4 \pm .6$
	plagioclase	.39	(see text)	99.5	- - -
Ito 512	hornblende	.24	$3.379 \times 10^{-12} m/g$	88.7	$8.0 \pm .6$
	plagioclase	.67	(see text)	99.3	- - -
M.B. 1-69	dike whole rock	1.15	$1.025 \times 10^{-12} m/g$	20.0	$5.0 ^{+.5}_{-1.0}$

low Ar^{36} peak leaving its actual height resolution somewhat imprecise. However, there is no question that the dike is younger than the pluton, which it intrudes.

Discussion

The age of 8.2 m.y. for the pluton is still anomalous, because it is older than the rocks into which it intrudes. The dike is of about the same age as the overlying andesites and might be part of the same system.

What are the reasons for the apparent discordance between the ages of the volcanic rocks and the pluton? Two main possibilities appear: 1) That the field relationship of the Laurel Hill pluton intruding the Rhododendron Formation and the overlying andesites is incorrectly interpreted, and actually that the contacts are in part or entirely volcanic rather than intrusive; or 2) that the K-Ar age of the Laurel Hill pluton is anomalously old.

Let us examine the first possibility. The field relations depend on interpretation of the contact regions. The contact zones were deeply weathered in the outcrops along the highway and were largely covered in the river valley just south of the road.

It is possible that the pluton intrudes the Rhododendron Formation without intruding the overlying andesites. If the Rhododendron Formation is Clarendonian (Wise, 1969) and if the range of Clarendonian time is 10-12 m.y. (Evernden and others, 1964) or from about 9.4 m.y. to less than 12.4 m.y. (Kistler, 1968), then the intrusion at 8.2 m.y. is consistent. If, however, the Rhododendron Formation is closer to 7 m.y. old as a hornblende age from a boulder in the lower part of the formation indicates (Wise, 1969), and if the Laurel Hill pluton actually intrudes the overlying andesites for which Wise (1969) reported an age of 5.5 m.y., then the second

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possibility must be considered.

In a discussion of anomalous ages we probably should include the age of 11.6 ± 1.2 on a whole rock sample of the pluton given by Wise (1969). This value points out the problem of whole rock K-Ar dating of coarse-grained crystalline rocks. The fact that the feldspars contain such a large excess of atmospheric argon (and incidentally unusually large total volumes of gas) would suggest that any whole rock analysis might be overwhelmed by atmospheric argon to the detriment of the precision and probably the accuracy of analysis. Not having the complete analytical data on Wise's (1969) results, any further discussion would be speculative.

The presence of the large amount of gas in the fusion of the feldspars, taken along with the high atmospheric argon and the broken appearances of the mineral grains as seen in thin section, suggests that this intrusion was emplaced rather close to the surface in a partially solidified state. The gas content (aside from argon) was not analyzed and may be largely water from meteoritic (and connate?) sources. Wise (1969) suggests that high water pressure was present at the time the feldspars crystallized, and that possibly it persisted through final emplacement, leading to water adsorption by the crystals of the pluton. It follows that a cool, shallow intrusive would not have the characteristic contact relationships to be expected. This may in part account for the field problems associated with the Laurel Hill pluton.

The second possibility -- that the pluton is younger than 5.5 m.y. old and that the hornblende K-Ar ages are incorrect -- must now be examined. If this is so, then the dikes most probably would fall at the younger end of their range, or 5 m.y. to 4 m.y. The occurrence of three events -- the extrusion of the 5.5 m.y. volcanics, the intrusion of the pluton into the volcanics, and the cutting of the cooled pluton by the dikes at 4 to 5 m.y. in less than $1\frac{1}{2}$ m.y. is not impossible but just a tight fit. If all the rocks were from the same magma chamber, then some of the objection might be lifted, especially if the dikes were actually as young as 4 m.y.

If the pluton is between 4 m.y. and 5.5 m.y. old, then the hornblendes from it must contain about 1.3 to 1.8×10^{-12} moles/gm of excess argon 40. This amount is less than that found in some anomalous hornblendes (Pearson and others, 1966; Damon and others, 1967), and hence this is a possible reason for the apparent age. The excess could, in part, be caused by the slow cooling of the parent magma at depth prior to intrusion, and the resultant memory of an older "age" in the hornblendes as finally emplaced. This remnant argon could be combined with or overshadowed by, absorption of radiogenic (and later on atmospheric) argon from the coexisting gas phase in the magma. There is no independent quantitative evidence for this, and the possibility of potassium loss further clouds the issue. With the present data the question of anomalous Ar^{40}/K^{40} ratios in the hornblendes from the Laurel Hill pluton versus anomalous field relationships leads the author to favor the latter choice. Certainly more field study of the pluton-volcanics contact is called for.

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Summary and Conclusions

From the above discussion it appears that the Laurel Hill intrusion is most probably older than the 5.5 m.y. volcanics, and may very well be 8.2 ± .2 m.y. old.

An interesting, but circumstantial, corroboration of this age is obtained from the magnetic data (Ito and Fuller, 1970) which shows a reversal occurring in the Laurel Hill pluton. Nagata (personal communication, 1970) has found independent evidence for a reversal of this type occurring at 8.2 m.y. The pluton was, in turn, intruded by a dike at about 5 m.y., or penecontemporaneously with the volcanic activity at 5.5 m.y.

Acknowledgments

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* * * * *

NEW MICROSCOPE HELPS FIND OIL

The photographs reproduced opposite were taken at the Pan American Research Center in Tulsa, Okla., using a remarkable new invention -- the scanning electron miscroscope. The equipment enables the research technician to magnify an object, such as a microfossil, as much as 50,000 times. The image is viewed on a small cathode ray tube similar to the screen of a television set. From the image provided by the tube, paleontologists, petrologists, and palynologists at Pan American can take photographs of greatly magnified minute fossils and rock particles. Photographs of these objects provide information about the oil-bearing formations that is vital in the search for petroleum reservoirs. An article in Pan Am's magazine, Horizons, (October 1969) describes how the equipment is used, as follows:

Palynologists use the scanning electron microscope (SEM) in the study of pollen, spores, and coccoliths, the skeletal remains of a minute form of marine life. These minute plant remains are keys in determining the age of rocks and are useful in correlation of subsurface strata.

Petrologists use the SEM to examine the surface of minute sand grains; one objective is to determine how the grains are bonded together to form rock. A question which the SEM helps to answer is: Why do pores of some rocks hold oil and gas while those of others do not?

For example, tiny rock samples from two adjacent wells in Montana, one productive and one dry, were put under the scanning microscope. Examination of the photographs revealed that pores of rocks from the productive well were slightly larger than those from the dry hole, but more importantly, they were not clogged by fine-sized particles. With equipment available previously, the difference would have been difficult to see.

One of the most important uses of the SEM is in the study of fossil Foraminifera. These microscopic animals are the most widely used fossils in the oil industry, particularly in areas like the Gulf Coast. Ordinary photographic equipment has never been satisfactory for viewing the complex features of Foraminifera. But with the SEM, the paleontologist can for the first time obtain almost perfect illustrations, thus adding a new dimension to his ability to see and study these microorganisms.

Explanation of photographs

1. A tiny fossil foraminifer magnified X78.
2. A close-up of a pore of the same foraminifer magnified X7,340 reveals the skeletal remains of even smaller life within the specimen's pores.
3. Discoaster perpolitus (plant-like). Age 68 million years. X3,760.
4. Coccolithis grandis (plant-like). Age 45 million years. X3,850.
5. Florilus (foraminifer). Age 15 million years. X92.
6. Artemisia (pollen). Age modern. X 760.
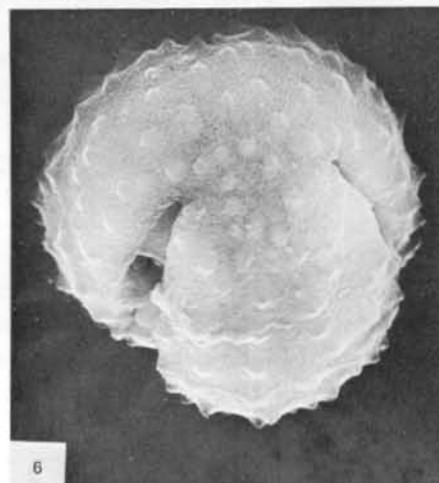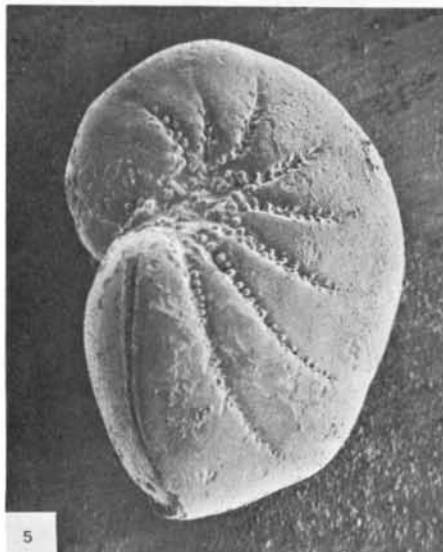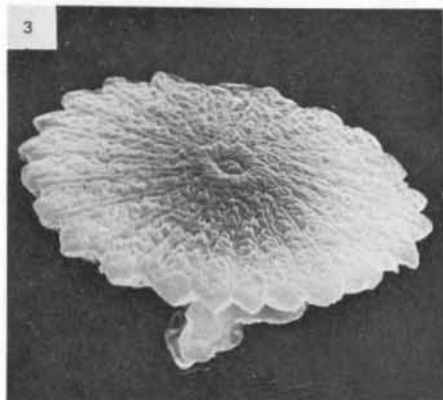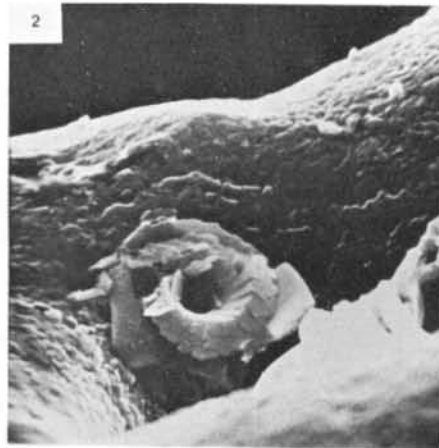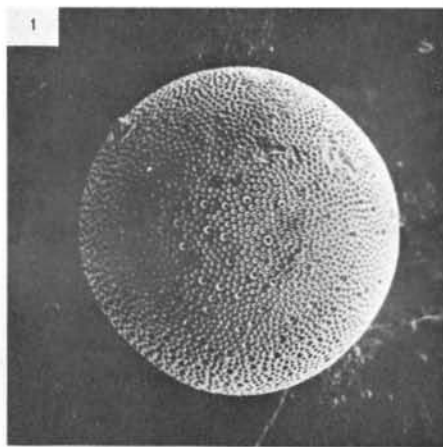
ASPINALL OUTLINES ACTION ON PLLRC RECOMMENDATIONS

At the American Mining Congress convention in Denver, Colorado, September 1970, The Honorable Wayne N. Aspinall, Chairman of the Public Land Law Review Commission, presented a paper in which he suggested a timetable for implementing the Commission's recommendations*. Excerpts from his speech, entitled "Future Public Land Policy -- where do we go from here?", are quoted as follows:

"Now that the Public Land Law Review Commission has submitted its report and recommendations, there remains the important unfinished business of obtaining a meaningful, constructive revision of the public land laws, including those laws affecting the discovery, development and production of mineral resources. As a result of our study one thing has been made clear: there is a vital need for such revision. Everyone -- whether praising the report or not -- agrees that we cannot continue much longer under the existing laws and procedures."

"We have not asked that each and every detail of the Commission's report be endorsed. We do ask endorsement of the basic principles, after which the details will be worked out by reasonable people to assure that the public interest is served. The many people who have dedicated themselves to the idea that there should be a meaningful revision of the public land laws make certain that progress will be made and action taken beginning in the 92nd Congress, which convenes next January."

"The questions most frequently asked are: How long will all this take? What will the time table be? What is the order of priorities?

"The very complexity of the subject matter makes it difficult -- almost impossible -- to have one or two omnibus bills that would embody all, or even a majority, of the Commission's recommendations. Compounding this situation is the divided jurisdiction among the various committees of Congress. An omnibus bill would immediately run into this problem. It obviously seems logical, as the first order of business, to determine whether we can implement the Commission's recommendation to place jurisdiction over public land matters in one committee of each House of Congress."

"Similarly, we should find out at an early date whether it is going to be possible at this time to carry out the Commission's recommendation to merge the Forest Service with the Department of Interior and thereby place in one department the four major public land management agencies. There is little point in pursuing legislation on the assumption that the Forest Service either will or will not remain in the Department of Agriculture apart

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* "One Third of the Nation's Land," the report of the Public Land Law Review Commission, containing 400 recommendations for revision of public land policies, was presented to the President and Congress in June, 1970.

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from the other land management agencies.

"We can, in my opinion, determine these matters, of both legislative and executive jurisdiction over public land matters, rather quickly."

"We should also start work on implementing those recommendations the Commission has made concerning the basis of future public land policy. Such legislation might be introduced as an omnibus bill to cover all aspects of planning, including the establishment of goals and objectives for public land use, and the administrative procedures to be followed in conjunction with such use. This, we submit, would be in harmony with the concept of the legislation establishing the Commission, as well as with the Commission's view of building public land law on a foundation of principles. Interested groups, including yours, should be prepared to submit views on such legislation before you get to the point of recommending the terms of proposed legislation addressed to the specific problems of mining, or other particular uses of the public lands."

"Once we have established a firm foundation of policies upon which action is to be based, we can proceed to take up individual pieces of legislation dealing with various aspects. If we do not go about this with a plan for logical and orderly consideration of public land policy, we will find ourselves right back where we are today, with disjointed, uncorrelated laws.

"We recognize that this procedure will be time consuming. But, no matter how we view it, the process must be time consuming. It is going to take patience and the service of dedicated people to see this through. The legislative process will require that the bills be taken up in sequence through several Congresses. A Congress, as you know, runs for a period of two years and it therefore appears that it will take a minimum of six, eight, or ten years to implement substantially all of those recommendations made by the Commission that can and should be considered as being for the immediate future.

"In this connection, may I remind you that the Commission was looking forward to the year 2000, and that some of its recommendations are of a long-range nature, which none of us expect to be implemented immediately."

"...We urge each of you to become familiar with all of the recommendations and be ready to participate in the legislative process when it begins next January. We believe the Commission's report provides an excellent starting point for the legislation that is necessary. With the help of all concerned citizens, and citizen and industry groups, we know that this next phase of the work will be completed -- just as the last phase was -- within a time frame that will be reasonable while giving full consideration to the public interest."

* * * * *

HOW TO JOIN THE CLUB*

All you have to do to belong to the wildcatters' club is to hire a drilling rig, lease some undrilled land, and dig a hole in the ground from 5 to 25,- 000 feet deep and hope you find oil or gas. This makes you a bona fide member of the club.

The average hole price for shallow wells ranges $15 to $20 a foot and the well deeper than 15,000 will cost you about $700,000, and the world's deepest well, 25,340 feet, cost three million.

Members' benefits include the fun of grinding up diamond bits, paying high interest rates on borrowed money, pumping drilling mud in and out of the hole, and risking a blow-out that wipes out your investment over night. It's sort of like playing financial Russian roulette with a howitzer.

Your chances of finding enough oil or gas to make a profit are about two out of a hundred holes, so you see you could sink a lot of bread before you chickened out.

For 39 years the Oil Scouts have listed every wildcatter's well in a big black book called "International Oil and Gas Development." The Scout's 40th Year Book names 9,654 United States wildcatters who joined the club in 1969, and tells you where and how they spent their money. Obviously, one can't list them all here, but just the deepest holes drilled (in states west of the Mississippi) in 1969 will chill your Scotch blood.

In Alaska, six wildcats out of 30 hit pay, and oil men spent more than 900 million dollars there in 1969 just for leases. Here again the year's deepest well, drilled to 15,454 feet by Shell Oil on federal land, was a duster.

In central California, Standard Oil of California drilled the deepest well of the year to 12,572 feet -- it was dry. Offshore of California, Humble drilled the year's deepest well -- also dry at 15,456 feet. In southern California one deep well produced oil when Continental Oil Co. drilled to 13,630 feet for a new pay in the San Miguelito Field, and Standard of California drilled a dry hole to 13,868 feet.

In Colorado, wildcatters drilled 500 exploratory tests and only 64 found oil or gas. The deepest test went to 16,381 feet, and finally produced new gas at 2,200 feet in the Lay Creek Field. The deepest tests in Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, and South Dakota were all dry.

In Texas, the deepest test in San Antonio, North Texas, Panhandle and West Texas found production. A 16,580 test by Cherryville Corp. in East Texas, a 17,622 foot test in Gulf Coast by North Houston Operators, a 7,256 test in West Central Texas by Westrons Petroleum were all dry.

In Utah, Flying Diamond drilled the deepest hole -- dry, to 11,420 feet, and in Wyoming, Marathon drilled deepest test to 19,817 feet -- and by now you know. It was dry.

*Excerpts from Internatl. Oil Scouts Ann. Pub., v. 11, No. 9, Sept.1970.

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26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
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36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
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OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

NICKEL-BEARING STREAM SEDIMENTS
FROM SOUTHWESTERN OREGON

Introduction

An anomalously high nickel content has recently been found in some of the stream-sediment samples collected by the Department in southwestern Oregon. The samples are from streams draining areas of known ultramafic rocks, the largest of which is the Josephine ultramafic sheet (figure 1), in southeast Curry and southwest Josephine Counties. Since only a few of the many samples collected from streams draining the ultramafic rocks were high in nickel, it was reasoned that the anomalous samples were derived from areas of relatively high nickel content within the ultramafic mass. It was felt that if concentratable nickel-bearing minerals could be found in the samples, the area might warrant exploration for possible economic deposits

Geology of the Josephine Ultramafic Sheet

The Josephine ultramafic sheet is composed chiefly of an olivine-rich harzburgite with lesser amounts of pyroxenite and dunite. Large areas of this ultramafic mass have been serpentinized to varying degrees. Serpentinite is concentrated along the margins of the body in fault zones and around later intrusives, which include gabbro and diorite stocks and diabasic and dacitic dikes. The thickness of the ultramafic sheet is not known; Wells and others (1949, p. 10) state that it probably does not exceed 15,000 feet.

Preliminary Sampling and Testing

The Department conducted a stream-sediment sampling program from 1963 to 1967, sampling more than 3,000 sites in southwestern Oregon. The sediments collected were initially analyzed for copper, zinc, molybdenum, and mercury. Splits of all these samples were run by semiquantitative spectrographic analysis for 30 elements by the U.S. Geological Survey's Denver laboratory. The results were released as an open-file report with maps in 1969 (Bowen, 1969). The high nickel values were recognized as a result of the spectrographic analyses. Samples considered anomalous are those with 3,000 or more parts per million nickel (see Table 1).

Because of its high nickel content and accessibility, locality No. 28

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FIGURE 1

Generalized Outline of Josephine Ultramafic Sheet Showing Locations of Anomalous Nickel Samples

x   Sample sites.

960   Sample sites with 3,000 or more p.p.m. Ni.

    Peridotite and Serpentinite.

OREGON

SCALE
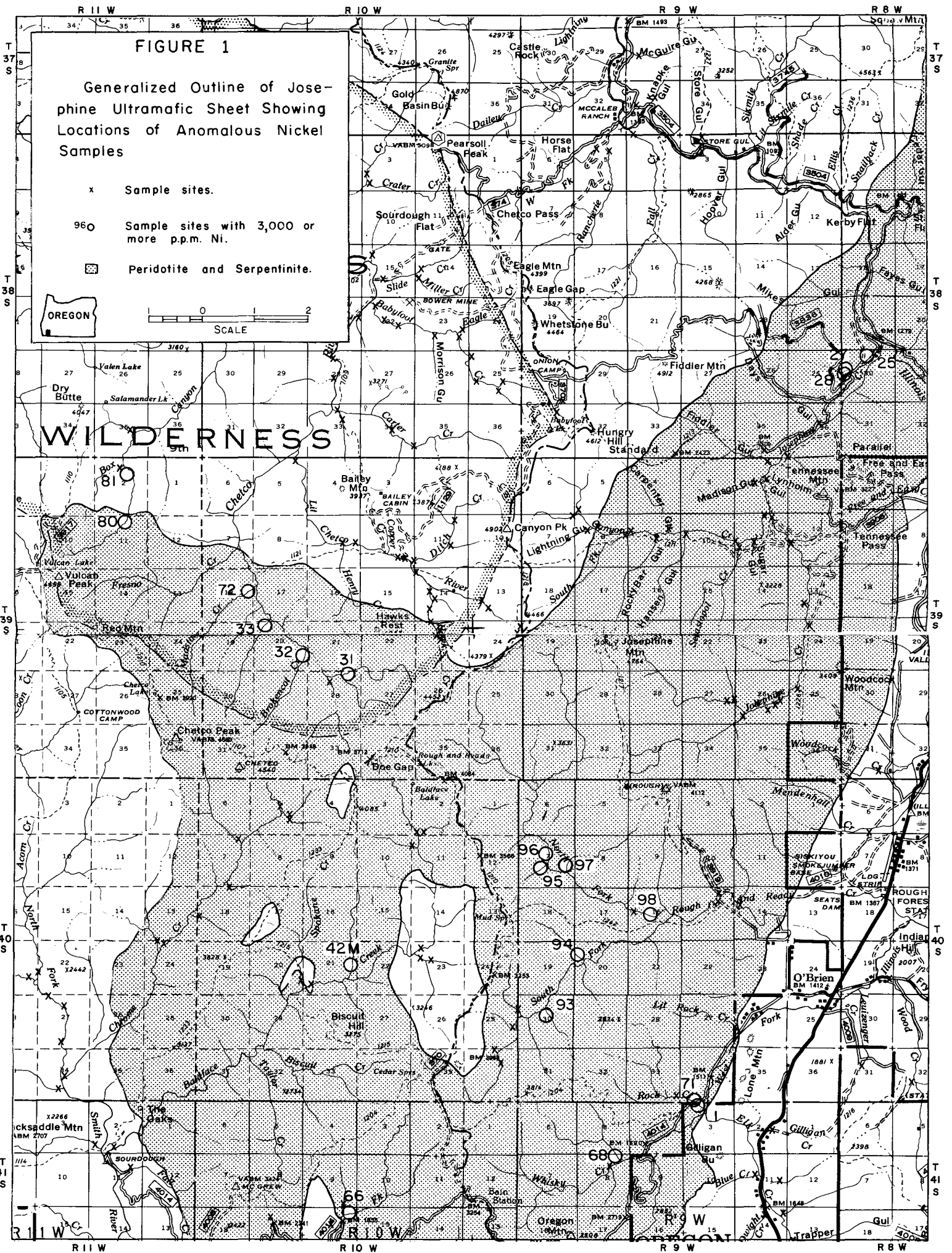
Table 1. Anomalous nickel samples.

Quadrangle	Sample No.	Name of Creek	Location	Sec.	T.S.	R.W.	Ni (ppm)
Gold Beach	24*	S. Trib. Hunter Creek	NW	18	37	13	5,000
Chetco Peak	93	S. Trib. S. fk. Rough & Ready	$N\frac{1}{2}$	30	40	9	5,000
Chetco Peak	94	N. Trib. S. fk. Rough & Ready	NW	20	40	9	5,000
Chetco Peak	95	S. Trib. N. fk. Rough & Ready	SW	7	40	9	5,000
Chetco Peak	96	N. fk. Rough & Ready	C	7	40	9	3,000
Chetco Peak	97	N. Trib. N. fk. Rough & Ready	SE	7	40	9	5,000 +
Chetco Peak	98	N. fk. Rough & Ready	NW	16	40	9	3,000
Chetco Peak	66	Diamond Creek	NE	16	41	10	3,000
Chetco Peak	68	Trib. Whiskey Creek	NE	8	41	9	3,000
Chetco Peak	71	Rock Creek	SW	34	40	9	5,000
Chetco Peak	72	Madstone Creek	$E\frac{1}{2}$	18	39	10	3,000
Chetco Peak	80	Box Canyon Creek	$N\frac{1}{2}$	11	39	11	5,000
Chetco Peak	81	Trib. Box Canyon Cr.	NE	2	39	11	3,000
Chetco Peak	31	Chetco River (head)	$N\frac{1}{2}$	28	39	10	3,000
Chetco Peak	32	Broken Cot Creek	SE	20	39	10	3,000
Chetco Peak	33	Un-named trib. Chetco River	NW	20	39	10	3,000
Chetco Peak	1	Rock Creek	NW	3	41	9	3,000
Chetco Peak	42M	Un-named trib. to Baldface Creek	SE	21	40	10	3,000
Cave Junction	25	Un-named trib. Josephine Creek	$N\frac{1}{2}$	30	38	8	3,000
Cave Junction	27	Un-named trib. Josephine Creek	$W\frac{1}{2}$	30	38	8	3,000
Cave Junction	28	Un-named trib. Josephine Creek	$W\frac{1}{2}$	30	38	8	5,000

* Not on the map.

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Table 2. Nickel analyses of reference group stream sediments, Cave Junction quadrangle.

Sample No.	Name of Creek	Location Sec.	TS.	RW.	Nickel analyses (wet chemical) percent (USBM)	Spectrographic (ppm) (USGS)
17	E. Fk. Chapman Cr.	SE 24	39	8	0.025	500
28	Trib. Josephine Cr.	W½ 30	38	8	0.41	5,000
44	Little Elder Cr.	43	40	8	0.066	700
67	Trib. Josephine Cr.	NW 24	39	9	0.12	1,500
87	N.Trib. Josephine Cr.	W 26	39	9	0.18	2,000
97a	Trib. Althouse Cr.	SE 3	41	7	0.10	1,000
98a	Johnson Gulch	NE 10	41	7	0.11	1,000

was resampled, and nearly all of the subsequent work was done on bulk samples from that locality. Preliminary testing by the Department, which included screening, gravity concentration, and magnetic separation, failed to show significant variations in nickel values.

The Department then requested Jack C. White of the U.S. Bureau of Mines in Albany, Oregon to perform characterization and mineral dressing tests on the sediments from locality No. 28. The first step was to compare the high nickel sample with standard samples. Sediments low in nickel from nearby streams, some of which drained ultramafic areas, were analyzed by wet-chemical methods at the Bureau of Mines to establish reference samples with which to compare the high nickel material. Table 2 shows that sample No. 28 contained more than twice as much nickel as any other sample in the reference group.

Analytical Tests by U.S. Bureau of Mines

Petrographic examination of screen sized fractions shows that all fractions, including the minus 200 mesh material, consist predominantly of fine-grained rock fragments. Only a small percentage of discrete mineral particles was present in any size fraction, indicating that little or no concentration of a single mineral can be expected by size classification. Nickel percentages and distribution are shown in Table 3. Nickel was not significantly concentrated in any size fraction.

A polished briquette of the 10/20 mesh size fraction was examined petrographically and was analyzed by electron microprobe to identify nickel minerals and to indicate the possibility of physically beneficiating the material. Although serpentine rock fragments were the most abundant constituent in this size fraction, nickel was identified in at least three phases

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Table 3. Nickel distribution in screen sized products.

Size, Tyler mesh	Weight, percent		Nickel analysis, percent		Nickel distribution, percent
10/20	44.68		0.41		44.69
20/35	27.14		0.41		27.15
35/65	15.49		0.39		14.74
65/150	7.05		0.41		7.05
150/200	1.79		0.47		2.05
Minus 200	3.85		0.46		4.32
Total	100.00	Calculated head	0.41	Total	100.00

by electron microprobe analysis.

Serpentine grains contain approximately 0.2 percent nickel in isomorphous substituion and a few scattered minute high-nickel inclusions. Probably more than half the nickel in this sample occurs in the silicate crystal lattice and, therefore, cannot be concentrated by physical beneficiation.

A small percentage of manganese oxide - iron oxide grains containing higher percentages of nickel and some cobalt were present. Such oxides are precipitated during weathering and leaching (laterization) of nickel-bearing ferromagnesian rocks (Rankama and Sahama, 1950, p. 684). Concentration of similar manganese oxide minerals by attrition scrubbing and sizing of Philippine laterite is described in Bureau of Mines Report of Investigations 6063 (Banning and others, 1962). The published data indicate that manganese oxides occur as small segregations within weathered nickel-bearing rocks rather than as massive deposits. The oxide grains should, therefore, be considered as small, high-grade segregations from a low-grade deposit rather than as small pieces of a larger high-grade deposit.

Electron microprobe analyses from high-nickel and low-nickel areas are given in Table 4.

A back-scattered electron photograph and X-ray scans of an oxide grain are shown in Figure 2. The back-scattered electron photograph seems to show relict structure of a mineral that has been replaced. Coincidence of manganese and nickel indicates codeposition of these two metal oxides. Iron occurs as a thin surface coating and in low Mn-Ni areas within the grain.

An additional nickel-bearing phase is nickel-iron sulfide which occurs as a few scattered inclusions within serpentine grains.

Possibilities of physically beneficiating this material appeared to be remote; however, concentrations of nickel and cobalt in oxide particles and the presence of nickel-iron sulfides indicated that preliminary laboratory

Table 4. Electron microprobe analyses of two areas in an oxide grain.

	Percent	
Element	High nickel area	Low nickel area
Manganese	25	12
Iron	10	28
Nickel	12	3.5
Cobalt	2	1.5
Aluminum	5	5
Silicon	2	8
Magnesium	<1	<1

mineral dressing tests were justified.

A 500-gram sample was stage ground through 325 mesh to liberate nickel sulfide minerals and a froth flotation test was made on the ground material in an attempt to concentrate the sulfide minerals. Potassium amyl xanthate was used as collector (Table 5).

Nickel was not concentrated by froth flotation indicating that very little nickel is present in the form of sulfide minerals, a conclusion which is in agreement with the microprobe data.

The discrete manganese oxide - iron oxide grains offered the possibility of magnetic concentration. A series of magnetic products was made with a hand magnet and the Frantz electromagnetic separator. The products are listed in Table 6 in decreasing order of magnetic susceptibility. The 0.2 amp product contains 33 percent of the sample weight and 48 percent of the nickel in the sample. This slight concentration of nickel would not be of commercial interest at the present time.

Table 5. Flotation products from the ground stream sediment sample.

Product	Weight, percent	Nickel analysis, percent	Nickel distribution, percent
Concentrate A	1.40	0.43	1.43
Concentrate B	1.54	0.45	1.64
Concentrate C	2.44	0.45	2.61
Tailing	94.62	0.42	94.32
Total	100.00	Calculated head 0.42	Total 100.00
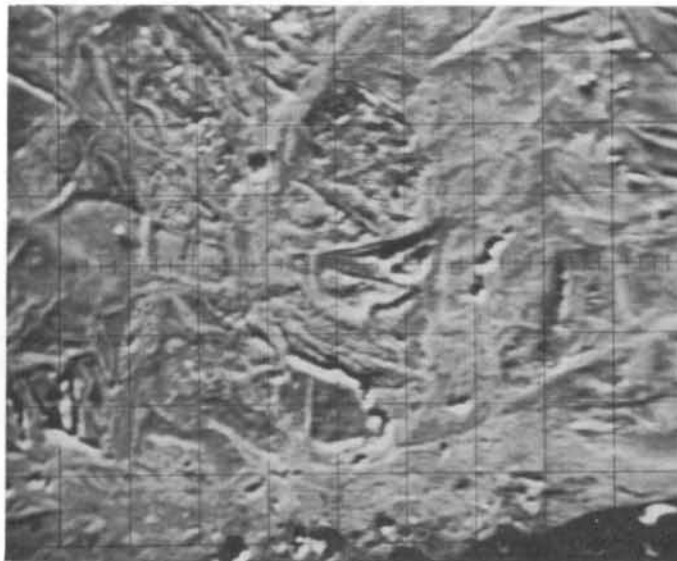
Backscattered electrons

Iron

Figure 2.   Electron microprobe scans of a manganese oxide – nickel oxide grain. Pictures are $275\,\mu$ wide (original magnification before reduction for printing was 350 x). (Above and opposite)

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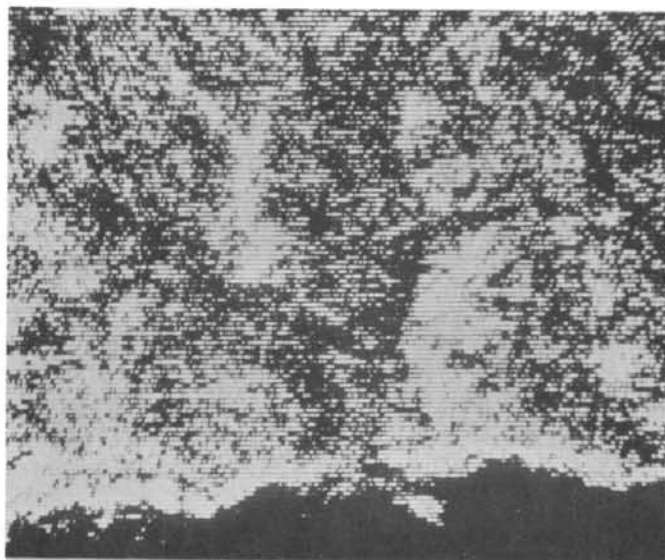
Manganese
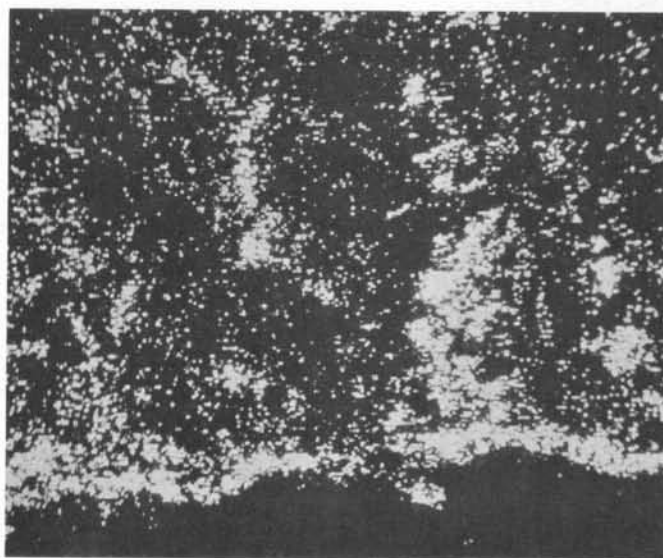
Nickel

Table 6. Magnetic products from stream-sediment sample No. 28.

Product	Weight, percent	Nickel analysis, percent	Nickel distribution, percent
Hand magnet	20.46	0.32	19.53
0.2 amp	33.00	0.49	48.24
0.3 amp	8.89	0.35	9.28
0.5 amp	15.74	0.28	13.15
Non-magnetic	21.91	0.15	9.80
Total	100.00	Calculated head 0.335	Total 100.00

Conclusions

Although the data developed here suggest that beneficiation of the material is impractical or impossible, it should be pointed out that these tests were run on only one of the several anomalous nickel sample localities. The Department believes that further investigation of other high-nickel sample areas may be justified.

References

Banning, L. H., Anable, W. E., Quicho, R. B., Hess, H. D., and Good, P. C., 1962, Metallurgical investigations of Philippine nickeliferous ores: U.S. Bureau of Mines Rpt. Inv. 6063.

Bowen, R. G., 1969, Geochemical stream-sediment sampling in southwestern Oregon: Oregon Dept. Geology and Mineral Industries open-file rept.

Rankama, Kalervo, and Sahama, Th. G., 1950, Geochemistry: Univ. of Chicago Press.

Wells, F. G., Hotz, P. E., and Cater, F. W., Jr., 1949, Preliminary description of the geology of the Kerby quadrangle, Oregon: Oregon Dept. Geology and Mineral Industries Bull. 40.

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PLIOCENE MAMMAL STUDY PUBLISHED

"Pliocene Mammals of Southeast Oregon and Adjacent Idaho," by J. Arnold Shotwell, has been published as Bulletin 17 by the Museum of Natural History, University of Oregon. The bulletin can be ordered from the Museum. The price is $2.00.

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"SPATTER CONE PITS"
SAND MOUNTAIN LAVA FIELD, OREGON CASCADES

By Jim Nieland*

Three "spatter cone pits" in the Cascade Range of Oregon were explored in 1970 by the Oregon Grotto of the National Speleological Society. The pits are situated in the Sand Mountain Lava Field, an area of recent volcanism between Santiam Junction and Belknap Crater (figure 1).

The Oregon Grotto group was prompted to explore the area by an article in the July 1965 ORE BIN, "Recent volcanism between Three Fingered Jack and North Sister, Oregon Cascade Range," by Edward M. Taylor. Taylor describes three areas of the Sand Mountain alignment that contain vertical conduits ("spatter cone pits"). Two areas are located at the foot of Nash Crater -- one on the south side and one on the northwest side. The third area is associated with a vent half a mile southwest of the Sand Mountain Cones.
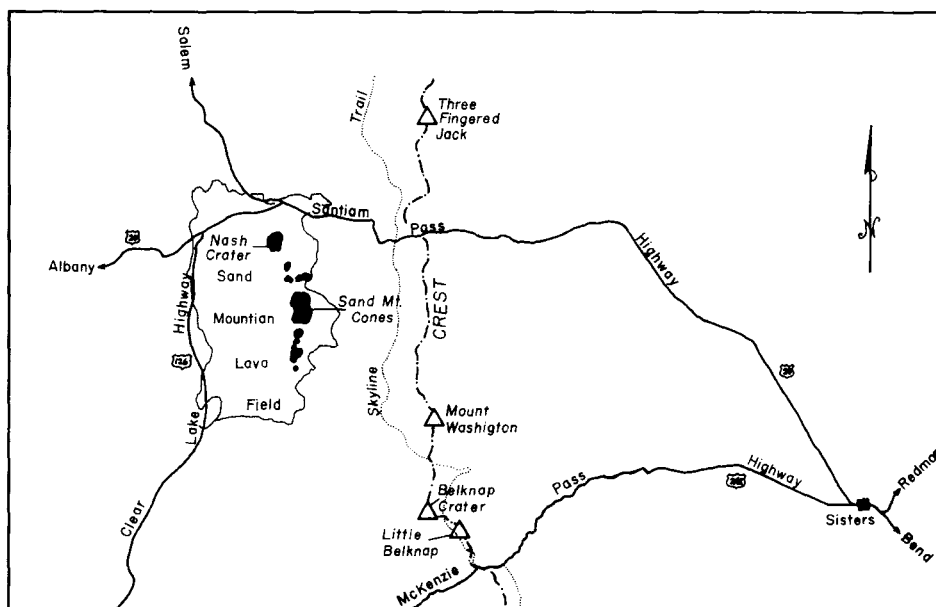
Figure 1. Index map showing location of the Sand Mountain Lava Field (adapted from Taylor, 1965).

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* Geology student, Portland State Univ., and member the Oregon Grotto.

PLAN

Lava Gutter

True North

Figure 2

SANTIAM PIT

Brunton Compass and
Tape Survey by Jim
Nieland and Libby
Kramm, June 12, 1970.

Tree Roots
Sand

Levee 4' High

Ice 6/12/70

Spatter Cone
Entrance

0   10   20   30   40
Scale in Feet

PROFILE
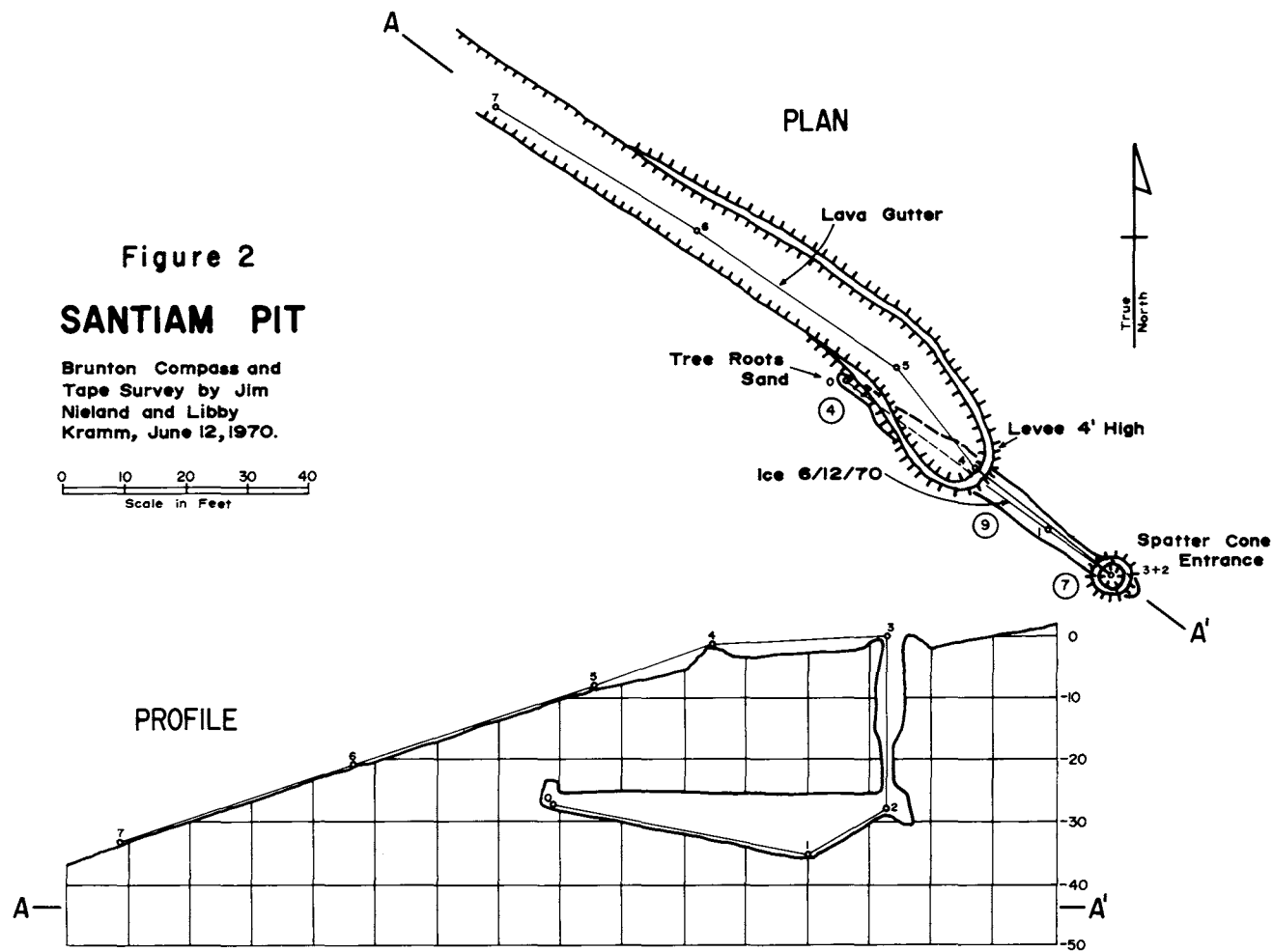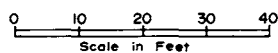
"Spatter cone pits" (a term adopted for these features by the writer) are formed by the accumulation of lava spatter around a vertical conduit or vent. Originally all spatter cones probably had an open vent, but the majority of the vents have been plugged by later lava or filled by debris from weathering of the conduit walls.

Because of their depth, some of the pits are potentially very dangerous to enter. It is suggested that future investigators take extreme caution in exploring them. None of the pits can be entered safely without full vertical gear.

Nash Crater Area

Santiam Pit

Only one of the Nash Crater conduits has been investigated. It is located approximately 200 feet northwest of a broad depression rimmed with spatter at the northwest base of Nash Crater. A 5-foot spatter cone surrounds a 30-foot-deep pit (Santiam Pit) which connects with a 50-foot lava-tube segment (see figure 2). At the time of the investigation, the lava tube was blocked at its western end by sand fill and at its eastern end by debris which had fallen in through the entrance pit. Ice was found at the lowest point in the tube and a cone of snow remained at the foot of the pit when visited on June 12. At the surface, immediately down slope from the spatter-cone entrance, a lava gutter is oriented over the trend of the underlying lava tube.

Sand Mountain Area

The Sand Mountain pits (Century and Moss Pits) are located in the vent area of the Clear Lake Lava Flow, half a mile southwest of Sand Mountain Cones. The vent area consists of an east-west-oriented ridge about 1,000 feet long (figure 3). At its western end is a circular pit about 50 feet in diameter, which displays several flow units and probably represents a collapse depression over a lava source. A smaller pit 200 feet to the east separates the collapse depression from a spatter ridge 600 feet long. The west end of this ridge contains a shallow crater 30 feet in diameter (Taylor, 1965). Along the crest of the spatter ridge there are two "spatter cone pits," 4 and 8 feet in diameter and as much as 94 feet deep.

Moss Pit

The westernmost pit (Moss Pit) is about 8 feet in diameter at the surface and 63 feet in depth (figure 4). The floor at the eastern base of the pit slopes steeply downward another 10 feet, giving the pit a total depth of 73 feet.

Figure 3

CENTURY AND MOSS PITS

BRUNTON COMPASS AND TAPE
SURVEY BY JIM NIELAND, LIBBY
KRAMM AND STEVE KNUTSON.
SEP 23, 1970.

0 10 20 40 60 80 100   200 FEET

DISTANCE BELOW SURFACE

MAGNETIC NORTH

Century Pit

4780
4770
4760
4750
4740
4730
4720
4710
4700
4690
4680

B   B'

Moss Pit   Century Pit
4790
4780
4770
4760
4750
4740
4730
4720
4710
4700
4690
4680

A   A'

4750

4750

4720

4726

4766

4730
4740
4750
4760
4770
4780

B

4782

4750

4760

4770

CENTURY PIT
4767

MOSS PIT

Air Flow 9/23/70

A   A'

B'
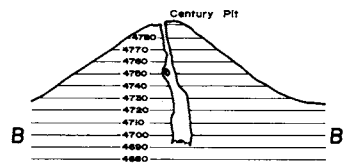
Figure 4.   James H. Wolff beginning descent into Moss Pit, one of
several "spatter cone pits" investigated in an area of recent
volcanism between Santiam Junction and Belknap Crater.

Century Pit

The entrance of Century Pit, located 145 feet to the east of Moss
Pit, is surrounded by a 2-foot-high wall of spatter. The pit is vertical to
almost vertical over its entire 94-foot depth. The pit narrows somewhat at
a point 25 feet below the surface, but bells out at greater depth to form a
room 10 feet wide and 25 feet long at the bottom. At the western end of
this room, a small opening leads downward an additional 6 feet, where it
is blocked by breakdown. A strong current of air issued from the breakdown
of this opening, when visited on September 23. The total depth of the pit,
including the small hole at the bottom, is 100 feet, making it the deepest
pit presently known in Oregon.

Age of the Pits

The approximate time when these "spatter cone pits" formed can be
determined from the age of the lava flows with which they are associated.

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The Clear Lake Lava Flow, which issued from the vent area near Sand Mountain, is approximately 2,950 years old B.P., as determined by radiocarbon dating of wood submerged in Clear Lake at the foot of the flow (Benson, 1965). This establishes a similar age for the Sand Mountain pits (Century and Moss Pits). The Lava Lake Flow, part of which issued from the vent at Santiam Pit, is estimated by Taylor (1965) to have occurred approximately 3,470 years ago B.P. This indicates that the Santiam Pit is about 500 years older than the Century and Moss Pits.

References

Benson, G. T., 1965, Age of Clear Lake, Oregon: The ORE BIN, v. 27, No. 2, p. 37-40.
Taylor, E. M., 1965, Recent volcanism between Three Fingered Jack and North Sister, Oregon Cascade Range: The ORE BIN, v. 27, No. 7, p. 121-147.

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EARTHQUAKE LEAFLETS AVAILABLE FROM USGS

Four pamphlets on earthquakes, written in a nontechnical style, are available free upon request from the U.S. Geological Survey, Department of the Interior, Washington D.C., 20242. The pamphlets are titled: "Safety and survival in an earthquake," "Earthquakes," "The San Andreas Fault," and "Active faults of California." The pamphlets contain information about the origin and nature of earthquakes and describe procedures that might be taken before, during, and after an earthquake.

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ENGINEERING GEOLOGISTS HOLD CONFERENCE

Herbert G. Schlicker, Department engineering geologist, attended the annual meeting of the Association of Engineering Geologists in Washington, D. C., October 20-24, 1970. The conference, the 13th for the organization, had as its theme "Engineering Geology and Man's Environment." Included were two days of field trips, a day of technical sessions, and a day devoted to a symposium entitled "Geological and Geographical Problems of Areas of High Population Density," with participants from universities and consulting firms in France, England, The Netherlands, Sweden, Wales, and Japan.

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LAND AS A BASE*

By Ralph S. Mason**

For the purpose of our discussion today geology may be defined as the "Study of the earth, the natural forces at work on it, its composition, structure, and mineral wealth." In a similar manner, land-use planning may also be defined as the "Study of the earth, its capabilities and limitations with respect to the needs of man and the environment."

Geology involves the study of the distribution and thickness of surface and subsurface rock types and structures; the engineering characteristics of soil and rock; the porosity, permeability, depth to water table and the factors influencing the water table; the prevalence or absence of geologic hazards such as landslides and faults; the potential for consecutive conservation (including determination of mineral resources and secondary and tertiary uses for mined lands); the relative sensitivity of the land to attack by man (this includes nearly everything that man does); and the best means of minimizing such damage.

Land-use planning is being, and always will be, stretched by three main forces - economics, politics, and environment. We must conduct our day-by-day activities at a profitable level. We must live, work, and plan together under guidelines established at the political level. Lastly, we must see that neither of these forces overrides the need for preservation of the environment. Of the three, the last is by far the most important despite our almost complete attention for the past 7000 years to the first two only.

Clearly, we must reorient our priorities. We have been taking the easy way out, at the expense of the environment, for far too long. Man's future activities will have to be completely planned on a full cycle basis. Such planning will sooner or later include every facet of our existence, including but certainly not limited to such diverse items as: strict maximum population controls; complete reuse of all waste products; stabilization of air, water, and vegetative resources; complete, or very nearly complete, recycling of most mineral products; restriction of all power generation to sources using solar, geothermal, or, in a few cases, hydro energy; and a complete appraisal of the total capabilities and liabilities of all land and water areas followed by mandatory "best use" of these areas.

Fortunately for man, certain segments of our environment have the

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ability to recover from the assaults made upon them. Our air, water, and vegetative resources exist today largely because they can "fight back," but even with this recuperative ability they are severely damaged. Large areas of our land surface have suffered irreversible harm, due in part to denudation of the vegetative cover and in many cases to total disregard of basic geologic principles. Our reserves of ground water have been depleted in many areas and threatened with contamination in others, and again ignorance of geologic conditions is often to blame.

It is difficult to equate the organic with the inorganic, the animate with the inanimate, and the renewable with the nonrenewable. But it is just this difficulty that is leading us into yet one more environmental blind alley. Our mineral resources are mostly inorganic, totally lifeless, and certainly not reproducible. Furthermore, they rarely have the charismatic potential that wildlife, trees, and running water so spontaneously generate.

Friends of mining and the mineral industry are few, but the consumers of their products include every living man, woman, and child on the face of the earth during their entire lifetimes. With little public interest and even less support and understanding, it is no wonder that we have plundered our mineral resources, taking only the very richest of the ores, fabricating them into myriads of forms, using them once and then discarding them. Our environment is suffering at all levels from the lack of public concern that has been applied to the production of our mineral resources, their processing into usable materials, and their eventual disposal in the most convenient manner.

A clearer understanding by the public and particularly by bodies of government of the over-all economics of our mineral resources is necessary before any effective steps can be taken to solve this rapidly magnifying problem. We are exhausting known mineral reserves at an ever-increasing rate, and yet the latest figures available show that we are graduating less than 150 mining engineering students a year in this country – and half of them are from foreign countries. Basic geological mapping, the necessary predecessor to the discovery of large, low-grade mineral deposits and to all land-use planning by state and federal agencies, is falling far behind and little hope of any change is apparent. Importing foreign ores is becoming increasingly common, but the adverse effects on our balance of payments and dependence on distant and perhaps not friendly suppliers at some future time pose serious question marks.

The beneficiation, smelting, refining, and fabricating of raw mineral ores leave much to be desired, although the industry has made great strides in recent years. Controls by pollution-abatement agencies have been enforced at the back door of the plant, rather than at the front. A totally new approach to the problem of gaseous, liquid, and solid wastes produced by these plants must be made in cooperation with industry, local, state and federal governments, and the public. The presence of industry is vital to any community and the current attitude so often expressed by many people

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of "You can't do it here – go somewhere else" is patently fallacious, irresponsible, and ethically wrong. We cannot expect someone else to do our dirty work for us. Solutions are possible but public hysteria and ignorance by governing bodies have no part in this critical decision-making process.

Our handling of waste metals and minerals also requires a comprehensive understanding of basic geologic concepts. It makes little economic or environmental sense to mine minerals, refine and fabricate them, use the end products once, and then pitch them out. We are running out of raw material on the one hand and polluting the countryside on the other. Just possibly we might be able to survive the effects of continued dumping, but parts of the mineral pipeline are going to run dry before long, unless we start reusing our waste materials. Substitutes are available – at a price. The economic geologist is constantly looking for new minerals to fill old needs, but substitutes often impose compromises. The mining engineer is faced with the problem of extracting ore of lower and lower grade in steadily increasing quantities. Modern copper mines are digging ore containing as little as 12 pounds of copper per ton – and moving more than 300,000 tons of ore and waste per day. What will we do when we are forced to mine ore containing only 6 pounds of copper?

Although our ultimate goal, as a hopefully viable society in the years to come, should be the total reuse of all our waste, this is not likely to be achieved – at least not immediately. Some mineral, chemical, and nuclear wastes will have to be stored until they can be reclaimed. The storage period might conceivably extend over many months or years. The storage of these materials will in most cases be in a totally geological environment – a hole in the ground. Just where these holes are to be located is already claiming the attention of our geologists. This is no simple task. There is no lack of suitable places for burying all kinds of wastes – if the geologic factors were the only consideration. Objections have already been raised, however, by residents of various communities which have been "offered" a waste-disposal facility. The alarm is not based on scientific principles nearly as much as on purely sociologic ones – Community "A" does not want to become the dumping ground for Community "B."

Solutions to all of these problems are possible with the expertise available. The cost will be staggering. Regardless of the expense, we must make a concerted start now. Regardless of our feelings, we must base our decisions on facts and these will have to come from the earth itself, the workshop of the geologist.

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Engineering geologists estimate that permafrost –– permanently frozen ground –– underlies about 20 percent of the entire land surface of the world.

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THERMAL SPRING AND WELL MAP PUBLISHED

A map of the State of Oregon showing the location of thermal springs and wells has been published as Miscellaneous Paper 14 and is now available from the Department offices in Portland, Baker, and Grants Pass. The price is $1.00.

The information for the map (scale 1" = 16 mi) was compiled by R.G. Bowen and N.V. Peterson, Department geologists. In addition to showing the location of all known thermal springs and wells, the map gives pertinent data about each locality, such as maximum temperature, rate of flow, utilization, and references to literature. In general, the definition of "thermal" waters used by other authors is followed -- that is, 15° above the mean annual temperature.

A large part of the compilation came from U.S. Geological Survey Professional Paper 492, by G. A. Waring and others, "Thermal Springs of the United States and Other Countries of the World." Additional sources of information were the various Survey Water-Supply Papers, water well records from the Survey's Ground Water branch office in Portland, and water well records from the State Engineer's office in Salem. Field work consisted mainly of measuring temperatures with a maximum reading thermometer where the temperatures were unknown or believed unreliable.

The map (Misc. Paper 14) is of a preliminary nature, and the Department hopes its publication, in addition to providing basic information, will encourage persons with knowledge of other thermal springs in the state to report the locations, so that more complete data can be issued later.

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DR. OSBORN APPOINTED BUREAU OF MINES DIRECTOR

On October 7, 1970 President Nixon announced his intention to nominate Elburt Franklin Osborn to be Director of the U.S. Bureau of Mines. The appointment has since been confirmed. Dr. Osborn has been vice president for research of the Pennsylvania State University since 1959. Prior to this he served as associate dean and dean, College of Mineral Industries at the University. He is a former director of the American Geological Institute (1956 - 1959), president of the Geochemical Society (1967 - 1968), and president of the Mineralogical Society of America (1960 - 1961). Dr. Osborn holds memberships in 17 professional societies.

Dr. Osborn, 59, received his B.A. at DePauw University in 1932, his master's degree at Northwestern in 1934, and his Ph. D. from California Institute of Technology in 1937. He is a member and past president of both Phi Beta Kappa, Penn State Chapter, and Sigma Xi, Penn State Chapter. He is the author of over 90 published articles.

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PORTLAND TO HOST NORTHWEST MINERALS CONFERENCE

The Pacific Northwest Metals and Minerals Conference will be held in Portland April 5, 6, and 7, 1971. The conference is jointly sponsored by the local sections of AIME, AWS, and ASM.

The conference will include technical sessions covering mining and exploration, nuclear and aerospace metals, industrial minerals, steelmaking, welding, heat treating, and gold and money. Special topics covered in the sessions will include geothermal power, undersea mining, and deep-ocean drilling.

There will be two field trips to the reactive and exotic metals complex in the Albany area and the huge new mine-mouth, coal-fired steam generation power plant near Centralia, Washington.

A full slate of social activities for the delegates and a special series of events for the ladies round out the conference.

Featured speaker will be Hollis M. Dole, Assistant Secretary of the Interior, who will address the delegates at the banquet. Also participating will be a panel of experts on gold who will be coming from as far away as South Africa.

Additional information may be obtained from Ralph S. Mason, 1069 State Office Building, Portland, Oregon 97201.

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LEWIS NAMED USBM LIASON FOR OREGON

Walter E. Lewis has been named U.S. Bureau of Mines liaison officer for Oregon. He has been research director of the Bureau's Twin Cities Mining Research Center, Minneapolis-St. Paul, Minnesota since 1964. He is a graduate mining engineer from Washington State University, and also holds master's and engineer of mines degrees from the University of Missouri, Rolla.

Mr. Lewis started with the Bureau in Minneapolis in 1949 as supervisory mine examination and exploration engineer and transferred to Washington, D.C. in 1955. In Washington his range of duties included Commodity Specialist for Iron, Assistant to the Chief Mining Engineer, Assistant Chief of the Rare and Precious Metals Branch, and Assistant Chief of the Branch of Mining Research. Prior to his employment with the Bureau of Mines, he worked for the U.S. Bureau of Reclamation on the Central Valley Project and in various capacities in the mining industry in Idaho, Montana, Utah, and California.

Mr. Lewis' office is in Suite 7, Standard Insurance Building, 475 Cottage Street N.E., Salem, Oregon; telephone number: 585-1793 (Ext.245).

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UNITED STATES GOVERNMENT MAKES LAST SILVER SALE

The U.S. Treasury Department on November 10, 1970 brought to a close
the sale of surplus silver offered through the General Services Administra-
tion. Awards of 1,567,899 ounces of silver resulted from the November 10
bid opening. A balance of approximately 23 million ounces remains in the
Treasury, of which about 15 million ounces is in bars containing gold and
must be refined. The remaining eight million ounces is in various forms and
finenesses, most of which would require refining and processing to be of sig-
nificant commercial values. Since the GSA weekly sales program began on
August 4, 1967, the government has sold, through competitive bids, 305
million ounces of surplus silver. Of this total, the Treasury supplied 212
million fine ounces obtained from the melting of silver dimes and quarters.
The estimated profit to the government from the sale of silver under this
program will be approximately $147 million.

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AGREEMENT REACHED ON EISENHOWER SILVER DOLLAR

Senate and House conferees have reached agreement on the minting of 150
million 40 percent silver Eisenhower dollars. The legislation was attached
as an amendment to a bill that would bring one-bank holding companies
under federal regulation. Also authorized was production of cupro-nickel
dollar and half-dollar coins for general circulation and the sale by GSA of
2.9 million rare silver dollars which have been held in the Treasury for
many years.

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EDWIN T. HODGE

Dr. Edwin T. Hodge, noted Oregon geologist, died at his home in Portland
on November 7, 1970 at the age of 81 years. Dr. Hodge was professor of
geology at the University of Oregon and at Oregon State College. He
served as consulting geologist for federal, state, and municipal agencies in
Oregon and performed geologic investigations throughout the United States
and in many foreign countries. As consultant to the U.S. Army Corps of
Engineers he located the site for the Bonneville Dam and supervised its foun-
dation work. He is particularly well known for his comprehensive mineral-
resource surveys and for his geologic studies of the lower Columbia River and
of north-central Oregon. He was a member of many professional organiza-
tions and held numerous honorary positions. Dr. Hodge was the founder of
the Geological Society of the Oregon Country, which is now in its 36th
year.

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INDEX TO THE ORE BIN

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AVAILABLE PUBLICATIONS

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8.	Feasibility of steel plant in lower Columbia River area, rev.1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
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53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
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58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass .	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
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Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37) .	0.50
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GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka . .	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
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Geologic map of Oregon west of 121st meridian: (over the counter) . . . . folded in envelope, $2.15; rolled in map tube, $2.50	2.00
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat folded in envelope, $2.25; rolled in map tube, $2.50	2.00

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