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OREGON'S MINERAL INDUSTRY IN 1965

By Ralph S. Mason*

Oregon's mineral industry surged upwards to an all-time high in 1965, with a preliminary estimate by the U.S. Bureau of Mines of $68,457,000. This is a 7-percent increase over the previous year. Of particular interest, at a time when price increases are common throughout industry, is the hold-the-line performance turned in by Oregon producers of lime, stone, and sand and gravel. These three commodities accounted for 70 percent of the total value of state mineral production and individually scored tonnage gains ranging from 7 to 15 percent. Not one of these three commodities increased in unit value, however, and two of them decreased somewhat.

The state's metallurgical industry continued strong and healthy. Plans were announced for a new steel mill; enlargements to an existing reactive metals plant; and increased productive capacity at a large mine and smelter.

Employment in the state's mining industry increased 13 percent over last year -- more than three times as much as in the booming construction industry. Mercury producers, reacting to skyrocketing world prices, were active at several mines scattered across the state.

Offshore oil exploration saw two deep-water rigs in action, with four deep tests completed. Hopes for offshore hard-minerals mining were snuffed by failure of the state to enact legislation at the last session of the legislature.

The Metals

Mercury

Interest in cinnabar deposits throughout the state increased predictably after the unprecedented rise in mercury prices. A detailed report on mercury activity in the state during 1965 follows this general summary.

Gold and silver

Big news in Oregon gold circles was the announcement late in the summer that the Buffalo mine in the Granite district of eastern Grant County

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Some of Oregon's Minerals at a Glance
Preliminary Figures for 1965
(in thousands of dollars)

	1964	1965
Clays	$ 262	$ 248
Gold	23	13
Lime	1,918	2,022
Sand and gravel	25,158	24,000
Stone	19,296	22,000
Misc.*	16,631	18,372
Estimated total	$64,269	$68,457

* Cement, copper, diatomite, gem stones, lead, nickel, silver, zinc.

had been sold to the Union Pacific Railroad. James P. Jackson, Jr., owner-operator of the mine, will continue to direct operations. The new owners have announced that operations will be accelerated. The Buffalo has a record of production extending back to 1903. The 600 level, developing an additional 250 feet of ore below the lowest workings on the 400, was driven by Jackson several years ago. This last summer Union Pacific conducted a diamond drilling program to determine mineralization beyond the present limits of the underground workings.

Oak Mine, Inc., of Grants Pass explored the Oak mine near Jumpoff Joe Creek in northern Josephine County. Reopening work was conducted by Lloyd Frizzell, Bob Shannon, Ernest McTimmonds, and Francis Adams. The main values are in copper, zinc, gold, and silver. The ore consists of sphalerite, pyrite, pyrrhotite, chalcopyrite, and some galena.

The Turner-Albright copper and gold mine southwest of Grants Pass in southern Josephine County was explored during the year by McPhar Geophysics, Ltd., of Toronto, Canada. Exploration consisted of drilling out an anomaly discovered last year with an induced polarity survey. Massive, brecciated sulfides were encountered between the north and south workings. Lloyd Frizzell, consulting geologist, supervised the drilling, which was done by Bob Shannon of Grants Pass.

Dave Vallandigham of Provolt completed construction of a gold mill on Powell Creek in southern Josephine County, and reworked ore from the old Dark Canyon mine dump. The mill circuit includes a primary jaw crusher, 25-ton ball mill, Clark Cone, sand classifier, a four-cell Denver flotation unit, and a 15-foot Wilfley table. Vallandigham plans to break new ore in the mine in the near future.

Juan Muñoz of Prineville retimbered the old Mayflower mine in Crook County and performed a detailed sampling of the workings. The Mayflower is an old gold-silver producer which was discovered about 1885.

Gerald Whitney of Athena re-activated his gold placer property in the Mormon Basin district of northern Malheur County. The property was operated prior to World War II but has been inactive since that time. Due to shortage of water, the placer can be worked only in the spring and early summer.

Old hard-rock gold mines sometimes never die. The Ashland mine

ACTIVE MINES IN OREGON, 196[illegible]

Gold Placer

Mine	County
Winterville	Baker
Cape Blanco	Curry
Vincent Creek	Grant
DeJanvier	Jackson
Bobbett	Jackson
Leopold	Josephine
Beck	Josephine
Leland	Josephine
Speaker	Josephine
Maloney	Josephine
Gold Bar	Josephine
Beardrift	Josephine
Gold Nugget	Josephine
Basin Creek	Malheur
Camp Carson	Union

Gold-Silver Lode

Mine	County
Crown Point	Baker
Pedro Mountain	Baker
Record	Baker
Dutchman	Douglas
Dixie Meadows	Grant
Buffalo	Grant
Fleming	Jackson
Oregon Belle	Jackson
Hatch	Jackson
Oregon King	Jefferson
Oak	Josephine
Turner-Albright	Josephine
Dark Canyon	Josephine
Snow Bird	Josephine

Antimony

Mine	County
Gray Eagle	Baker
Jay Bird	Jackson

Copper

Mine	County
Bolivar	Coos

Nickel

Mine	County
Hanna Nickel Co.	Douglas

Mercury

Mine	County
Cave Creek	Baker
Paramount	Baker
White Wonder	Baker
Bear	Crook
Blue Ridge	Crook
Independent	Crook
Lost Cinnabar	Crook
Mother Lode	Crook
Red Devil	Curry
Jackson & Lerwill	Douglas
Elkhead	Douglas
Broadway	Grant
Canyon Creek	Grant
Long Walk	Grant
Double Link	Harney
Hiveley	Harney
Doodlebug	Jackson
War Eagle	Jackson
Ashwood	Jefferson
Gray Butte	Jefferson
Angel Peak	Lake
Gray	Lake
Glass Ridge	Lake
Manzanita	Lake
McManmon-Justrom	Lake
Ryan	Lake
Black Butte	Lane
Bretz	Malheur
Breitenbush	Marion

Building Stone

Mine	County
Moon Mesa	Baker
Cinder Hill	Deschutes
Red Rock	Deschutes
Willowdale	Jefferson
Jones Marble	Josephine
Kah-Nee-Ta	Wasco

Lightweight Aggregates

Mine	County
Boise-Cascade	Deschutes
Central Oregon Pumice	Deschutes
Permanente	Gilliam
Pacific Diatomite	Lake
Cloverleaf Mines	Washington
Empire Bldg. Materials	Washington

Silica

Mine	County
Big Quartz	Douglas
Bristol Silica	Jackson

Limestone and Lime

Mine	County
Chemical Lime Co.	Baker
Ideal Cement Co.	Josephine
Oregon Portland Cement Co.	Baker, Polk

Sand and Gravel, Crushed Stone

Active commercial producers in every county and nearly every community in the state total more than 200. Numerous additional quarries operated by state, city, county, and federal agencies. and by logging companies using aggregate for private use.

near the city of Ashland in southern Jackson County is being refurbished as a tourist attraction. The Ashland consists of more than two miles of tunnels and shafts and has a history of production reaching back before the turn of the century. Ben Gassaway and Norman Easley are planning to reopen the mine, using a narrow-gauge railroad to haul visitors to stations underground where typical mining equipment will be in operation.

The Oregon King mine in Jefferson County continued to explore and develop ore on several levels during the year. The mine is known for its high silver content, with relatively smaller amounts of gold.

Nickel

Hanna Mining Co. continued to mine and smelt nickel ore at its Riddle, Douglas County, installation. As a result of additional smelter capacity installed in 1964 and minor improvements in 1965, the labor force has been increased to about 500 men. The Hanna operation has been in continuous production since 1954.

Antimony

W. H. Holloway continued development at the Jay Bird mine in southern Jackson County. In Baker County, A. W. Brandenthaler explored the old Gray Eagle mine near Baker. A disseminated ore zone was struck on the 165-foot level late in the year.

Exploration projects

Federal Resources Corp. of Salt Lake City terminated its exploration work in the Bohemia district of Lane County in mid-year. The Bohemia district has long been known for its gold, silver, copper, lead, and zinc mineralization. At the Lucky Boy mine in the Blue River district of Lane County, a California group did some minor exploration for lead and zinc.

Industrial Minerals

Sand and gravel and stone

As the year 1965 came to a close, value of sand and gravel and stone totalled $46,000,000 and represented 39,000,000 tons of products. The $46,000,000 is the pit-price and the 39,000,000 tons rebuilt dikes, dams, reservoirs, and miles of roads and highways destroyed by the December, 1964 floods. Some of this vast tonnage of construction material went into new concrete buildings which formed the nucleus of the building boom that helped bring the state's economy to a fast boil.

Oregon producers of stone and sand and gravel also turned in a remarkable performance by holding down the selling price. The stone producers sold their product for a cent less per ton than they did a year ago, while sand and gravel actually declined from an average of $1.38 per ton in 1964 to $1.20 in 1965.

Industry's awareness of some of the problems arising from gravel-pit operation in areas adjacent to housing developments was indicated by an operator at Salem. Applications for zone changes to permit expansion of operations were coupled with long-range plans to convert the area into housing with a central lake occupying the abandoned pit.

Two Oregon products, native ingenuity and concrete, were combined by Paul Harmon, a Eugene contractor, to produce a long-overdue improvement to motoring. Harmon invented and is manufacturing a pre-cast, one-piece railroad crossing which is simply dropped into place across the highway. The rails fit into preformed slots.

Lightweight aggregates and pozzolan

Empire Building Materials Co. and Cloverleaf Mines, Inc., continued to mine and process expansible shale at their quarries in northern Washington County. In addition to producing lightweight concrete aggregate, Empire turned out pozzolan for use in concretes at the $250,000 pozzolan mill erected at its Sunset Tunnel plant site. Empire announced plans to market dry-bagged masonry pozzolan-cement to replace the lime-cement mortars which have been used in construction for many decades. Ready-mix concretes using 25 percent pozzolan are specified for jobs using pumping equipment to place the concrete. Pozzolan reduces cost, improves workability of the mix, and reduces heat of hydration during the setting period.

Pozzolan was also produced at a plant in Gilliam County run by Permanente Cement Co. Raw material is a gray, finely divided volcanic ash. Some of the plant's output was used in the construction of the John Day Dam on the Columbia River.

Two operators at Bend in central Oregon, Boise-Cascade and Central Oregon Pumice Co., continued production of natural lightweight aggregates. Both lump pumice and scoria are mined by the companies and crushed and blended into a variety of mixes.

Lightweight concretes were used increasingly in commercial and public construction, as architects turned more and more to pre-cast slabs and modules, many of them of intricate design and of considerable size.

Pacific Diatomite Co. mined and processed diatomite from its pits in northern Lake County. The company markets industrial absorbents and extenders, and is experimenting with insulation board and pipe and conduit coverings. Drilling at the deposit north of Silver Lake revealed a thickness of at least 40 feet.

Building stone

Quarrying operations were carried out at the Kah-nee-ta Stone quarry on the Warm Springs Indian Reservation in Wasco County by the Stone Center; at the Moon Mesa quarry on Dooley Mountain in Baker County by A.W. Brandenthaler; at the Willowdale quarry in northern Jefferson County by Ray Bohlman; at the Cinder Hill Co. quarry in Deschutes County; and at the Jones Marble quarry in Josephine County by W. H. Holloway. The Kah-nee-ta, Cinder Hill, and Jones Marble quarries produced various-sized pieces of rubble; Moon Mesa supplied either rubble or veneer; and Willowdale sawed blocks out of the solid in a variety of lengths.

Lime, limestone, and cement

Chemical Lime Co. quarried high-grade limestone during the snow-free months at its Baboon Creek quarry high in the Elkhorn Mountains of Baker County. The stone was burned at the company kilns near Baker and sold as either burnt or hydrated lime. Oregon Portland Cement Co. quarried stone at Lime, Baker County, and produced portland cement at its plant nearby on Burnt River. The Oswego plant in Clackamas County, also operated by OPC, used limestone barged from Texada Island, B.C. Ideal Cement Co. manufactured cement at its Gold Hill, Jackson County, plant, using limestone trucked from Marble Mountain in Josephine County. Ideal suffered considerable damage to its power-plant facilities on the Rogue River during the 1964 Christmas floods. Ash Grove Lime & Portland Cement Co. operated its highly automated lime plant at Portland with stone obtained from Texada Island. The same source of raw material was used by Pacific Carbide & Alloys Co., Portland, for the production of calcium carbide. Oregon Portland celebrated its 50th anniversary and also 50 years of operation at its Oswego plant during the year. The company's second plant at Lime was fired up in 1923. A historical review of the company's activities appeared in the February 1965 ORE BIN.

Bentonite

Central Oregon Bentonite Co. quarried crude bentonite at its Silver Wells deposit on Camp Creek in eastern Crook County. The company sold its product for stock pond and irrigation canal sealing.

Materials for Lunar Research

Rocks from five localities in the state, selected by the New York Academy of Science as Lunar Reference rocks, were collected by the Department of Geology and Mineral Industries and shipped to various space-age companies and lunar research organizations. The rocks include basalt, welded tuff, obsidian, rhyolite, and serpentine. In addition, several large blocks of basalt were shipped to a Baltimore firm that is developing a drill for use on the moon. Pioneer Construction Co., Portland, supplied the five-ton boulders from its St. Helens Road quarry. The possibility of using certain areas of central Oregon for "hard" and "soft" simulated lunar landings with spacecraft was explored by industry representatives during the year. The Surveyor lava flow on the flanks of Newberry Crater and some of the pumice flats in the Bend area were selected as possible test sites.

Metallurgical Plants

The exotic-metals industry complex located at Albany continued in full operation during the year. The Electrodevelopment Laboratory of the U.S. Bureau of Mines pursued its investigation of various refractory metals by means of electrometallurgical testing. Wah Chang Corp. extracted zirconium, hafnium, columbium, and tantalum metal from their respective ores. Increased zirconium demand kept production facilities operating at capacity. Commercial production and fabrication of high-strength columbium alloys also increased. Finished mill products were fabricated from zirconium, hafnium, columbium, tantalum, titanium, molybdenum, and tungsten. Northwest Industries machined reactive metals to close tolerances for high-temperature and severe-corrosion applications. Oregon Metallurgical began the erection of a titanium sponge plant to round out its production and fabrication facilities for this space-age metal. OreMet has been obtaining its sponge from various sources, including England and the Soviet Union. The new sponge furnace is scheduled to go on the line early in 1966. Integration of production facilities was prompted by marked increases in titanium castings markets.

Cascade Steel Rolling Mills announced plans to erect a steel rolling mill in Portland that will have an annual capacity of 50,000 tons. Reynolds Metals Co. started construction of a 30,000-square-foot cast house at its Troutdale plant. Vertical direct-current casting units, plus two 90,000-pound holding furnaces, are also being installed.

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MORE LAND WITHDRAWALS FOR FUN AND GAMES

A study of the land withdrawals in Oregon requested by the U.S. Bureau of Land Management and the U.S. Forest Service during 1965 reveals that more than one third has been for recreation. The balance of the lands which are to be withdrawn will be used for various purposes, mainly the creation of reservoirs--which will have definite recreational possibilities. A total of 16,944 acres is involved in the federal withdrawals from mineral entry.

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QUICKSILVER IN OREGON IN 1965

By Howard C. Brooks*

Quicksilver prices climbed to all-time highs during the year. Starting from an average of $182 per flask for the month of August 1963, the value reached $709 in June 1965 (Figure 1). As a result of the price spiral, Oregon again resumed its role as an important producer of the liquid metal. Approximately 1,400 flasks were produced during 1965 in contrast to output of only four flasks in 1963.

Most of Oregon's 1965 output came from two mines: the Black Butte in Lane County and the Bretz in Malheur County. Both were reopened in 1964 and resumed production late in that year. A combined total of about 10 flasks was produced during 1965 from the Canyon Creek prospect in Grant County, the Glass Buttes mine in Lake County, the Mother Lode mine and Bear claims in Crook County, and the Elkhead mine in Douglas County. Elsewhere in the state there was much prospecting activity.

A Review of the Market

Market analysts agree generally that the cause of the 1963-1965 mercury price spiral was, very simply, lack of metal. Industrial consumption has been expanding greatly, while for several years mercury prices followed a downward trend that sharply curtailed mine output.

As shown in Figure 2, U.S. mercury consumption has been running along in excess of 50,000 flasks annually for 10 years. A sharp upward trend in consumption, beginning in 1961, reached an all-time high of 82,000 flasks in 1964. Despite this great demand, mercury prices dwindled steadily from an annual average of $290 per flask in 1955 to $189 in 1963. Mine output in 1958 was 38,067 flasks or about 72 percent of consumption. Production in 1964 was 14,142 flasks or only 17 percent of consumption.

The most important single factor in the supply pinch is the heavy demand for mercury for the expanding production of chlorine and caustic soda. These two basic big-tonnage chemicals are used in the manufacture of paper, plastics, textiles, rubber, glass, paints, pharmaceuticals, and a wide variety of other products. Consumption has also been rising sharply in such fields as the manufacture of mildew-proofing and anti-fouling paints, pharmaceuticals, dental preparations, and general laboratory use.

Figure 3 shows how United States production, plus imports, has lagged behind consumption since 1961. At the same time, world output fell from

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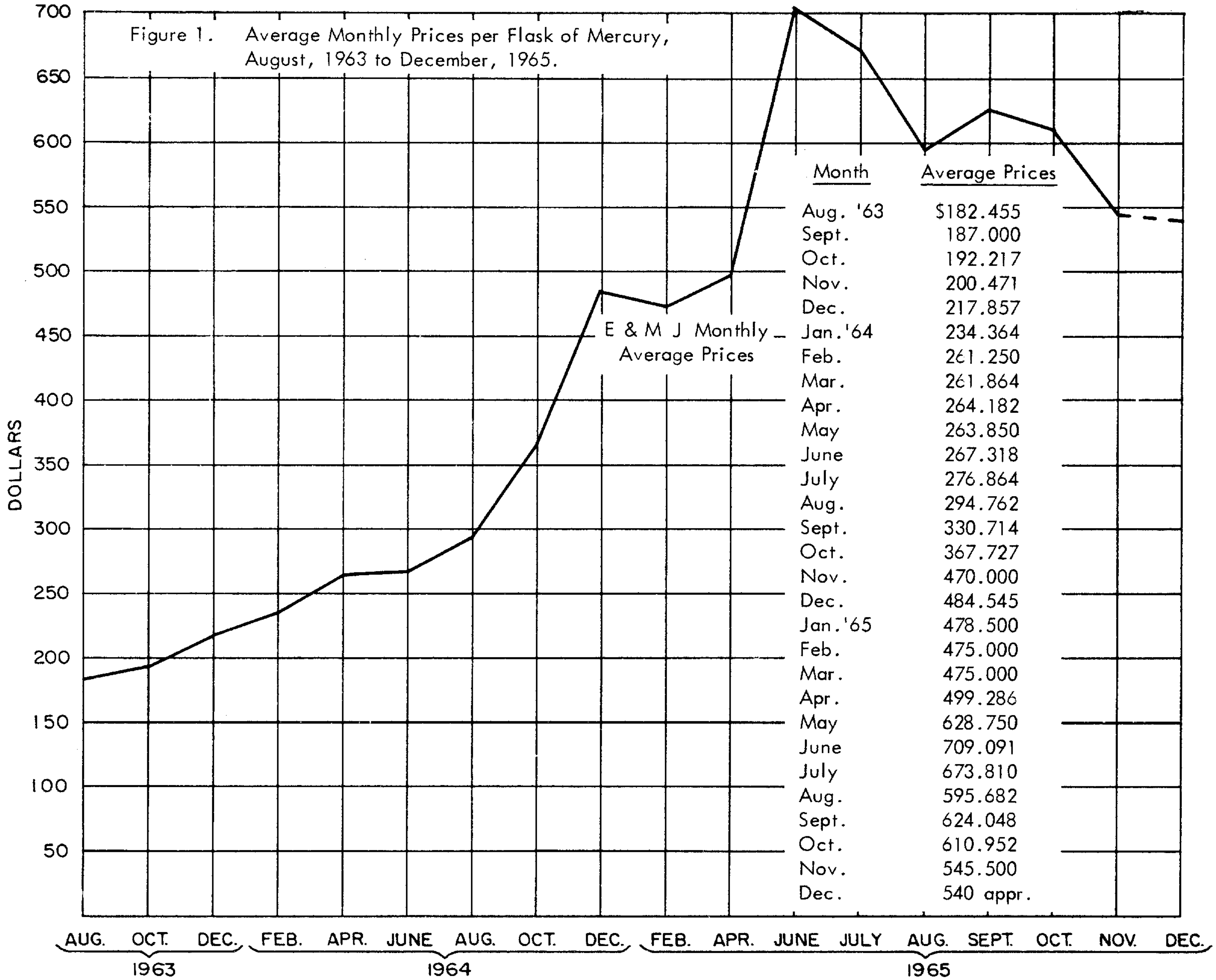


Figure 1. Average Monthly Prices per Flask of Mercury, August, 1963 to December, 1965.

Month	Average Prices
Aug. '63	$182.455
Sept.	187.000
Oct.	192.217
Nov.	200.471
Dec.	217.857
Jan. '64	234.364
Feb.	261.250
Mar.	261.864
Apr.	264.182
May	263.850
June	267.318
July	276.864
Aug.	294.762
Sept.	330.714
Oct.	367.727
Nov.	470.000
Dec.	484.545
Jan. '65	478.500
Feb.	475.000
Mar.	475.000
Apr.	499.286
May	628.750
June	709.091
July	673.810
Aug.	595.682
Sept.	624.048
Oct.	610.952
Nov.	545.500
Dec.	540 appr.

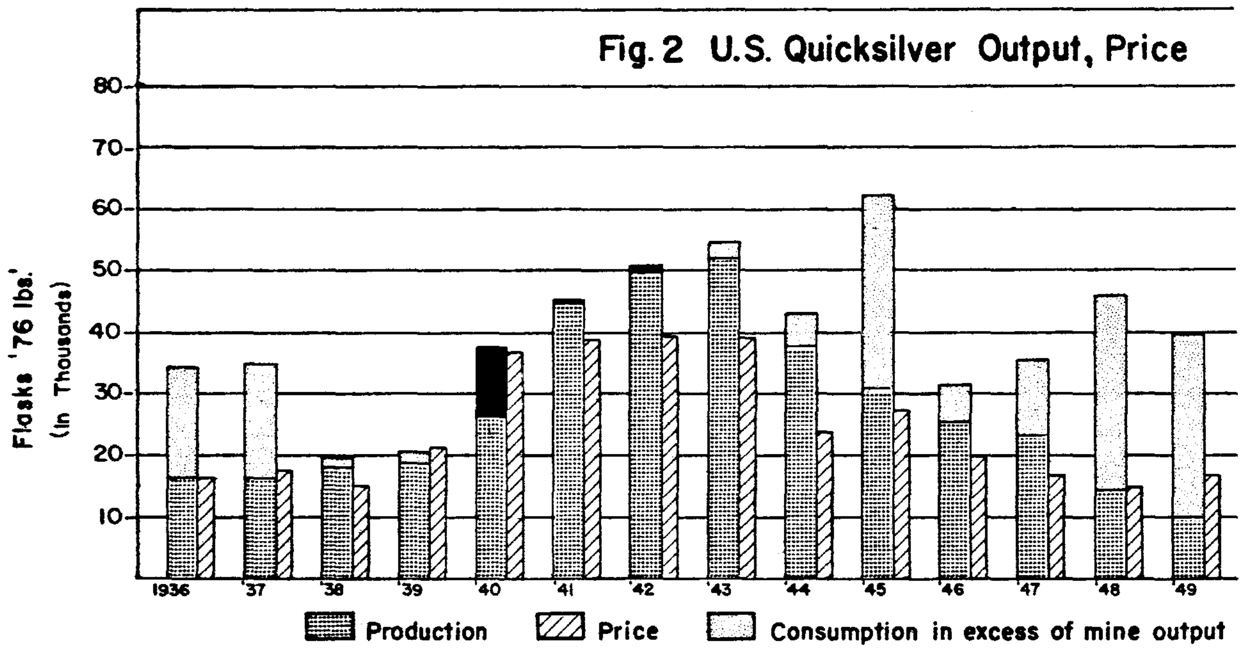
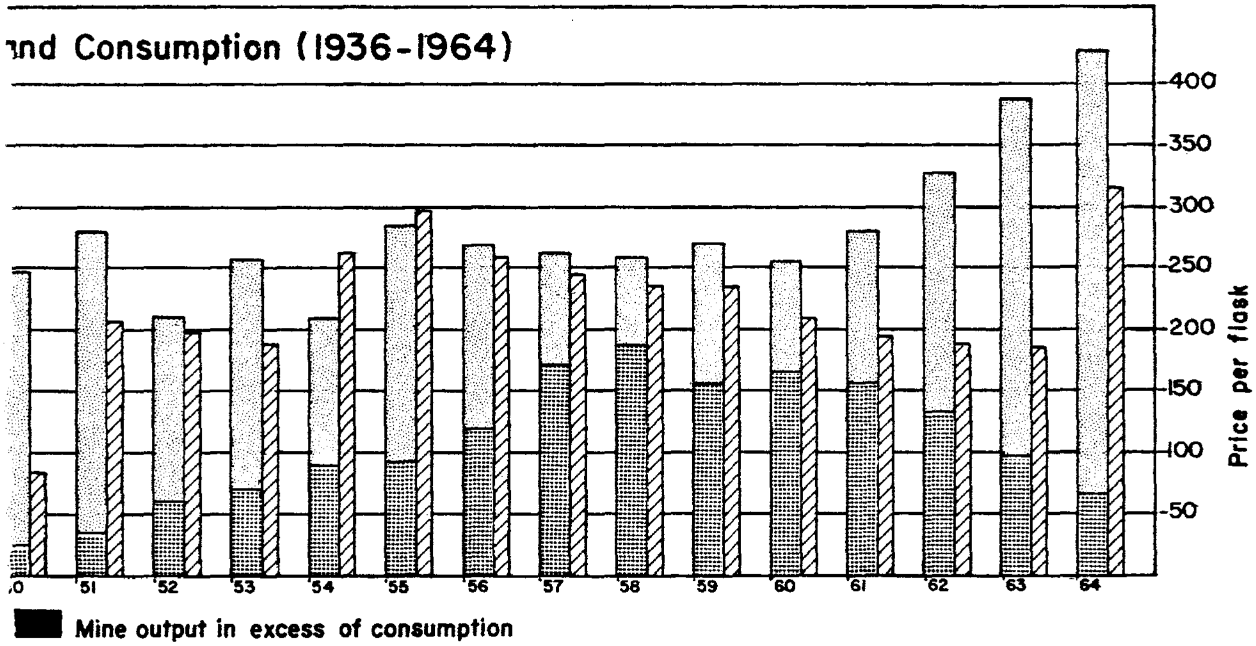


Fig. 2 U.S. Quicksilver Output, Price

242,000 flasks in 1960 to 239,000 in 1963. Also, in 1963 Russia and China began importing quicksilver for industrial use, whereas formerly they exported it.

The bulk of the world's output of quicksilver comes from 7 countries which, in the order of their productivity in recent years, are: Italy, Spain, the United States, Russia, China, Mexico, and Yugoslavia. Spanish and Italian production accounted for 40 to 50 percent of world output in recent years, while United States producers accounted for only 10 or 12 percent. This means that Spain and Italy normally control the world market price of quicksilver. American producers have neither a large enough share of the market nor the financial strength to absorb the short-range loss necessary to firm a depressed market, and therefore must dance to whatever tune Spain and Italy choose to play. Most domestic producers can operate only when prices are high. In 1964 domestic output came mainly from three mines: Cordero in Nevada and New Idria and Buena Vista in California. Almost certainly these mines would have closed before now if the price break had not come when it did.

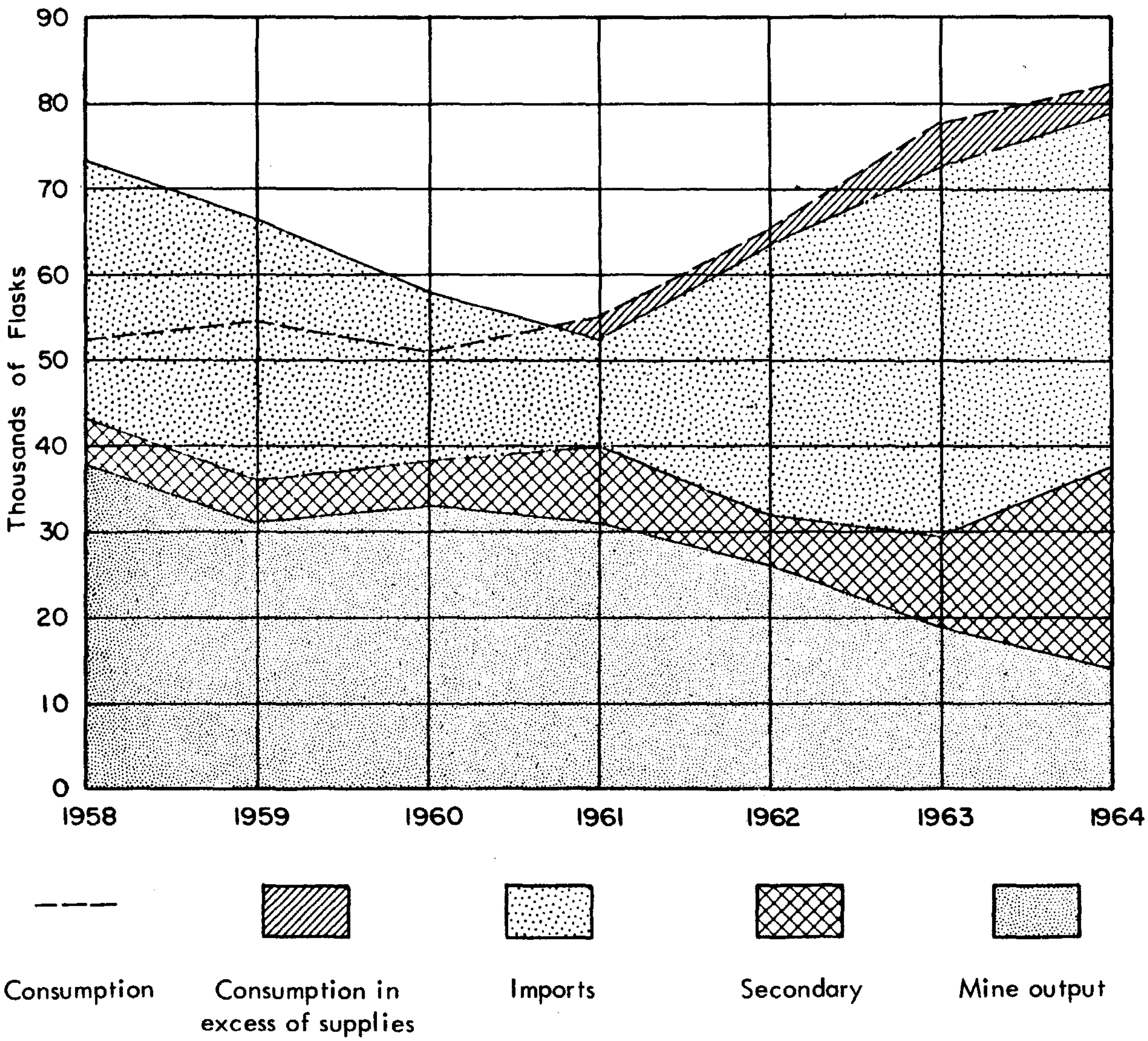
The price escalation began in September 1963 when Monte Amiata, Italy's largest producer, stopped selling and announced that it wanted more money for its product. A few weeks later, Spain temporarily withdrew from the market because of lack of supplies. Encouraged by these events, United States producers became reluctant to part with their product and prices rose steadily upward. United States brokers and consumers then became fearful and began attempting to fill their larders against future needs before prices



should get out of hand. With this added burden on the market came the realization that the world's mercury cupboard was getting bare. Prices then rocketed from a $267 average in June 1964 to $505 on November 20. The average selling price for December was $484. Prices settled back slightly to around a $475 average for the first three months of 1965; then in April they took off again, reaching the all-time monthly average high of $709 per flask in June. From this peak, prices have declined to an estimated average of $540 for December.

Prices might yet be in the $600 to $700 range were it not for the intervention of the United States Government. In March 1964 the Atomic Energy Commission released as excess to its needs some 72,500 flasks of the metal. Of this 55,000 flasks were made available for public sale through the General Services Administration. Great concern was voiced by American producers, and Government-industry hearings were held to discuss disposal plans. At the time very few people realized just how scarce mercury really was, but everyone involved could readily predict that 55,000 flasks dumped on the market would wipe out the domestic industry, already nearly defunct because of the long price depression. However, when domestic consumer needs became urgent, emergency offerings were called for and sales began in February 1965. More than 30,000 flasks were sold by year's end -- most of it considerably below existing market prices. In October an additional 38,000 flasks of AEC surplus stock was turned over to GSA for future sale.

A new uptrend in domestic production has begun. Old mines are being reopened and prospectors are heading for the hills in large numbers.



Year	Mine output	Secondary	Imports	Total supplies	Consumption
1958	38,067	5,400	30,196	73,663	52,617
1959	31,256	4,950	30,260	66,466	54,895
1960	33,223	5,350	19,515	58,088	51,167
1961	31,662	8,360	12,527	55,549	55,763
1962	26,277	5,800	31,516	63,593	65,301
1963	19,100	10,520	43,126	72,746	77,963
1964	14,142	23,780	41,107	79,029	82,608

Figure 3. United States quicksilver consumption versus supplies, 1958 to 1964. (From U.S. Bureau of Mines statistics.)

How long the boom will last is debatable, but past performances of the market indicate that present high prices will bring about eventual over-supply of mercury and a subsequent depression in prices. This has happened four times since World War I. Unless United States' mineral policies are changed there is little reason to expect that it will not happen again. For many years industry leaders have been pleading with the Government to establish a policy that would stop the yo-yo-type existence of the mercury producers. As a matter of fact, all that industry has received from Government is harassment. For example, the 110,500 flasks declared surplus by Government in 1964-65 represented almost as much quicksilver as domestic mines produced in the past 5 years. One can only marvel at the tenacity of the quicksilver miner and wonder what sort of "helping hand" Government will offer next. The really distressing factor is that without a healthy domestic industry the United States is almost totally dependent on foreign sources of supply that could be cut off in time of war.

Oregon's Quicksilver Industry

Quicksilver occurrences are widely scattered throughout Oregon. More than 250 deposits have been prospected over the years and quicksilver has been produced from at least 70 of them. Most of the productive ones in the past have been in the southwestern, central, and southeastern parts of the state.

Oregon quicksilver mines have produced a total of about 105,000 flasks valued at 15 million dollars. More than 90 percent of past production has been contributed by 5 mines: Bonanza in Douglas County, Black Butte in Lane, Horse Heaven in Jefferson, and Bretz and Opalite in southern Malheur. The Bonanza is the largest producer with an output of 39,488 flasks. Yield from the other 4 ranges from 12,000 to 17,500 flasks each.

Since 1927, when continuous production began, trends in output have closely followed the cycles of United States production. The yearly average output from 1927 through 1945 was 4,265 flasks, with a peak of more than 9,000 flasks in both 1940 and 1941.

Following the cancellation of purchase contracts late in World War II and the acquisition of large stocks of foreign quicksilver by the United States Government, prices began a decline which resulted in closure of nearly all domestic quicksilver mines. Oregon's production in 1950 was 5 flasks valued at $81.26 per flask.

High prices brought about by the Korean conflict and Government support programs during the 1950's saw partial revitalization of Oregon's quicksilver industry, and 3,993 flasks were produced from 8 mines in 1957. From this, Oregon output dwindled to 4 flasks from a single property in 1963. A detailed account of Oregon's quicksilver industry and descriptions of the mines and prospects are given in the Department's Bulletin 55, "Quicksilver in Oregon," published in 1963.

As a result of the price rise in 1964, the Black Butte and Bretz mines were reopened to produce most of the 126-flask output for the state that year, as well as most of the 1,400 flasks for 1965. Prospects are good for continued operations at these and some of the other mines, assuming continued strength of the market. Figure 4 shows the location of mines and prospects that were active during 1965.

Quicksilver Developments During 1965

Black Butte mine

The Black Butte mine in southern Lane County lies near the head of the Coast Fork of the Willamette River 17 miles south of Cottage Grove. The deposit was discovered in 1890. Output from several different periods of operation totaled about 16,500 flasks. The period of greatest productivity was from 1927 to 1943, when 13,571 flasks were produced by the Quicksilver Syndicate, which still owns the property.

Except for a short time during 1956-57, the mine lay idle from 1943 until present operations were begun by the American Mercury Corp., lessees, in 1964. The furnace, a 4-foot by 60-foot rotary kiln, installed in 1956 but little used, was revamped and production began in November. The furnace has a capacity of 80 tpd and is oil fired. Present output is at the rate of about 70 flasks per month from ore averaging $2\frac{1}{2}$ to 3 pounds per ton. Recovery averages 97.5 percent.

Thirty people, including office and supervisory personnel, are employed at the mine. Ten to twelve miners work on each of two shifts, and four men operate the furnace plant on staggered shifts. Burt Avery, formerly of the Bonanza mine, is superintendent. The mine foreman is Ralph Emerson. Mining by the present operators has thus far been confined to the 1,100 and 900 levels with the 1,100-level adit being the main access and haulageway. The ore is trucked from there to the furnace plant, less than half a mile away. Small bunches of ore left from previous operations are being exploited and new ore is being developed as the 1,100 level is driven to the southeast.

A new adit level 125 feet below the 1,100 level is being driven in the search for ore. Plans call for drifting southeastward along the main ore zone with close-interval long-hole drilling. Very little exploratory work has been done between the 1,100 level and the 1,600 or Dennis Creek level 500 feet below.

Bretz mine

The Bretz mine lies in the Opalite mining district of southern Malheur County, Oregon and northern Humboldt County, Nevada. The district is centered about 15 miles west of McDermitt.

Mining began at the Bretz in 1931. Production during three different periods of operation, 1931-36, 1940-44, and 1956-61, totaled 16,000 flasks. Six more or less distinct ore bodies scattered over a linear distance of 3,000 feet have been worked by open pit.

The present operations conducted by the Bretz Mining Co. involve an agreement between Samuel S. Arentz of Salt Lake City and Minerals & Chemicals Philip Corp. of New Jersey. Work to reopen the mine began in July, 1964. Production began in November and is now at a peak for the year of 120 to 150 flasks a month. Twenty-five men are employed.

During 1965 a large quantity of low-grade material stockpiled from previous operations was treated, and low-grade ore was mined from the edges of old ore bodies. Much exploration drilling was done, some to considerable depth. Prospects for continued operation are good, providing market prices remain strong. Underground mining is being considered for the future.

Ore treatment at Bretz differs from that at most mines. Instead of being furnaced directly, the ore is concentrated by flotation and the concentrates are then roasted in a small Herrshoff furnace. The float plant has a daily capacity of about 150 tons. Over-all tonnage of ore treated is much greater than this, however, since much waste rock is previously removed by a new scrubber unit which was added to the mill circuit in 1964.

Baker County

Old workings of the Paramount prospect near Greenhorn were reopened and examined by Tony Brandenthaler of Baker. Work ceased in late summer. Surface trenching and sampling was also done by Mr. Brandenthaler at the White Wonder prospect near Whitney.

Early in the year Robert Hulin and Fred Williams erected a one-tube, wood-fired retort on their Cave Creek property in the Burnt River Canyon area. Available surface ore proved too low grade for successful operation on so small a scale. Little or no new development work was done.

Crook County

National Minerals Corp. leased the old Mother Lode and Blue Ridge mines in the Johnson Creek district and the Bear claims in the Marks Creek district. Ore from the Mother Lode was trucked to Black Butte for treatment. Seventy dry tons of this ore yielded 243 pounds of quicksilver. Some additional surface trenching was done on the other two properties, but the company had financial difficulties and work ceased in October. Owners Dick Tooley, Shirley Quant, and Ed Brewer resumed development of the Bear claims and before shutting down for the winter produced a little more than a flask of quicksilver from high-grade ore, using a small retort at the Blue Ridge mine.

The Independent prospect adjacent to the Mother Lode mine was leased to Juan Muñoz. Soil sampling and drilling was done and will be continued next spring.

At the Maury Mountain mines five miles south of Post, Oregon Pacific Industries Corp. leased the Lost Cinnabar No. 1 claim owned by Selby Towner. Some of the old workings were rehabilitated during the year. An extensive exploration program is reportedly planned for 1966. The adjoining Eickemeyer property is now owned by C. F. Taylor.

Curry County

Vern Shangle and Ed Pease of Medford took a short option on the Red Devil cinnabar prospect. The Red Devil, discovered in 1963 by Everett McTimmonds of Grants Pass, is near the head of Diamond Creek in secs. 8 and 9, T. 41S., R. 10W., just north of the California border. Bulldozer trenching and shallow drilling is said to show low-grade cinnabar mineralization over a considerable area.

Douglas County

Floyd Morin and Bill Holley formed the Alcona Mining Co. to operate the Elkhead mine. The old rotary furnace plant was completely rebuilt and enlarged. A small output was made late in the year. Ore was mined from the upper edges of the old glory holes by power shovel and trucked to the furnace.

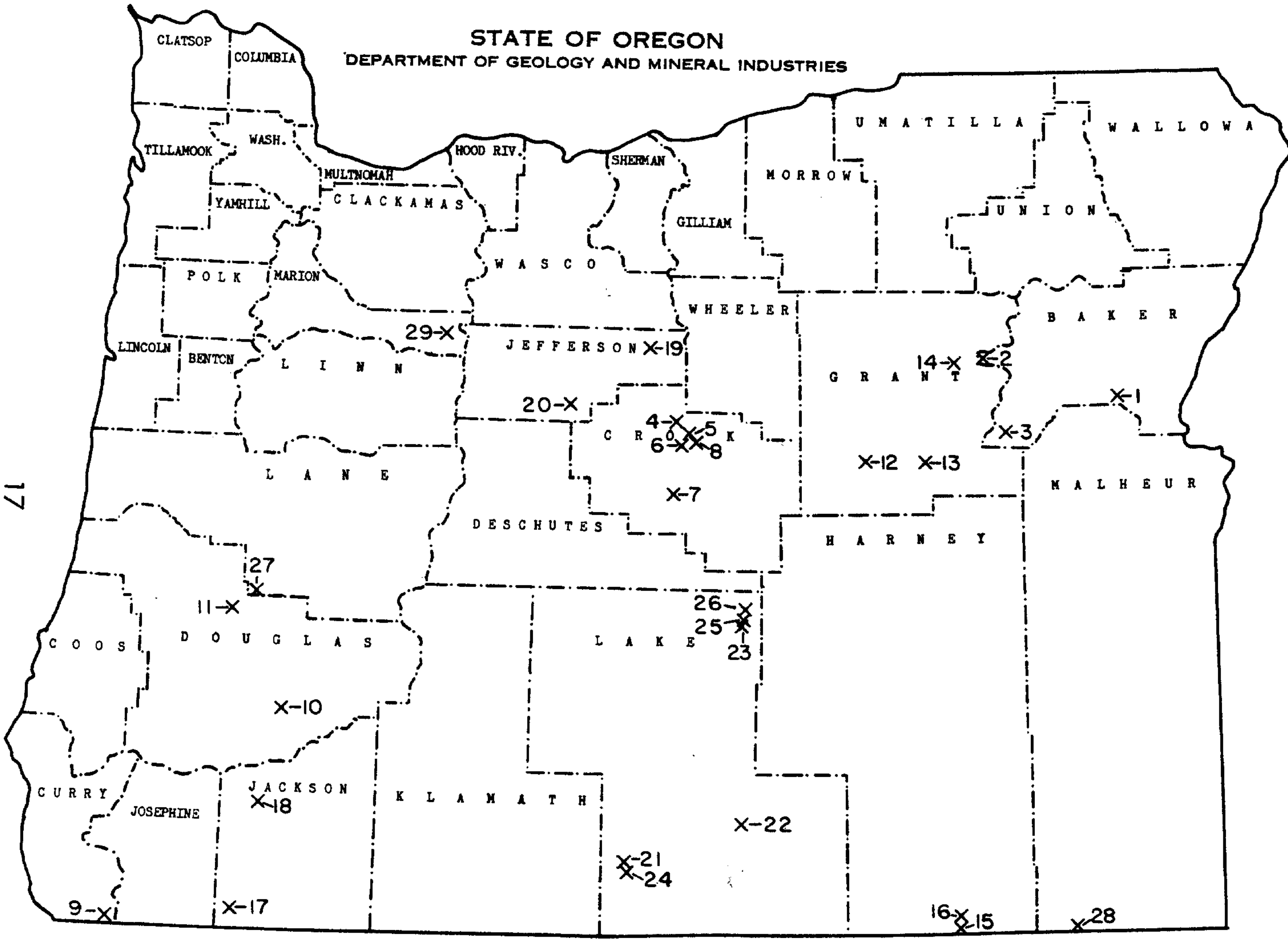
Charles Jackson and Vernon Lerwill located a new prospect in the Tiller-Drew area in sec. 17, T. 29S., R. 1W., and did surface prospecting and dozer trenching during the summer. Cinnabar at this occurrence is associated with a fault breccia zone in the Western Cascades volcanic series of Tertiary age.

Grant County

Cordero Mining Co. dropped its exploration sub-lease on the Canyon Creek prospect in early spring after completing contemplated tunneling and long-hole drilling. The prospect is near the south fork of Canyon Creek 12 miles south of Canyon City. Lessees Lawrence Roba and Banday Sintay resumed efforts to develop the mine but were financially unable to continue work beyond mid-summer. They plan work for 1966.

Production from this prospect, which was discovered in 1963, has been about 24 flasks, 20 in 1964 and 4 in 1965. Cinnabar occurs along a fault zone in upper Triassic graywackes and shales.

Broadway Minerals, Inc., was organized and leased the Broadway prospect in the Murderers Creek area southwest of Canyon City. The prospect is owned by Homer York of Prineville and Cecil Rannels of Canyon City. A 20-ton per day rotary furnace, formerly employed at Glass Buttes, was



Mine or Prospect	County
1. Cave Creek	Baker
2. Paramount	Baker
3. White Wonder	Baker
4. Bear*	Crook
5. Blue Ridge	Crook
6. Independent	Crook
7. Lost Cinnabar No. 1	Crook
8. Mother Lode*	Crook
9. Red Devil	Curry
10. Jackson and Lerwill	Douglas
11. Elkhead*	Douglas
12. Broadway	Grant
13. Canyon Creek*	Grant
14. Long Walk	Grant
15. Double Link	Harney
16. Hiveley	Harney
17. Doodlebug	Jackson
18. War Eagle	Jackson
19. Ashwood	Jefferson
20. Gray Butte	Jefferson
21. Angel Peak	Lake
22. Gray	Lake
23. Glass Ridge	Lake
24. Manzanita	Lake
25. McManmon-Justrom Gp.*	Lake
26. Ryan Group	Lake
27. Black Butte*	Lane
28. Bretz*	Malheur
29. Breitenbush	Marion

* Production in 1965.

Figure 4. Quicksilver mines and prospects that were active during 1965.

moved to the property in mid-summer. No production was made. The old shaft was deepened to 50 feet and about 15 feet of drifting was done from the 40-foot level. Results were discouraging and work was stopped in mid-December.

Art Moothart, Jim Davis, and Harland Jones prospected a new discovery called the Long Walk in the Susanville area (sec. 14, T. 10S., R. 33E.). Several dozer trenches were cut during the summer, one of which exposed thin, widely spaced seams of cinnabar in sandstones and shales.

Harney County

Exploratory work, including drilling, was done by lessees on the Double Link prospect in the Pueblo Mountains east of Denio. Owners Woodley and Tiller report that construction of a treatment plant is planned.

Delbert Hiveley of North Bend reported discovery of a new prospect near Spring Creek in section 12, T. 40S., R. 34E., also in the Pueblo Mountains.

Jackson County

Joe Inman and Joe Fitzpatrick, veteran placer miners, teamed up with Chauncey Florey of Medford and are working the Doodlebug quicksilver prospect (old Palmer Creek prospect) at the head of Bailey Gulch off Palmer Creek. They have extended one of the old adits to more than 250 feet in length. A two-tube batch-type retort has been constructed and development ore is being stockpiled.

The portal of the "coal adit" at the War Eagle mine was reopened by Ben Baker and Dick Costello for owner Jack Bullock of Vancouver, Wash. Nothing further was done.

Jefferson County

Messrs. Rodman, Womack, Chandless, and Lyons of Culver, Oregon installed a small rotary furnace at their Gray Butte prospect east of Culver. The furnace has been used very little to date. Development of the prospect is continuing.

The Ashwood prospect, a quarter of a mile east of Ashwood, was leased for a short time during the summer to National Minerals Corp. An old open cut was enlarged and a short adit was driven.

Lake County

At Glass Buttes, exploratory work was done by three different companies. Jackson Mountain Mining Co. began surface exploration of the Ryan Group of claims in April and continued through December. Numerous dozer trenches were cut and a small amount of rotary drilling was done. A large tonnage of low-grade opalite ore is said to have been developed and plans for construction of a treatment plant are being considered. The McManmon-Justrom claims were leased to a group headed by A. G. Mackenzie and Vincent Ryan. Some diamond drilling was done but, according to McManmon, attempts to reach the projected main ore zone at a depth of about 500 feet were unsuccessful because of badly fractured ground. Equipment was removed in November. McManmon produced a small amount of quicksilver from ore high-graded from the property and treated in a retort at his home near Bend. Glass Ridge Mining Co. continued development, mainly bulldozer work, of its claims in the southern part of the area.

Homestake Mining Co. began a preliminary study of the Manzanita prospect in the Quartz Mountain area 30 miles west of Lakeview. The property is owned by Don Tracey, Ross Foster, Dean Lange, and R. A. Briggs and sons.

In July the Angel Peak mine, also in the Quartz Mountain area, was leased to Raynold Johnson and an associate of Reno, Nev. Much bulldozer work was done but the results are said to have been discouraging. The furnace has been removed from the property. Johnson also leased the Gray prospect north of Plush late in the year.

C. H. Gillmore of Lakeview reported finding cinnabar near Cox Flat in the Thomas Creek area.

Marion County

At Breitenbush Hot Springs, where cinnabar was discovered in 1963, Earl Smith, John Hennamon, and associates have erected a 3-tube Rossi retort. No production has been reported.

* * * * *

MINERAL EXPLORATION PROJECTS IN 1965

The Department initiated a long-range study of the Kalmiopsis Wild Area in Curry County in 1965, to map the geology and make an inventory of all mineral occurrences. The area contains at least 50 mines and prospects for gold, silver, copper, chromite, and iron. The Department's geochemical exploration program continued its testing for copper, molybdenum, zinc, and mercury in southwestern Oregon during the 1965 field season. Another Department field investigation during the year involved the use of electrical resistivity to extend known areas of ferruginous bauxite in northwestern Oregon. In a cooperative undertaking with the University of Pittsburgh, the Department obtained diamond-drill cores of Cenozoic lavas to be studied at Pittsburgh for variations in paleomagnetism.

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OIL AND GAS EXPLORATION IN 1965

By V. C. Newton, Jr.*

A new phase of offshore exploration was initiated in Oregon in April, 1965 when two oil company groups began drilling on federal shelf lands. Extensive seismic studies made between the years 1961 and 1965 indicated substantial thicknesses of sedimentary rocks under the continental shelf region bordering Oregon and Washington. Besides the favorable thicknesses of sedimentary rocks, folds and faults were defined which could provide traps for oil and gas accumulations. The next step in exploration, then, was to drill into the offshore rocks to see if they contained hydrocarbons.

Before deep drilling could be done on the State and Federal submerged lands, it was necessary for the oil companies to obtain leases. This they did by competitive bidding in October and December, 1964.

Four deep test holes were drilled off the Oregon coast in 1965; all were on Federal lands. Nine firms participated in the operations. It is fairly certain that no commercial amounts of oil or gas were found in these holes, but the companies have not released any details on the findings as yet. Comments by some of the oil company representatives suggest that drilling has closely verified seismic results; this is at least a favorable indication.

Exploration work onshore in Oregon last year was at a standstill. Gulf Oil Corp. abandoned the last onshore hole in February 1964. Gulf's "Porter 1" was located 14 miles southeast of Corvallis. This terminated operations in the Willamette Valley where, in 1962-1963, four deep wildcats were drilled within an 18-month period and more than 600,000 acres of land were under lease. Results of the Willamette Valley drilling were discouraging.

During the past 20 years of search for oil and gas in Oregon, 23 exploratory wells have been drilled deeper than 5,000 feet. More than half of these were in western Oregon. Figure 1 shows rock sections encountered in six of these deep drillings. It is evident from these logs that volcanic rocks played a prominent part in the Tertiary history of the State; however, sedimentary rocks attained considerable thicknesses in marine and continental basins. At least 15,000 feet of Tertiary marine sedimentary rock is exposed in western Oregon. Thick sections of Tertiary lake beds occur in continental basins of southeastern Oregon. In central Oregon, several thousand feet of unmetamorphosed pre-Tertiary marine rocks are exposed in

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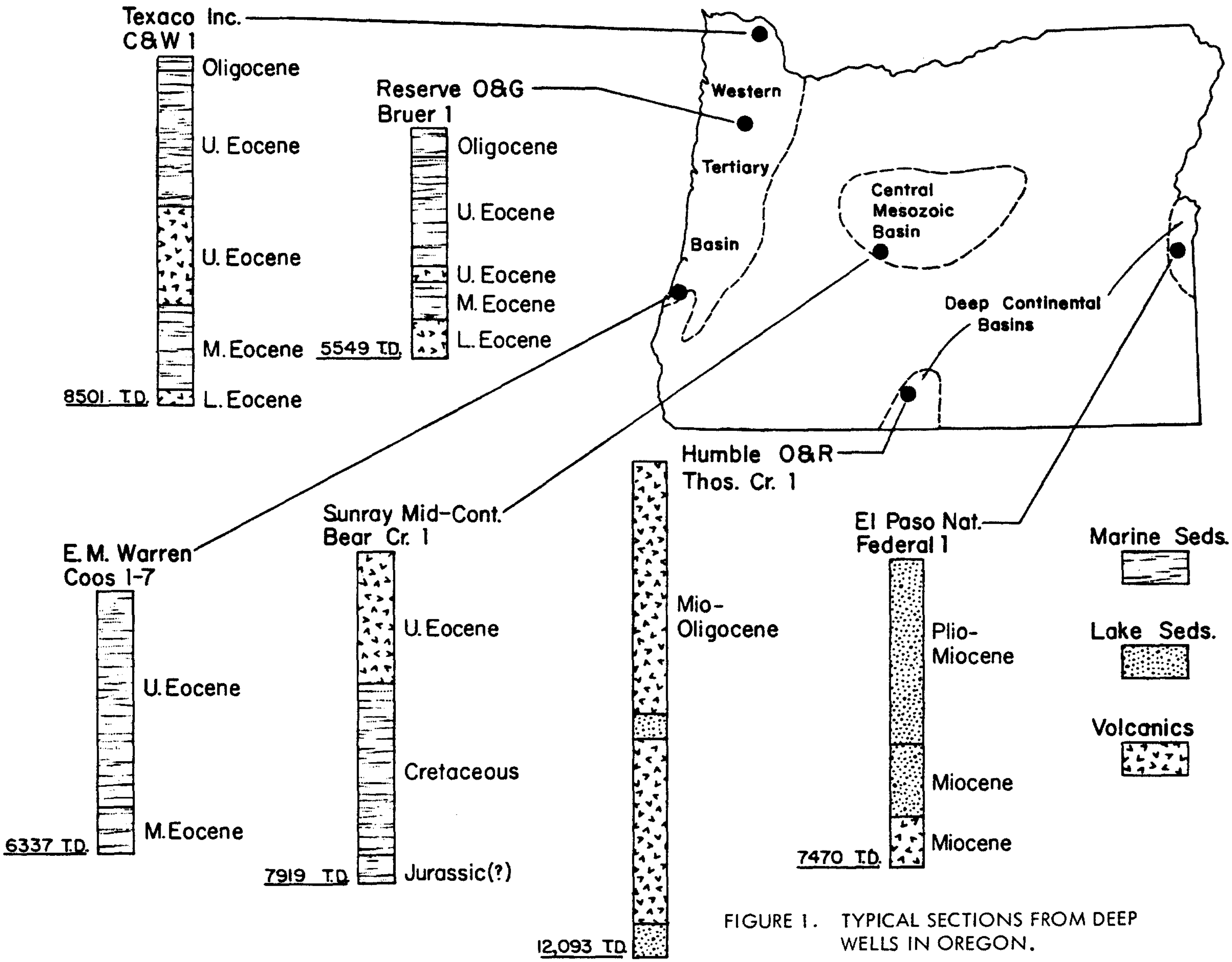

FIGURE 1. TYPICAL SECTIONS FROM DEEP WELLS IN OREGON.

windows of Tertiary volcanics.

Onshore Activity

The Department did not issue any new drilling permits in 1965; however, three permits were active, as follows:

Permit	Company	Well	Location	Depth	Status
18	Riddle Gas&Oil Producers, Inc.	Wollenberg 1	Sec. 28 T.30S., R.6W. Douglas County	1,100'	Plugged and abandoned 11-21-65.
52 PB*	Marvin Lewis	Crossley-Jennings 1	Sec. 31 T.6S., R.4W. Polk County	5,549'	Plugged and abandoned 8-27-65.
54	J. T. Miller	Ray Adams 2	Sec. 11 T.8S., R.5W. Polk County	622'	Abandonment pending 12-31-65.

* Originally drilled by Reserve Oil & Gas Co. under Permit 38.

The Department released the following well records after holding them confidential for the two-year period required by law:

Permit	Company	Well	Location	Depth	Records
51	E. M. Warren	Coos 1-7	Sec. 7, T.27S., R.13W. Coos County	6,337'	Sonic log Electric log Mud log Cuttings

Fewer oil and gas leases were in effect in Oregon last year than for any one-year period since 1950. An estimated total of 75,000 acres was under lease for hydrocarbon minerals on December 31, 1965. Private lands comprised approximately 56,500 acres of the total, Federal lands 17,300 acres, and State lands 1,200 acres.

Offshore Activity

Oil companies had to overcome many technological obstacles involving operations in deep water when they drilled four test holes to depths below 5,000 feet off the Oregon coast in 1965. In addition to mechanical problems, weather along the Oregon shore was found to be inclement even in the summer months and caused many delays in the work.

Standard Oil Co. of California and Union Oil Co. continued exploring

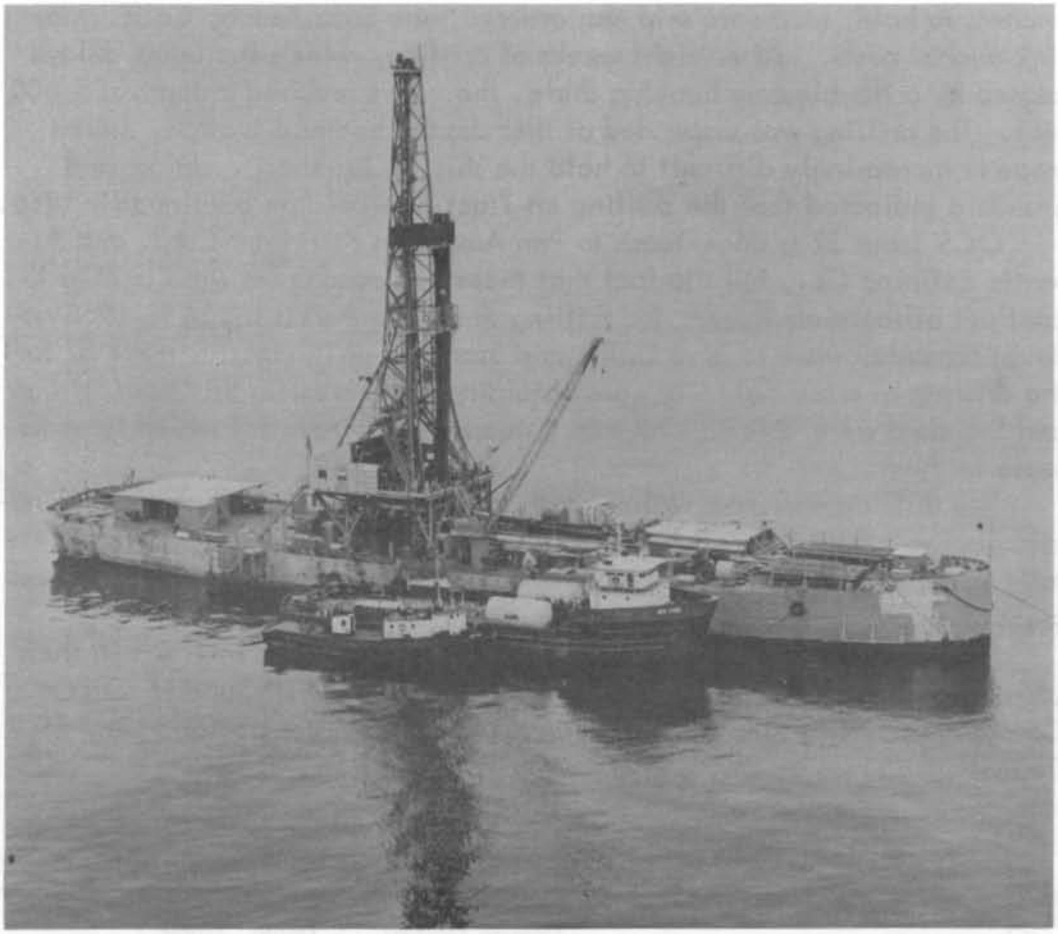

Figure 2. Western Offshore Drilling & Exploration Co. Barge No. III; it was converted from a World War II Navy tanker by Puget Sound Bridge & Dry Dock Co. at Seattle in 1964.

offshore in the Northwest as partners. The two firms jointly leased 167,000 acres of Federal outer continental shelf lands in 1964. Wodeco III (Western Offshore Drilling & Exploration Co. Barge No. 3), a large, center-well drilling barge, was contracted for by Union and Standard for the drilling work (see figure 2). Drilling was begun on OCS (outer continental shelf) Tract 74 by the two companies on April 20, 1965, 11 miles off the coast from Lincoln Beach.

Rough seas thwarted the first two attempts to drill to 1,000 feet and set conductor pipe. During this time the ship's heavy crane was severely damaged while casing was being loaded, and Wodeco III had to be towed into Astoria for repairs. Despite several discouraging delays, a third test hole was drilled to 12,628 feet in 13 weeks. The hole was abandoned as a dry test.

Wodeco III was next moved 25 miles southward to Tract 57, 16 miles offshore from Seal Rock. Hard bottom at the new site would not allow anchors to hold, so a core ship was ordered from Long Beach, Calif., to sink anchor posts. After eight weeks of drilling, which included delays caused by a troublesome heaving shale, the crews reached a depth of 5,600 feet. The drilling was suspended at that depth, because October storms made it increasingly difficult to hold the ship on location. Union and Standard indicated that the drilling on Tract 57 would be continued in 1966.

OCS Tract 57 is under lease to Pan American Petroleum Corp. and Atlantic Refining Co., but the fact that these two companies were unable to contract offshore equipment for drilling their Northwest leases in 1965 no doubt prompted them to give Union and Standard an interest in Tract 57 for the drilling of a test hole. Besides obtaining an interest in this tract, Union and Standard were able to evaluate a nearby site (Tract 55) which is under lease to them.

The drilling agreement allows both Pan American and its partners to obtain geologic data before another year passes. Geologic information is vitally important, since the Federal leases are valid for only five years unless production is found within that time.

Pan American and Atlantic Refining reportedly share interests in their 155,000 acres of Oregon and Washington OCS leases with Superior Oil Co., Canadian Superior, Sinclair Oil & Gas, and drilling contractor J. Ray McDermott.

Summary of offshore drilling in 1965.

OCS Tract	Company	Well	Oregon Lambert coordinates	Depth Drilled	Water Depth	Status
18	Shell	ET No. 1	X = 985,000' Y = 893,000'	5,600'	470'	Drilling
43	Shell	ET No. 1	X = 958,516' Y = 227,419'	3,348'	320'	Abandoned
43	Shell	ET No. 2	X = 959,642' Y = 227,714'	8,306'	325'	Abandoned
57	Union-Standard	Grebe No. 1	X = 978,950' Y = 327,200'	5,603'	195'	Suspended
74	Standard-Union	Nautilus No. 1	X = 1,020,659 Y = 457,162	12,628'	425'	Abandoned

In July, Shell Oil Co. towed the large floating platform Blue Water II from Eureka, Calif., to OCS Tract 43, located 17 miles off the coast from Newport. Drilling proceeded without any problems to a depth of 3,300 feet, then heaving shale became a serious obstacle. The test finally had to be abandoned because of the caving hole problem. The Blue Water II was moved

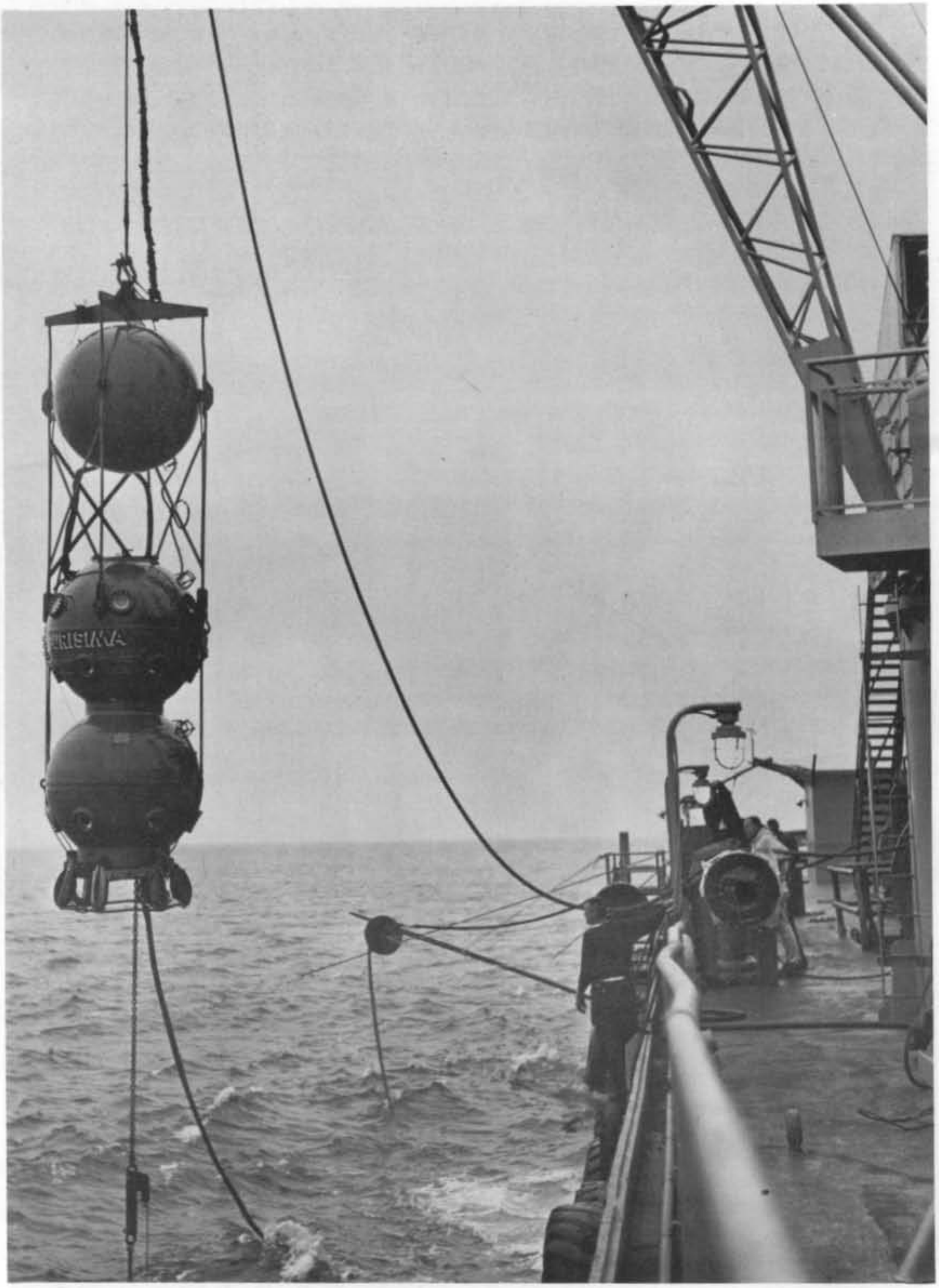

Figure 3. Diving bell used by Standard and Union Oil Companies for drilling operations off the Oregon coast in 1965.

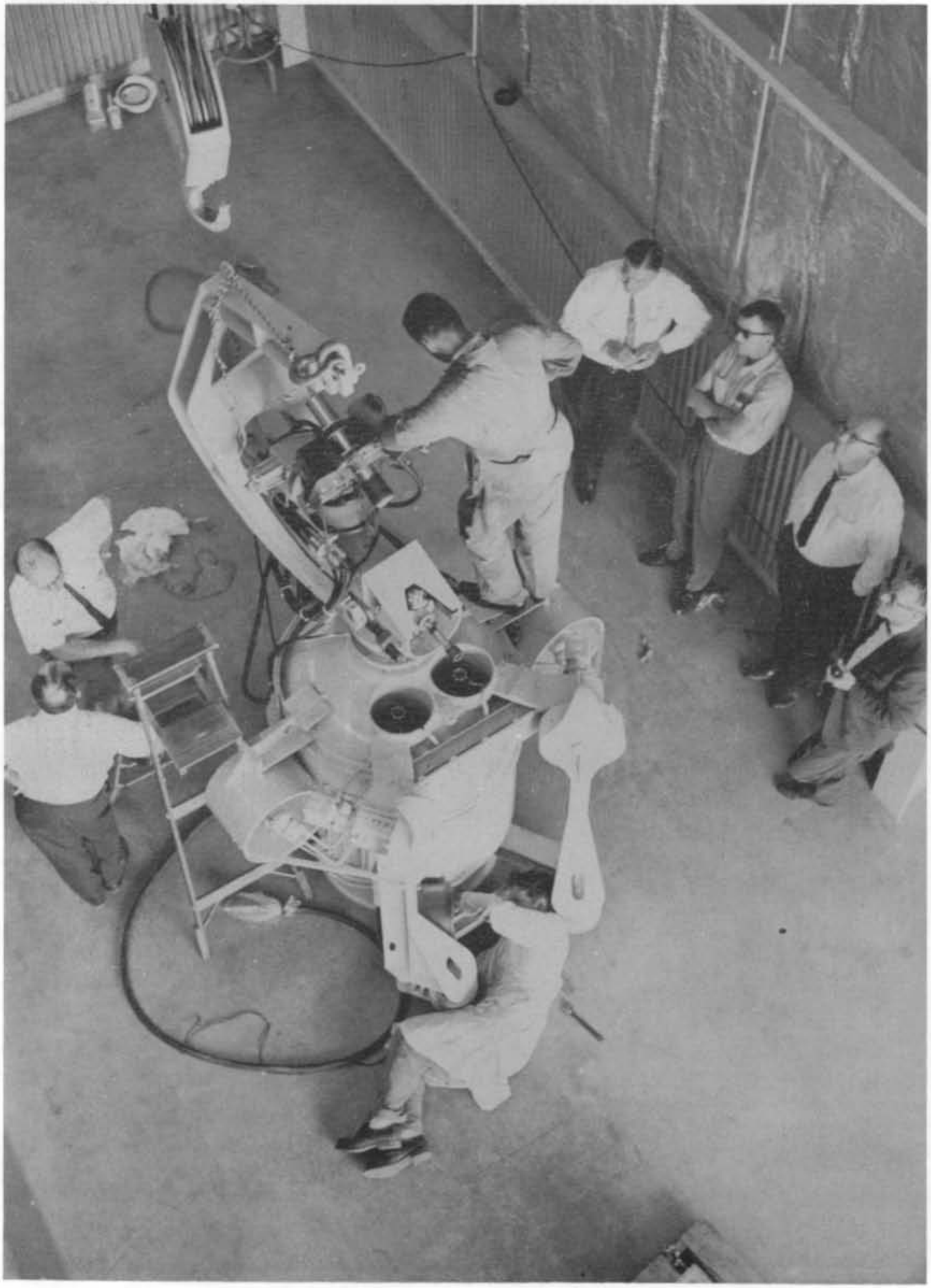

Figure 4. Shell Oil Co.'s $300,000 underwater Mobot, which was developed jointly with the research group of Hughes Aircraft Co.

Figure 5. Electronic control panel for Shell's Mobot. Movements of the Mobot are monitored by use of closed-circuit television.

1,000 feet south and a second hole drilled to 8,306 feet. The hole was abandoned in October as a dry test.

Blue Water II was then towed 125 miles north to Tract 18, 25 miles offshore from the coastal town of Seaside, not far from the mouth of the Columbia River. Heavy seas and strong winds greeted the Blue Water II off the northern coast, so that three attempts were made before surface casing could be set. Drilling advanced to 5,600 feet before wind-driven swells caused the huge floating island to shift location and shear off the riser pipe connecting Blue Water II with installations on the ocean floor. Drilling was resumed after a three-week delay.

Offshore Research

The first season of drilling offshore in Oregon was one of experimentation. Techniques were tried which will be used in offshore work all over the world, especially in the North Sea, where water depth and weather are similar.

Remotely controlled latching devices for making connections with underwater wellheads were tested by both drilling groups in 1965. Standard and Humble gained experience with the apparatus while drilling with Wodeco III in 600 feet of water off the coast of southern California in 1964. The ship was moved off location in southern California waters to avoid a storm, and two weeks later returned to the site, re-entered the hole, and resumed drilling. Underwater television and sonar equipment enabled them to find the ocean bottom equipment and slip the drill pipe into the hole.

Union and Standard experimented with diving techniques as well as mechanical devices when they were drilling off Oregon last year. Divers from Ocean Systems, Inc., Santa Barbara, Calif., reached a depth of 422 feet while working for Union and Standard. Because of the extreme depth, the divers breathed a mixture of oxygen and helium to prevent bends. Divers stayed on bottom for several minutes, then spent three hours returning to the surface. After reaching the ship, they entered a decompression chamber for another three hours.

A diving bell was also employed on the Union-Standard operation. The bell consisted of two seven-foot spheres weighing five tons (figure 3). The diving bell (Purisima - a Union Carbide research vehicle) was designed to work at depths as much as 2,000 feet. One chamber can be kept near atmospheric pressure and the other at water pressure, so that an observer can use the upper compartment while a diver uses the lower one.

Shell's highly sophisticated underwater robot, or Mobot (manipulator-operated robot) was used in operations off the Oregon coast this past year (figure 4). The Mobot is approximately 14 feet tall and weighs 7,000 pounds, and can be used to a depth of 1,000 feet. The mechanical man's main tool is a socket wrench which exerts 1,000 ft./lb. torque at 20 rpm. Valves and bolts in the underwater installations are aligned in a horizontal plane, so that the Mobot can manipulate them.

The Mobot can be monitored from the surface through its television head and sonar-scanning gear (figure 5). Besides a socket-wrench arm, the Mobot has swimming motors which guide it to a track on the wellhead. Shell offers a similar but more versatile Mobot to industry on a lease basis for $2,500 per 8-hour day and $315 per hour overtime. Human divers are now competing with these Mobots, and one diving firm engaged in offshore work predicts it will have divers working at depths as much as 1,000 feet, breathing mixtures of oxygen and helium.

Offshore drilling equipment also provided a means of experimentation by Oregon State University's Department of Oceanography this past summer. University scientists placed electronic devices on the Wodeco III so that ocean currents and tidal surges could be studied. Results of this research will be published in an article written by W. V. Burt and S. Borden for a future issue of The ORE BIN.

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WHAT PRICE GOLD?

Part IV. The Unique Economics of Gold*

By Pierre R. Hines**

"Nature herself makes it clear that the production of gold is laborious, the guarding of it difficult, the zest for it great, and its use balanced between pleasure and pain."

Diodorus Siculus, First Century B. C.

THE MINING OF GOLD

Gold comes from three principal sources: gold placers; gold ore in lodes in rock formations where gold is the important value; and gold in base-metal ores in which gold is a by-product.

1963 Gold Production, U.S.A.[1/]

		Troy oz.	Percentage
Placers		184,563	12.7
Dry and siliceous gold ores (lode)		748,200	51.4
Copper ores)	by-product	438,543	30.2
Other base-metal ores)	by-product	82,704	5.7
Total		1,454,010	100.00

1/ Source, U.S. Bureau of Mines figures.

The above table gives the relative percentages of the three sources of gold in the United States in 1963. This review is concerned primarily with the gold from placers and lodes, because the production of gold from the base-metal ores is dependent upon the prices of the base metals and not on the price of gold. The three sources have to be separated in discussion to avoid confusion about the economic principles governing gold production. The history of gold mining and how gold

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* Part I, "Proposed plans for the improvement of the international monetary system," and Part II, "The official policy of the U.S. Treasury upon international monetary systems," were published in the September, 1965 ORE BIN, with Part III, "The relief given to foreign gold mines by their governments," in the December, 1965 issue.
** Mining Engineer, Portland, Oregon.

deposits occur in nature are essential to the understanding of the economics of gold. This review can sketch only briefly an outline of these two subjects.

Gold Placers

Occurrence

Most gold placers are formed by the erosion of a surface which has outcrops of gold ore. Weathering decomposes the rock, runoff water carries the disintegrated rock down the ravines and gullies to the creeks, and down the creeks to the rivers. In the process the rock is ground to sand and gravel.

Gold, which is resistant to chemical attack, occurs commonly as the native metal and only rarely as a telluride. Weathering frees the metallic gold from the associated rock. Its specific gravity is many times greater than that of the associated minerals; therefore, it sinks in running water and lags behind while the greater part of the sand and gravel is swept on. Thus the gold is concentrated and a placer deposit is formed.

History of production

Ancient placers: Placer gold is pure enough without metallurgical treatment to be worked and formed into ornaments, jewelry, and other objects. The sands and gravels in which placer gold is found are easy to dig and handle. It is not surprising, then, that the earliest cultures knew and used gold. Nor was the metal difficult to recognize. Its yellow, bright, and glistening grains and nuggets on a background of black sand at the point of a high-grade sand bar would be hard to overlook.

Time has wiped out all surface traces of some of the ancient placers, but others are still known and to this day may yield small amounts of gold. Although the source of gold used by some of the ancient cultures remains a mystery, the size of their reported stores and treasures contributes to the evidence of the antiquity of the gold-mining art.

The earliest known gold mining was in Egypt. Golden objects have been found there dating from the fifth millenium and the beginning of the fourth millenium B.C., proving that gold has been mined for 6,000 years (Sutherland, 1959, p. 27 and 33). Authorities agree (Rickard, T.A., 1932, p. 209-214) that the first gold was recovered from placer deposits. It was mined in Egypt almost continuously from the start of the fourth millenium B.C. to the beginning of the Christian era, or for approximately 4,000 years.

The sources of Egyptian gold are known, except for the region of Punt, whose location is disputed. The principal source was a belt of gold-bearing granitic rock 500 miles long extending southward from the Gulf of Suez and lying between the Nile River and the Red Sea, also farther south to the Sudan, Eritrea, and Ethiopia (Emmons, 1937, p. 384-390; Sutherland, 1959, Chap. II; Rickard, 1932, Chap. IV). Both placers and deposits in rock formations occur in this area. The Nile itself, in the stretch between the first and fifth cataracts, had rich gold placer deposits (Sutherland, 1959, p. 26-27).

The island of Thasos, and Macedonia and Thrace on the mainland opposite, were early sources of gold. Whether the Cretans, about 2000 B.C., or the Phoenicians, about 1200 to 1400 B.C., were the first to mine gold there, or whether they got it through trade, is not certain. The mines were old and well known when Philip of Macedonia reopened them about 350 B.C. Herodotus describes accurately their location on the mainland, but time has removed all traces of them (Dominian, 1911, p. 576; Rickard, 1932, p. 358). Phrygia and Lydia (Turkey) became the most important gold-mining districts in the first millenium B.C. (Dominian, 1911; Sutherland, 1959, p. 65). The river Pactolus was famous for the placer gold recovered from its bed. Dominian (1911) places it as the tributary of the Gediz (Hermus, rising on the northern slope of Mt. Timolus). Sardis is on the Gediz about 45 miles from the Aegean. The wealth of Croesus and of Midas, the King of Phrygia, as well as the treasures of Troy, all came from this rich gold-bearing region.

The southeastern end of the Black Sea was an ancient source of gold. The seaport of Poti is in the Land of the Colchis, where Jason is believed to have stolen the golden fleece (Rickard, 1945, Chap. III). The river Phasis, which empties into the sea at Poti, was rich in alluvial gold. Pontus to the southwest of Colchis furnished Mithridates VI (120-63 B.C.) the gold with which he carried on his war with Rome (88 to 63 B.C.). Still later, Justinian, Byzantine emperor from 527 to 565 A.D., obtained gold from the Tchoruksu River, which flows into the Black Sea at Batumi. Tchoruk means "golden," and only recently was its name changed to Coruh Suku. The Dzanzul copper mines on a tributary of the Tchoruksu had ancient workings whose implements and utsensils were pronounced to be Phoenician by the British Museum.

Many gold districts about which little is known are referred to in ancient records. Archaeological exploration in some cases has found sufficient gold in various forms to verify their existence. Some of them are Bokhara and the valley of the Oxus River (Sutherland, 1959, p. 70; Emmons, 1937, p. 347); Arabia; Ophir of the Bible; County Wicklow in Ireland; Wales; the headwaters of the Po River in northern Italy; and the rivers of the Ganges and the Indus (Sutherland, 1959, p. 90).

Probably the Cretans and the Phoenicians obtained gold from southern Spain by trading, and later on--when the Cartaginians founded Cadiz--they mined gold there. The headwaters of the Guadalquivir and the gold-bearing gravels of the Sierra Nevada were mined first. Spain's mineral wealth was one of the causes of the Punic Wars. After the second Punic War (218-201 B.C.), Rome drew large amounts of gold from southern Spain, but the really great amounts came from the Asturias in northwestern Spain after it was conquered by Augustus in 30 B.C.(Sutherland, 1959, p. 93-96; Emmons, 1937, p. 326-327). The remains can still be seen of the vast workings of the alluvial terraces on both slopes of the Cantabrian Mountains. The belt mined was about 80 miles long and was equal in production to that of any previous mining district. Rome drew gold from many old sources and some new; about the latter little is known. It not only mined gold but also obtained it by taxes, levies, tribute, and plunder.

Gold mining was disrupted by the fall of the Western Roman Empire (476 A.D.) and, later, the Eastern Roman Empire. It languished for more than 200 years. The Arabs invaded Spain in 711 and by the end of the summer had conquered half of it and within seven years they had taken over the entire country (Stephenson, rev. 1962, p. 129). They worked the Spanish gold mines vigorously. Later, in the eighth century, they extended their rule a thousand miles south of Marrakech to Timbuktu in West Africa. Timbuktu became a gold-collecting center for Nigeria and the Gold Coast (Sutherland, 1959, p. 115-116). Most of the Arabs' gold came from placer deposits. Their gold coin circulated throughout the Mediterranean.

Later discoveries: During the Dark Ages gold was washed irregularly in the Tiber, Po, Garonne, Rhine, and Rhone Rivers. Trade and mining revived in the 9th century, and in the 13th to 15th centuries expanded rapidly. New discoveries of gold were made in Germany, Bohemia, Silesia, and Hungary. Late in the 16th century Germans washed out 100,000 pounds sterling of gold from the rivers in Scotland. The Middle Ages ended with the 15th century. The discovery of the New World opened a new and great source of gold.

The first gold which the Spaniards took out of Mexico and Spanish America came from the accumulated hoards of the natives and was in the form of ornaments and utensils. Mexico did not have any large placer gold deposits, but Colombia, Peru, Bolivia, Venezuela, and the Guianas did. At least half of all of the gold produced from these last five areas came from the river placers of Colombia, which still yield 300,000 ounces yearly. The gold that Spain received from the New World doubled or trebled the gold stocks of Europe and made a radical change in its finances, economics, and the course of its history. In the 18th century Brazil supplied Portugal with large amounts from placer mining.

Russia was the largest producer from 1820 to 1848 and the gold came mostly from placers. The Lena River gold field in Siberia ranks as one of the great gold placers in the world. It probably produced $400,000,000 from 1846 to 1926. The Urals and Siberia have many other large gold placers (Emmons, 1937, p. 328-348). Since 1917 the U.S.S.R. has given out very little information on its industry, but its gold sales and exports in recent years show it is active.

Gold was not found in the United States until 1800 and then only in small deposits in the Southern Appalachians. The output from this region has never been large, although placer mining has continued to this day.

The discovery of gold in 1848 in California was the start of the modern Golden Age in mining. It opened a gold field on the western slopes of the Sierra Nevada that extended from the Feather and Yuba Rivers on the north roughly to the Stanislaus on the south in a belt about 100 miles long and 60 miles wide. From 1849 to 1852, the gold came almost entirely from placer mining and it amounted to about 3,200,000 ounces (Rickard, 1932, p. 766). "Mineral Resources of the United States" gives a total of at least $1,175,000,000 ($20.00 an ounce) for the placer gold taken from this field since 1848 (A.I.M.E. Lindgren Vol., 1933, p. 427). The first mining was done by manual labor with no better tools or gold-saving devices than the Romans had in northern Spain. Whether the placers on the west slope of the Sierra Nevada in California yielded more gold than some of the ancient gold fields is a conjecture, but that this was one of the most important discoveries is a certainty.

The discovery of gold in Australia in 1851 was the direct result of the 1849 California gold rush. E. H. Hargraves, when he heard the news, sailed from Sidney and arrived in San Francisco in October, 1849. While he was working on the Stanislaus and Yuba Rivers, he was struck by the similarity of the geology and rocks to a region in New South Wales which he knew. He returned to Sidney early in 1851, went to Bathurst and then to Ophir Creek, which flows into the Macquarie River. There, on February 12, 1851, he discovered gold. He then prospected the Macquarie for about 70 miles of its length and was successful in finding gold along the entire distance. He asked for a bonus and the Colonial Secretary gave him 500 pounds Australian; later the Legislative Council of New South Wales voted him 10,000 pounds Australian, and Victoria 3,200 pounds. A committee in the City of Melbourne offered a reward of 200 pounds Australian to the discoverer of gold located within 200 miles of the city. Gold was found at Buninyong in September, 1851; this was the beginning of the famous gold fields of Ballarat and Bendigo in Victoria.

During the decade from 1848 to 1858, the combined gold production of

California and Australia is estimated to have been $1,200,000,000, while the world's gold stock at that time was $1,500,000,000. This enormous gain in stocks gave great concern to the economists and bankers of that day (Rickard, 1945, Chap. VIII).

The consequences of the California gold discovery were far reaching. The search for other gold fields was vigorous. Prospectors scratched every stream bed, creek, and gully testing for gold, and when their gold pans showed a color they followed it to the source. The search was not only in the western United States but in British Columbia and New Zealand, and continued to include any region in which it was practical to mine. Some of the famous fields found in the West were California Gulch at Leadville, Central City, and Clear Creek, all in Colorado; Alder Creek at Virginia City, Montana; the placers of northwestern California and southwestern Oregon; and many smaller ones. The prospectors found not only gold placers but many ore deposits of other metals which became famous mining camps.

Hydraulicking and dredging: When the rich gold gravels were exhausted in 1865 in California, hydraulicking of the high banks and benches started. Hydraulic mining uses high-pressure water jets to wash down the sand, gravel, and dirt and to convey them over the sluice boxes, where the gold is collected, and on to the waste dumps. When practical, it is the cheapest method of removing and transporting dirt, clay, sand, and gravel. Hydraulicking in the Sierra Nevada was so extensive that by 1893 the debris was choking the Sacramento and San Joaquin Valleys and threatening navigation. The Caminetti Act of 1893 prohibited dumping the placer tailings and debris into the tributaries of the two rivers and required they be stored behind dams. As a result, hydraulicking in the Sierra Nevada rivers practically ceased (Peele, 1941, sec. 10, p. 552).

The gold dredge was brought from New Zealand to California in 1896. The chain-bucket or bucket-ladder dredge was developed from it in 1901 and a new cycle of placer mining commenced. A gold dredge is a combination of a bucket excavator and elevator, a gold-saving plant, and a stacker which piles up the tailing behind, all mounted on a barge floating on a river or an artificial pond. It made profitable the digging of large yardages of sand and gravel whose gold content was too low to work by previous methods, and it could dig down to 100 to 120 feet below the water line. Dredging was the cheapest method of working gold placers, next to hydraulicking, since it performed the whole operation from mining to recovering the gold and stacking the tailing. California gold dredging costs in 1912 to 1916 ran from 3.37 cents to 6.28 cents per yard. This opened a new field of placer mining and gave it new life (Peele, 1941, sec. 10, p. 577-589). Finding of gold placers in the Klondike in 1896 to 1898 was followed by more discoveries at Nome, Fairbanks, the Yukon, and other places. When the rich gravels were worked out, dredges were installed and Alaska and the Yukon became a famous gold-dredge field.

The last great placer discovery was in New Guinea in 1932. Eventually, as drilling proved more and more ground, eight great gold dredges were flown in by airplane (Rickard, 1945, Chap. XV). The Japanese captured the gold field in World War II and did considerable damage to the machinery. Dredging was resumed after the war; at present, only some limited hydraulic ground is being sluiced.

Effects of price fixing: The U.S. Congress passed the Gold Reserve Act on January 30, 1934, authorizing the President to reduce the weight of gold in the dollar to not less than 50 percent nor more than 60 percent. The next day President Roosevelt fixed the weight of gold in the dollar to correspond, raising the price of gold from $20.67 to $35.00 an ounce. The object of this Act was to raise the price of commodities, but incidentally it stimulated gold mining. So placer mining flourished

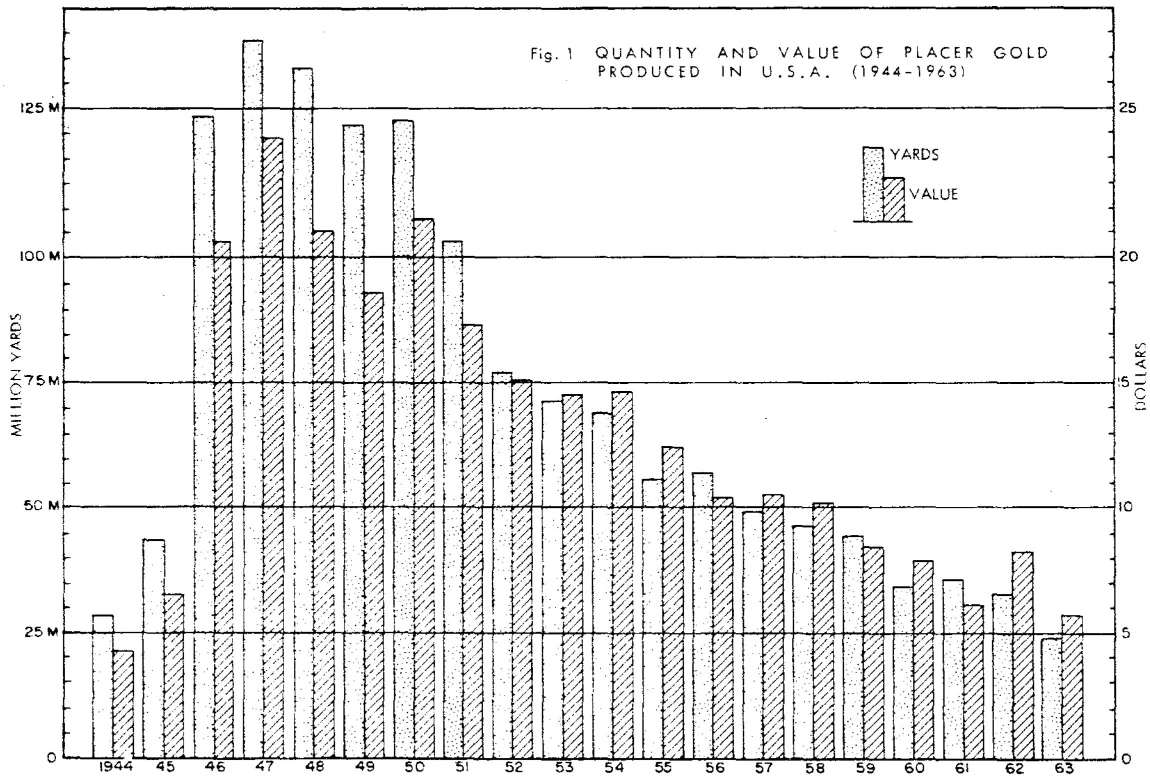
Fig. 1 QUANTITY AND VALUE OF PLACER GOLD PRODUCED IN U.S.A. (1944-1963)
YARDS
VALUE
MILLION YARDS
DOLLARS
125 M
100 M
75 M
50 M
25 M
0
25
20
15
10
5
1944
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63


Fig. 2 BUCKET LINE DREDGES U.S.A.
CUBIC YARDS
VALUE
AVERAGE YIELD PER YARD
MILLION YARDS
MILLION DOLLARS
AVERAGE YIELD PER YARD
125
100
75
50
25
20
15 .30
10 .20
5 .10
1944
'45
'46
'47
'48
'49
'50
'51
'52
'53
'54
'55
'56
'57
'58
'59
'60
'61
'62
'63

again until 1942, when War Production Board Order L-208 closed all gold mines in the United States. Order L-208 was rescinded July 1, 1945 and gold dredging resumed. Whereas the cost of labor and supplies had gone up during the war, the principal cost of gold dredging is in the big investment in dredges and land. This investment had been made before World War II and already had been partially amortized. The cost of power had risen slightly. Gold dredging continued until rising costs became prohibitive or no profitable dredging ground could be found.

Figure 1 shows the total value and the number of yards mined annually from 1944 to 1963 for all placer mines in the United States. As bucket-line dredging accounts for seven-eighths of all placer gold mined now, figure 2 was constructed to show the number of yards and the total value produced annually by gold dredging alone, and also the average yield per yard. Both figures show the gradual decline in placer mining in the United States. Figure 2 shows how the average yield per yard has increased to meet the rising costs of dredging. Placer mines supplied only 12.7 percent of the total gold production in this country in 1963. If gold dredging continues to decline at its present rate, it will come to an end in the United States in another 10 years.

There are several reasons for the decline in placer mining. Profitable placer ground has become hard to find. Long ago, wherever a pack could be carried, a canoe paddled, or a horse or mule could travel, and today wherever a "jeep" can climb or an airplane can land, the prospector has already been. Placer gold always leaves a golden trail. A single gold "color" in a gold pan was sufficient for an old prospector to start in to trace it to its source. This method of prospecting has not been improved on in recent years, nor need it be. What is now left is usually a false lure for the inexperienced.

The price of gold has remained fixed at $35.00 an ounce since 1934, and in the meantime all placer mining costs have gone up and up and up. At the same time, as more yardage has been mined the yield per yard of the gravel left has become poorer. Now the two curves have crossed each other. Then, too, the government regulations covering gold mining, especially placer mining in the Western States and some foreign lands, are so restrictive that these regulations alone are sufficient to make placer mining unprofitable.

The only thing remaining to do to save placer mining is to raise the price of gold. How much there is to save is a question, and those who could best answer it are gone. Placer mining is an ancient industry which has seen its best days if the gold price stays at $35.00 an ounce. New placers have come with the exploration of virgin regions but few unexplored areas now remain.

Gold Lodes

Occurrence

Gold lodes do not occur in the few simple forms which gold placers do. They appear in rocks of every age from the Precambrian to Quaternary. Lode gold deposits follow various geological structures, such as fault zones, anticlines, synclines, stringers, fissures, shattered zones, strata, dikes, and contacts between an igneous rock and some other rock. Ore deposits are classified according to the physical-chemical conditions under which they were formed. Lindgren's classification is the one in general use (A.I.M.E., 1933, Ore deposits of the Western States, p. 20-21).

The deposition of the gold is rarely uniform but varies from rich to lean. The form of deposition may be in bands, in a series of lenses separated or connected, in irregular shapes like splashes of ink on blotting paper, or at vein intersections. Visible gold is not common in an average ore, and it is necessary to sample frequently, assay, and plot the gold assays on an accurate mine map to guide its mining.

The geologic knowledge of gold deposits is extensive, and there is published information on all of the above variations. Among the better known books is W. H. Emmons' "Gold Deposits of the World." Not only Emmons' but several other volumes on the economic geology of ore deposits must be studied earnestly to appreciate the fact that geology is the "door" to finding and producing gold. The key or the lock-combination to the "door" is always hard to find and is never duplicated.

Lode gold deposits are difficult to discover. They do not always crop out, and if they do only a small area may be exposed or it may be hard to distinguish from the surrounding rock. Also, the outcrop may be covered by overburden, muskeg, or a body of water. Placers, a good sign of lode gold in the vicinity, are not always formed or may have been swept away in a previous geological period, thus giving no indications of a hidden gold deposit. The history of gold mining is full of the element of luck, the fortuitous circumstances which led to the discovery of most of our famous gold-mining districts. The rarity of these important finds is reflected in the gold-production records which show up as pulsations or surges when great new gold-mining districts are opened.

History of production

Early lode mines: Mining of gold from hard-rock formations is an ancient art, but the exact date when it began is not known, nor is it known whether the first lode ore mined was turquoise, copper, or gold. The Egyptians were the first recorded miners, and Diodorus at the end of the second century B.C. described their methods (Sutherland, 1959, p. 29; Rickard, 1932, p. 209-214). The rock was broken by heating with a wood fire and then cooling with cold water, which caused it to crack. The cracked rock was pried out with a gad or moil and hammer; the broken rock was carried out in baskets or skins by boys; the rock was broken down to pea size, then ground to fine sand in granite mortars. The ground material was washed on inclined tables and the golden particles caught on the rough surface were removed by sponges. It was all laborious hand work, particularly the grinding in a mortar. The total man-days required to extract gold from a ton of rock would be 20 to 30 times that needed to extract gold from a yard of placer gravel. The man-days needed to produce an ounce of gold would depend upon the richness of the rock and the placer gravel. It could easily take 10 man-days to yield an ounce of gold from a placer, while to produce an ounce of gold from ore with 10 man-days' labor would require an ore running two to three ounces per ton, which is a very high-grade ore. Because of the very nature of the two sources of gold, placers would be mined long before deposits in rock formations were.

The simplicity of the methods for extracting gold from rock formations did not require any great technical advance or knowledge, so the Egyptians probably mined lode gold for several thousand years before Diodorus' account in 200 B.C. What proportion of the Egyptians' gold came from lode deposits will never be known. The remains of their gold mining can still be seen in the desert between the Red Sea and the Nile River. It is estimated that at one place a million tons of ore were mined; at another three to four miles of tunnels are still standing. The important fact is that the total of gold from all sources was enormous. It appears that gold was more desired then than now. An autocratic government with plenty of slave labor not only mined gold for 4,000 years but also sent expeditions by sea to Africa and Arabia looking for it. Archaeologists have found records of the gold received annually by some of the Pharaohs; also the gold in their treasuries, their gifts of gold to other monarchs, and the gold which went into their tombs. More than that, the temples had large amounts of gold, and later rings and small bars of gold were used in commerce. Until 1200 to 1400 B.C. Egypt was the main source of gold in the ancient world.

The silver mines of Greece are famous because the revenue from them built the fleet which defeated the Persians in the naval battle at Salamis in 480 B.C. The Greeks' gold came mostly from placers; the only well-known gold mines in rock formations were in the Rhodope Mountains in Thrace and Macedonia (Dominian, 1911, p. 569-589).

The mines in Spain worked by the Romans were lead, lead-silver, copper, and mercury. Spain's gold placers were notable, but the gold veins were seldom rich enough to mine.

The history of gold mining is unknown from the fall of the Western Roman Empire to Medieval times. During this period gold was scarce in western Europe. Gold mining revived in the 13th and 14th centuries when mining of lode gold commenced to displace placer mining. Gold mines were opened in a belt from Germany, through Czechoslovakia, Silesia, Austria, Hungary, and Rumania (Transylvania). Mining was still done byheating the rock with fire and cooling it with water, although other advances were made. Ground water prevented the ancient miners from going deep. During the Middle Ages, water power was used to drive crude pumps for raising the mine water to the surface, and where the elevation permitted it small drainage tunnels were driven. The hard work of grinding the ore was done by wooden gravity stamps with iron shoes, and driven by water wheels. Gold became plentiful again in western Europe.

At the beginning of the 16th century, the gold of the Americas began to arrive in Europe. The Spaniards mined silver ore in Mexico and South America, but they mined very little gold ore from rock formations. They contributed to the arts of mining and metallurgy by using horses and mules for hoisting ore and turning arrastras; by designing the arrastra itself for grinding and amalgamating silver and gold ores; and by instituting the patio process, which was the basis for the Washoe process that recovered gold and silver from the ores of the famous Comstock Lode in Nevada. Mexico has been the leading producer of silver for 400 years. El Oro near Mexico City was the only important gold-mining district, and it is now exhausted.

United States: The use of steam power and the better quality of iron available at the end of the 18th century benefited all mining. The Comstock Lode was discovered in 1859. It was the premier gold-silver mining district of the United States, the gold being about 40 percent of the value expressed in dollars. But it was also more than the premier gold-silver producer, because it was the turning point at which gold production from deposits in rock formations commenced to grow rapidly, eventually to become the principal source of gold. The Comstock Lode was a great fissure, $2\frac{1}{2}$ miles long and in places several hundred feet wide. It was mined down to 3,000 feet, but the great bonanzas were all above the 2,000-foot level. The mining problems were so many and difficult that if it had not been a bonanza it would have been abandoned. Mining the huge ore bodies exposed large areas of weak roof which had to be supported while the ore was removed; the problem was solved by the invention of the square-set method of timbering. The quantities of hot water and the heat made it almost impossible to mine at times. Then the recovery of the gold and silver had to be solved, and the Washoe process or pan-amalgamation process was contrived. Many modern methods of drilling, blasting, hoisting, pumping, and ventilating were introduced. The conversion of the wooden stamp mill to cast iron and wrought iron was an important advance. Steam power and better cast iron and wrought iron made many of the mining and milling methods possible.

It would be difficult to say which deserved the greater credit for giving the incentive to the search for gold and silver, the Gold Rush of '49 to California or the discovery of the Comstock Lode. Many placer miners left California and went to the Comstock, later returning to California about 1864. They took back with them the knowledge of hard-rock mining and ore recovery which they had gained on the Comstock. This was the beginning of the mining of gold deposits in rock formations in California, particularly on the Mother Lode and in Grass Valley and Nevada City. Other gold fields found in the United States were notably: the Homestake mines in the Black Hills of South Dakota, 1874; Alaska Treadwell and Juneau district, Alaska, 1882; Cripple Creek, Colo., 1891; Tonopah, Nev., 1900; and Goldfield, Nev., 1902.

The above districts produced roughly 30 percent of the gold mined from lodes (dry and siliceous ores) in the United States; the balance of the lode gold came from smaller mining districts or from single mines such as Oatman, Ariz., Bodie, Calif., and Camp Bird, Telluride, and Gilpin County, Colo. The Carlin mine near Reno, Nev., began producing in May of 1965 and is the first important new gold mine discovered in the last 35 years. The geological occurrence of the gold in the famous mining districts and mines of the United States has been varied and diverse. According to their geological character, their productive life has been from 20 to 90 years. Their depth has been from a few hundred feet to more than 4,500 feet. Koschman and Bergendahl (1961) have given a good review of their future ore reserves.

Australia: The rich placers of Ballarat and Bendigo in Australia led to the source of their gold, which was the great gold reefs of the same names. It was not until 1882 that the Mount Morgan mine in Queensland became a great gold producer. Western Australia is a vast arid waste and prospecting was held back by natural hazards. It was not until 1891 that a real gold find was made at Coolgardie and it did not last (Rickard, 1945, p. 204). Kalgoorie nearby turned out to be one of the great gold deposits, famous for its "Golden Horseshoe," so named after the shape of the outcrop of its vein or lode system. Kalgoorie produced 529,000 oz. in 1963, and is now the principal gold-mining district in Australia (Mining Engineering, October 1964). Australia has held fourth place in world gold production for a number of years.

South Africa: Seventy percent of the world's gold production now comes from a mining district called the Witwatersrand in South Africa. Its name has been shorttened to the Rand, or the Rand gold fields. The field is in the shape of an arc about 300 miles in length. Fifty-nine working mines are scattered in bunches along it at the present time. No other gold field is similar or compares in size, extent, depth, or past and present gold production. It produced 29.3 million ounces of gold in 1964 and has produced to date a total of approximately 675 million ounces worth 23 billion dollars. A knowledge of its history, the manner in which the gold occurs, its mining, and its economics is essential to every student of gold and money. This review can give only a brief outline sufficient to bring out a few of its elements and controlling principles.

The Rand is a grand geological structure, a basin of sedimentary beds 25,000 feet thick consisting of quartzites, slates, and conglomerates, known as the Witwatersrand Group. The basin is roughly 160 miles long and 70 miles wide, of which only the rims have been prospected. About 300 miles of the rim has been explored, and only about 40 percent of it has gold-bearing areas. The beds dip steeply 50° to 80° at the surface, and as they go down flatten out to 30° to 40°. The gold occurs in the conglomerates which are called bankets by Rand miners. A conglomerate is a gravel containing rounded and water-worn fragments consolidated into rock. The gold-bearing conglomerates are locally known as reefs or leaders or reef leaders. They have been mined to 11,000 feet vertical depth, and plans have been made to go down to 13,000 feet. The gold follows channels in the conglomerate. The conglomerate may extend laterally for miles and down to depths beyond practical mining limits, but the gold is not so uniformly distributed. The gold-bearing areas are large and so are the barren areas. The thickness of the pay ore varies from 30 to 8 inches; 13,000,000 ounces a year comes from an 8-inch streak.

The persistency of the gold-bearing reefs and leaders has been the foundation for the continuous and increasing production for the 80 years since the 1886 discovery. Careful geological surveys have guided the drilling for and the location of the extensions of the known gold-bearing reefs. A shale carrying sufficient magnetite so it can be traced by magnetic instruments lies above the gold-bearing group; it has been successfully traced to the Far West Rand group, which accounts for 21 percent of the gold production now and has further promise.

The average yield of gold per ton of ore in 1913 was 6 dwt. ($6.00); in 1937, 4.4 dwt. ($7.70) after the gold price was raised to $35.00 an ounce; in 1953, 3.89 dwt. ($6.81). As prices of materials and labor went up, the yield in 1958 per ton of ore became 5.23 dwt. ($9.15); and recently 7.12 dwt. ($12.50) (Kriz, 1965). Fixing the price of gold at $35.00 first increased production and, secondly, made lower grade ores profitable. Then, as costs increased with high prices for supplies and higher wages, richer ore had to be mined to make a profit, leaving behind unmined lower grade ore. The extension since 1950 of the old Rand into the Orange Free State brought into production a new group of seven mines whose rich ores yield 9.8 dwt. (17.15) and account for 35.8 percent of the present total production. The greatly increased production has come from the new rich mines, while the old Rand has been dying from exhaustion of high-grade ore. Although notable advances in mining practices have been made, they have not been sufficient to keep up with inflation. Based on present conditions, the gold production is expected to decline gradually within the next three or four years. The new mines have a life expectancy of 20 years or more, but their production is not sufficient to maintain the present rate.

It is hard even for a mining engineer to grasp the size of the Rand, which mines 80,000,000 tons of ore in one year to produce 29,000,000 ounces of gold worth one billion dollars. The gold is only 1.25 parts in 100,000 by weight in the ore. Gold mining on the Rand employs roughly 450,000 miners, of whom 11 percent are Europeans and the balance natives. The City of Johannesburg, located in the center of the old Rand, started from nothing and grew with the gold-mining industry until it has a population of 1,100,000 people today. For more information on the Rand see: Emmons, 1937, p. 421-437; World Mining, 1965, p. 22-26; Robertson, 1965; Mining Engineering, 1962, p. 41-48; Kriz, 1965.

Canada: Canada did not become an important gold producer from lode mines until about 1924. The increase in the price of gold in 1934 brought on an increase in the production rate, so that by 1938 Canada took second place in free-world gold production exclusive of the U.S.S.R. Canadian production continued to rise, and in 1941 reached a peak of 5,345,000 ounces. Thereafter it decreased slowly and in the last two or three years has been about 4,000,000 ounces. During the past 10 years, 83 percent of the Canadian gold has come from dry and siliceous ores, 15 percent as a by-product of base-metal ores, and 2 percent from placer mining. The total gold production has been 136,000,000 ounces valued at $6,500,000,000Can.

Porcupine was the first of the great Canadian gold-mining districts. It was discovered in 1909 in Ontario. It has three great mines whose production is now declining - the Hollinger, Dome, and McIntyre-Porcupine. Since 1910 Porcupine has produced more than a billion and a half dollars in gold. The Hollinger on and off for many years has been the premier gold mine in North America. Kirkland Lake was the second great gold-mining district in Ontario, located 60 miles east of Porcupine. Discovered in 1912, it had three large mines, Lake Shore, Wright-Hargreaves, and Teck-Hughes. Kirkland Lake has produced 50,000,000 ounces of gold valued at $750,000,000Can.

The Lake Shore and the Hollinger competed for first place in gold production in North America over the years. Then they were surpassed by the Kerr-Addison in the Larder Lake district 20 miles east of Kirkland Lake. As early as 1906, gold was found at Larder Lake and started a rush which dwindled to nothing in 1910. The mines were reorganized and refinanced many times, but it was not until 30 years later, in 1936, that a series of events occurred which could happen only in mining. A large body of ore of profitable grade was found which had been narrowly missed previously, and Kerr-Addison suddenly boomed on the big stock exchange at Toronto. Kirkland Lake has produced today more than 750 million dollars. Its production is dropping gradually, as depth, rock bursts, and ever-increasing costs eat up the profits.

Canada has a large number of gold-mining districts which produce 52 percent of the gold from auriferous quartz mines. They are Cadillac-Malartic and Bourlamaque-Louvicourt districts, Que.; Port Arthur, Ont., and Red Lake, Patricia district, Ont.; Bralorne-Pioneer and Caribou Gold, B.C.; and the Yellowknife district, N.W.T. From 1952 through 1962 these mines produced a yearly average of 3,760,000 ounces, which is 70 percent of the 1941 peak year.

The rocks in most of Quebec, Ontario, and Newfoundland, and in parts of Manitoba, Saskatchewan, and the Northwest Territories, all of which comprise more than half of the land area of Canada, are of Precambrian age - some of the oldest rocks known. They have been intruded by granitic and porphyritic rocks, with which most of the gold deposits are associated. Ontario produces two-thirds of the output from auriferous quartz gold mines, and Quebec one-sixth. Gold is abundant in this vast area of Ontario and Quebec, but it occurs as networks of veins or in shear zones, many of which do not show on the surface. They cannot be traced as the conglomerates are traced on the Rand. The geology of the Ontario-Quebec area is important but too complex to be described in detail here. The Canadian Shield is a treasure house of metals - gold, iron ore, nickel, copper, lead, and zinc.

A great batholith occurs along the coast of British Columbia. A batholith is a large, irregular, deep-seated igneous mass which may broaden as it goes downward. Several productive gold mines have been found on both the eastern and western sides of this batholith. The geology here is different from that of Ontario and Quebec.

Canada still has a potential for future gold production - one of the few regions that does. For more information on Canadian gold mines see: Hoffman, 1946; Canada, Dept. of Mines and Technical Surveys, 1964; Verity, 1962, p. 256-272; Beard, 1964; Ross, 1965; Emmons, 1937, p. 38-106; and Wansbrough, 1965.

World production: Figure 3 shows what is happening to the individual

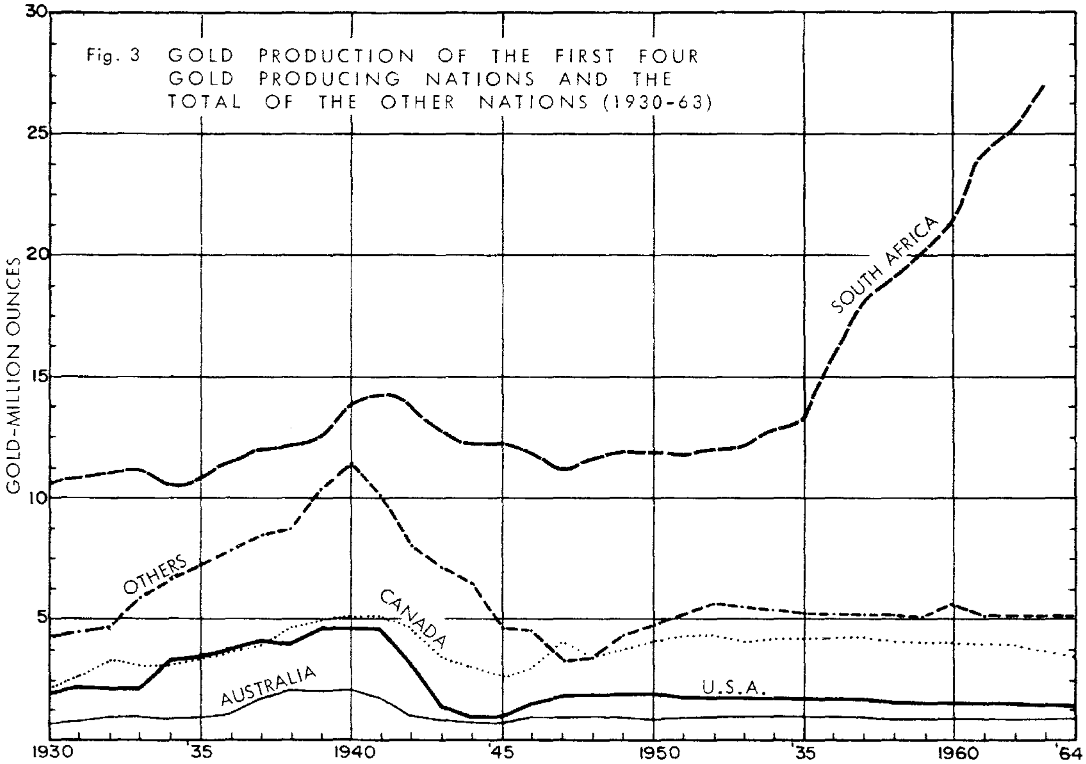
Fig. 3 GOLD PRODUCTION OF THE FIRST FOUR GOLD PRODUCING NATIONS AND THE TOTAL OF THE OTHER NATIONS (1930-63)
GOLD-MILLION OUNCES
30
25
20
15
10
5
SOUTH AFRICA
OTHERS
CANADA
AUSTRALIA
U.S.A.
1930
'35
1940
'45
1950
'35
1960
'64

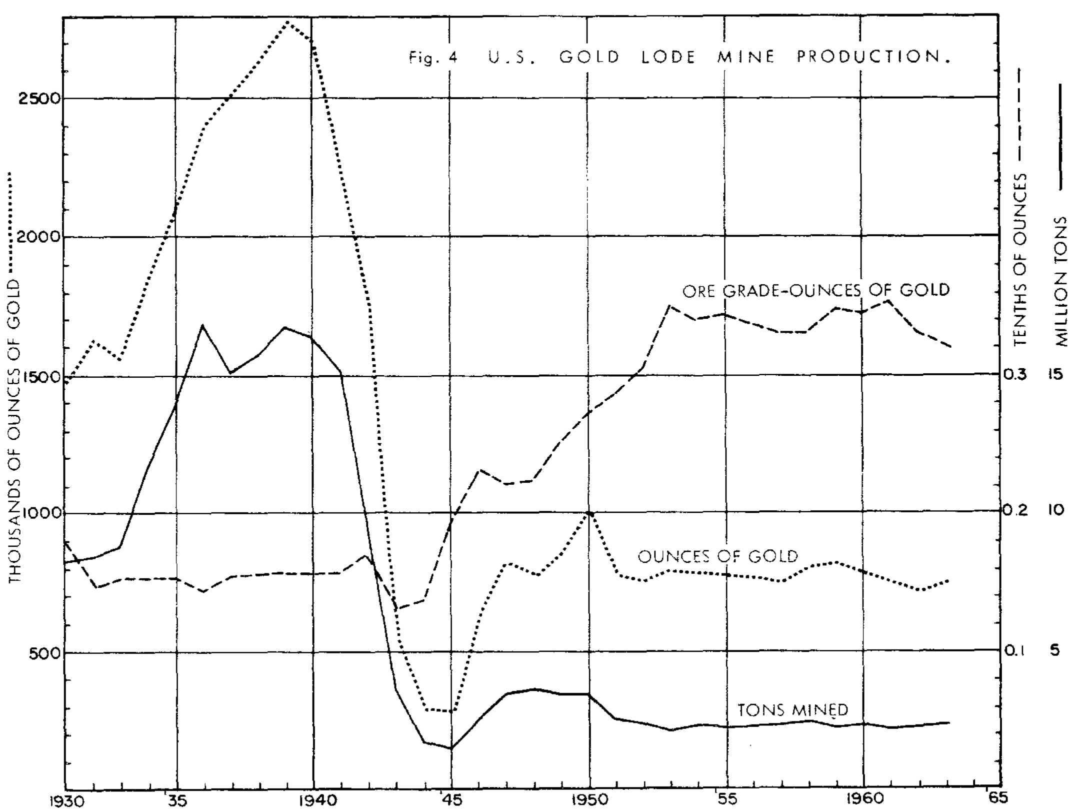
Fig. 4 U.S. GOLD LODE MINE PRODUCTION.
THOUSANDS OF OUNCES OF GOLD
TENTHS OF OUNCES
MILLION TONS
2500
2000
1500
1000
500
0.3 15
0.2 10
0.1 5
ORE GRADE-OUNCES OF GOLD
OUNCES OF GOLD
TONS MINED
1930
'35
1940
'45
1950
'55
1960
'65

gold-producing countries. The first four countries in order of gold production and the others in one lump sum have been plotted separately. The only increased production is in South Africa; Canada, the United States, and Australia show a gradual decline; the others are barely holding to the same annual production. The increase by South Africa comes from new, high-grade mines and from mining ores which contain uranium as a by-product. The decline in other countries is due to the fixed price of gold.

Processing methods

Gold ore at or near the surface of the ground is usually oxidized. The oxidized zone may extend downward for only a few feet but can extend for hundreds of feet. The gold itself is not oxidized, but the sulfides with which it is associated are. The oxidizing action frees the very fine gold particles which were locked up in the sulfides. The oxidized ores are called free-milling ores, which means the greater part of the gold may be recovered by amalgamation with mercury, an old, simple, and cheap process. The gold recovery may be from 70 to 85 percent. When the unoxidized sulfide zone is reached, the ore becomes refractory, the gold recovery falling off rapidly so that only 10 to 30 percent may be recovered by amalgamation. Often a further recovery of the gold-bearing sulfides can be made by various concentrating devices and machines; for example, blankets, corduroy, vanners, and flotation. The concentrate has to be shipped to a smelter or treated by another process, which means high freight and treatment cost, and lower recovery.

Mac Arthur and the Forests patented the cyanide process in 1887 and 1888. They discovered that a weak solution of potassium cyanide would dissolve gold and that the gold could be precipitated from the solution by finely divided zinc. The ore to be treated was reduced to a suitable size and leached in a tank with a weak cyanide solution to dissolve the gold; the solution was drained from the ore, then clarified and passed through a series of boxes filled with zinc shavings, where the gold was precipitated while the barren solution overflowed and was returned.

The final product of the cyanide process is gold bullion. Bullion worth $100,000 and 900 fine weighs only 218 pounds, so a large amount of gold can be transported easily by any means, such as mule back, airplane, automobile, or railway. The mill supplies - lime, cyanide, steel for grinding, zinc, etc. - weigh only about 10 to 12 pounds per ton of ore milled. Power is not a serious problem. Summing up, the cyanide process is well fitted for the requirements of ore treatment in remote regions of rough country and poor transportation. It is the process most generally used for dry and siliceous ores where gold is the principal value; it has increased gold recovery and made profitable mines which otherwise could not have operated. The cyanide process is one of the valuable advances made in gold production, and so far no better process has been discovered to supplant it (Dorr, 1936).

By-Product Gold

By-product gold comes from copper and from lead-zinc ores, with most from the copper ores. Its production depends upon the price of those metals rather than on the price of gold. Less than 10 percent of total world production is by-product gold. More than half of gold production during the last six years has gone into industrial uses, the arts, and hoarding. Less than half went into the world's gold stocks.

Therefore, even if gold were abolished as a monetary unit and the principal gold mines shut down, by-product gold would still be in demand. Thirty-six percent of the United States' gold production comes from by-product gold. It would supply only nine percent of this country's consumption. Since by-product gold is produced regardless of the economic principles which govern the gold production of placer and lode mines, it complicates and masks the true situation if the three are considered jointly. For this reason they are taken up separately.

Rising Costs of Production

Figure 4 shows graphically what is happening to the mines producing gold from dry and siliceous ores in the United States. Gold-mine production has dropped to 26.7 percent of the peak in 1939; the number of tons mined to a fifth; the grade of the ore has almost doubled. With a pegged price for gold, the only way a gold-lode mine can meet inflation and rising costs is to mine selectively higher and higher grade ore. If it can't, it must close.

Since the reopening of the gold mines in 1945, the Homestake Mining Co. has produced three-quarters of the lode-mine gold in the last decade, and consequently figure 4 reflects its operations in this period more clearly than those of the few other mines now operating. Koschmann and Bergendahl (1961) in their forecast upon gold production under favorable conditions show distinctly how many gold mines have been shut down since the end of World War II and how the Homestake production dominates the statistics. Not only have many mines stopped mining, but some famous districts are dormant.

Figure 5 shows the relative changes in the United States' gold production from 1930 to 1963 for the three sources - lode, placer, and base metal. It illustrates what has been said previously about the marked decline of gold from placer mining and from dry and siliceous ores.

Figure 6 tells how the price of gold first stimulated gold production after it was raised from $20.67 an ounce to $35.00 in 1934, and then how it depressed gold production later while its price remained nailed down by law for 30 years. The plot also depicts how, in the meanwhile, wages rose 500 percent and commodity prices 265 percent.

The price of copper is also plotted on figure 5. It rose from 5+ cents per pound in 1932 to 31 cents in 1964. Gold and copper are not strictly comparable, because about 85 percent of the copper ore mined in the United States is by the open-pit method. The copper mines have made sufficient advances in open-pit mining to hold their mining costs per ton down to about the same level for the past decade, while high-cost gold mining underground has not been able to make any great reductions in labor costs. Why can't gold mining shift from under ground to open pits? This is a fair question. They do when the geology of a gold deposit lends itself to open-pit mining, but auriferous quartz mines which can be so mined are rare and valued highly. The new (1965) Carlin mine in Nevada is such an open-pit mine. The initial capital expenditure was $10,000,000 in preparation for mining and milling 2,000 tons daily. While a low operating cost will be achieved, the first cost of machinery, equipment, and preparations for mining is high, because of the increases in these items of two and a half to three times since World War II (Engineering and Mining Jour., 1965; Mining Engineering, 1965; Fortune, 1965).

A good example of how costs have risen in this country is shown in the table

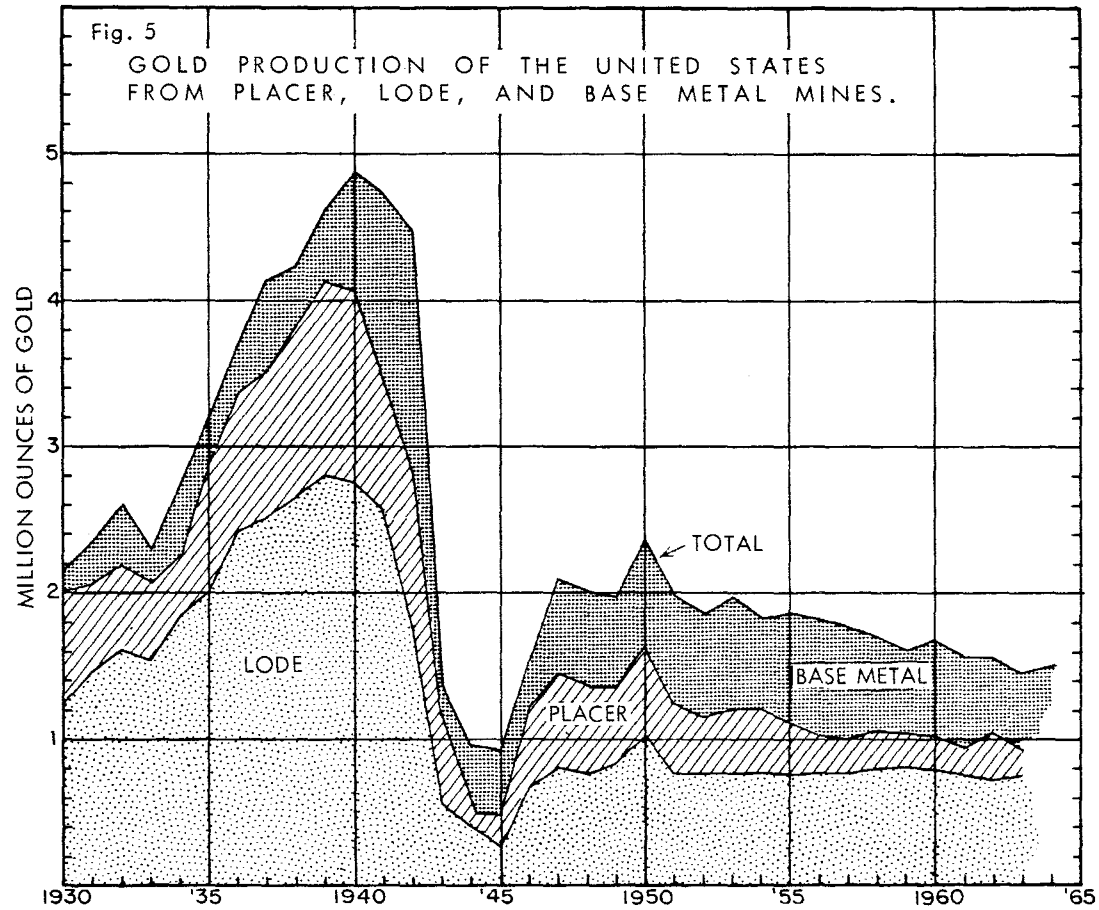
Fig. 5
GOLD PRODUCTION OF THE UNITED STATES FROM PLACER, LODE, AND BASE METAL MINES.
MILLION OUNCES OF GOLD
TOTAL
LODE
PLACER
BASE METAL
1930
'35
1940
'45
1950
'55
1960
'65

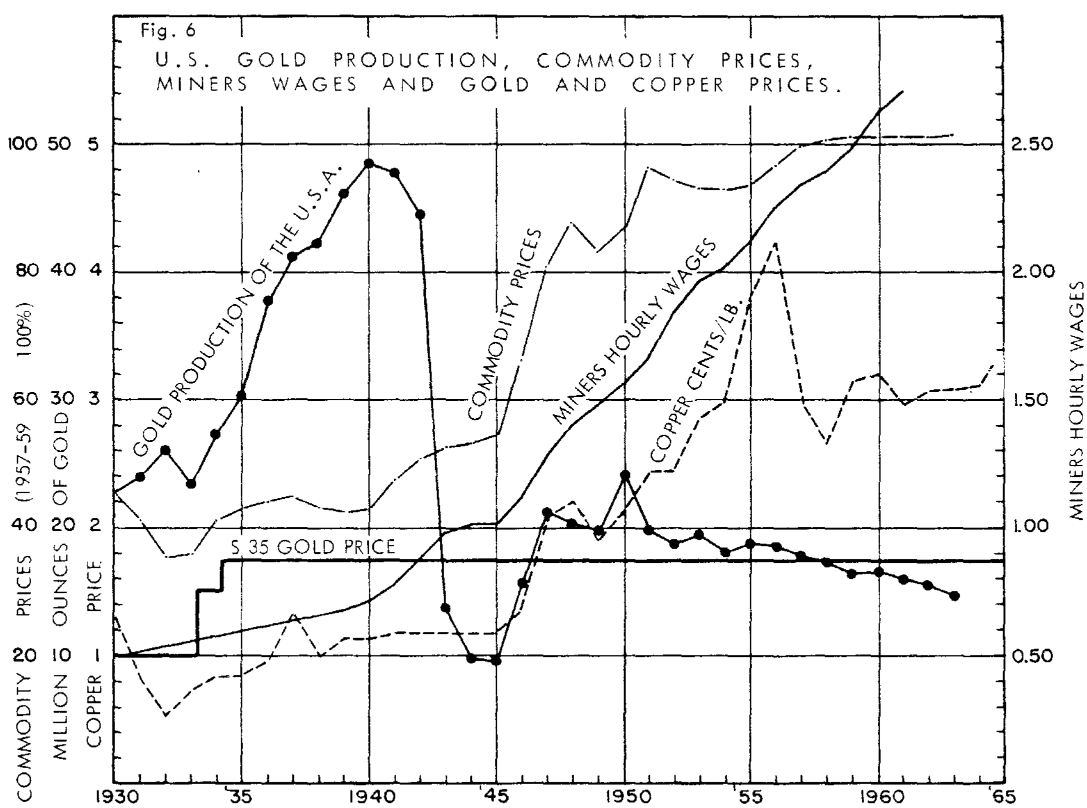
Fig. 6
U.S. GOLD PRODUCTION, COMMODITY PRICES, MINERS WAGES AND GOLD AND COPPER PRICES.
GOLD PRODUCTION OF THE U.S.A.
COMMODITY PRICES
MINERS HOURLY WAGES
COPPER CENTS/LB.
$ 35 GOLD PRICE
COMMODITY PRICES (1957-59 100%)
MILLION OUNCES OF GOLD
COPPER PRICE
MINERS HOURLY WAGES
1930
'35
1940
'45
1950
'55
1960
'65

Homestake Mine Costs

	1941*	1962*	1964**	1965***
Production	1,499,988 tons	1,868,741 tons	2,032,955 tons	2,031,500 tons
Gold content	$13.02/T	$10.85/T	$10.68/T	$10.88/T
Payroll	$ 4,500,000	$ 10,000,000	$ 11,331,000	$ 11,345,298
Local taxes	337,739	806,000	867,000	939,306
Employee benefits	207,137	629,638	717,000	1,081,448
Supplies & equip.	1,230,668	4,023,000	5,194,000	5,500,000

* McLaughlin, 1963, p. 28.
** Kellar, Feb. 2, 1966
***Kellar, Feb. 7, 1966

"The outlook for the year 1966 is not encouraging. In the year immediately ahead we already foresee approximately $130,000 per year increase in social security taxes (including medicare), a further increase in the cost of supplies and materiel of $100,000 per annum, $75,000 per annum reflecting the impact of a full year of the increased sales tax rate of 3% which became effective July 1, 1965, $30,000 per annum in increased electric power costs and $70,000 per annum increased cost in county taxes, to say nothing of possible future wage increases." (Harder, 1966)

of statistics above concerning the Homestake mine in South Dakota.

Tyler (1959) gives a thorough discussion of 1959 mining costs, explaining how they have risen since World War II. All mining costs everywhere have gone up since 1934. Of the 48 lode gold mines in Canada in 1964, 44 have received assistance under the Emergency Gold Mining Assistance Act (Canadian Minerals Year Book 1964, Gold, p. 1). Of the 59 mines operating on the Rand, 16 are losing money or are making an unsatisfactory profit. The South African Government is assisting Rand mines in several ways. The gold-mining industry is not the only American industry which has suffered from inflation. It is, however, the only American industry which is forced by law to sell its product to the U.S. Government at a price fixed in 1934 and which has received no subsidy or relief of any kind.

ECONOMICS OF GOLD

The Scarcity of Gold

Gold has been sought and mined for more than 6,000 years, not just by individuals but by kings, governments, conquerors, adventurers, and corporations. All five continents and many of the world's islands have been searched and mined. The airplane, helicopter, four-wheel-drive automobile, and the shallow-draft motorboat have opened the wilderness and made it easy of access. Scarcely any virgin land or unexplored areas where gold might be found remain, except the sea floor which is receiving increasing attention. Gold never was plentiful in the past nor is it plentiful today. New mines will be found, but their ability to maintain the present rate of annual production is doubtful; an increase in production is not foreseeable at a price of $35.00 an ounce. The scarcity of gold is a continuing fact which the monetary authorities refuse to recognize. In spite of predictions to the contrary, the world has never suffered from a surplus of gold, even when the discovery of great bonanzas doubled the gold stocks.

Important Factors in Gold Production

Geology of the deposit

Geology bears much the same relationship to gold mining that climate does to agriculture. It is the most important principle in the evaluation of a gold mine or a gold-mining district. Geology determines the ease or difficulty of finding and following the ore; the size and persistence of the ore bodies; the grade and distribution of the gold in the ore; the method of mining and metallurgical treatment; and the ultimate value of the deposit or district. When the great variation in all of these elements is considered, only an experienced mining engineer or a mining geologist can determine what their total effect is upon the economics of a given mine or district.

It is particularly the geology which distinguished the South African Rand from other gold-mining districts and at the same time geology is responsible for making it the greatest gold-mining district ever found.

Recovery process

The gold dredge is an important element in gold production, because it makes profitable the mining of large, low-grade river bars and benches which otherwise would not be mined.

The cyanide process is the principal metallurgical process used for recovery of gold from dry and siliceous ores, because it recovers more gold at less cost than the older methods.

New discoveries

Gold is not linked to supply and demand the way most metals are. The supply is limited and the demand unlimited. Gold production rises and falls in a series of irregular waves, depending upon the discovery of new deposits. This is a matter of historical record. If the production of the important individual gold-mining districts in the United States is plotted separately, these waves take shape and explain the ups and downs of the overall production. These waves are of variable magnitudes and are a function of the geology of the mining district and of the ore occurrence (Hines, 1959). The policy of gold miners is to get out the gold from a new discovery as rapidly as is consistent with maximum profit, and this policy governs production.

Effect of Price Changes

When the price of gold was raised from $20.67 an ounce to $35.00 in 1934, the production of gold was stimulated. The primary purpose of the raise, however, was to increase the prices of agricultural products and thus benefit the whole domestic economy, not just the gold-mining industry. After all, in the United States the price of gold had not changed for a hundred years, and under the gold standard it was not necessary.

Following World War II, as inflation raised the price of commodities and wages went up, the price of gold remained fixed. The result was that the cost of mining a ton of ore or producing an ounce of gold kept climbing and profits kept going down. The fixed price of gold then depressed gold mining everywhere except on the South African Rand, where new, high-grade mines were found and some old mines were able to market uranium as a by-product of gold mining.

If the U.S. Treasury had been as zealous in stabilizing the purchasing power of gold as it has been in maintaining the price of $35.00 an ounce, the price would not be the factor it now is in suppressing the production of gold. Raising the price would open mines now shut down; conserve ore by saving gold in ore too low-grade to mine at present prices, ore which will be lost on account of the tremendous cost of reopening an abandoned mine; start new projects now unprofitable; and encourage the search for new deposits.

Recently, several economists have argued that if the National Treasuries and the Central Banks refused to support gold, which they now do by buying and selling it freely at $35.00 an ounce, the value would collapse, because the number of purchasers and the amount of the funds are not sufficient to buy all of the gold now used for monetary purposes. It may be true that the price would fall, but the value would not for mankind has always valued gold.

If the price of gold dropped ever so little, the gold mines would have to shut down. The base-metal mines could not supply the demand for gold for industrial and artistic purposes. When the price had gone down far enough, speculators would enter the market. It is, indeed, probable that a syndicate would take over and control the price as is done in the marketing of diamonds. Many individuals in the United States who have not been able to buy and own gold for 30 years would do so. In time, gold would increase in price to a point where it could be produced profitably, and then the value of paper money would fall.

The high prices for shares in gold mines disproves the idea that the price of gold can be set by a few monetary authorities. Applying the economics of commodities to the economics of gold is always a mistake. The economics of gold is particular and not general. Man has an inborn appreciation of gold which is beyond abstract ideas.

Future Supply of Gold

The supply of gold for the future depends upon the discovery of new mines, the future price, and the decisions of the international monetary authorities. The Administration at Washington has ordered a survey made of the gold mines in this country to determine what the effect upon production would be if the price of gold were raised to several different levels. This is badly needed information.

The only forecast which can be made with any confidence now is that, if the price remains at $35.00 an ounce, production from deposits now being mined and whose principal value is gold will continue to decrease and eventually will stop. It is doubtful that new discoveries will do anything but postpone the day when gold mines cease to produce.

Three trustworthy forecasts based on present knowledge are: "How about gold?" (Koschmann and Bergendahl, 1961): "Gold output of Witwatersrand will fall fast after peaking about 1968" (World Mining, 1965, p. 22-27); and "Review of gold production (McLaughlin, 1960, p. 9-13).

Official Ignorance

The word "ignorance" as defined in the dictionary means "the condition of not being informed." It is strictly in this sense that the word "ignorance" is applied here to the U.S. Treasury's position on gold. Let us now re-examine the Treasury's official position.

In 1962, Robert Roosa, then Under-Secretary for Monetary Affairs, testified before the Committee on Interior and Insular Affairs of the U.S. Senate as follows:

> Mr. Roosa: "Gold is special, because it is the monetary metal and it is different. In our view, in the United States it is not a commodity, and, therefore, is not subject to any of the same criteria, the same approaches that may be relevant for Congressional action with respect to other metals or other kinds of commodities, cotton for instance."
>
> Senator Anderson: "You do believe that $35.00 an ounce adequately represents the cost of production of gold?"
>
> Mr. Roosa: "Yes, sir."
>
> Senator Anderson: "Do you have statistics which permit you to say that?"
>
> Mr. Roosa: "The evidence is basically that of the capability of the principal producing mines elsewhere to produce gold at that price. Now I would add this further point--that so long as gold is a worldwide monetary metal, what is important to us is that gold is produced, becomes available, as it does, increases as I say, in output in 10 years of nearly 50 percent, plus gold coming from other sources and into the known streams; this is in addition to mining, reprocessing, reclaiming and so on of gold; there has been an increase of about 75 percent in total annual availabilities of gold over the last 10 years.
>
> "So the final criterion is whether the price is producing a supply, and it is, and it turns out in economic life all the time that particular areas find that that is not the thing they can do best, and they do something else.
>
> "I am afraid, with respect to gold mining, that may be the case in this country."
>
> Senator Gruening continues the questioning.
>
> Senator Gruening: "It is correct, is it not, that it was raised in 1934 from $20.70 an ounce to $35.00 and has remained there ever since?"
>
> Mr. Roosa: "Yes."
>
> Senator Gruening: "And it is fixed there by Government action?"

Mr. Roosa: "Yes."

Senator Gruening: "And the miners are not allowed to sell it for any more?"

Mr. Roosa: "Yes."

Senator Gruening: "Is there any other industry that is subject to that kind of limitation?"

Mr. Roosa: "No, sir, this is because gold is gold."

It is worth while to analyze Mr. Roosa's evidence in detail. His opening statement is correct, but he does not stick to it. His belief that $35.00 an ounce for gold is adequate is not sustained by the gold-production costs in the United States, Canada, Australia, and for the old mines on the Rand. His opinion that the price of $35.00 an ounce is adequate to supply the world's gold requirements is questionable on two grounds. First, is the present supply of gold really sufficient? Certainly, no wider area of disagreement in monetary matters could be found than how much gold is needed for world trade. Second, will the supply take care of the future? Those in the gold-mining industry competent to judge do not think so. To Mr. Roosa's closing remark that "Gold is gold" should be added "And the U.S. Treasury is the U.S. Treasury."

What Price Gold?

Gold has a dual nature, one as a metal and the other as a monetary unit--its price is fixed, the demand infinite, the supply scant. Consequently, the economics of gold is unique. Ignorance of these simple facts of gold production has done great harm to the future supply of the world's gold and particularly to the gold-mining industry.

Future supply is just as important for gold as for any other commodity. It takes years to find a promising gold occurrence, more years to explore it, several years to develop it and to work out the metallurgical treatment. The total time required to bring a gold mine into production today may run from 6 to 10 or more years and there is no guarantee that it will be profitable even then.

It also takes considerable time and involves much risk to reopen an old mine.

Metal miners work the richest ores first, and as these become exhausted the miners are forced to turn successively to lower and lower grade ores. A grade of ore is eventually reached below which mining is no longer profitable and mining stops. Mining will not resume until lower costs of production are achieved, or improved methods of mining and metallurgy with higher recovery are found, or the price is increased.

If the monetary authorities cannot look farther ahead than their immediate requirements for a money in which citizens and countries will have confidence, the people will have to pay eventually for this lack of foresight.

Authorities may set the price of gold by law, but they cannot fix its production costs. Nature does this, which is undoubtedly why monetary authorities find it easier to print money than to encourage the finding and mining of gold.

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SPARTA SEISMOLOGOCAL STATION OPERATION CHANGED

The U.S. Coast and Geodetic Survey took over the operation of the Blue Mountains Seismological Station near Sparta in Baker County January 1, according to the Environmental Science Services Administration of the U.S. Department of Commerce.

The station was operated the first three years by Texas Geotechnical Corp. under contract from the Air Force, serving both world-wide explosion detection and earthquake-reporting service.

It is considered one of the highest-gain or most sensitive stations in the world and under the new assignment will be the sensing unit for the new sea-wave warning system announced by the Department of Commerce.

Stations making up the system will be located at Adak, Sitka, and Palmer (Alaska) under the Coast and Geodetic Survey. Multiple seismic array systems are being constructed at the sites which will automatically record data from remotely located seismic instruments. Observers will be able to read very quickly required seismic data so that warnings can be issued much more rapidly and protection against seismic sea waves generated by local earthquakes will be provided for the first time.

A similar seismic array system will be installed at CGS's new Northwest Observatory at Newport, Wash., increasing the warning system for waves generated locally along the West Coast. Communications will be relayed to Honolulu Observatory, Pacific headquarters. Newport, located 60 miles north of Spokane, will also provide geomagnetic data and with a special sensing capability will be a valuable addition to the Pacific Seismic Sea Wave Warning System.

Baker station will automatically furnish data to Newport, needed in the release of wave-warning information to Honolulu Observatory. (The Record-Courier, Baker, Oregon, December 16, 1965.)

* * * * *

WELL RECORDS AVAILABLE

The Department released records of the Gulf Oil Corp. "Porter 1" oil test drilling from its confidential files on February 1, 1966. However, Gulf released this information to the public through the Salem Printing & Blueprint Co. shortly after abandonment in January 1964. The test hole was located 5 miles west of Halsey in the NE$\frac{1}{4}$ sec. 27, T. 13 S., R. 4 W., Linn County.

* * * * *

THUNDER EGGS ON EXHIBIT

A permanent collection of sawed and polished thunder eggs is on exhibit at the Department's museum in the State Office Building in Portland. Upon request, the eggs were graciously supplied by the various rock and mineral clubs in Oregon as examples of the new "State Rock." Included in the exhibit are a few cabochons cut from thunder eggs. Most of the stones are from the well-known Priday Ranch locality east of Madras in Jefferson County; a number are from the Ochoco region near Prineville in Crook County; several are from Opal Butte in southern Morrow County; and one is from a locality east of Burns in northern Harney County. One specimen, which came from an outcrop in the vicinity of Idleyld Park in Douglas County, represents the first reported thunder-egg locality west of the Cascades. The entire collection demonstrates not only that thunder eggs are objects of beauty and interest, but also that enthusiasm for collecting, cutting, and polishing these and other agate materials is shared by a great many rock and mineral clubs throughout the state.

An illustrated report telling how the thunder egg became the State Rock, where it is found in Oregon, and theories on its origin was published in the October 1965 issue of The ORE BIN.

* * * * *

OIL AND GAS REPORT REVISED

The Department has just issued "Oil and Gas Exploration in Oregon" as Miscellaneous Paper 6. This report, originally compiled in 1954 by R. E. Stewart, has been revised and brought up to date by V. C. Newton, Jr., Petroleum Engineer for the Department. The new edition contains a history of exploration in Oregon, a review of the geology of sedimentary basins, the development of Oregon's oil and gas laws, exploration statistics for both onshore and offshore drilling, tabulated data on each well including gas and water analyses, and a comprehensive bibliography. Included with the report is a map of Oregon showing the location of all the wells drilled. The 41-page book sells for $1.50 and may be obtained from the Department of Geology and Mineral Industries, 1069 State Office Building, Portland.

* * * * *

ALDRICH MOUNTAIN QUADRANGLE PUBLISHED

The U.S. Geological Survey has recently issued "Geologic Map of the Aldrich Mountain Quadrangle, Grant County, Oregon," by T. P. Thayer and C. E. Brown. The map, designated as GQ-438, is accompanied by a short text on a separate sheet which describes the Tertiary geology of the area. Tertiary units include the Clarno Formation, Picture Gorge Basalt, Columbia River Group undivided, Mascall Formation, and Rattlesnake Formation. Pre-Tertiary rocks, shown on the map, include Paleozoic rocks of probable Permian age intruded by Late Permian or Early Triassic peridotite, gabbro, serpentine, and albite granite. Lying unconformably on the older rocks are Late Triassic and Late Cretaceous sedimentary formations.

The Aldrich Mountain quadrangle lies between Dayville and Mt. Vernon a few miles north of the Suplee-Izee pre-Tertiary inlier. A report on the geology of the Suplee-Izee area by W. R. Dickinson and L. W. Vigrass will be published by the Department this spring. GQ-438 may be obtained from the U.S. Geological Survey, Denver Federal Center, Denver, Colo. 80225, for $1.00.

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NOTES ON LATE TERTIARY FORAMINIFERA FROM OFF THE CENTRAL COAST OF OREGON

By

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Introduction

Since 1960 the Department of Oceanography at Oregon State University has been collecting rock samples from the continental shelf and slope off Oregon. Most of them were obtained from Stonewall and Heceta Banks during the completion of a doctoral research project by Maloney (1965). Information on sampling techniques, location data, and lithologic descriptions are given by Maloney and Byrne (1964) and Maloney (1965).

Foraminiferal faunas have been extracted from rocks taken at 34 stations. A study of these has revealed chronologically and paleoenvironmentally useful assemblages from 12 stations (Figure 1). The dominant or distinctive members of the faunas are reported and discussed here as a contribution to a better understanding of the geologic evolution of the Oregon continental margin. Knowledge of the faunas is particularly important, since most of them are not represented onshore in the state, and since they exist in a section actively being explored for petroleum.

Age

Age determinations previously reported for rock samples off the central coast of Oregon range from late Miocene to perhaps Pleistocene (Byrne, 1962, 1963; Byrne and Maloney, 1965). Both mollusca and foraminifera were used in these determinations, some of which were made by the writer.

All but one of the samples examined contain foraminifera dated as Pliocene or younger. The one exception comes from station 113 at the northwest corner of Stonewall Bank (Figure 1). The siltstone from this locality contains a well-preserved assemblage (Table 1) that is completely different from any of the others studied. It is referred to the lower part of the Relizian Stage of the middle Miocene (Table 2) as defined for the California

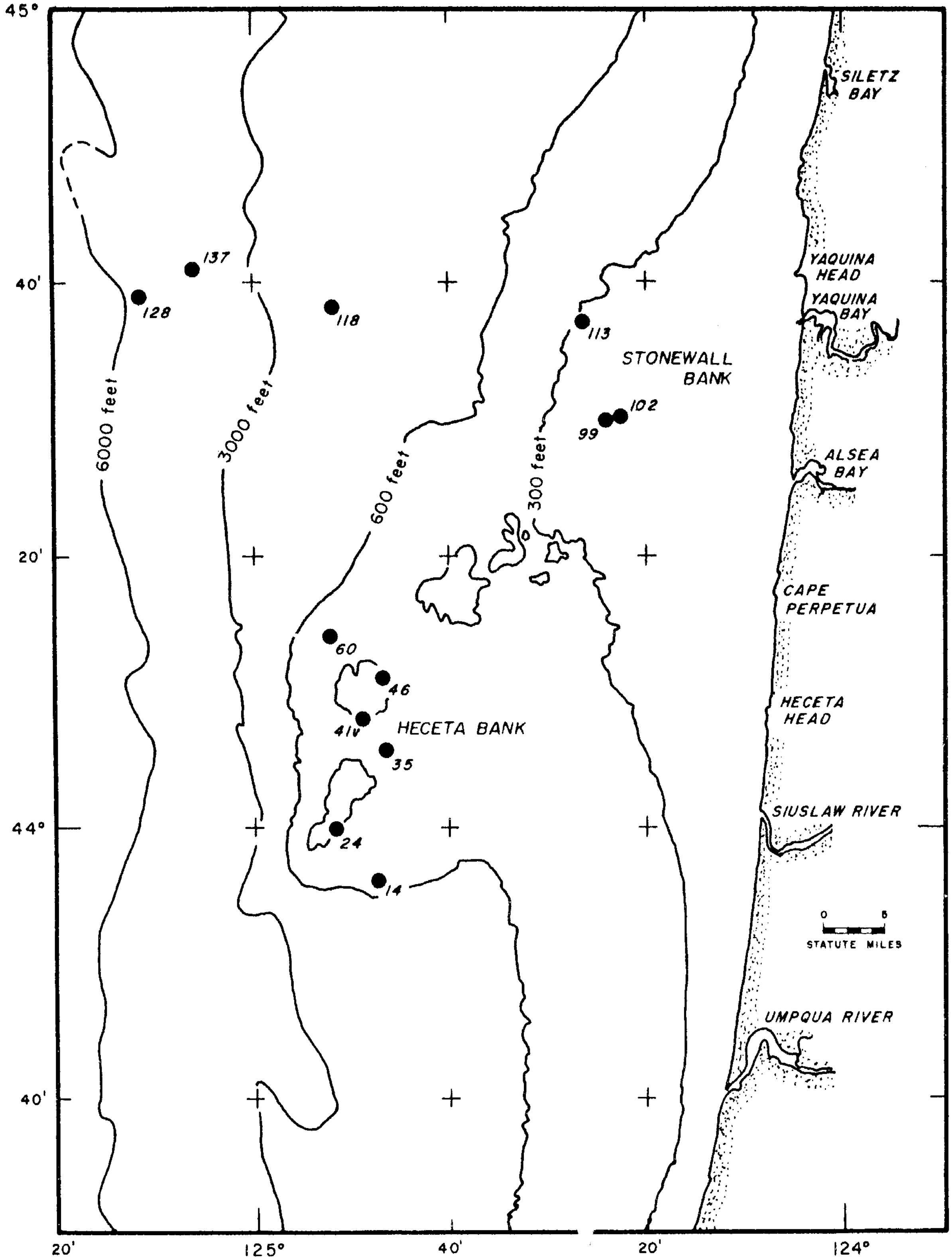

Figure 1. Simplified bathymetric map of the central Oregon continental margin showing locations of rock samples used in this study. The base is adapted from a map compiled by Byrne (1962).

TABLE 1. Relative abundance of dominant and distinctive benthic foraminifera from Oregon offshore rocks. Station numbers in parentheses are accession numbers of the OSU Department of Oceanography. (A = abundant, C = common, R = rare)

SPECIES \ STATION	14(6301-2-95)	24(6209-21)	35(6301-2-68)	41(6209-17)	46(6209-12)	60(6301-2-24)	99(6212-9)	102(OC 0021)	113(OC 0001)	118(OC 0042)	128(OC 0041)	137(6305-3A)
Baggina cf. *B. californica* Cushman									C			
Bolivina advena striatella Cushman									C			
Bolivina argentea Cushman										A		
Bolivina brevior Cushman									C			
Bolivina seminuda foraminata R. E. and K. C. Stewart					R							
Bolivina seminuda seminuda Cushman										C		
Bolivina semiperforata Martin					C							
Bolivina spissa Cushman	C	C	C	C		C						
Bolivina subadvena sulphurensis Cushman and Adams					R					C		C
Bulimina striata mexicana Cushman												C
Bulimina subacuminata Cushman and R. E. Stewart		C					C					
Buliminella californica Cushman									A			
Buliminella exilis (H. B. Brady)	A				A	C				C		
Cassidulina delicata Cushman	A		R			A				C		
Cassidulina cf. *C. modeloensis* Rankin									C			
Cassidulina subglobosa H. B. Brady			A				C					
Cassidulina cf. *C. tumida* Natland					C							
Cassidulinoides cornuta (Cushman)						A						
Cibicides mckannai Galloway and Wissler												C
Epistominella carinata pacifica (Cushman)			C	C		C		C				
Epistominella carinata parva (Cushman and Laiming)									R			
Epistominella carinata smithi (R. E. and K. C. Stewart)			A									
Loxostomum pseudobeyrichi (Cushman)	C				C							
Nonion pompilioides (Fichtel and Moll)											R	
Nonionella costifera (Cushman)									R			
Plectofrondicularia advena (Cushman)	C											
Stilostomella adolphina (d'Orbigny)						C						
Stilostomella advena (Cushman and Laiming)						C						
Uvigerina juncea Cushman and Todd								A				
Uvigerina peregrina hispidocostata Cushman and Todd				C			A					C
Uvigerina peregrina peregrina Cushman	C	C	C	A	C	C				A		A
Uvigerina cf. *U. segundoensis* Cushman and Galliher										R		R
Uvigerina senticosa Cushman											C	
Uvigerinella californica ornata Cushman									C			

Table 2. Estimated paleodepths and ages of the foraminiferal faunas reported on table 1 and approximate amounts of uplift of the Oregon Continental Margin. Depths are in feet.

Station	Present Depth	Paleodepth	Approximate Uplift	Age
102	150	350	200	?
99	180	3500	3300	Pliocene
113	270	1000	700	Middle Miocene (Relizian)
46	288	3000	2700	Pliocene (? Early)
24	300	2500	2200	Pliocene
41	300	3500	3200	Pliocene
35	378	2500	2100	Pliocene
60	396	2500	2100	Pliocene (? Early)
14	456	2500	2000	Pliocene
118	1800	3000	1200	Pliocene (? Early)
137	2160	3500	1300	Pliocene (? Early)
128	5250	9000	3800	?

section (Kleinpell, 1938). Definitive foraminifera include Baggina cf. B. californica, Bolivina advena striatella, Buliminella californica, and Uvigerinella californica ornata. The only reported occurrence of Relizian foraminifera from onshore Oregon is in strata of the Astoria Formation in the southern part of the Astoria Embayment (Snavely, Rau, and Wagner, 1964). Foraminiferal assemblages almost identical to the one reported here are present at several localities in the Grays Harbor area of western Washington (Rau, 1948; Fowler, 1965). The fauna occurs very high in the Astoria Formation as defined in that area.

Most foraminiferal species from assemblages considered to be Pliocene or younger are still living off Oregon. Others are living in somewhat warmer water as far south as Central America (Smith, 1964). Very few, if any, are extinct. This situation makes an age assessment somewhat difficult. Since the faunas came from firm rocks exposed on the shelf and slope, and since they represent environments much deeper than present depths at the sampling sites, at least a pre-Wisconsin and probably a pre-Pleistocene age is indicated.

Detailed foraminiferal biostratigraphic analyses of complete Pliocene sections have been made for the southern California area (Natland, 1953 and 1957; Ingle, 1962). Nevertheless, it is often impossible to place isolated foraminiferal faunas correctly into the established frameworks, because apparent stratigraphic differences are due to shifting biologic depth facies and not to evolution. In the Oregon offshore area, not even a physical stratigraphic framework is available for positioning isolated samples. One must, therefore, attempt to use the California zonations. Such long-range comparisons are at best subjective and must be used carefully. The presence of such species as Bolivina seminuda foraminata, Bolivina semiperforata, and Bolivina subadvena sulphurensis is reasonable assurance that many of the samples are Pliocene, but it is premature to try to affix lower, middle, or upper designations. However, some of the Oregon faunas have marked similarities to lower Pliocene Repettian faunas of the Los Angeles and Capistrano areas in Southern California (Martin, 1952; White, 1956). The nearest equivalent foraminiferal faunas in the Northwest are from the Quinault Formation of western Washington (Cushman, Stewart, and Stewart, 1949; Fowler, 1965) and the Wildcat Series of northern California (Cushman, Stewart and Stewart, 1930).

Faunal assemblages comparable to those from the late Miocene Montesano Formation of western Washington (Fowler, 1965) have not been recognized in the Oregon offshore area by this investigator. This suggests a possible stratigraphic break between the middle Miocene and Pliocene in this area.

Planktonic (floating) foraminifera are among the most reliable organisms for interregional correlations of Mesozoic and Cenozoic strata (Bandy, 1964). However, little is known of planktonic zonations in cool temperate areas, particularly in the Northwest. All of the Oregon offshore samples contain planktonic foraminifera, but only Globigerina pachyderma (Ehrenberg) is considered, at this time, to have any stratigraphic value. Bandy (1960) has demonstrated for the southern California section a dominance of right-coiling forms of this species in the lower and upper Pliocene and the Recent, and left-coiling specimens in the middle Pliocene and Pleistocene. This information has helped to affix possible narrow limitations on the Pliocene determinations of some of the Oregon samples (Table 2).

Paleobathymetry

Knowledge of the distribution and ecology of modern foraminifera has expanded greatly in the last 20 years (Phleger, 1960). Studies of modern benthic (bottom dwelling) foraminifera have made known a regular succession of distinctive assemblages from shallow to deep water. This knowledge is being used by paleontologists to make paleoenvironmental interpretations that markedly advance our understanding of geologic history (Bandy and Arnal, 1960; Bandy and Kolpack, 1963).

Although exact ages are difficult to determine for the Oregon offshore faunas, very definite conclusions can be drawn on the paleobathymetry by comparing fossil species with modern ones. All of the faunas examined were deposited at water depths of 350 feet or greater, and most originated at upper middle slope depths of 2,500 to 3,500 feet (Table 2). Abundant specimens of Uvigerina juncea in sample 102 are diagnostic of outer shelf depths of about 350 feet, the shoalest reported in this paper. Modern homeomorphs of the extinct middle Miocene species characterize upper slope depths of about 1,000 feet. Depths of 2,500 to 3,000 feet are represented by large numbers of typical specimens of Bolivina spissa, Buliminella exilis, Cassidulina delicata, Epistominella carinata smithi, Loxostomum pseudobeyrichi, and Uvigerina peregrina peregrina. Significant numbers of Uvigerina peregrina hispidocostata at stations 41, 99, and 137 indicate depths of approximately 3,500 feet. A Nonion pompiliodes - Uvigerina senticosa paleobathymetric assemblage from station 128 lived at a depth of 9,000 feet or greater, the deepest recognized in the offshore area.

Of particular note is the marked difference in paleodepths of 3,500 and 350 feet between two adjacent stations on Stonewall Bank, 99 and 102 respectively. These may represent two formational units separated by an unconformity or fault.

The inferred paleodepths are considerably greater than the present depths at the sample stations. Amounts of uplift indicated range from 200 to more than 3,500 feet (Table 2). No trends in the rate of uplift of the Oregon continental margin are apparent in the data. This is largely because there is no assurance that samples from the same geologic horizon are being compared.

Summary and Conclusions

On the basis of foraminiferal evidence, rocks from the Oregon offshore area are considered to be younger than most of those cropping out along the Oregon coast. All but one of them have been dated as Pliocene or younger. The one exception is dated as middle Miocene and probably represents a late phase in the development of the Astoria Formation. The other samples come from unnamed stratigraphic units that are not known to be exposed onshore.

All of the faunas were deposited at water depths greater than those existing at the collecting sites. The differences range from 200 to more than 3,500 feet. These differences are interpreted as expressions of the amount of uplift of the Oregon continental margin. Some areas have probably been elevated more than 3,500 feet since the middle Pliocene. Previous estimates of perhaps as much as 5,000 feet of uplift (Maloney and Byrne, 1965; Byrne, Maloney, and Fowler, 1965) were based upon incomplete faunal analyses.

Acknowledgments

This study was carried out under contract with the Office of Naval Research, contract Nonr 1286(10). Samples were collected aboard the R/V ACONA. Neil J. Maloney processed the samples and prepared faunal slides. Thanks are extended to John V. Byrne and Susan J. Borden for critical and editorial reading of the manuscript.

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SOUTHEASTERN MALHEUR COUNTY MAPPED

"Reconnaissance Geologic Map of the West Half of the Jordan Valley Quadrangle, Malheur County, Oregon," by G. W. Walker and C. A. Repenning, has been issued by the U.S. Geological Survey as Miscellaneous Geological Investigations Map I-457. It may be obtained from the Geological Survey, Federal Center, Denver, Colorado 80225, for 75 cents.

The map area lies in the southeastern corner of Oregon in a region not previously mapped geologically. Idaho and Nevada are its eastern and southern boundaries, and long. 118° and lat. 43° are its western and northern boundaries. U.S. Highway 95 traverses the map area from the northeast corner near Jordan Valley to the Nevada line near McDermitt. The scale of the map is approximately 1 inch = 4 miles.

This part of the state is underlain by terrestrial volcanic and sedimentary rocks ranging in age from Miocene to Recent. Vertebrate faunas of Miocene, Pliocene, and Pleistocene age are the basis for dating much of the sedimentary strata and fossil localities are listed. At least 20 geologic units are shown on the map by colors and patterns and are described in the map legend. Although no formational names are given to these geologic units, some are correlated with known formations in other areas.

* * * * *

OCEAN CURRENT OBSERVATIONS FROM OFFSHORE DRILLING PLATFORMS

By

W. V. Burt and S. Borden
Department of Oceanography, Oregon State University

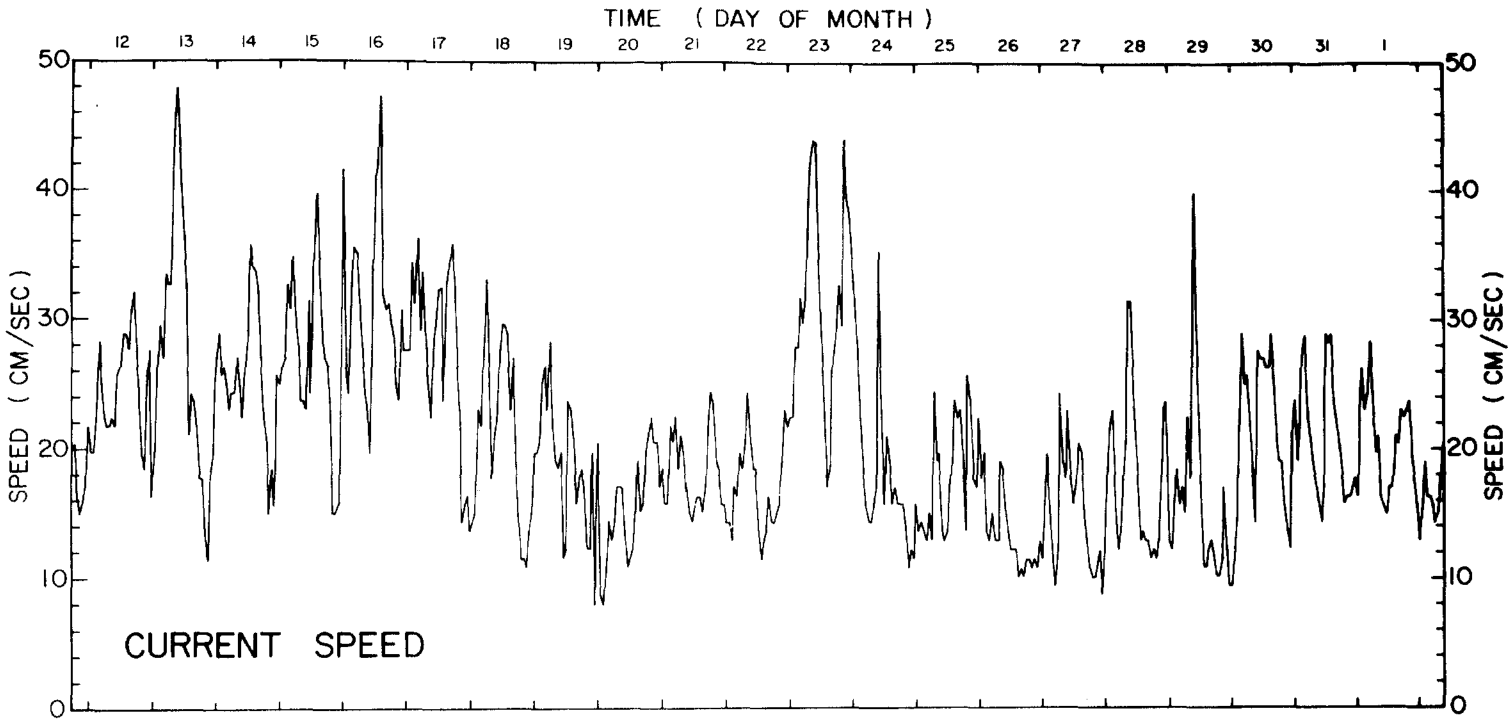
In early May of 1965, the Department of Oceanography at Oregon State University began a program of detailed current measurement in conjunction with the offshore oil exploration on the continental shelf off the Oregon coast. For several years, we have been surveying the currents in this area, and in the area farther seaward, but only in a general way. Only the surface currents had been measured in any detail, and those only by using floating devices such as drift bottles and drogues. The relative water motions below the surface had been inferred indirectly from observations of the temperature and salinity of the water. But on the continental shelf, where we know the currents should be quite variable, we had few direct observations to support our theoretical studies. We were, then, eager to take advantage of the opportunity to use the drilling platforms and the logistical support their operations could provide us in studying the current structure in more detail.

We made arrangements to use two of the drilling platforms operating offshore in the Newport area: WODECO III*, leased jointly by Union Oil Co., Standard Oil Co. of California, and others; and BLUE WATER, operated by Shell Oil Co. All of our work to date has been done either on or near the WODECO III, first located about 20 miles northwest of Newport, and later on Stonewall Bank about 18 miles west of Waldport.

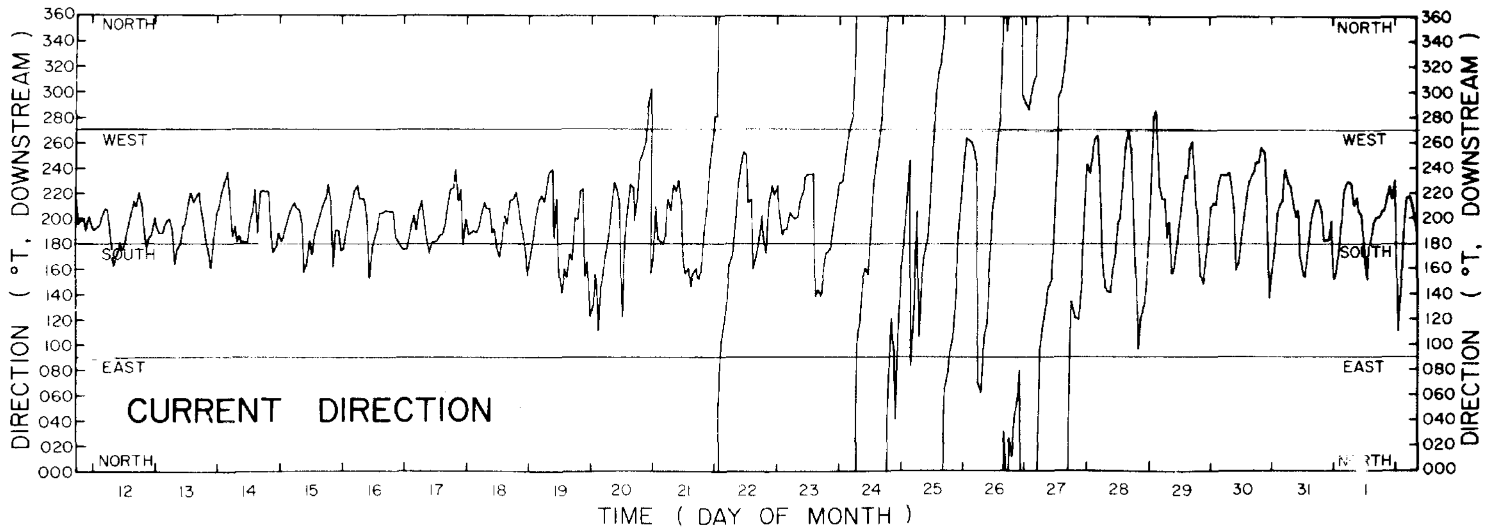
The project is designed to provide information about the currents and their causes and effects, as well as data for statistical studies. Eventually, we hope to have enough data on the currents and their driving forces to be able to make predictions about what can be expected to occur in this area in the future.

Currents were measured in four different ways: (1) with a fixed array of current meters suspended from a taut wire between an anchor and a subsurface buoy located about a mile from the WODECO III, (2) with a "yo-yo" instrument system that was lowered from the deck of the WODECO III, (3) by optically tracking floating devices in the area near the WODECO III, and (4) indirectly, as inferred from temperature and salinity of the water in the area. By using all these methods, we will be able to view the current structure in a variety of ways, and thus examine it in more detail than had been possible in the past.

* Western Offshore Drilling & Exploration Co. Barge No. 3



CURRENT SPEED AT A DEPTH OF 20 METERS
JULY 11 TO AUGUST 2, 1965
44° 51.5' N. 124° 15.2' W
(NINE MILES WEST-NORTHWEST OF DEPOE BAY)



CURRENT DIRECTION AT A DEPTH OF 20 METERS
JULY 11 TO AUGUST 2, 1965
44° 51.5' N, 124° 15.2' W
(NINE MILES WEST-NORTHWEST OF DEPOE BAY)

Preliminary analyses of the data taken last summer show that the currents are highly variable, and also quite strong. The accompanying figures show the current speed and direction at a single point 20 meters below the sea surface at the drilling location about 20 miles northwest of Newport. The data shown were taken continuously between July 11 and August 2, 1965. Current speeds ranged from 9 to 48 cm/sec, or from about 0.1 to 1.0 knots (1 knot equals about 50 cm/sec). Current speeds changed as much as 30 cm/sec within one day. The current generally set toward the south-southwest, but sometimes rotated through a complete clockwise circle (as on July 27).

Much of this variability can be attributed to the tides. When our observations have been fully analyzed through the use of computers, we should be able to predict this tidal variability with some accuracy. Other variations observed are apparently related to the winds, but just how they are related, we do not yet know. Continued series of observations of these currents, accompanied by regular meteorological observations both at sea and on the nearby shore, will provide a much stronger foundation for future predictions.

The detailed studies begun this summer form an important part of our comprehensive program, which encompasses the area from the coast to more than 200 miles off shore. The information gained from this project is a vital link in our chain of information on changes in oceanographic variables between our coastline and the open sea. Our findings from these efforts should be very useful to those who wish to exploit the rich area off our coast, not only for prediction of what they can expect to find there, but in forecasting the difficulties they might encounter in achieving their goals.

Acknowledgments

Financial support for this program has been furnished by NSF Grant GP 4472 and ONR Contract Nonr 1286(10), NR 083-102. The generous assistance of the crews of WODECO III and BIG TIDE, Standard Oil Co., and California Research is gratefully acknowledged. Without their support, this program could not exist.

* * * * *

REPORTS RELEASED BY GEOLOGICAL SURVEY

Two reports of economic interest to Oregon have been published by the U.S. Geological Survey. One is concerned with energy sources in areas of recent volcanism, and the other with potential power production from the Nehalem River. Circular 519, "Geothermal energy," may be obtained free from the Geological Survey, Washington D.C. 20242. Water-Supply Paper 1610-C, "Water power resources in Nehalem River Basin, Oregon, with sections on geology of sites," sells for $1.25 by the Superintendent of Documents, Government Printing Office, Washington D. C. 20402.

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LATE JURASSIC ICHTHYOSAUR FROM SISTERS ROCKS COASTAL SOUTHWESTERN OREGON

By

John G. Koch* and Charles L. Camp**

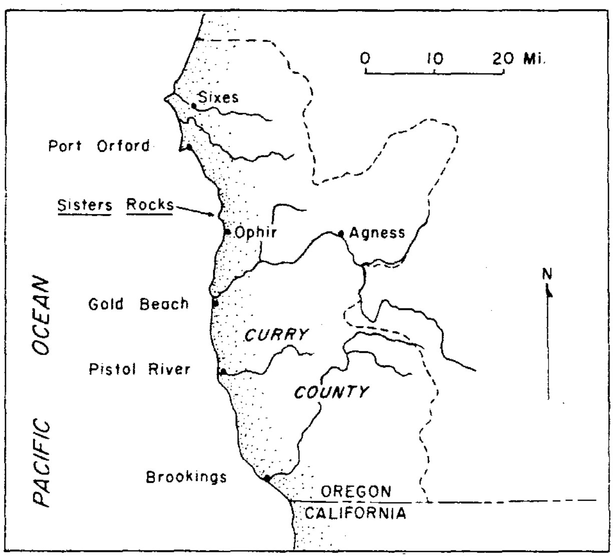

Figure 1. Index map of southwestern Oregon.

Introduction

Ichthyosaur teeth and jaw fragments collected at Sisters Rocks (Figure 1) in 1961 by N. V. Peterson1/ were given to J. G. Koch for use in his thesis studies. The remains have since been described in detail (Camp and Koch, 1966) and donated to the University of California, Berkeley, Museum of Paleontology (Loc. No. V6169, Spec. No. U.C. Mus. Pal. 65.304), where other Pacific Coast ichthyosaur fossils are kept.

Ichthyosaur Morphology, Habitat, and Evolution

Ichthyosaurs were Mesozoic reptiles that lived in the sea. They had numerous fish-like attributes and grossly resembled porpoises (Figure 2). The elongated head bore large eyes and consisted primarily of narrow, beaked jaws with many pointed teeth. Unlike other marine reptiles, they lacked a distinct neck; and the streamlined body tapered into a large tail fin -- the main propulsive organ. Their limbs were modified into two sets of paddle-like paired fins, and a dorsal fin served as a keel. Most of the complete specimens have a length of less than 10 feet, although the skull of an

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** Department of Paleontology, University of California, Berkeley.

1/ Geologist, State of Oregon Dept. of Geology and Mineral Industries.

Early Jurassic ichthyosaur (Leptopterygius) from Europe is 7 feet long, indicating a total body length of nearly 45 feet. Some specimens from the Triassic of California, Nevada, and Oregon are more than 60 feet long.

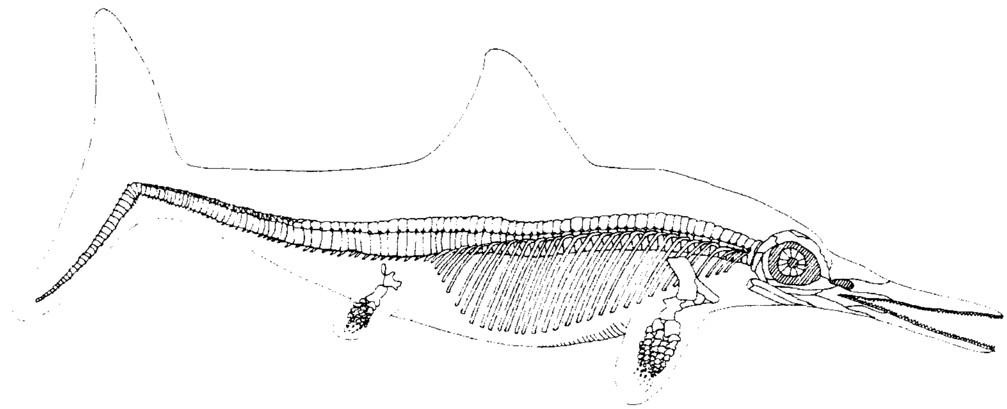

Figure 2. A Jurassic ichthyosaur, greatly reduced. (Redrawn from Romer, "Vertebrate Paleontology.")

Other marine reptiles also existed during the Mesozoic. Their occurrence was a significant reversal in the evolution of life, for shortly after reptiles evolved from amphibians during the late Paleozoic some reptilian stocks became adapted to the aquatic environments.

The oldest known member of the aquatic reptiles was the long-necked Early Permian Mesosaurus, which lived in bays, lagoons, and possibly in fresh water. It has been cited as the ichthyosaur's ancestor, which, because of anatomical dissimilarities, is very doubtful. The ichthyosaurs apparently originated during the Triassic, flourished during the Jurassic, and became extinct by the end of the Cretaceous.

Oregon Specimen

The coastal Oregon, Sisters Rocks ichthyosaur remains were found as an isolated, fist-sized, crushed mass in a mudstone intercalated with thinly bedded, graded, graywacke sandstones. Elsewhere, identical rocks of the Otter Point Formation contain latest Jurassic, Tithonian (Portlandian - Purbeckian) ammonoids and the pelecypod Buchia piochii (Gabb).

The Otter Point Formation at Sisters Rocks and several other places includes radiolarian cherts, volcanic flows and breccias, and many graded beds (Koch, 1966). It evidently is a eugeosynclinal deposit.

The dark, reddish-brown jaw pieces, a very small portion of the original rostrum, bear several well-preserved teeth (Figure 3). These are conical and fluted, and, within their hollow bases, they contain a brown powder that may be decayed cement. The largest tooth is about 36 mm long and 14 mm wide at its base. The jaw fragments range up to 8 cm in length and include opposing upper and lower dentitions with distorted occlusion.

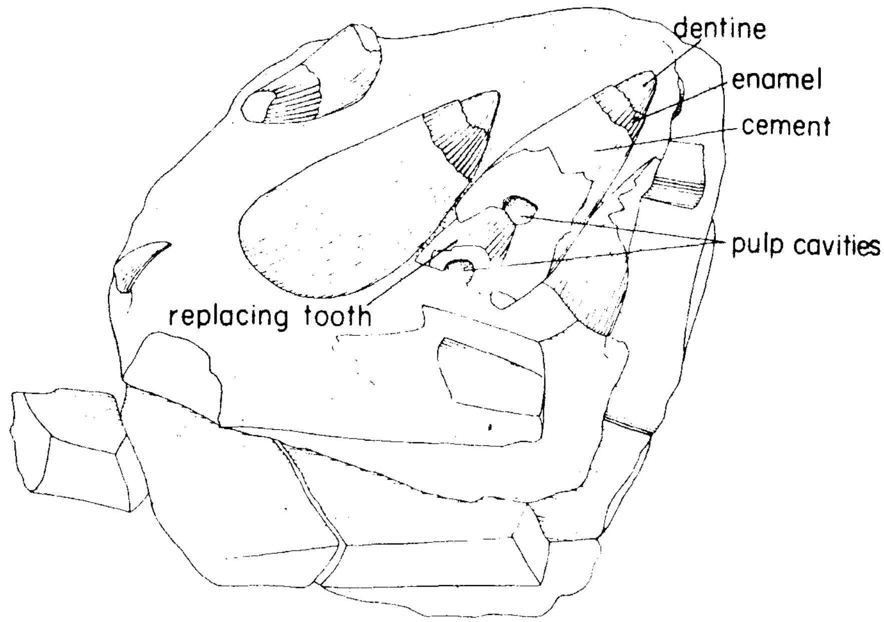

Figure 3. Crushed rostrum viewed from right side (X 1). Large lower teeth are opposed by a small upper tooth.

Other Ichthyosaur Specimens

Ichthyosaur remains have been collected at only a few places along the Pacific Coast, including the Sisters Rocks locale. Most of the specimens are very incomplete, although some Triassic skeletons are as well preserved as ichthyosaurs from the High Plains and Rocky Mountains of the United States and from the Jurassic of Solnhofen, West Germany. Cervical vertebrae were obtained from the medial Cretaceous (Albian?) of Wheeler County (Mitchell quadrangle, NE$\frac{1}{4}$ sec. 23, T. 11 S., R. 21 E.), Oregon (Merriam and Gilmore, 1928), whereas the Jurassic fossils from California and Oregon consist only of jaw fragments and teeth. The Jurassic ichthyosaur remains from California were found in probable Franciscan Formation radiolarian chert cobbles among Quaternary gravels along Corral Hollow Creek and Del Puerto Canyon on the eastern side of the Diablo Range. Evidently the Pacific Coast medial and late Mesozoic environments, characterized by nearly continuous tectonism and rapid, typically mass-flow sedimentation, were unfavorable for ichthyosaur preservation.

Identification and Stratigraphic Significance

Dr. C. L. Camp identified the coastal Oregon specimen as _Ichthyosaurus californicus_ and those from coastal California as _I. franciscanus_ and _I. californicus_ (Camp, 1942; Camp and Koch, 1966). Both species are of probable Late Jurassic age. The Oregon ichthyosaur is definitely Tithonian (latest Jurassic) in age, based on other fossils from the Otter Point Formation. But those from California were tentatively dated as Tithonian by comparison with specimens from Germany, although Taliaferro (1943, p. 195) cited them as firm evidence of such an age for the Franciscan Formation.

I. californicus does not permit detailed temporal correlation of the Franciscan Formation with the lithologically similar Otter Point Formation of coastal southwestern Oregon, but it does support other fossil evidence of a Tithonian age for at least part of the Franciscan. However, there is considerable evidence that the widespread Franciscan complex of the California Coast Ranges represents a long span of time, ranging from Late Jurassic into the Late Cretaceous (Bailey and others, 1964).

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COPPER ORES DONATED TO DEPARTMENT MUSEUM

A large collection of high-grade copper ores and native copper from Arizona has been donated to the Department by Mr. F. W. Libbey, mining engineer and former director of the Department. Many of the specimens are bonanza-type ores from famous old Arizona mines that were major producers early in the century. In addition to the copper minerals, the collection includes rich tungsten, silver, and gold ores from Arizona mines, and free gold from Cripple Creek, Colo. A portion of the collection is on exhibit at the Department's Portland office.

* * * * *

The ORE BIN
Volume 28, No. 4
April, 1966

GRAVITY MEASUREMENT PROGRAM IN OREGON

John V. Thiruvathukal* and Joseph W. Berg, Jr.*

The earth derives its gravitational field from the distribution of density within it and its motion. In addition, the field is affected by the attraction of external bodies. As can be seen in Figure 1, it is layered in shells about the central core. The density ranges from 12.3 grams/cc at the center to

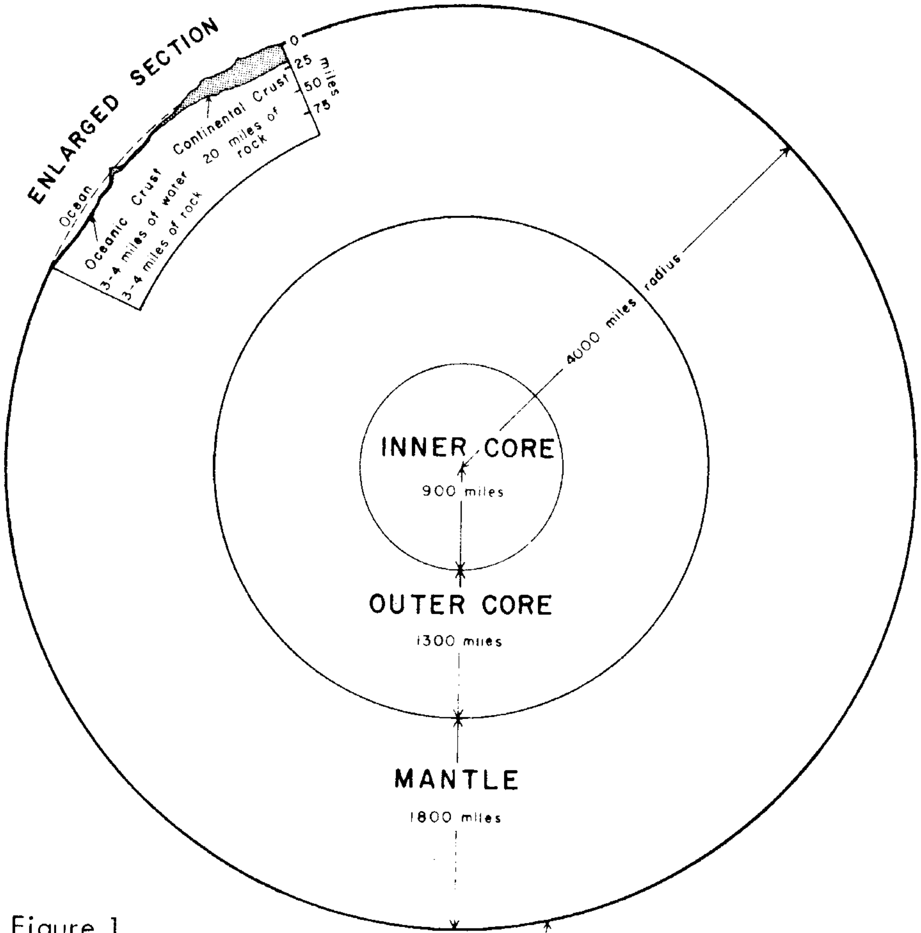

Figure 1.
Cross section of the earth.

* Dept. of Oceanography, Oregon State University, Corvallis, Oregon.

about 2.6 gr/cc at the surface. The average density of the earth is about 5.5 gr/cc. The gravity varies from 978 cm/sec^2 (or gals) at the equator to 983 gals (or cm/sec^2) at the poles. This variation is generally termed the "latitude" effect and is due to a combination of the earth's equatorial bulge (more mass) and the centrifugal force from rotation. Also, there may be variations of gravity with longitude because of the figure of the earth being better approximated by a triaxial ellipsoid than an ellipsoid of revolution. Aside from this, the earth is assumed to be fairly uniform in density distribution below a few hundred kilometers beneath its surface. However, considerable variation of the earth's gravity field can be attributed to near-surface mass variations.

Measurements of the earth's gravitational accelerations can be made by modern instrumentation to 1 part in 100 million (10^{-2} mgal.) of the total field. These measurements are made with a gravity meter. A simplified diagram of a gravity meter is shown in Figure 2. The instrument is essentially a pendulum which is sensitive to vertical accelerations. The deflections of the beam at various locations on the earth's surface are related to variations in the gravitational field.

Figure 3 shows an actual La Coste-Romberg geodetic gravity meter. In order to measure the vertical component of gravity, the meter must be level. Also, it is thermostatically controlled to maintain an operating temperature to within $\pm$ 0.1° centigrade. It is a portable instrument, weighs about 30 pounds, and is easily carried by one man.

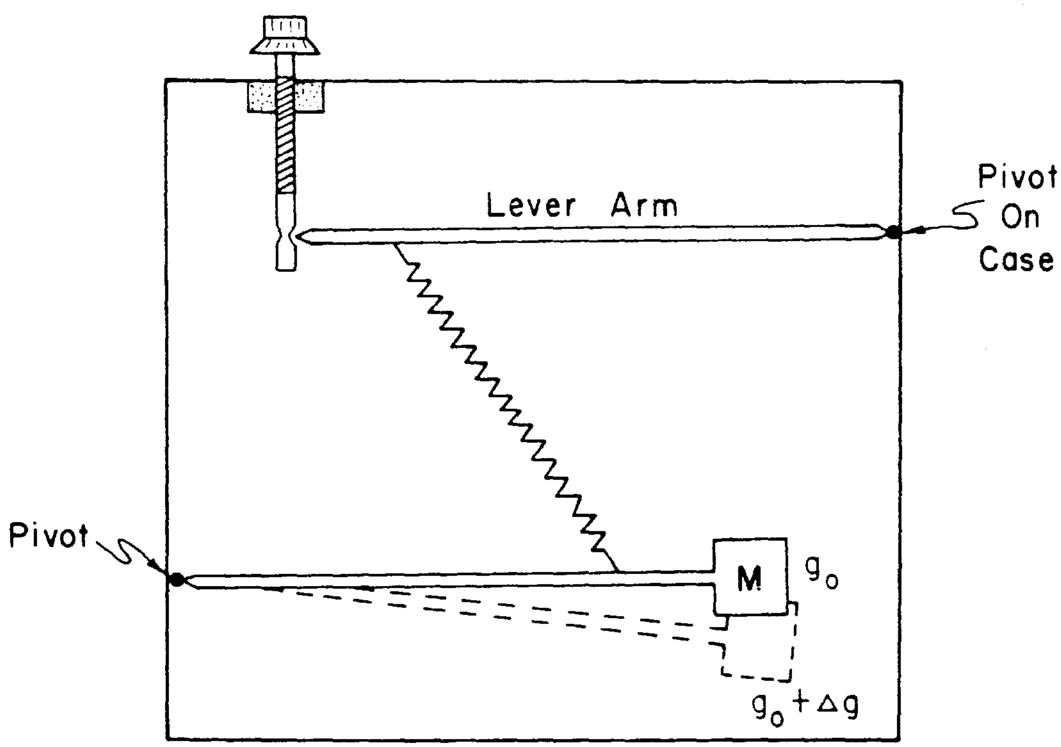

Figure 2. Simplified diagram of La Coste-Romberg gravity meter.

Figure 3. La Coste-Romberg gravity meter in use.

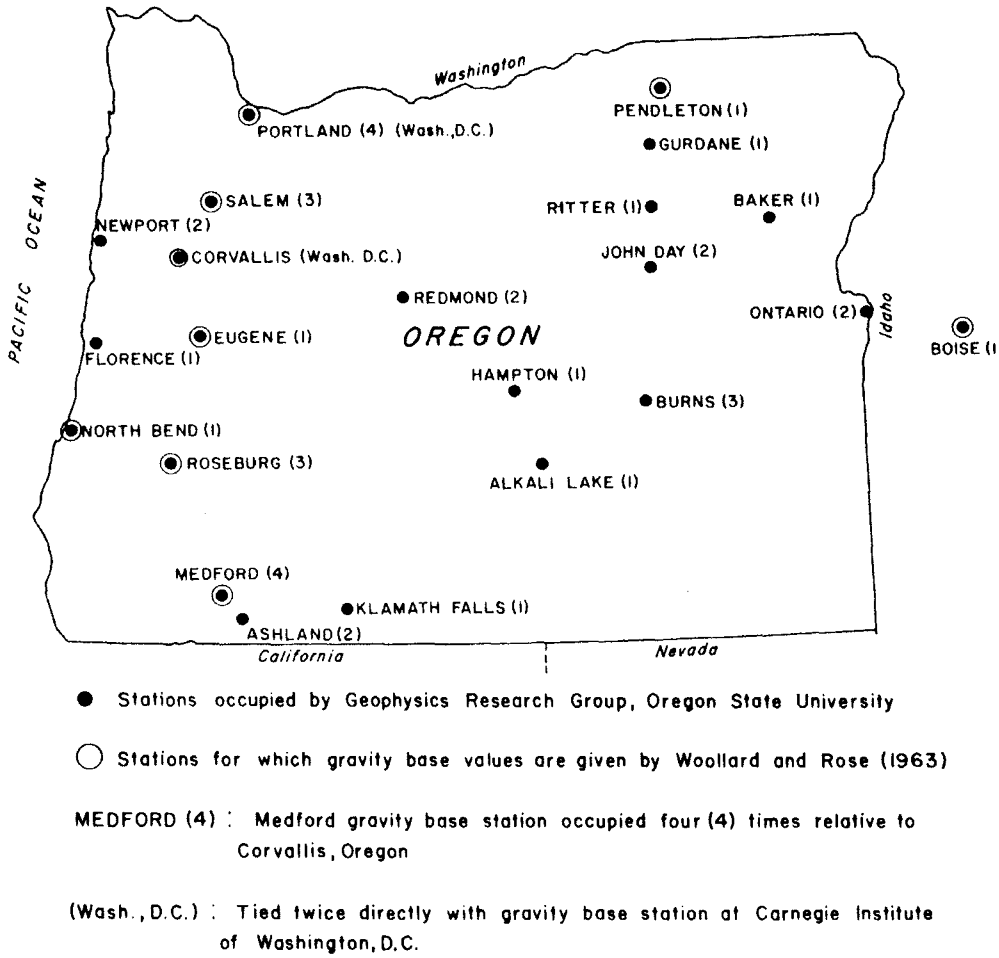

Figure 4. Gravity base station control in Oregon.

Gravity measurements vary about 0.1 mgal per foot of change in elevation, increasing in magnitude as one goes toward the center of the earth. For interpretation purposes, it is necessary to correct gravity measurements to a datum elevation. Thus, the elevation of gravity stations must be measured. In some cases, when a low order (± 10 ft.) of control is necessary, altimeters can be used. When high-order control (± 0.1 ft.) is required, precise surveying techniques must be used.

It is important to have accurate gravity base-station control. This is usually accomplished by establishing base stations in the area of interest. The gravitational accelleration of a base station is very accurately determined. Dr. George Woollard (Woollard and Rose, 1963) initially established about 10 gravity base stations in Oregon. Gravity values at these stations were measured relative to Potsdam, Germany. We have upgraded his work and increased the number of base stations to 32 (Berg and Thiruvathukal, 1965), as shown in Figure 4. All other gravity measurements in the state are relative to the gravity values of these base stations.

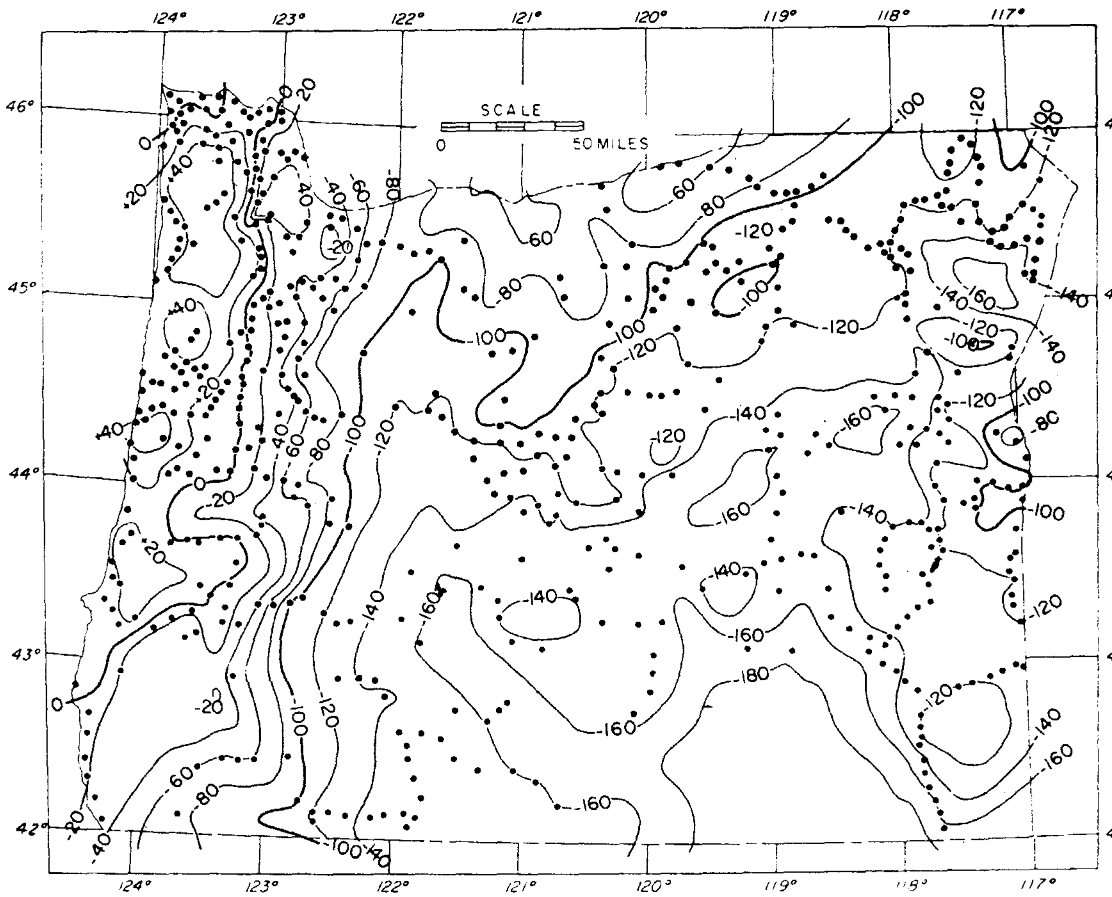

Figure 5. Bouguer anomaly gravity map of Oregon (Woollard and Rose, 1963).

More than 8,000 gravity measurements have been taken in Oregon by oil companies, governmental agencies, and universities. Figure 5 shows a preliminary gravity map of Oregon (Woollard and Rose, 1963) based on about 1800 measurements. The contour interval of this map is 20 mgal (20/1000 cm/sec^2).

Distinctive features of this map are: (1) the isolated highs along the coast indicating basalt flows; (2) the steep gradient about 50 miles east of the coast, indicating major structural features (such as faulting); (3) the serpentine contours in the vicinity of the Cascades, probably related to the distribution of volcanism; and (4) the generally decreasing field to the southeast, probably related to major variations in regional geology (such as greater thickness of the earth's crust to the east).

Interpretation of gravity measurements is generally made in terms of subsurface mass distributions. For example, Figure 6a shows a hypothetical observed gravity profile (corrected for latitude). The measurements as shown on Figure 6a would be influenced by topography and subsurface mass distributions. To facilitate interpretation, the gravity readings should be corrected to the datum elevation (sea level in this case). This is done by

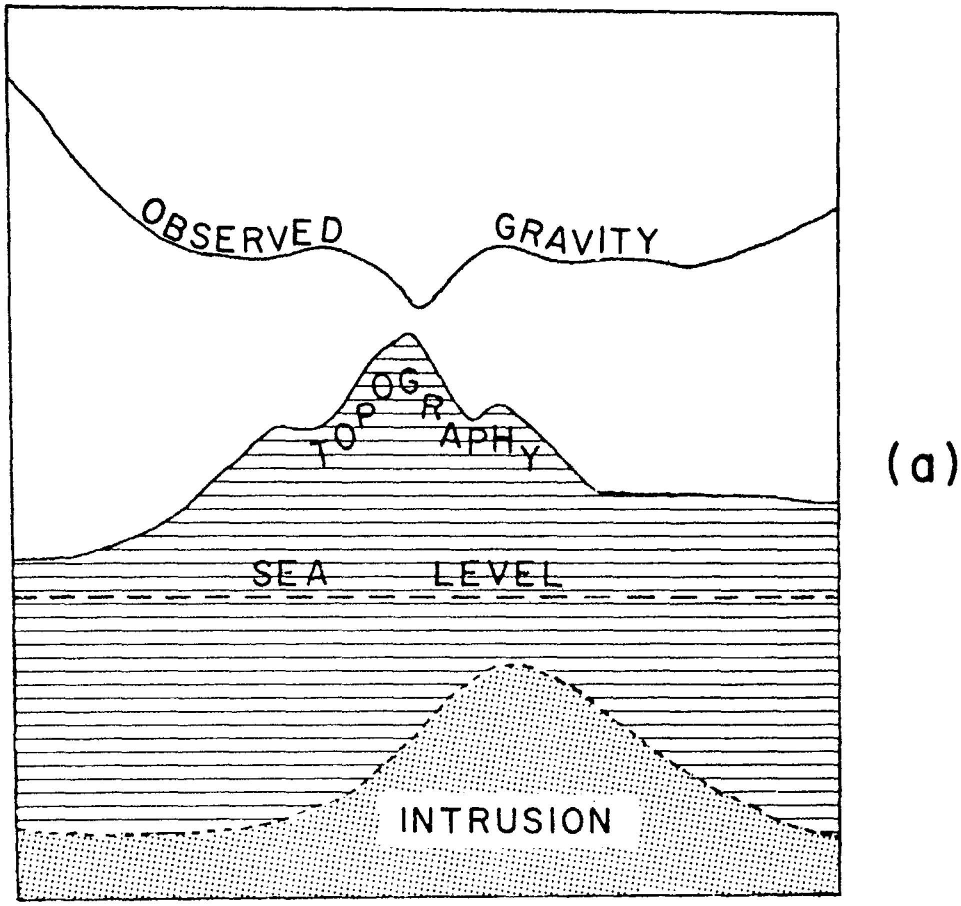

Figure 6a. Hypothetical uncorrected gravity profile.

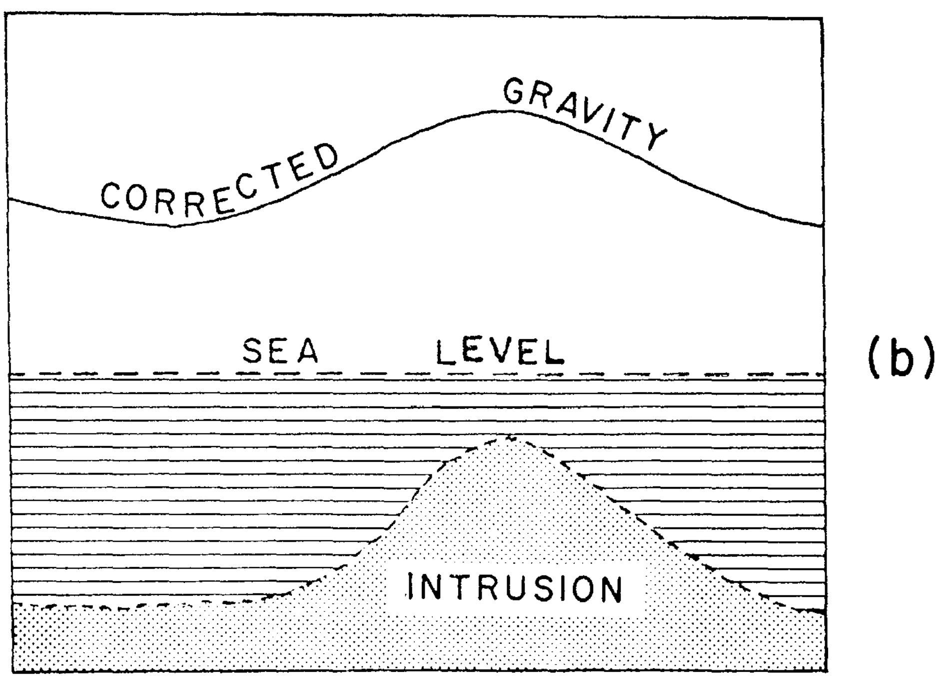

Figure 6b. Hypothetical corrected gravity profile.

removing the effects of the land mass above sea level and also applying corrections for the elevations of the stations.

Figure 6b shows the corrected gravity profile. The effect of the subsurface mass is quite evident in these data. Usually, an interpretation is made using the corrected data with the aid of high-speed computers. Interpretations of gravity data are usually made of mass distributions in the crust and mantle of the earth. In addition to the above, information regarding the shape of the earth can be determined from the data.

Currently, more gravity measurements are being made in cooperation with the Army Map Service to provide better station density in Oregon. We have finished processing all data on hand for the state and are starting a new map which will show considerably more detail than the one shown in Figure 5. The tentative completion time is about the spring of 1966.

Acknowledgments

This work is being sponsored by the National Science Foundation under Grant GP 4465.

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PIERRE R. HINES HONORED

Fifty years of membership and service in the American Institute of Mining, Metallurgical, and Petroleum Engineers has been celebrated by Pierre R. Hines. A retired consulting mining engineer with experience in many parts of the world, Hines was honored by the Oregon Section of AIME with the presentation of the Society's Legion of Honor scroll March 18. He has been identified with the Gold and Money sessions which were a feature of the past two Northwest Metal and Mineral conferences held in Portland. The final chapter of Hines' four-part article, "What Price Gold?", appeared in the February, 1966, ORE BIN.

* * * * *

THE PRINCIPLE OF DISCOVERY AND THE PROBLEMS ARISING THEREFROM*

By Raymond B. Holbrook**

The Constitution of the United States says Congress shall have power to dispose of and make all needful rules and regulations respecting property belonging to the United States. In the exercise of this authority, Congress passed the General Mining Law.

The heart and core of the General Mining Law is discovery of mineral. It is both the reward for the labor and anxiety of the discoverer and the incentive for others to search for essential minerals.

It is very clear that discovery of a valuable mineral deposit is required for a valid mining location. These terms are not defined in the Mining Law and it does not indicate the extent or value of minerals necessary for a valid location. The most frequently quoted definition of discovery is the "prudent man rule" given in an 1894 decision of the Department of the Interior. This rule has now been drastically changed, the most serious changes being made recently.

By 1933 the Department of the Interior had adopted the rule that a valid discovery for a placer claim located for sand and gravel required a showing that the material could be mined at a profit. By 1960 this rule had been extended to several other commonplace minerals (pumice, gypsum, limestone, clay, building stone). In 1961 the Department held that a discovery which merely warrants further exploration is not sufficient, but that the discovery must warrant development of the deposit.

Until 1964 the Department of the Interior consistently maintained that it was not necessary for metalliferous minerals to be found in paying quantities or have commercial value for a valid discovery. Then the Department extended the marketability rule to manganese, a valuable metallic mineral, by holding in the Denison and related cases that the claims did not have valid discoveries because the manganese ore could not be mined at a profit. It is generally believed that this decision eliminated the prudent man rule, as it has been known, and extended the marketability rule to include all locatable minerals. The marketability test requires a discovery of ore that

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* Presented at the 1965 Mining Show, American Mining Congress, Las Vegas, Nevada, October 11-14, 1965.

** Counsel, Western Operations, U.S. Smelting, Refining & Mining Co., Salt Lake City, Utah.

can be mined, processed, shipped, and sold with a resulting profit.

The Department of the Interior has acknowledged these changes in the Mining Law. I quote from a paper delivered in 1964 by H. R. Hochmuth, then Associate Director of the Bureau of Land Management:

> "There can be no gainsaying that the Mining Law of 1872 is not administered as it was originally written and intended. There has been a definite trend in decisions toward more stringent requirements to establish the validity of the claim. The requirements are innovations which have been superimposed on the basic law by the need for standards which can serve to prevent the subversion of the law for non-mineral purposes. Examples of this may be found in the narrowing application of the rule of discovery, the employment of the rule of marketability and the concern for economic values...."

The impact of this concept of discovery requirements is illustrated by applying it to locations for deposit of the following ores:

1. A newly discovered deposit of uranium ore for which there is no present market.
2. A complex ore that cannot be treated with satisfactory results by presently known methods, even though the deposit looks attractive in the light of anticipated metallurgical improvements.
3. A porphyry deposit which is too low grade for a profitable mining operation, but would be profitable if technical developments reduce mining or treatment costs, or metallurgy improved, or metal prices increased.

I doubt such locations are valid under the marketability test.

Another change in rules by the Department of the Interior has increased the risk of applying for patent. Prior to 1960, when a patent application was denied on the ground of inadequate discovery, the Department of the Interior merely rejected the application and the mining claimant could retain possession of the claim and continue to develop it, no worse off with respect to its validity than before the application was filed. In 1960 the Department ruled that an adverse decision on the issue of discovery in a patent proceeding necessarily results in a declaration that a claim is null and void. Now an applicant for patent is betting that his claim will be found valid; failing, his claim is lost. It is a "win or lose" proposition.

The adverse effect of the Department of the Interior's narrow and unrealistic discovery requirements on development of our mineral resources is demonstrated by the decreasing number of applications for mineral patent being filed and the number of patents being issued. They are only a fraction of what they used to be. How long will risk capital be available under a system where one doing exploration work is a mere tenant at will, subject to dispossession by the Department of the Interior; where there is no real security of tenure until he has proven by a profitable operation that the mineral showing he relied on in spending his labor and money is a valuable mineral deposit.

We have referred to "erosion of the Mining Law." In my opinion, administrative decisions have now made the law practically inoperable. It has been admitted that the Law is not being administered as it was originally written and intended. This I view as administrative legislation. If the Mining Law is to be repealed, the repeal should be by action of Congress and not by an administrative course which renders it unworkable.

I believe the only real relief from these problems will come from Congress' reasserting its constitutional power to make all needful rules and regulations respecting the public domain.

Until subverted, the General Mining Law served us well. It is my firm conviction that its basic principles should be preserved. I have no suggestions at this time as to how this should be done, but I am certain that the mining industry will give all needed assistance and fully cooperate with the Public Land Law Review Commission in developing an effective program.

* * * * *

PACIFIC NORTHWEST MINERALS & METALS CONFERENCE SET

The annual Pacific Northwest Minerals and Metals Regional Conference will be held on April 21-22, 1966, at the Olympic Hotel in Seattle, Wash. The conference is jointly sponsored by the American Institute of Mining, Metallurgical and Petroleum Engineers and the American Society for Metals. Two days of technical sessions will include papers on a wide variety of subjects. Of prime interest to Northwest geologists will be the three papers to be presented on off-shore mining and oil exploration, with special emphasis on the areas lying off the Oregon, Washington, British Columbia, and Alaska coasts.

The current interest in gold mining is reflected in three papers which will review conditions at the Homestake mine in South Dakota, the Bralorne-Pioneer mine in British Columbia, and the new Carlin mine in Nevada.

There will also be six papers dealing with extractive metallurgy. One entire session will be devoted to the use of nuclear explosives in mine blasting. Numerous other papers in the fields of exploration, geology, physical metallurgy, and metal working will be presented. Further information may be obtained by writing Mr. Tom Van Zandt, Registration Chairman, 2700 16th S. W., Seattle, Wash. 98134.

Plans are already well along for next year's meeting, which will be held at the Sheraton Motor Inn in Portland April 19-21. One of the features of this meeting will be the Third Gold and Money Session.

* * * * *

LAKEVIEW URANIUM MINE AND MILL TO REOPEN

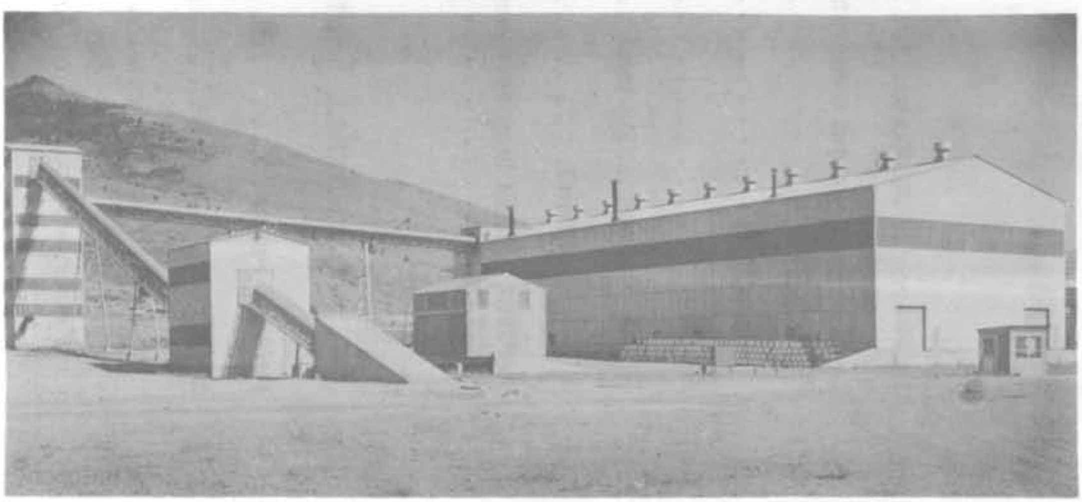
Preparations to reopen the uranium reduction plant (see photograph below) and the Lucky Lass and White King uranium mines near Lakeview have been announced by Clemons M. Roark, vice-president and general manager of Continental Mining & Milling Co. of Chicago. Continental has been granted an Atomic Energy Commission contract for the sale of 230,000 pounds of uranium oxide from ores to be produced through December 31, 1966.

Roark said his company's plans for the plant, in addition to re-establishing the leaching process for uranium ores, includes installation of a flotation circuit for such minerals as lead, silver, gold, and copper, and a concentration circuit for mercury. First on the agenda is the uranium, including reopening the two mines to begin stockpiling ore, and replacement of equipment in the plant itself. The start of uranium ore reduction will depend on delivery of equipment, but Roark said he is encouraged in having already located most of the needed machinery.

Sale of the reduction plant was completed at Eugene March 4 after AEC announced approval of the contract. The plant was sold to Continental by Oregon Pacific Industries Corp., a local group of six investors that bought the plant a year and a half ago from Kermac Nuclear Fuels Corp. of Oklahoma City, with the specific idea of inducing an industry to open an operation there andre-establish local payrolls. Negotiations with Roark have been carried on for many months. Other members of Oregon Pacific are Roy Matchett, vice-president, Nancy Taylor, treasurer, Jim Olson, and Ed Taylor.

Continental has leased the Lucky Lass and White King mines from the owners, and work has been started in opening the roads and hauling pumps and other equipment to the mines. White King owners are Don Tracy, John Roush, Wayland Roush, and Walter Leehmann, Jr. Lucky Lass owners are Don Lindsey, Bob Adams, Clair Smith, and Choc Shelton.

(From the Lake County Examiner, March 10, 1966.)



GOVERNMENT LAND ACQUISITION IN OREGON [1/]

A Summary of Land Acquisition by Federal,
State, and Local Governments up to 1964.

Land area of the State	61,598,720 acres
Land in government ownership and control --	
Federal	32,089,445 acres
State	1,621,605 acres
Tax-exempt Indian land	690,348 acres
Total	34,401,398 acres
Percent of land in government ownership and control	55.8%

FEDERAL LAND BY ORIGIN

Public domain	30,565,521 acres
Acquired	1,523,923 acres
Total	32,089,445 acres

FEDERALLY OWNED LAND BY PREDOMINANT USAGE AND COST*

Predominant Usage	Acres	Cost
Agriculture	770	$ 15,000
Grazing	3	0
Forest and wildlife	31,458,635	75,356,000
Parks and historic sites . .	160,895	52,000
Office building locations . .	36	2,512,000
Military (excl. airfields) . .	4,563	1,882,000
Airfields	95,746	132,000
Harbor and port facilities .	876	308,000
Power development and distribution	31,016	9,378,000
Reclamation and irrigation .	257,719	5,194,000
Flood control & navigation .	44,205	109,110,000
Institutional	895	283,000
Housing	1	0
Storage	17,252	118,000
Research and development .	14,641	134,000
Vacant	49	3,000
Other land	2,144	3,241,000
Totals	32,089,445	$207,718,000

Source: General Services Administration.

* Original cost, not present valuation.

1/ Reprinted courtesy of American Forest Products Industries, Inc.

FEDERALLY OWNED LAND BY AGENCIES
As of June 30, 1962 *

Agency	Public Domain (acres)	Acquired Land (acres)	Total Acres
Agricultural Research Service	14,594		14,594
Forest Service	14,408,036	1,060,416	15,468,452
Maritime Administration		906	906
Public Health Service		1	1
Bureau of Mines		47	47
Bureau of Land Management	15,321,175	93,466	15,414,641
Fish and Wildlife Service	244,639	205,659	450,298
National Park Service	158,303	2,592	160,895
Bureau of Indian Affairs		1,252	1,252
Bureau of Reclamation	244,025	28,536	272,561
Bonneville Power Administration	40	1,550	1,590
Bureau of Facilities		15	15
Coast Guard	460	166	626
General Services Administration		52	52
Veterans' Administration		475	475
Federal Aviation Agency	617		617
Federal Communications Commission		109	109
Army	8,440	10,892	19,332
Air Force	269	741	1,010
Navy	37,320	61,035	98,355
Corps of Civil Engineers	16,422	46,789	63,211
Totals	30,454,340	1,514,698	31,969,039

Source: PUBLIC LAND STATISTICS, 1963. U. S. Department of the Interior.

* Latest year for which this tabulation is available.

GOVERNMENT-OWNED RECREATION AREAS, 1960

Owner	Number of Areas	Total Acres *
National Park Service	3	160,872
U. S. Forest Service	14	14,960,840
U. S. Fish and Wildlife Service	12	469,822
Corps of Engineers	8	57,767
Bureau of Reclamation	7	133,420
State Parks and Recreation Division	174	59,730
State Board of Forestry	6	743,740
State Game Commission	72	61,114
State Highway Commission	24	2,517
Counties	116	10,232
Other	10	6,715
Totals	446	16,666,769

Source: "List of Public Outdoor Recreation Areas, 1960," Outdoor Recreation Resources Review Commission Study Report No. 2.

* Land and water.

NOTE: Since the above list was compiled, the Congress passed Public Law 88-607, which provides that certain lands administered by the Bureau of Land Management of the Department of the Interior shall be managed under principles of multiple use and to produce "... a sustained yield of products and services, and for other purposes." Outdoor recreation is specified as one of the uses for which these lands are to be managed.

LAND ACQUISITIONS PROPOSED OR UNDER CONSIDERATION BY GOVERNMENT
As of July 1, 1964

Federal

- The Fish and Wildlife Service has been given approval to purchase 5,371 acres in Benton County to establish a Willamette National Wildlife Refuge.
- S. 1137 would authorize acquisition of private land variously estimated at from 4,000 to 15,000 acres to establish an Oregon Dunes National Seashore. The proposed boundary of the area would include an estimated 15 private residences and two commercial enterprises as well as two State Parks.

AREAS IN OREGON NATIONAL FORESTS INCLUDED IN WILDERNESS PRESERVATION SYSTEM BY PUBLIC LAW 88-577, THE WILDERNESS ACT OF 1964

Name of Area	Gross Acres
Diamond Peak	35,440
Eagle Cap	220,280
Gearhart Mountain Fremont	18,709
Kalmiopsis	78,850
Mountain Lakes	23,071
Mt. Hood	14,160
Mt. Washington	46,655
Strawberry Mountain	33,653
Three Sisters	196,708
Total	667,526

LAND ACQUIRED BY THE FEDERAL GOVERNMENT BETWEEN JULY 1, 1962 AND JUNE 30, 1963

9,225 acres

STATE-OWNED LAND BY MAJOR USES 1962

Farming and grazing	652,303 acres
Forest land not grazed	793,541 acres
Special public services*	125,761 acres
All other land**	50,000 acres
Total	1,621,605 acres

Source: Economic Research Service, U. S. Department of Agriculture.

* Areas used primarily for parks, wildlife reserves, institutional sites and miscellaneous other special uses. Includes an undetermined acreage of forest and woodland some of which has commercial value.

** Consists largely of State-grant land not under lease and with no reported use.

HOUSE BILLS CONCERN MINING INDUSTRY

S. 1446 - Establish National Wild Rivers System - Church (Idaho) Leg. Bull. 65-10, p. 3). Passed, amended, by Senate January 18. Now in House Interior Committee.

As amended would initially establish these seven Wild Rivers (all or portions thereof): Salmon (Idaho), Clearwater (Idaho), Rogue (Oregon), Rio Grande (New Mexico), Eleven Point (Missouri), Cacapon (West Virginia), and Shenandoah (West Virginia). Would also provide for the study of 18 additional rivers for possible later inclusion in the system.

Would not affect the applicability of U.S. mining and mineral leasing laws within the system, except that all activities under these laws would be subject to "such regulations as the Secretary of the Interior, or the Secretary of Agriculture in the case of national forest lands, may prescribe to effectuate the purposes of this Act."

H.R. 4665 - Deductibility of exploration expenditures - Ullman (Ore.) (Leg. Bull. 66-1, p. 2). Unanimously approved February 7 by House. Now in Senate Finance Committee.

Would allow a taxpayer to elect to deduct currently all exploration expenditures incurred before the beginning of the development stage of a mine. Would require, however, that if such exploration expenditures result in a producing mine, the taxpayer include in his income, or reduce his depletion deduction by, the amount of exploration expenditures properly chargeable to that mine. In addition, if a mining property is sold or otherwise disposed of, any gain would be taxable as ordinary income to the extent of the exploration expenditures incurred with respect to the property sold. Would apply only to expenditures for exploration in the United States or the Outer Continental Shelf; would apply to all minerals except coal, oil and gas.

H. R. 8989 - Federal noncoal mine safety code - O'Hara (Mich.) (Leg. Bull. 66-1, p. 2). Senate Labor subcommittee scheduled public hearings on March 21 and 22 on this and similar Senate bills.

Would authorize a federally promulgated and enforced mine health and safety code. Would also provide for state promulgation and enforcement of mine health and safety regulations if the state plan is approved by the Secretary of the Interior.

* * * * *

OREMET ADDS TITANIUM SPONGE PLANT

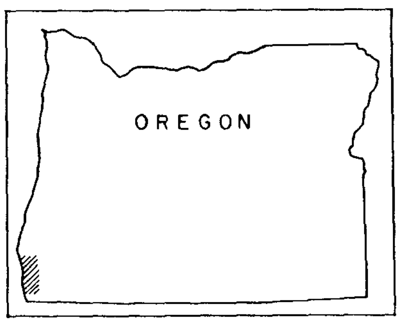
Oregon Metallurgical Co., Albany, has added a titanium-sponge plant to its facilities. Initial production has begun and the company plans to expand the operation to three units, each capable of producing 1.2 million pounds of titanium sponge per year, according to Stephen M. Shelton, president and general manager.

* * * * *

The ORE BIN
Volume 28, No. 5
May, 1966

LATE JURASSIC UNCONFORMITY EXPOSED IN SOUTHWESTERN OREGON

By R. H. Dott, Jr.*



Location of area described.

Introduction

Although for many years the Late Jurassic Nevadan orogeny has been considered the most profound and widespread single tectonic event represented on the Pacific Coast, surprisingly little evidence was known for dating it accurately. Most recent workers in southwestern Oregon have considered major mountain building and metamorphism to have occurred during latest Jurassic time, that is, prior to deposition of the lower Myrtle Group (Riddle Formation) of the Roseburg region and the Otter Point Formation (Koch, 1966) of the Oregon coast. Both formations are of Portlandian (Late Jurassic) age. But not one locality could be cited in which a pre-Portlandian age for the orogenesis was proven definitively by a closely dated unconformity. The crucial contact is almost everywhere concealed or faulted.

In 1959 an unconformity was discovered on the Elk River near Port Orford where the massive Humbug Mountain Conglomerate (Koch, 1966), which was assumed to be entirely of Early Cretaceous age, rests upon older meta-sediments. Nearby, the meta-sediments are intruded by the Pearse Peak Diorite (Koch and others, 1961). Subsequently, Koch (1966) studied an extensive sequence of unmetamorphosed Portlandian sediments farther south near Rogue River (the Otter Point Formation). But, though he discovered many new fossil localities and showed for the first time that strata of Portlandian age contained important volcanic rocks, he was unable to find an exposed basal contact. In the Collier Butte area, 15 miles southeast of the lower Rogue River area, Burt (1963) and Schwab (1963) showed that the

* University of Wisconsin, Madison, Wisconsin.

Dothan Formation has been metamorphosed to schists mapped as the Colebrooke Schist by J. S. Diller (1903), and that outliers of unmetamorphosed Portlandian and Cretaceous strata apparently rest unconformably upon a metamorphic and igneous complex that was affected by orogeny. Moreover, the Portlandian and Early Cretaceous sediments contain fragments of schist, vein quartz, diorite, potash feldspar, and probably serpentinite. But the elusive unconformity was not clearly exposed there, either!

Finally, in July 1965, I was fortunate in finding an exposed unconformity with very clear stratigraphic relationships and faunal age control near Barklow Mountain on the divide between Johnson Creek drainage and the North Fork of Elk River. The area is on the line between the Powers and Agness 15-minute quadrangles, 10 miles southwest of Powers and 18 miles east of Port Orford (fig. 1). At last it is possible to point to definitive evidence in southwestern Oregon of the pre-Portlandian age of the Nevadan event.

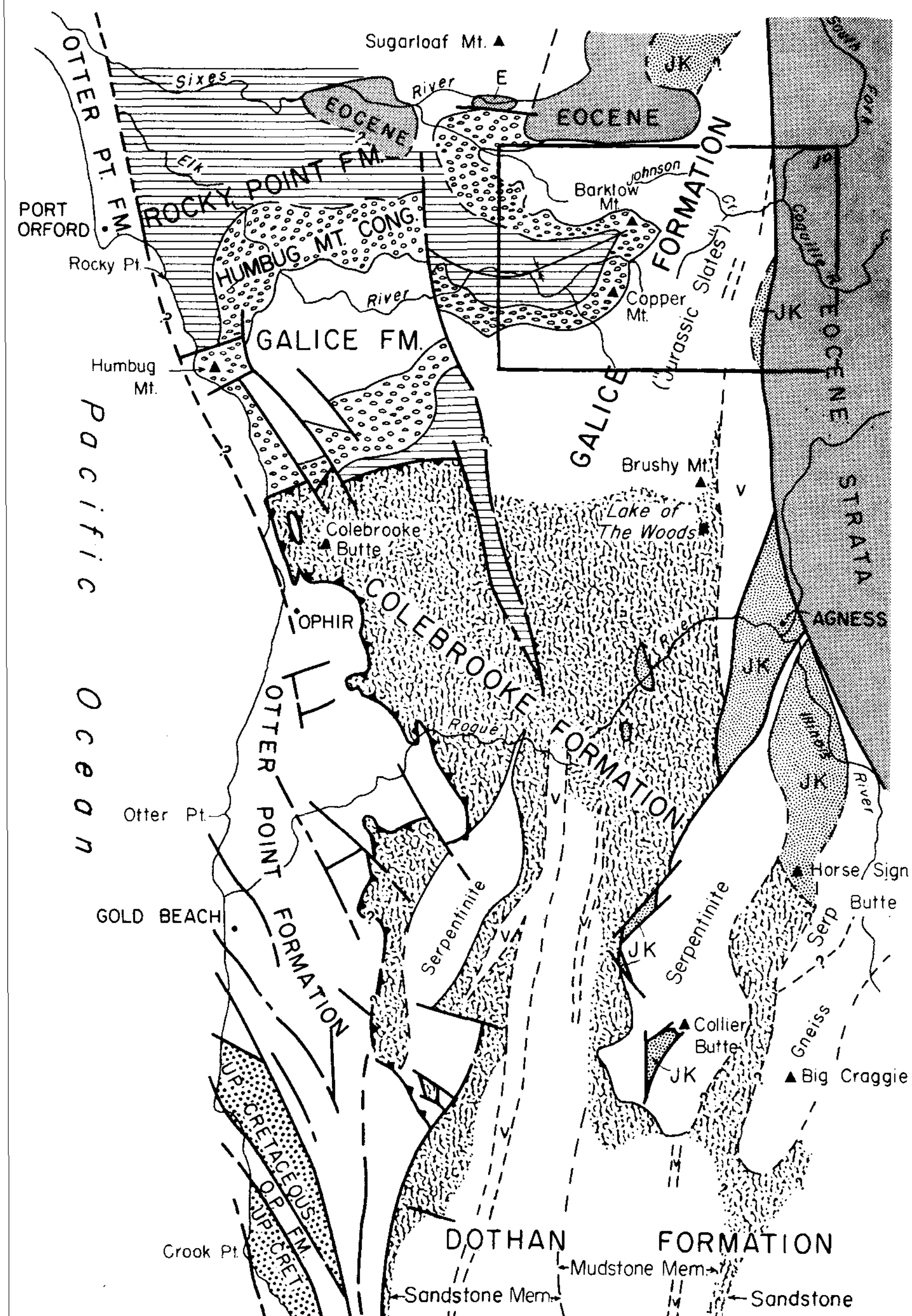
In addition to demonstrating the nature of the basal Portlandian contact, a structurally undisturbed (though poorly exposed) relation between Portlandian and Early Cretaceous strata is also preserved on Barklow Mountain. Koch (1966) postulated an unconformity between them on the basis of subtle petrographic differences and differing degrees and patterns of deformation. On Barklow Mountain, fossiliferous Cretaceous conglomerate is concordant with similar-appearing fossiliferous Portlandian conglomerate, so that if any discontinuity exists between them here it must be minor.

An Enigma in Diller's Mapping in the Port Orford Folio

"Jurassic Slates"

In mapping the old 30-minute Port Orford quadrangle, J. S. Diller (1903) lumped vast areas of exposed semi-slates and slightly foliated sandstones with the typically unmetamorphosed "Myrtle Formation," which he had named earlier in the Roseburg area. In 1903 the entire "Myrtle Formation," later elevated to group rank, was regarded as of Cretaceous age.

Figure 1. Generalized geologic and index map of part of southwestern Oregon showing distribution of major stratigraphic units now recognized (most igneous plutons omitted for clarity; JK - undifferentiated latest Jurassic and Early Cretaceous strata, essentially synonymous with Myrtle Group; v - volcanic rocks). Note lateral metamorphic gradation (dotted line) from Galice Formation south into schists of the Colebrooke Formation and, in turn, gradation from schist to the essentially unmetamorphosed Dothan Formation farther south. Boundary between Otter Point and Colebrooke Formations is shown as a thrust fault as suggested in Dott (1965) and by U.S. Geological Survey personnel. Detail of outlined area is shown in figure 2. (Scale: 1 inch = approximately 5.6 miles.) →


Sugarloaf Mt.
EOCENE
E
EOCENE
JK
Sixes River
Elk
ROCKY POINT FM.
OTTER PT. FM.
PORT ORFORD
Rocky Pt.
HUMBUG MT. CONG.
River
GALICE FM.
Humbug Mt.
Barklow Mt.
Johnson Cr.
Copper Mt.
GALICE FORMATION
(Jurassic Slates)
JK
EOCENE STRATA
South Fork
Coquille R.
Brushy Mt.
Lake of The Woods
Pacific Ocean
Colebrooke Butte
OPHIR
COLEBROOKE FORMATION
Rogue River
AGNESS
JK
Illinois River
JK
Otter Pt.
OTTER POINT FORMATION
GOLD BEACH
Serpentinite
JK
Serpentinite
Horse/Sign Butte
Serp
Gneiss
Collier Butte
JK
Big Craggie
UP. CRETACEOUS
O.P. FM.
UP. CRET.
Crook Pt.
DOTHAN FORMATION
Mudstone Mem.
Sandstone Mem.
Sandstone

The lumping was done in spite of the fact that Diller's party had found pre-Myrtle fossils in an area of slaty rocks on Sucker Creek 3 miles east of Barklow Mountain (fig. 2). Diller acknowledged that some definitely older ("Jurassic") slates were included in the "Myrtle Formation" as mapped.

> "It is certain that near the divide between Elk River and Johnson Creek ... Jurassic slates occur, but their area must be small. The Jurassic sediments closely resemble those of the Myrtle Formation, and in the field they were not separated. The crest of Barklow Mountain is well characterized by an abundance of Aucella crassicollis, and the whole was mapped as belonging to the Myrtle Formation." (Diller, 1903, p. 2, column 3).

Fossils in the slates were compared to those of the Mariposa Slates of the Sierra Nevada, California. Wells and Peck (1961) later recognized the distinctiveness of the Johnson Creek slates and referred them to the Galice Formation of Kimmeridgian age; it is still correlated with the Mariposa.

Diller shrewdly recognized a pattern to the distribution of the Mesozoic fossils of the Port Orford quadrangle such that Aucella piochii (Gabb) (now referred to the genus Buchia) occurred along a line extending south-southwest from the vicinity of Powers through Copper Mountain to the vicinity of Ophir on the coast about 10 miles north of Gold Beach. The "Jurassic slates" of Johnson Creek lay near this line and the Cretaceous fossil Aucella crassicollis Keyserling (also now referred to the genus Buchia) occurred both to the east and west of it. Thus an "anticlinal arch" was inferred (Diller, 1903, p. 2, columns 3 and 4), but Diller did not discern the complete significance of this "arch" with respect to the full extent of the "Jurassic slates." Curously, however, careful scrutiny of Diller's and his associate's field notes*, combined with examination of key localities mentioned therein, has showed that in the field the party actually observed the distinctive slates over a very large region. In several areas they even found unmetamorphosed, fossiliferous conglomerate and sandstone overlying the slates. For example, they reported in succession up the east side of Copper Mountain (2 miles south of Barklow Mountain; see fig. 2) slate, "gabbro" (diorite), and conglomerate with Buchia piochii (Gabb) and on the west slopes of the mountain near the forks of the Elk River, Buchia crassicollis (Keyserling) was found in abundance. To the north, on the southeast extension of Barklow Mountain, they found much the same succession--slates overlain by the

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* Copies kindly made available by the U.S. Geological Survey library, Denver Federal Center, Denver, Colorado. But it is easier to obtain than to read the notes; therefore, in sympathy for any possible subsequent users of them, I include herein several critical quotations, which were won from the documents at great cost of time and eye strain.

same coarse conglomerate containing Buchia. Of the latter locality, Diller wrote:

> "North of the gap slates and sandstones, then conglomerate to top and all along crest to highest point. Collier found robust Aucella [Buchia] on crest....As seen on Copper Mountain, it [conglomerate] must be 500 - 1,000 feet thick. Returning I collected chips of the igneous rock in the gap between Iron and Bray [Barklow] Mountain....it appears to have many small dikes or fingers....Brays Mountain [is] conglomerate with sandstone and slate [and dikes below]....under cliffs at south end of Bray Mountain we found numerous Aucella, apparently large and small." (Diller Notebook, D-35, 1899, p. 61-62) (Statements in brackets added for clarity.)

This locality at the south end of the ridge extension of Barklow Mountain, which was erroneously referred to in the field notes as "Bray Mountain," is very near the unconformity locality discovered in 1965.

Age of metamorphism and plutonism

Diller (1903, p. 2) recognized that the conspicuous metamorphism of the Colebrooke Schist (fig. 1) had pre-dated the "Myrtle Formation," because he found schist fragments in Cretaceous conglomerates. On very dubious grounds, he referred that metamorphism to an age as old as Devonian. But it is clear that he saw no relationship between the Colebrooke Schist and the lower grade "Jurassic slates"! This failure produced a serious fallacy in turn in his age assignment of the dioritic plutons of the old Port Orford quadrangle. Because these plutons, all of which he called "gabbro," penetrated and thermally metamorphosed rocks mapped by him as "Myrtle Formation," the plutonism was inferred to be post-Cretaceous in age (1903, p. 4, columns 1-2). Yet at the same time he noted (p. 4, column 4) that conglomerates of the "Myrtle Formation" contained pebbles of dacite-porphyry like that of dikes apparently closely related to the "gabbro" and to certain "granite type" plutons. On the other hand, he observed that the dacite-porphyry dikes penetrated serpentine, which in turn was considered post-Cretaceous. The obvious dilemma posed by these statements was not adequately treated in the folio, but in field notes there is revealed a nagging uncertainty over the true relative age of the igneous activity. The following quotations are pertinent:

> "[On Blackberry Creek] many pebbles are granitic -- see chip 5276 biotite granite -- while another and large one appears porphyritic -- see 5277, dacite porphyry -- but does not appear to be the rock cutting the serpentine. I did not see any of the

certain gabbro in the conglomerate. I suppose it is younger than the conglomerate although I did not recognize any contact metamorphism." (Diller Notebook D-35, 1899, p. 71.)

"[Northwest of Blackberry Creek] This conglomerate is full of Aucella fossils....The conglomerate is in places very coarse, containing boulders 3 or 4 inches diameter; some of the boulders are schist but most are igneous rock." (Collier Notebook, D-36A, 1899, p. 86.)

"Ascending Bray Mountain [actually Barklow Mountain] come to conglomerate, some having pebbles 4 inches in diameter. One looks like gabbro....number 5437 diorite?" (Diller Notebook, D-36, 1900, p. 53a.)

"The conglomerate of [Mount] Avery as of Butler appears to have much igneous material in it....chips look like the common igneous rock [that is, "gabbro"]. If so, it would seem that [Cretaceous] conglomerate [is] younger than some of igneous." (Diller Notebook, D-36, 1900, p. 76a.)

The relative age enigma persisted into the published folio solely because the slaty rocks intruded widely by the diorite were not differentiated from unmetamorphosed, true "Myrtle" strata. There can be no doubt that at least the vast bulk of diorite pre-dates "Myrtle" deposition, for dioritic clasts, as well as phyllite, slate, and foliated graywacke, are persistent in both Portlandian and Early Cretaceous conglomerates. Indeed, perusal of the field notes reveals that such fragments were found at many more localities than is implied in the folio text. Flaws in the work of J. S. Diller and his associated are few, but the failure to assess properly the "Jurassic slates" and, therefore, also the true age of the diorite plutons was a serious oversight that has gone uncorrected until now.

Reinterpretation of the "Jurassic slates" and the pre-Portlandian unconformity

Galice-Colebrooke-Dothan rocks delineated

Study of Diller's field notes strengthened a growing suspicion that slaty rocks underlie practically all of the eastern portion of the area mapped by Diller as the "Myrtle Formation" on the old Port Orford quadrangle; this portion extends south-southwest from Powers through the Johnson Creek area and for at least 15 miles beyond. Moreover, the field notes suggested that an increasing metamorphic gradient exists from north to south into the large mass of Colebrooke Schist that straddles the Rogue River and extends south to the Collier Butte area (fig. 1). Reconnaissance along logging roads confirmed the prevalence of slates and foliated sandstones from Lake of the Woods north almost to Powers. Definite Colebrook Schist was mapped by Diller at Lake of the Woods, 3 miles north of Rogue River (10 miles south of Johnson Creek). But only 1 mile north of the lake, in an area mapped as the "Myrtle Formation," Diller reported:

> "The rocks of Brushy Mountain are certainly considerably metamorphosed and the slates are scarcely distinguishable from some of those in the real schists.... There is no conglomerate along the trail along Brushy Mountain, but the sandstone...is abundant.... The sandstone seems to be somewhat squeezed and slaty." (Diller Notebook, D-35, 1899, p. 55).

And south of Blackberry Creek, about 5 miles to the northwest, he reported:

> "I find scattered coarse gabbro, no definite hornfels, but sandstone is somewhat schistose. Approaching the highest point of divide halfway to Panther Mountain the sandstone becomes more fissile, i.e. slaty. The shale becomes slate like that of Brushy Mountain and a fine conglomerate becomes schistose." (Diller Notebook D-35, 1899, p. 69).

Slates were also reported at a number of other scattered localities, notably on Ophir Mountain and on Foster Creek, 2 miles north and 2 miles northeast respectively of Brushy Mountain.

Results of studies by geologists from the University of Wisconsin near the coast seemed to demand that a major angular unconformity exists between Portlandian strata and older Jurassic metamorphic and igneous rocks. Because it could not be clearly demonstrated there, the Collier Butte area was examined (fig. 1). Though the latter area provides somewhat clearer evidence, it was not fully satisfactory. The Copper Mountain-Johnson Creek area farther north seemed to offer the last hope for finding the elusive evidence. In 1960 I had attempted with J. G. Koch to reach Copper Mountain from the west, but lack of time precluded our ascending its critical east slope, where an apparently uninterrupted fossiliferous sequence had been reported. In 1965 I approached from the east by way of new logging roads in the Johnson Creek drainage basin.

The long-sought unconformity was found to be exposed in the upper Johnson Creek drainage, especially on the spur extending west from Granite Peak to the cuesta ridge southeast of the Barklow Mountain fire lookout tower. This is the ridge erroneously termed "Bray Mountain" throughout most of Diller's field notes but not on the published folio maps; this misnaming led to considerable initial confusion in using the notes. The lower east slopes of the cuesta expose dark semi-slates and foliated sandstones

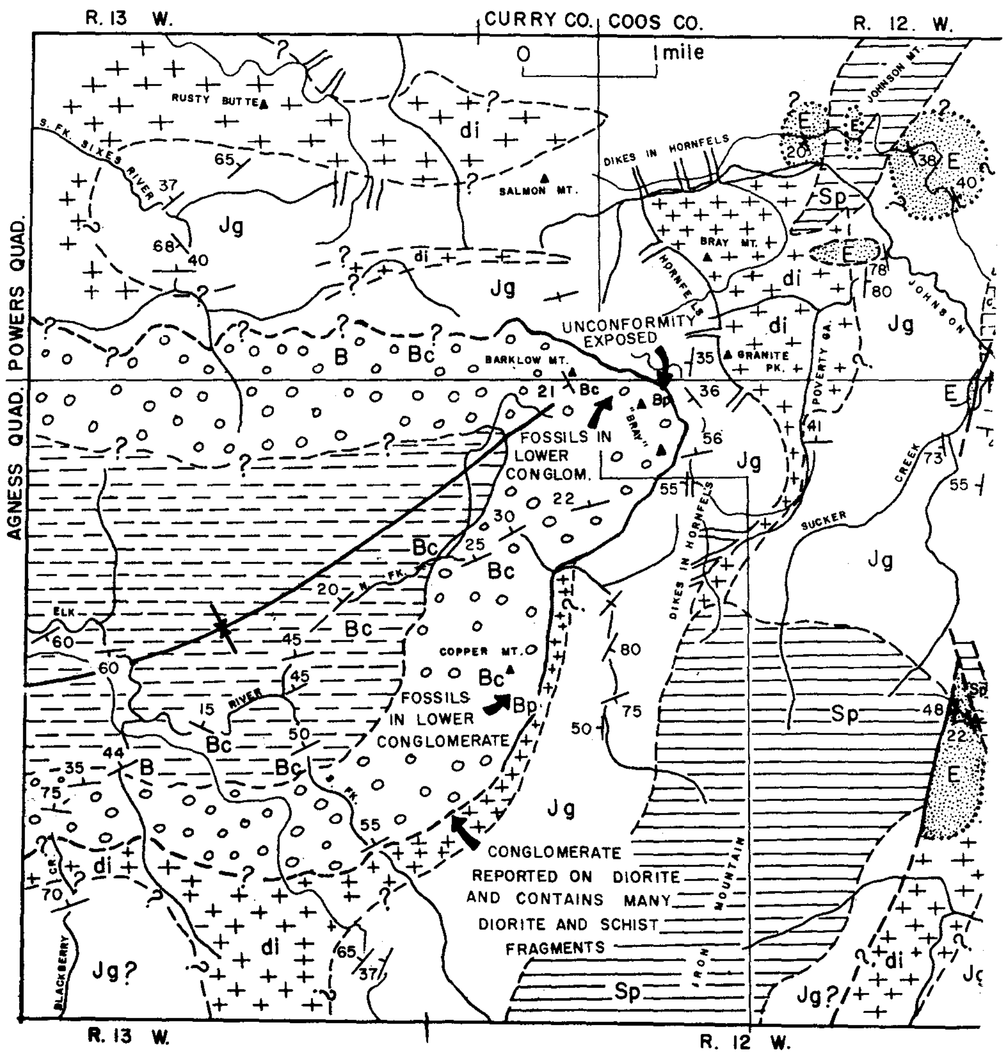
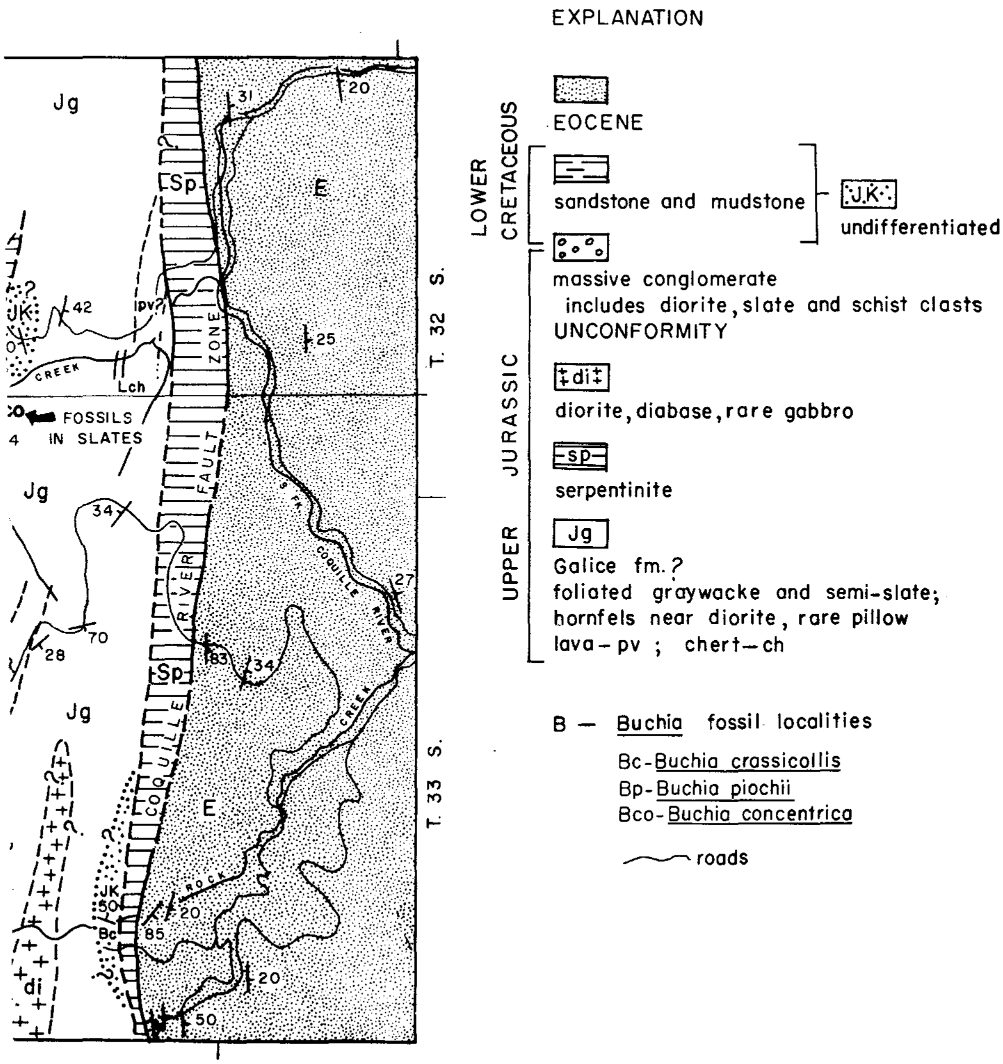


Figure 2. Geologic map of upper Elk River and Johnson Creek area east side of Barklow Mountain and probable extension of igneous bodies to the Galice Formation(?). See Figure



howing location of sub-Portlandian unconformity observed on south-
:onformity westward; note also location of fossils and relationships of
or location of area.

that are intruded by the Bray Mountain-Granite Peak diorite mass (fig. 2). Near the intrusive contacts, prominent hornfels zones occur. The clam Buchia concentrica (Sowerby) was found in identical slaty rocks in lower Sucker Creek (2 miles east) at a locality cited by Diller. This establishes a Jurassic (late Oxfordian to early Kimmeridgian) age (Imlay, written communication, 1965) for the metamorphic rocks, which are here tentatively assigned to the Galice Formation on both lithologic and faunal grounds.

Because of lithologic similarity and apparent lateral continuity, all of the slaty rocks from Johnson Mountain and Johnson Creek south to the true Colebrooke Schist near Rogue River are also considered to represent the Galice Formation (fig. 1). This belt of Galice outcrops clearly defines the "anticlinal arch" that Diller referred to vaguely in the Port Orford folio. The Galice slates might, indeed, be mapped as Colebrooke, but because of their very low metamorphic grade, their faunal content, and general lithology, they are instead here referred to the Galice Formation. These slates are no more metamorphosed than is the type Galice farther east, and they also closely resemble the Galice? metasediments of the Lower Elk River-Pearse Peak area near the coast (Koch, 1966).

A lateral gradation apparently occurs from Galice Formation semi-slates southward to more typical Colebrooke Formation greenschist facies rocks near the Rogue River. In turn, however, the Colebrooke schists also grade southward into essentially unmetamorphosed rocks assigned to the Dothan Formation in the vicinity of Collier Butte (Dott, 1965). Therefore, the Colebrooke Formation appears to include metamorphic equivalents both of the Galice and of the Dothan Formations; clearly, metamorphic grade has a very irregular geographic pattern in southwestern Oregon. The Colebrooke name is here reserved for schists and phyllites whose original character is thoroughly altered and whose original formational affinities are not clear.

Conglomerate sequence above unconformity

Above the Galice metasediments on the cuesta west of Granite Peak are coarse, massive unmetamorphosed conglomerates forming bold outcrops such as Diller described for this same locality (see quotations above for "Bray Mountain"). On a freshly cut log-skinning trail, the conglomerate was found resting discordantly upon eroded slaty rocks. Well-rounded pebbles and cobbles (averaging 2 to 4 inches in diameter; maximum 2 feet) consist of rock types (table 1) that were clearly derived from the older metamorphic and igneous complex. Near the base of the conglomerate a zone of very fine sandstone contains abundant Buchia piochii (Gabb) of Portlandian age (Imlay, written communication, 1965). More coarse pebble and cobble conglomerate occurs above this zone clear to the cuesta summit. At Barklow Mountain lookout half a mile northwest Buchia crassicollis (Keyserling) of Early Cretaceous (Valanginian) age occurs in similar conglomerate and conglomeratic sandstone (fig. 2). The entire sequence appears to be

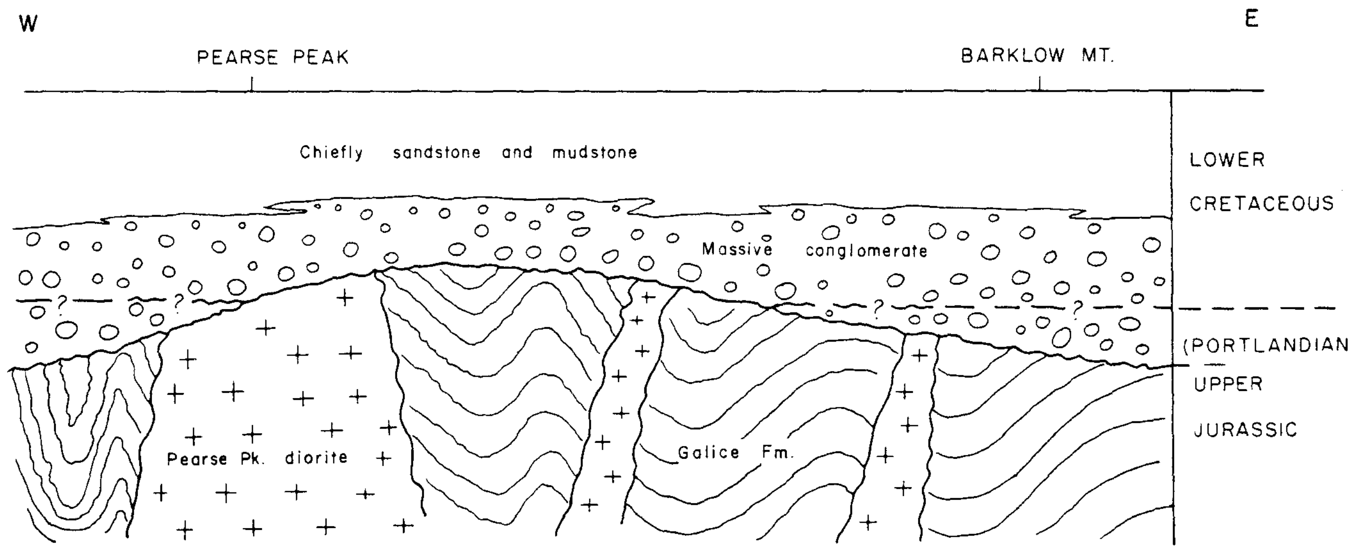


Figure 3. Restored cross section from Humbug Mountain near coast to Johnson Creek (across north end of Figure 1); shows inferred stratigraphic and age relations of the Humbug Mountain Conglomerate to older and younger rocks. Length of line of section is about 20 miles.

Table 1. Composition of conglomerate clasts on cuesta southeast of Barklow Mountain (104 clasts)

	Basal portion	Middle of cuesta face
Volcanic	29 percent	29 percent
Diorite	21	39
Chert	17	21
Foliated sandstone	15	8
Quartz	2	3
Hornfels and phyllite	6	0
Indeterminate	10	0
	100 percent	100 percent

concordant, though some of the middle portion is obscured by dense vegetation.

The coarse, massive Humbug Mountain Conglomerate, named and mapped by Koch near the coast, extends eastward around a large synclinal structure through Copper Mountain to Barklow Mountain, and thence northwestward for nearly 10 miles along the south side of the Sixes River drainage. Apparently it occurs north of the Sixes River, for Diller reported presumably identical conglomerate at Sugarloaf Mountain (7 miles northwest of Barklow Mountain); its possible extent beyond that point is unknown. The basal portion of the conglomerate is unfossiliferous on the lower Elk River, where it unconformably overlaps Galice? metasediments, but Cretaceous fossils occur at higher levels nearby (Koch, 1966). Between Barklow Mountain and Humbug Mountain the conglomerate appears to be much thinner and to contain only Cretaceous fossils. These data suggest that Diller was correct in interpreting the Portlandian and Cretaceous strata as having "overlapped in a way to suggest deposition in a sea having islands" (1903, p. 2, col. 4).

Figure 3 shows a restored interpretation of the relations of the Humbug Mountain Conglomerate to other rocks. In such a monotonous and massive conglomerate it is impossible to know if a minor unconformity, such as Koch postulated (1966), does exist between Portlandian and Cretaceous strata. Near more topographically positive areas one may indeed have formed, but it appears that in at least some areas essentially continuous gravel deposition occurred. Moreover, it is entirely possible that farther from the island gravel sources, thick mudstone and sandstone sequences typical of the Portlandian Otter Point Formation (Koch, 1966) accumulated. Thus the nearby Otter Point (fig. 1) appears to be in part a temporal (that is, lateral lithofacies) equivalent of the lower Humbug Mountain Conglomerate. But if large-scale faulting has occurred, the two may originally have been deposited rather far apart. In either case, the paleogeography and sedimentology of southwestern Oregon at the end of Jurassic time was extremely complex.

Conclusions

It is clear that Diller combined two very different sedimentary sequencies that are in fact separated by a major angular unconformity representing the classic Nevadan orogeny. The unconformity is well exposed in the Barklow Mountain area where unmetamorphosed Late Jurassic conglomerates overlie Galice slates intruded by diorite. The "Jurassic slates" of Diller are far more extensive than was indicated in the Port Orford folio, and they appear to be completely gradational to the more intensely metamorphosed Colebrooke Formation. The Humbug Mountain Conglomerate, originally considered to be entirely of Early Cretaceous age, is now found to contain Late Jurassic (Portlandian) fossils in the Barklow Mountain area. Although a minor unconformity may exist within it, the conglomerate appears to represent continuous deposition of gravels here.

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GOVERNOR HATFIELD SALUTES 50TH ANNIVERSARY OF AAPG

Governor Mark O Hatfield holds an ornamental paper weight fashioned from a drilling core of 230,000,000-year-old Permian limestone presented to him on March 23 during a special ceremony recognizing the 50th anniversary of the American Association of Petroleum Geologists. Participating in the presentation are (from left to right): Dr. W. D. Wilkinson, Chairman, Department of Geology, Oregon State University; Governor Hatfield; Dr. Keith F. Oles, Department of Geology, Oregon State University; and Hollis M. Dole, State Geologist.

The American Association of Petroleum Geologists is the world's largest geological organization. It has some 15,000 members in the United States, Çanada, and 73 foreign countries. Headquarters are in Tulsa, Okla. Objectives of the association are to advance the science of geology, especially as it relates to petroleum and natural gas and to encourage improvements in the methods of exploring for and use of these resources.

Dr. Wilkinson pointed out that the majority of graduates of the Oregon State University Department of Geology are recruited for employment by the oil industry. OSU now has about 100 undergraduate majors in geology and 30 students working for master's and doctor's degrees.

Governor Hatfield took note of contributions made by oil geologists in national and world development and of the potential for oil deposits off the Oregon coast. Drilling operations were started off shore a year ago and will be continued this year by oil companies.

In closing his official proclamation, Governor Hatfield said, "I would urge all our citizens to recognize the important part the petroleum geologist has played in the past 50 years of our nation's progress and join me in saluting the profession."

PROFESSIONAL GEOLOGISTS FORM OREGON SECTION

The American Institute of Professional Geologists is in the process of forming an Oregon Section. The present membership is 16, with several additional applications pending.

The Institute was founded on November 15, 1963, and was incorporated under the laws of the State of Colorado. As of January 1, 1966, there were 1,093 members. These members are found in all of the 50 states and in 12 foreign countries. Among the many purposes of the Institute, several are particularly noteworthy. These include:

1. To encourage higher professional and scientific standards by its members for the protection of the health, welfare, and economy of the public, and to aid in the public dissemination of knowledge of non-professional practice of geology.

2. To enforce the Code of Ethics of the Institute and to report infractions by members to the Executive Committee of the Institute.

Geologists interested in membership in the AIPG or in further information may contact the State Coordinator, Dr. Keith F. Oles, at the Department of Geology, Oregon State University, or either of the Associate Coordinators: Herbert G. Schlicker, State Department of Geology and Mineral Industries, 1069 State Office Building, Portland, Oregon 97201 or Dr. Ewart M. Baldwin, Department of Geology, University of Oregon, Eugene, Oregon.

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BULLETIN 58 ISSUED BY DEPARTMENT

"Geology of the Suplee-Izee Area, Crook, Grant, and Harney Counties, Oregon," has been published by the Department as Bulletin 58. The authors are William R. Dickinson, Geology Department, Stanford University, California, and Laurence W. Vigrass, Western Resources Consultants Ltd., Calgary, Alberta.

The Suplee-Izee area, which occupies about 500 square miles in east-central Oregon, is geologically one of the most interesting regions of the State. It consists of an inlier, sometimes called a "window," of fossiliferous Paleozoic and Mesozoic strata, largely of marine origin, surrounded by Tertiary volcanics. The geology is complex, but, since metamorphism and intrusion were minimal in this area, the original character of the strata, the details of deformation, and the fossil sequence have been preserved.

Drs. Dickinson and Vigrass, who chose the Suplee-Izee area for their doctoral dissertations, have presented in this joint report the most complete and definitive work to date on the stratigraphy and structure of this pre-Tertiary inlier.

The illustrated publication has 110 pages. It contains check lists of fossils, descriptions of measured sections, and a glossary of technical terms.

The multicolored geologic map accompanying the bulletin shows 32 geologic units and represents the finest color work ever achieved in a Department publication. Bulletin 58 may be obtained from the Department's offices in Portland, Baker, and Grants Pass. The price is $5.00.

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RESEARCH CENTER HEAD NAMED

H. Gordon Poole has been appointed head of the U.S. Bureau of Mines Albany Metallurgy Research Center. Haruo Kato, project coordinator of the physical metallurgy laboratory, has been acting head of the Research Center since the first of the year. Poole comes to the Bureau with a long background in metallurgical engineering dating back to 1931. He leaves the position of vice president and technical director of the Oregon Metallurgical Corp. at Albany to accept the new assignment.

Also stationed at the Bureau's Albany offices and laboratories are: Mark L. Wright, Area VII Minerals Resources officer; A. J. Kauffman, Jr., Head, Albany Office of Mineral Resources; Joseph W. Town, Head, Mineral Resources Services; and Harlan Jager, Administrative Officer for the Albany Station.

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CANYON CITY REGION MAPPED

"Geologic map of the Canyon City quadrangle, northeastern Oregon" by C. E. Brown and T. P. Thayer has been published as Misc. Geol. Invest. Map I-447 by the U.S. Geological Survey. This is the fourth in a series of Oregon geologic maps to be issued at this scale (1 inch equals approximately 4 miles) on AMS sheets, preparatory to publication of the eastern half of the State Geologic Map. The report covers a large region in the central Blue Mountains from Sumpter and Unity on the east to Paulina and Picture Gorge on the west. The pre-Tertiary inlier of central Oregon occupies part of the map. Rocks range in age from Devonian to Recent, and comprise 45 geologic units shown on the map by color and pattern.

Copies may be obtained from the U.S. Geological Survey, Federal Center, Denver, Colo. 80225. The price is $1.00.

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NEW WILDCAT UNDER WAY IN NORTHWEST OREGON

A shallow test drilling (permit 55) is being conducted by Butte Oil of Oregon, Inc., approximately 1 mile southeast of Forest Grove. The well is situated on the Russell A. Cowan property in the NW$\frac{1}{4}$ sec. 8, T. 1 S., R. 3 W., Washington County. Projected depth is 1,000 feet and the goal is the testing of Oligocene marine sediments below the Columbia River Basalt.

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The ORE BIN
Volume 28, No. 6
June, 1966

OREGON'S ASSAY SERVICE - HOW TO USE IT TO BEST ADVANTAGE

By N. S. Wagner*

The assay service performed by the State of Oregon Department of Geology and Mineral Industries is a cooperative arrangement. It is designed to encourage the prospector to search for mineral deposits and, then, to help him find out if he has ore worth developing. In exchange for assay data, the prospector provides the Department with certain information about the deposit that adds to the over-all knowledge of the State's mineral resources. The attached sheet entitled "Request for Sample Information" is the form on which this cooperative information is recorded.

The following paragraphs have been prepared to assist those using the Department's cooperative analysis service. Instructions are given for filling out the form and, equally important, some suggestions are offered for taking samples -- a vital operation all too often imperfectly performed.

Scope of Assay Service

The law governing this service entitles any individual, or group of two or more persons working together, to submit two samples per month for free laboratory analysis of grade and/or identity. In addition to the limitation of the number of samples that any applicant may submit, the law further stipulates that all samples must originate from prospects located in Oregon and that the applicant must furnish data regarding the location. Furthermore, in order to qualify, the applicant cannot be mining, milling, or shipping ore from the prospect, or hiring labor in development thereof. Neither can he be a mining engineer sampling the occurrence on a professional basis for evaluation purposes. Finally, because this is a publicly financed service, all information submitted regarding the prospect and all results of laboratory determinations are open to public inspection and may be published.

A more detailed account of the law is printed on the back of the form. However, the digest just given covers the basic requirements which both this Department and applicants for the service are obliged to meet when samples are submitted for analysis.

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* Geologist, State of Oregon Dept. of Geology and Mineral Industries.

How to Fill out the Sample-Information Form

The fill-in side of the forms contains: (1) provisions for data needed by the Department for mailing and filing purposes; (2) provisions for the information required by law in order for the applicant and the sample to qualify for the service; and (3) provision for a statement describing the analysis desired by the applicant, together with space for pertinent sample data the applicant should keep for his own records. A copy of the form will be returned to the applicant.

Clearly, the called-for information relates to data that must be available at the outset if an application is to be processed smoothly and the service made effective. It is essential, therefore, that the application forms be filled out carefully, completely, and accurately. In this respect, most of the requested data is comparatively easy to secure once an applicant understands what is needed, and why. However, to the uninitiated, certain of the requirements can be confusing; hence, those likely to prove troublesome are reviewed here in order to clarify application procedures.

Claims and ownership data: The first trouble spot on the form for some applicants is the heading calling for the "Name of the claim sampled." The intended entry here is the claim name WHEN THERE IS A CLAIM. Otherwise, if the sample originates from a tract of privately owned deeded land, the entry should be simply "deeded land." Or, if the sample originates from the Public Domain and no claim has been taken, the intended entry should be "none." In short, all that is required is a factual statement of the prevailing land status. Similarly, the appropriate entry under the "Name of property owners" is the name of the claim holder or recorded land owner WHEN THE SAMPLE ORIGINATES FROM A CLAIM OR FROM DEEDED LAND. Otherwise, the entry should be "Public Domain," "State," or "County" if the sample originates from public land.

Required location data - surveyed areas: Almost all parts of Oregon have been surveyed in accordance with standard Land Office practices, and maps showing the legal subdivisions for each county are on file in the Recorder's office at all Court Houses. In addition, the township-range-section grid is shown on all topographic quadrangle maps issued by the U.S. Geological Survey and on most land maps available from the U.S. Bureau of Land Management, the U.S. Forest Service, and other Federal and State agencies dealing with land-use problems. There are also the County and Township maps issued by commercial concerns, available for purchase in most cities and many smaller towns. Under the circumstances, it should not be difficult for an applicant to find a map showing the legal subdivision grid in his prospect area. For that matter, if a sample originates from deeded land, the required location data is already on file in the County Recorder's records. Likewise, if a sample originates from a claim, the locations

STATE OF OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1069 State Office Building - Portland, Oregon 97201

REQUEST FOR SAMPLE INFORMATION

The State law governing free analysis of samples sent to State Assay Laboratories requires that certain information be furnished the laboratory regarding samples sent for assay or identification. A copy of the law will be found on the back of this blank. Please fill in the information requested completely, and submit it along with your sample. Keep a copy of the information on each sample for your own reference.

Please print your name and address in space above

Date sample is sent: ____________________

Name of claim sampled: ____________________

Name of property owners ____________________

Are you hiring labor? __________ Are you milling or shipping ore? __________

Location of property or source of sample. (If legal description is not known, give location with reference to known geographical point.)

County__________ Mining district __________

Township __________ Range __________ Section __________ Quarter section __________

How far from passable road and name of road ____________________

	Channel (length)	Grab	Assay for	Description
Sample No. 1				
Sample No. 2				

(Samples for assay should be at least 1 lb. in weight; clay samples for ceramic testing at least 5 lbs.) IMPORTANT: A vein sample should be taken in an even channel across the vein from wall to wall. Location of sample in the workings, together with the width measured, should be recorded.

(Signed) ____________________

DO NOT WRITE BELOW THIS LINE - FOR OFFICE USE ONLY - USE OTHER SIDE IF DESIRED

Description ____________________

Sample Number	GOLD		SILVER					
	oz./T.	Value	oz./T.	Value				

Report mailed ____________________

LAW RELATING TO FREE ANALYSIS OF ORES, MINERALS, ETC.
CHAPTER 179, Section 10, Oregon Laws 1937.

The department shall make, or cause to be made, quantitative determinations of ores and minerals when submitted for the purpose, that are from original prospects or properties within the state of Oregon, and shall mail to the sender the results obtained within 10 working days after receipt of samples; said service shall be performed by the department without charge to the sender and shall be rendered in exchange for information for the records of the department stating the name and residence of the sender together with a history of the ore or mineral, giving as nearly as possible the location from which the sample was taken, including the name of the county, and any other matters that may be beneficial touching the same. All determination shall be performed under the following rules and regulations and subject to the following restrictions:

(a) No sample submitted by engineers sampling prospects or mines for the purpose of evaluation, or submitted by operating mines milling or shipping ore, or hiring labor, shall be accepted by the department for assay and/or analysis, except they be taken in the field by members of the department's staff in conducting the work of the department within the scope of this act.

(b) The number of samples which any single person or group of persons may submit shall be limited to two in any 30 day period and all samples shall be assayed or analyzed by the department in the order received, as far as possible.

(c) All information received and results of determination sent out shall be open to public inspection and may be published by the department.

(d) Before any work is done on the material submitted, all information required must be possessed by the department and the 10 day limit for reports will count from the time such data are received by the department.

notice should be on file also and this should contain an accurate legal description if it has been executed properly. In the last analysis, therefore, the only applicant who might have to hustle a little harder than the others to get his location data is the one who secures his sample from an unlocated prospect on the Public Domain. Even for him the task should not be great.

Figure 1 shows how sections are numbered on a township and how each section is subdivided.

Required location data - unsurveyed areas: When a sample originates from some of the few unsurveyed areas remaining in the state, the only course of action is to describe the location as clearly as possible with reference to conspicuous landmarks, in the same manner that is required for claim locations. When doing this, mention first the nearest well-known landmark in order to establish the general locality and then describe the location in terms of local references. Always emphasize distances and directions. Example: Five miles northwest of Twin Lake on the east side of Bear Gulch one-half mile above the Clear Creek Junction.

Mining district: Because mineral occurrences tend to be localized in some areas and not in others, a large percentage of the samples submitted for analysis originates from certain recognized parts of the state where mining and prospecting have been historically prominent. For this reason it is a help in filing and correlating assay results to have the name of the mining district from which the samples came. However, there are no recognized mining districts in much of the state and information concerning the identify and location of those that do exist is not always commonplace. Therefore, the recommended procedure for filling out this part of the form is to name the district if you know it. Otherwise, this particular entry can be answered with a question mark, thus (?), and the Department staff can determine the district from the township-range-section data.

Channel length - grab: What is meant by these headings will be discussed later in the section devoted to SAMPLING techniques.

Description: This word appears twice on the fill-in side of the application form -- once near the mid-section portion of the form in the part to be used by the applicant, and again near the bottom of the page in the space reserved for office use. The particular "description" referred to here is the one occurring in the applicant's part of the form.

The intent of this heading is to enable the applicant to record for his own information data that will insure his relating the assay result to the proper sample. For example, if an applicant submits six samples during the course of a year from the same prospect and does NOT describe each individual sample on each application form, he may find it difficult or even impossible to determine at a later date which assay report applies to a particular sample. This clearly makes the results meaningless if the samples originated from different parts of the prospect; hence the desirability of always describing each sample carefully.

How each applicant labels his samples will depend on the conditions existent on his prospect and the number of pits, cuts, natural exposures, and veins present. Since conditions vary at all prospects, no clean-cut rule can be given. However, the following are examples of the sort of descriptions that can be made. They apply to a season's run of samples from a prospect having two parallel veins with several pits and trenches on each:

No. 1 vein, north end of claim;
No. 1 vein, center of No. 2 cut;
No. 1 vein, east end of No. 2 cut;
Main pit on No. 2 vein, at collar;
Main pit, No. 2 vein, 6' below collar;
Re-sample, No. 1 vein, center No. 2 cut.

When samples are described in some such manner as this, there can be little or no confusion and a prospector should be able to relate each result to its proper feature on the prospect even years after the samples were taken.

Desired analysis - for recognized ores: With prospectors (and with mining engineers as well) there are two kinds of rocks and minerals -- those they recognize and are familiar with, and those that are new and strange. The ones that are familiar constitute no problem. They either rate as a common, non-commercial variety not meriting special analysis, or they signify a potential ore of certain recognized chemical substances deserving analysis. For the latter, the applicant simply states that what he wants is an assay for gold; or for copper; or for gold, silver, and copper; or for gold, silver, and tungsten; or for iron; or for chromium and iron; or for magnesium or for barium or for lime or for whatever the logical determinations should be. Definite stipulations of this kind are what should be made under the "ASSAY FOR" heading in all possible instances.

Desired analysis - for strange rocks and minerals: When an applicant is interested in a rock-mineral sample that he cannot classify and is uncertain what value, if any, it might have as an ore, the word "identify" should be written in the space provided. The material represented will then be classified and named. With this information, the applicant can then decide if the material merits additional analysis, and for what. In other words, never ask for a "complete analysis" or for "everything that is in it." Complete chemical analyses are very time-consuming and expensive to make, are beyond the capabilities of existing laboratory facilities, and are not within the scope and intent of the law under which this service is authorized. Instead, ask for an identification and be guided by the results in accordance with the procedure described above.

Sample size - for chemical analysis and fire assay: For either type of analysis, samples are pulverized to a powder and thoroughly mixed in the laboratory. However, laboratory equipment is not designed to process large volumes of rock on a mass production basis, nor are laboratory crushers capable of handling large pieces of rock. For this reason, sample size can be described as a matter of personal discretion, within certain limits.

The first limit is that a minimum sample size of one pound is required. This much is needed to offset crushing and pulverizing wastage and to provide the required amount of pulp for assay, plus an adequate reserve if reruns are necessary. The other limit has to do with over-sized samples. The laboratory is not the place to beat large chunks of dense, hard rock to crusher-feed size with a double jack. Neither is it practicable to handle samples that are excessively bulky, even when composed of small fragments.

Ideal samples from the laboratory acceptance standpoint approximate 5 to 7 pounds in weight of dry material with no fragments in excess of 2 inches in diameter, and preferably less. Preparing and quartering samples in the field is explained under SAMPLING. In the meantime, remember that 60-pound samples of fragmented rock and melon-sized chunks of solid rock cannot be accepted.

Sample size - for identity determinations: For identification purposes, sample size depends on the nature of the material. If it is a bulk sample of strange rock to be named, a two-fisted-size chunk is ideal, and even smaller fragments can be used. All that is necessary is to package such a sample and send it to the laboratory, along with the application form requesting identity. However, if the desired identification involves small, obscure grains of some strange mineral intermixed with other minerals in a complex ore, or contained in a placer-sand concentrate, the task is more complicated because of the need to direct laboratory attention to the precise mineral to be examined. With a rock, indicate the desired mineral by penciling a circle around several typical examples. Better yet, crush the rock and separate out the unknown mineral with a pair of tweezers or by panning. For this type of identification, a couple of spoonsful of the separated unknown mineral will probably be sufficient. The same procedure is used for mineral grains in a placer sand. Separate out the strange mineral you want identified as cleanly as possible; never send in a bulk concentrate or the unpanned raw gravel.

How to Take Samples

Sampling methods: Most conventional-type ores can be analyzed with a high degree of accuracy. However, the analytical results for any given sample are meaningful for evaluation purposes only to the extent that the

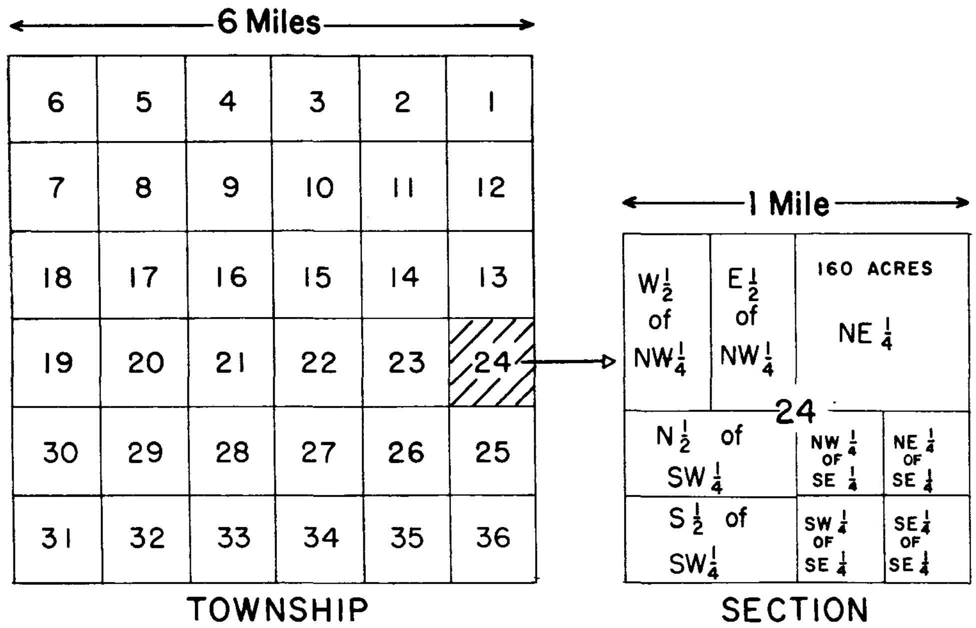

Figure 1. Township plat and section subdivisions.

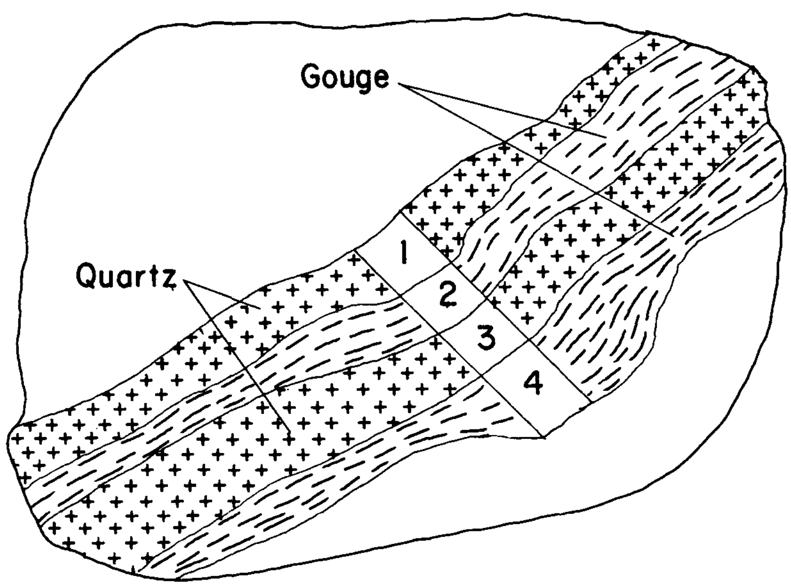

Figure 2. Channel sampling of quartz vein exposed in tunnel face. Sample 1 contains 0.18 oz. gold; sample 2 contains 0.01 oz.; sample 3 contains 0.10 oz.; and sample 4 contains 0.05 oz. A single sample across the entire width would give inaccurate results

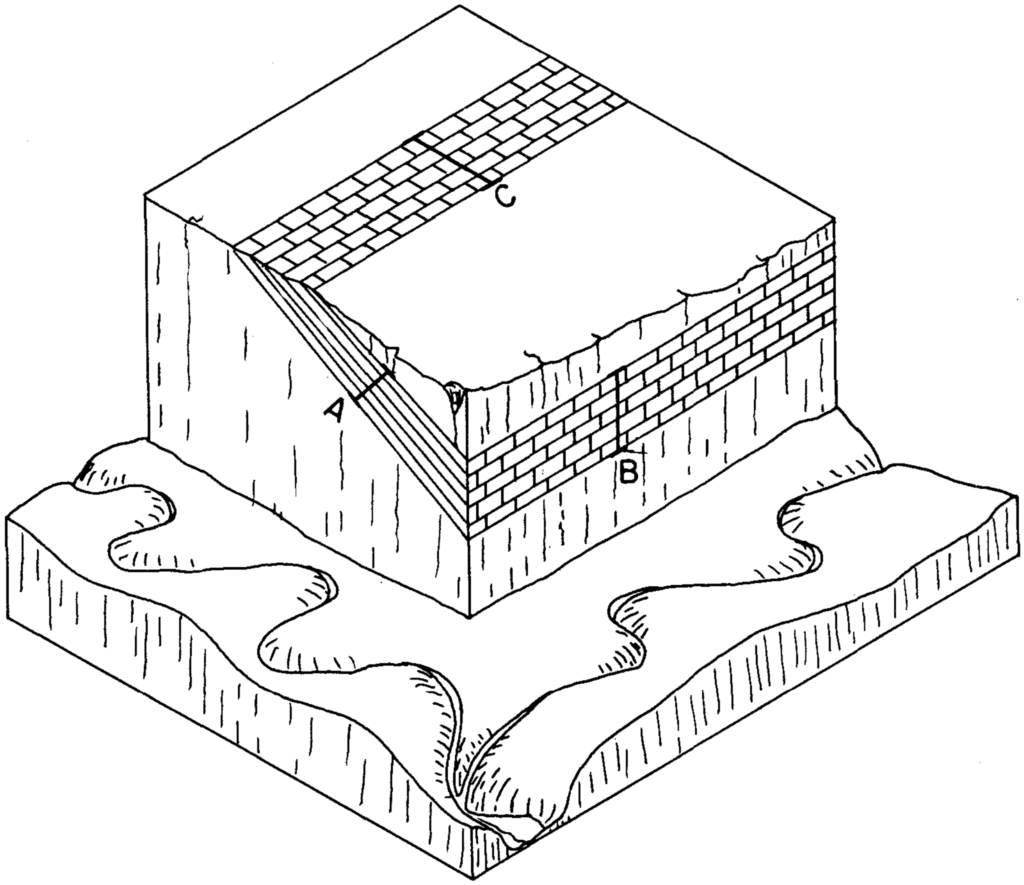

Figure 3. Channel sampling in limestone bed. A sample cut at "A" gives true width of bed. Samples taken at either "B" or "C" give measurements greater than true width but yield the same results when assayed.

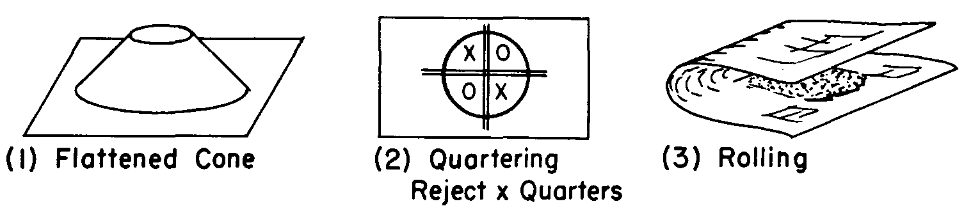

Figure 4. Cone, quarter, and roll process for reducing a bulk sample for shipment to assay laboratory.

sample is representative of the mineralization at the site from which it was secured.

The taking of a representative sample entails more than just breaking off a solitary chunk of rock from a vein, or gathering five or six chunks of rock from random locations on an exposed body of limestone. Instead, a representative sample contains fragments of all varieties of material present in the portion of the occurrence the sample is intended to cover. Furthermore, the amount of each kind of material included in the sample should be proportionate to its relative abundance in the section over which the sample was taken. For example, if a vein is made up of several bands of quartz which vary between themselves in width and in visible content of metalliferous minerals, and if these are separated in one or more places by partings of gouge and breccia, a sample composed of fragments from one of the quartz bands is in no sense of the word representative of the whole vein, any more than a dab of icing from the top of a thick layer cake is a representative sample of the whole cake. Neither is a sample representative if it includes fragments from all the quartz bands but not a proportionate amount of the gouge-breccia partings. Neither is it representative if it contains fragments from the parts that chip easily and just a few small fragments from the parts that prove difficult to break.

The above reasoning applies also to such bedded sedimentary strata as limestone, for example, in which the grade can vary from layer to layer and even within a single bed. A few chunks of material grabbed at random locations across the section are no substitute for a sample composed of fragments taken from a continuous channel or from a series of closely spaced, measured intervals.

Because mineral occurrences are likely to change in grade and character from place to place, and since significant changes are not always evident, the best possible sample that can be taken is a mined tonnage suitable for an actual mill test or a processing trial. Small, portable, hand-cut samples are the next best alternative. These can yield meaningful approximations of the chemical content of a mineral occurrence, provided they are taken properly at close intervals and in sufficient abundance to give an over-all picture.

<u>Channel sample:</u> By definition, a channel sample consists of all the material chipped from a groove, or channel, cut uniformly deep and uniformly wide along a course extending at right angles to the dip and strike of the occurrence being sampled. When taken properly, therefore, such a sample contains proportionate volumes of each and every kind and grade of material present in the section over which the channel extends. For this reason channel samples come closer to being representative of the occurrence than does any other form of hand-cut sample.

Figures 2 and 3 illustrate a channel cut on a typical vein. Note particularly how the course of the channel is laid out to extend at right angles to both the dip and strike so that the channel length corresponds to the true width of the occurrence. Channel length is important in the calculation of tonnage; hence, the channel course should be determined with care and channel length recorded for all samples.

Cuts or channels can sometimes be made easily and quickly with nothing more than a sampling pick. Again, the job may be difficult and time-consuming and require a single jack and moils. The method used depends on the nature of the material being sampled and the number and frequency of natural fractures. A canvas drop cloth, a powder box, and a helper rate as supplemental tools frequently worth having along.

The size of a sample will vary quite naturally with the width or thickness of the material being sampled. Therefore, a cut on a very narrow vein will have to be much deeper and wider than one on a wide vein, if a sufficient volume of material is to be obtained. In general, a channel cut 1 inch deep by 4 or 5 inches wide will provide a sufficient sample from a vein 3 to 5 feet wide. For situations where the width of the material being sampled is so great that a single sample would be too bulky, it usually pays to divide the channel into two or more sections. However, for truly great distances such as are represented by limestone beds several hundreds of feet thick, a continuous channel is impracticable to take and the chip technique described later is an acceptable substitute.

In practice, it is frequently impossible to chip out a channel that is uniformly 1 inch deep by 5 inches wide, because some parts of a vein may be highly fractured and loose, so that an abundance of fine fragments ravel out when picked only lightly. At the same time, an adjoining part of the vein may be composed of hard, blocky material that breaks out in large chunks so that all a sampler can do is to take each chunk as it comes and trim off a segment of the margin equivalent to the width and depth of his channel. Then too, with dense, tough quartz it may be more practical to moil fragments from an area half as deep and twice as wide as the channel dimensions cut in other portions of the vein. In short, there are occasions when it takes judgment, skill, and somewhat of a sixth sense in order to secure the proper amount of material from all parts of a cut across a vein which exhibits varied physical characteristics. Care must always be taken not to include excessive amounts of material that samples easily. Conversely, care must be taken to be certain that the required amount of tough, hard-to-break material is included in the sample. Besides being tedious to break, rock of the latter sort tends to chip in fragments that fly everywhere instead of into the sample bag. Here is where it helps to have a canvas "drop cloth" under foot and an assistant to hold a powder box close to and just below the channel to catch the sample pieces.

<u>Chip sample:</u> Samples of this type consist of chips of rock measuring an inch or so on a side taken at regular intervals of a foot, two feet, or whatever distance seems appropriate, along a line that cuts across the strata

of a sedimentary deposit or the width of a tabular body of mineralized material in a manner corresponding to the way channel lines are laid out. Therefore, the only basic difference between channel and chip samples is that the former includes material from a continuous, ribbon-like cut, while the latter consists of fragments from measured intervals. Because of the interval, chip sampling is not appropriate for veins and vein-like kinds of mineralization. Instead, it applies to special situations where sample sections of appreciable length need to be covered. Chip sampling is employed, therefore, mostly in sedimentary and non-metallic types of mineralization where extreme differences in grade are not so likely to occur over short distances as they are in metalliferous vein-type prospects. Even so, care should be taken to select as short a chip interval as is practicable in order to insure a good density of chip coverage along the section sampled. In this connection, it pays to over-sample by having the interval shorter than necessary rather than to have it so great that it might miss an important horizon of doubtful or off-grade caliber. It pays to remember that in non-metallic mineral occurrences significant differences in the quality of the material can exist without being readily visible; this is particularly true for critical impurities which can be the all-important determining factor governing marketability and use of the material being sampled.

Site preparation prior to sampling: Small amounts of contaminating chemical substances can sometimes be detrimental to the value of an ore. When such contaminants are a normal part of the mineralization, there is nothing a prospector can do about the situation. However, needless inclusion of soil, roots, and weathered rock in a sample can result in the introduction of detrimental contaminants, depending on the nature of the sample and the intended analysis. For example, inclusion of a little soil and a few rootlets may not seriously affect the value of a sample taken from the surface exposure of a vein and assayed for copper or gold, but the specifications for limestone for the manufacture of carbide are such that just a little vegetative matter will introduce enough phosphorous into a sample to make an otherwise excellent limestone appear unsuitable for such use. Knowledge of this sort can be gained only by studying the marketability factors applicable to various minerals as governed by milling and industrial requirements. However, since the objective of sampling is to determine the grade of the typical material present in a mineral occurrence, the best practice is never to include soils, roots, and weathered rock in any sample. Neither should incrustations precipitated from mine waters be included with samples taken underground, nor the grime of powdered rock normally found in underground workings due to blasting. In other words, before any sample is taken enough digging should be done at the sample site to expose clean, uncontaminated material.

In underground situations where a vein is to be channel sampled, the removal of an inch or so of exposed material from the sample area may be sufficient. On surface situations, however, much more digging may be necessary in order to expose uncontaminated mineralization. After all, weathering effects are not always limited to a thin veneer on an exposed rock face and soil traces and vegetation rootlets can penetrate deeply along crevices.

When chip samples are taken, especially of limestones, it is best first to chip off the exposed weathered surface at the sample site; then break out a chunk of the fresh rock and hew this down to the desired chip size. In this way, all exposed surfaces of the chip will be of fresh material.

Quartering: Samples that are heavy and bulky are difficult to handle and expensive to ship. They are also out of place in a laboratory for the reasons already cited. Nevertheless, it is often desirable and sometimes necessary to take large samples. When this is the case, such samples can be reduced in size in the field without affecting their quality, provided that the job is done properly.

The first step is to crush the entire sample, ideally to minus-$\frac{1}{4}$-inch mesh. The next step is to mix the crushed material until it is thoroughly blended. When this has been accomplished, the sample can be split down to desired size. The best way to do this is to feed the crushed material through a mechanical splitter designed expressly for the purpose. When no mechanical facility is available, the best way is to heap the crushed material into a symmetrical, cone-shaped pile (figure 4) on a suitable, smooth surface and then flatten the top somewhat by applying vertical pressure with a shovel or board. The flattened pile can then be quartered (divided into four equal parts) by slicing down through it vertically twice with a thin piece of sheet metal -- one slice at right angles to the other, with the intersection in the center of the pile. Opposite quarters can then be discarded to provide a sample one-half the size of the original. If this is still too large, it should be mixed again, and the coning and quartering process repeated. The use of a square of stout canvas for samples weighing less than 100 pounds greatly speeds the work of coning, quartering, and rolling.

No one step in this procedure is less critical than another. However, without mechanical equipment, the crushing part can be so very laborious, tedious, and time consuming that the temptation to short-cut soon becomes great. Unfortunately, the laws of statistics are such that hours of mixing will be to no avail if all large fragments in the entire sample are not first reduced to a multitude of small fragments -- the smaller the better. There are no short cuts with respect to the need of fine crushing prior to mixing, regardless of whether the crushing is done by a mechanical crusher or by elbow grease with a mortar and pestle. Nevertheless, if a sample is important enough to merit analysis, painstaking care to take it properly in the first place, and to quarter it accurately afterwards, is just as critical as painstaking care on the assayer's part when it comes to the making of his analysis in the laboratory.

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SUMMARY OF MINING LAWS*

Here are answers to some of the most frequently asked questions on mining laws:

1. How many claims can an individual locate?
   There is no limit, but $100 worth of work must be spent on each claim each year to hold it.

2. What is the size of a claim?
   Placer claims are 20 acres, quartz or lode claims are 300 feet wide on either side of the center line and 1,500 feet long.

3. How do I locate a quartz claim?
   The following steps must be done in order and within the time given: (1) At the point of discovery post a location notice. (2) Within 30 days erect stakes at the corners and center ends of the claim. Posts must be at least 4 inches in diameter and 3 feet high. (3) Within 60 days from date of discovery dig a shaft 4 feet square and 10 feet deep or a cut 4 feet wide, 10 feet long, and 6 feet deep along the vein and file a copy of the original location notice at the county clerk's office in the county in which the claim is located.

4. How do I locate a placer claim?
   (1) Post location notice at point of discovery. (2) Within 30 days claim (if area has not been surveyed) must be staked with materials similar to those used for quartz claims. Stakes must not be more than 1,320 feet apart and must be erected at corners and angles. If area has been surveyed, no stakes are required. (3) Within 60 days from date of discovery, at least 5 cubic yards of material must be excavated to expose the deposit. A copy of the location notice must also be filed, as for quartz claims.

5. What about assessment work?
   At least $100 worth of work of a mining nature or of benefit to the claim must be performed on each unpatented claim each assessment year. An assessment year begins at noon September 1. Claims that side line or end line each other may have all of the assessment work concentrated on one claim, provided such work is of benefit to all of the others. Upon completion of the work a Proof of Labor should be filed.

6. How do I know whether ground is open for location?
   Unless a claim is patented, $100 worth of work must be performed on it each assessment year and a Proof of Labor filed with the county recorder. This work should be quite apparent, but it must be remembered that a claimant could do his work at the <u>beginning</u> of an assessment year and then wait nearly two years to do some more work at the <u>end</u> of the following assessment year. Many claim holders do two years' work by starting late in August and continuing on into September until $200 worth of work has been done. Separate Proof of Labor filings should be made, however. If the ground shows no evidence of having been worked for several years and there are no

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* Prepared by Department staff.

records of Proofs of Labor, it is fairly safe to assume that the ground is open. Oftentimes local inquiry will help determine the status of ground in the area.

7. What is an association placer claim?

An association placer claim may be located by several locators, each of whom is entitled to an area of 20 acres. In other words, two locators may locate a 40-acre association claim, three could locate 60 acres. A maximum of eight colocators is allowed for one association placer claim. Only $100 must be expended annually on an association claim.

8. Can a claim be located on private land?

This depends on the status of the mineral rights to the parcel of land. If the surface and mineral rights have not been severed, no claim can be located. If the surface and mineral rights have been severed and the mineral rights are reserved to the federal government, it is technically possible to prospect the ground and to locate a claim. A person prospecting or locating a claim is liable for any damages to crops, livestock, etc., but the landowner must provide access to any claim that is located.

9. Can a claim be located on State land?

Some, but not all, State land is open to mineral entry. Following discovery, a location is made in the same manner as for claims on federal forests. A lease agreement must be obtained from the State Land Board, State Capitol Building, Salem, before any mining can be done.

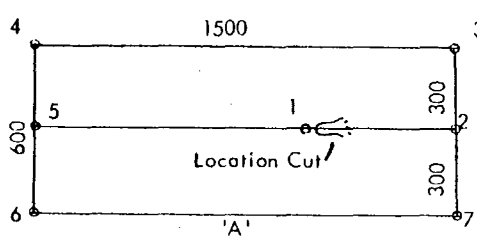
10. Can a claim be located on County land?

Following discovery and location an inquiry should be made to the County Court to determine the lease status of the land.

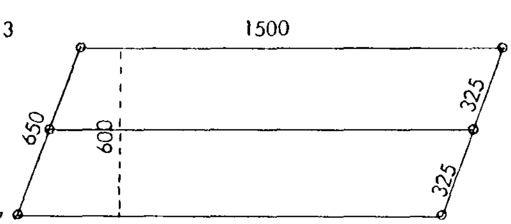
11. How can I patent my claim?

The best information on patenting procedures is contained in the pamphlet "Information Relative to the Procedure of Obtaining Patent to a Mining Claim" issued by the U.S. Bureau of Land Management and available from the Bureau's Land Office, 729 N. E. Oregon Street, Portland, Oregon 97232.

The accompanying diagrams show two typical plans for quartz claims. In diagram "A" the endlines are at right angles to the sidelines. In diagram "B" the endlines are at an oblique angle to the sidelines. In either case, the endlines must be parallel to each other. Note in "B" that the endlines are longer than 600 feet, but that the width of the claim is only 600 feet - the maximum permitted by law.



'A'



'B'

The location cut and the location monument (Post No. 1) must be somewhere along the center line. The distance from the location monument to the center end stake (No. 2) and also the distance from the location monument to center end stake (No. 5) must be given in the spaces provided on the claim location notice.

Adjoining claims must have their own set of claim posts, but the location notice should state that the one claim either endlines or sidelines the other.

* * * * *

MINING-CLAIM DEADLINE NEARS

Time is running out for people who live on invalid mining claims and want to see if they can be permitted to stay, the U.S. Bureau of Land Management has announced.

In 1962 Congress passed a law called the Mining Claims Occupancy Act, which allowed residents five years in which to see if they can qualify for continued residence on the property, according to J. R. Welch, chief of the Bureau of Land Management's minerals staff in Portland.

Welch said that in some cases people have bought or staked mining claims and lived there without discovering valuable minerals. In such cases the claims are invalid and residence is not allowed under the general mining laws. In other instances, mining claims that might have qualified for patent have been mined out and are, therefore, no longer valid. Also, persons unfamiliar with the mining laws have purchased quit-claim deeds to unpatented mining claims, thinking they were buying full title to the lands. Actually, if the claims were invalid, they acquired no rights at all, Welch explained.

Deadline for filing applications under the Mining Claims Occupancy Act is October 23, 1967. Welch said that inquiries should be directed to BLM's State Office, 729 N. E. Oregon Street, Portland, Oregon 97232.

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NEW DRILLING PERMIT ISSUED

The Department issued Drilling Permit No. 56 to Marvin Lewis of Salem, Oregon, on June 1, 1966 for the drilling of a shallow oil-test hole in northern Polk County. The proposed test is to be located approximately 140 feet south of the Reserve Oil & Gas Co. "Bruer No. 1," which was drilled to a depth of 5,549 feet and abandoned in July 1960. Marvin Lewis retested the Reserve well in 1964 but was unsuccessful in his attempts to find production; the sands proved to be wet. The new drilling, Marvin Lewis "Crossley-Jennings No. 2," is located approximately in the NE$\frac{1}{4}$ sec. 31, T. 6 S., R. 4 W., Polk County.

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ENERGY AND POWER OF GEOTHERMAL RESOURCES

By Gunnar Bodvarsson*
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Introduction

Geothermal resources are now being utilized for power generation and building heating in a number of locations in the world (see companion article by Groh). This industry is of a rather recent origin and has not yet been developed to its full capacity. A great number of undeveloped geothermal areas are found in various locations, mainly in the Circum-Pacific Belt. The State of Oregon obviously has a number of geothermal prospects.

The geothermal industry has many procedures and principles in common with the petroleum industry, although there are, as a matter of course, a number of peculiarities resulting from the special thermal processes involved. A considerable amount of descriptive literature is available on the various phases of the geothermal industry, but relatively few papers discuss the underlying physical principles.

The present paper has been written for the purpose of giving a brief review of the main physical concepts that have to be taken into consideration in geothermal exploration and exploitation. The material presented is largely an outgrowth of the writer's own experience in this field, both in Iceland and in other parts of the world.

For further information on this field, the reader is referred to the many important papers presented at the United Nations Conference on New Sources of Energy in Rome, 1961.

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* Gunnar Bodvarsson was born in Reykjavik, Iceland. He attended technical universities in Sweden and Germany, and received a degree in engineering from the University of Berlin. In 1946 he was appointed head of the Geothermal Research Department in Reykjavik and in 1961 he became an independent consultant for the Government of Iceland. He attended the California Institute of Technology at Pasadena between 1955 and 1957, obtaining a doctoral degree in geophysics. Dr. Bodvarsson has acted as a consultant for various official and private agencies. He has served three times as an United Nations expert on geothermal matters: British West Indies, 1951; Mexico, 1954; and Costa Rica, 1963. Since 1964 he has been a visiting professor at Oregon State University.

Heat Flow in Nature

It is well known that the temperature of the earth increases with depth, but the rate of increase varies considerably. In general, the values obtained for areas which are undisturbed by volcanism and thermal activity fall between 10° and 50° C/km. Hence, the normal temperature at the depth of one kilometer should be a few tens of degrees C. The temperature gradient indicates that the earth is losing heat by conduction at an average rate of about 1.5 microcal/cm^2 or about 60 kW/km^2. The major part of this heat flow is the result of a generation of heat by radioactive materials at depth. A minor part may possibly represent a very slow cooling of the earth.

Convection, that is, mass transport of heat by subsurface fluids such as magma, waters, and gases, is a much more efficient mode of transport than conduction; but its influence is restricted to certain areas where the transporting fluids are available, and, moreover, where they can move through the rock formations. The places where the convective transport dominates are the areas of volcanism and thermal activity, which are generally located along certain definite global structural features such as the Circum-Pacific Belt and Mid-Atlantic Ridge. It is believed that the deep large-scale fractures in these belts provide the necessary channels for magmatic fluids to rise from depths of more than 100 km to the surface or to near-surface layers.

The temperature of the magma at depth is of the order of 1,200° to 1,500°C and it follows that the sensible heat (above 0°C) carried by this magma is of the order of 400 to 500 calories/gram, or about 500 kWhr/ton. A considerable amount of heat is therefore carried by each unit mass of magma. The rising magma is partially poured out at the surface in the form of lava by volcanoes, and partially trapped in near-surface layers where it forms intrusives of various types and shapes such as stocks, dikes, and sills. There are indications that the amount of magma forming intrusives is considerably greater than the amount of lava which has been poured out at the surface. The size and distribution of intrusives varies greatly.

A body of magma which has been injected into the upper parts of the crust will be cooled because of both conductive and convective heat losses to the surrounding rock. The process of cooling is rather slow, even on the geological time scale. For example, the time required for a purely conductive cooling of a sill having a thickness of one km is of the order of a hundred thousand years. It is obvious that large intrusives supply a very great amount of heat to the surrounding country rock.

Magma has in many locations been intruded into, or close to, porous and permeable water-bearing horizons relatively near to the surface. The heat escaping from the cooling magma raises the temperature of the country rock and this may result in the setting up of convective ground-water currents involving high-temperature waters. The convecting fluids carry great amounts of heat to the surface where thermal water, steam, and gases are issued by springs. Moreover, the convective currents greatly contribute to the distribution of the magmatic heat to the surrounding country rock.

These conditions exist in the well-known thermal areas which are found in most of the volcanic belts of the world. The thermal areas vary considerably in size and subsurface temperature. In the largest, surface thermal activity may be scattered over surface areas of tens of square kilometers and the total flow of sensible energy escaping from these areas in the form of hot water, steam, and surface conduction cooling may be of the order of one million kW of heat flow. Measurements of the energy escaping from thermal areas in Iceland and New Zealand indicate that in each country these areas dissipate a total of about 5 million kW of heat flow.

Although the magmatic origin of thermal areas has been stressed above there are good reasons to mention that a number of well-known, relatively low-temperature, thermal areas may be of non-magmatic origin. They may represent the outlets for circulation systems which reach considerable depths, for example, 3 km where the normal temperature would be of the order of 100°C.

The Geothermal Reservoir

In the previous paragraphs we have drawn a crude picture of thermal areas in general and stressed the volcanic, that is, magmatic origin. On this basis we can conclude that the major high-temperature thermal zones consist essentially of two parts, first, the primary magmatic heat source, and second, the permeable water-bearing formation heated by the primary source. This second part forms the geothermal reservoir or heat mine, which in many cases can be exploited profitably.

It is only fair to stress the uncertainty of some of the concepts applied. In fact, although a considerable amount of research has already been carried out in some geothermal areas, very little concrete information is available as to the source-reservoir relation. This is still one of the major problems of geothermal research.

Sufficient information is available, however, to draw the sketch in Figure 1. This sketch shows a primary heat source, which may consist of a single large intrusive, or of a great number of dikes, emplaced directly below a horizontally layered reservoir rock located near the surface. Heat is being conducted and convected into the reservoir, which has been heated to a temperature considerably above the normal for its depth. The reservoir is assumed to have a relatively large horizontal permeability along the contact of individual layers. Hence, the encroaching ground water can flow into the reservoir rock.

Reservoirs of this type are encountered in some of the large thermal areas in Iceland, where the reservoir rock consists of a series of flood basalts 2 to 4km thick. The horizontal permeability along the contacts of

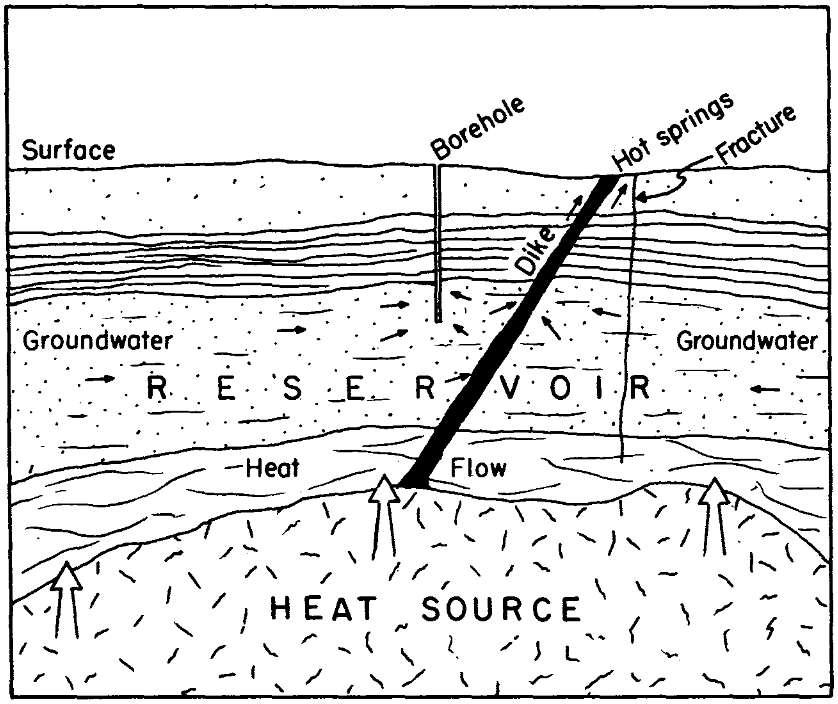

Figure 1. Sketch showing relationship of heat source to reservoir.

some of the lava flows is very great. A somewhat similar situation is encountered in the well-known thermal areas in Tuscany, Italy, where the reservoir consists of essentially a sedimentary series containing thick layers of limestones with solution openings. The thermal areas of New Zealand are also rather similar, since the reservoir there consists of a thick layer of highly permeable sediments. The horizontal extent of the reservoirs in these countries amounts to tens or hundreds of square kilometers.

With the help of this simple sketch, we are in the position to discuss a few important concepts which, to a certain degree, provide the foundation of geothermal reservoir mechanics. Within this context, it is helpful to realize that there is a rather close similarity between some of the processes encountered in petroleum and geothermal reservoirs.

Temperature measurements in boreholes in the major geothermal regions of the world have shown that the reservoir temperature is rather uniform below a certain depth, which may amount to a few hundred meters. This situation is indicative of a high permeability, since convection currents in the reservoir tend to equalize the temperature in the rock. The reservoir temperature at depth is perhaps the most important single reservoir concept and it has been called the base temperature of the thermal area. It is remarkable that the base temperature of the most of the major thermal areas of the world now under exploitation appears to be around 250° C.

The depth to the bottom of the reservoir is another concept of importance. This depth, which is sometimes called the base depth, is a vaguer idea than the base temperature. It depends on the permeability - that is, the reservoir terminates at the depth where the rocks become impermeable. There is little doubt that the reservoir depth is generally not less than 2 or 3 kilometers.

Two physico-chemical facts are of importance. First, the density of water at temperatures between 200° C and 300°C is considerably lower than the density below 100°C. For example, the density at 250°C is only 0.8 gm/cm^3, whereas the density at 50°C is 0.99 gm/cm^3. The high-temperature water within the reservoir, therefore, has a considerably lower density than the surrounding colder ground water. The surrounding water will exert a hydrostatic pressure on the reservoir and the density difference will then provide a strong gravity drive, if we borrow this concept from petroleum reservoir mechanics. Second, the solubility of many minerals in water increases substantially with the temperature; in this respect, silica is of particular importance. Moreover, the solubility of calcite is dominated by the amount of dissolved carbon dioxide. Since both temperature and pressure increase with the depth, we can expect the solubility of minerals to be much higher in the lower parts of the reservoir than in the near-surface layers. The reservoir fluids will, therefore, have a tendency to dissolve materials at depth and precipitate them near the surface. In many cases this leads to the formation of a rather impermeable cap rock above the main reservoir. Large thermal reservoirs may, for this reason, show very little surface display.

In geothermal reservoirs, heat is the principal commodity of economic value. It is, therefore, of utmost importance to be able to derive a measure of the heat content of a given reservoir. The above considerations show that this quantity will be proportional to the product of the reservoir volume and the sensible base temperature - that is, the excess reservoir temperature. In reservoirs with a base temperature of 250° C the excess temperature is of the order of 150° C, and it is easy to derive that the sensible heat energy content is then about 90 cal/cm^3 or about 100 kWhr/m^3. In the present context a more convenient unit is the MWyear, which is equal to 8.7 million kWhr. Expressed in this unit, the heat energy content would be roughly 10,000 MWyears/km^3. Hence, the total sensible heat energy content of a reservoir having a base temperature of 250° C, a thickness of 2 km and a horizontal extent of 50 km^2 would be about one million MWyears.

The available power, or rate at which this energy can be tapped, is another concept of great economic interest. Since water is the heat carrier, and the energy has to be "washed out" of the reservoir by the water flowing through it, the available power will depend completely on the magnitude and the geometry of the permeability of the reservoir - that is, on the rate at which water can be driven through it. It is independent of the energy content. A large reservoir with a negligible permeability may contain lots of energy, but its power is zero.

Exploitation

As already indicated, the exploitation of geothermal reservoirs is effected by a "washing out" of the sensible heat content of the rock. Wells are drilled into the reservoir in order to cut available fissures and permeable contacts. Because of the gravity drive of the encroaching colder ground water surrounding the reservoir, the high-temperature water in the fissures will be under artesian pressure and, in general, the wells will flow when a fissure has been cut. On the way to the surface, a part of the thermal water flashes to steam. Wells of this type will, in general, produce a steam-water mixture. Under certain circumstances, where there is a large exchange of heat between the water and the rock, the wells may even produce dry saturated or slightly superheated steam. The water produced by the wells is partially or wholly replaced by the inflowing ground water encroaching on the reservoir. Upon contact with the reservoir rock, this water is heated to the reservoir temperature and new thermal water is produced.

The heat-recovering process described above can theoretically be carried out as long as there is heat and water available. Moreover, under ideal circumstances, most or all of the sensible reservoir heat could be recovered. But actual situations are far from being ideal. In general, the permeability of the reservoir rock is unevenly distributed and the efficiency of the heat recovery is greatly reduced. This important matter will not be discussed further, but it is the opinion of the writer that under reasonably good circumstances the recovering of roughly 10 percent of the total sensible heat content should be possible.

If we base our considerations on a 10 percent recovery, we find that the geothermal reservoir discussed above, containing a total of one million MWyears of sensible heat, could produce about 100,000 MWyears of heat energy. Since a MWyear of heat energy corresponds to the heat content of about 5,000 bbls of petroleum, the reservoir would thus be roughly equivalent to an oil field containing about $\frac{1}{2}$ billion bbls of petroleum. This is an oil field of a substantial magnitude. The heat produced by such a reservoir is available in the form of a steam-water mixture produced by the wells and it can be utilized directly for building heating and chemical-process heating.

It is well known that the conversion of heat to electrical energy is a process of a limited efficiency. Thus, the conversion of the heat content of the steam-mixture produced by the wells to electrical energy has an efficiency of only about 10 percent. Hence, the over-all efficiency of the conversion of reservoir heat to electrical energy has an estimated efficiency of about one percent. In terms of electrical energy, the reservoir discussed above will be able to produce a total of 10,000 MWyears of electrical energy, that is, operate a power plant of 100,000 kW for a period of 100 years.

Exploration

In the initial exploration phase of a geothermal situation, we would be mainly interested in obtaining data on the following important characteristics: (1) the base temperature; (2) the horizontal extent and thickness of the reservoir; and (3) the permeability and the hydrological conditions.

The technique of exploring geothermal resources by the means of geological, geophysical, and geochemical methods falls into two classes: (1) the so-called direct or temperature-sensing methods, which have the aim of obtaining data on the subsurface temperature field, particularly the base temperature and the reservoir dimensions; and (2) the indirect or conventional structural methods, which have the principal purpose of uncovering the geological structure and providing information on the permeability situation. Since the second class of methods is largely identical with the conventional geological and geophysical methods in petroleum exploration and hydrology, our attention will be directed toward the direct methods which are of special importance in geothermal exploration. Three types of temperature sensing methods are available.

First is shallow temperature probing by the means of boreholes with depths ranging from 10 to 100 feet. An array of such boreholes is laid out in the area to be studied, and the temperature profile is measured accurately. Geothermal areas, even those with no surface display, will exhibit abnormally high temperatures in these boreholes. As of now, shallow probing is the most important direct exploration method in geothermal areas. This method yields important data on the magnitude and horizontal extent of geothermal anomalies. It has been used with success in many areas around the world. The relatively high cost is the main drawback of this method.

Second, the chemistry of water and gases issued by surface springs is indicative of temperatures at depth. As already pointed out, the solubility of many minerals in water is highly temperature dependent. Silica is mainly interesting because of its very slow precipitation from supersaturated solutions. The silica content of thermal waters issued at the surface will, in many cases, be almost equal to the silica content of the reservoir fluids. Since there is a relation between the solubility and the temperature, the silica content of the surface water will be indicative of the reservoir temperature and hence of the base temperature. This method has to be used with some care, since the nature of the reservoir rock has a dominant influence on the solubility of silica. But it has been of rather great value in Iceland, where conditions are quite favorable.

The third group consists of the D.C. conduction and the electromagnetic methods which measure the electrical conductivity of the subsurface. Due to high temperatures and relatively high concentrations of minerals in solution in thermal waters, the typical geothermal reservoir has a much higher electrical conductivity than ordinary rock formations. There may be a factor of 100 or even 1,000 involved. It is, therefore, possible to study geothermal reservoirs on the basis of electrical prospecting methods. But the D.C. conduction method has a rather limited depth penetration and the electromagnetic methods are still in an early stage of development.

Economics of Geothermal Heat Production

Under favorable conditions geothermal areas can provide a very inexpensive source of heat. Unfortunately, few reliable data have been made available on the production economics, but the following figures obtained from sources in Iceland should give a reasonable basis for areas where conditions are not too unfavorable.

Boreholes for natural steam in high-temperature thermal areas may have to be 2,000 to 5,000 feet deep and the main casing should have an inner diameter of not less than 8 inches. A borehole of this type can produce as much as 100 tons/hour of steam. The distance between individual boreholes may be several hundred feet. Including well-head facilities and piping of the steam to a collection center in the area, the total investment in boreholes and equipment has, in Iceland, been on the order of $5,000 per ton per hour of steam flow. On the basis of an interest rate of 6 percent, the production cost per unit mass steam delivered can be on the order of $0.15 to $0.20 per ton of steam delivered. These figures apply to relatively small installations. As a matter of course, the cost figures may vary considerably between areas.

In terms of cost per unit electric energy generated by natural steam, the above figures would indicate a steam cost of 1.5 to 2.0 mills per kWhr of electric energy. In the case of large installations under favorable conditions, a figure of 1.5 mills/kWhr should be easily obtainable.

Reference

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PLEASE STAY OUT OF OLD MINES!

Once again, please, if you are out in the hills just looking around, stay out of any old mines you come upon. The rock that was in the mine, along with any pretty minerals, is now on the dump. Look for them there.

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GEOTHERMAL ENERGY POTENTIAL IN OREGON

By Edward A. Groh*

An enormous source of heat exists within the depths of the earth. Throughout most of the world's surface this heat is too deep and too diffuse to be utilized as energy, but along the volcanic belts a concentration of it lies near the surface. Within these belts, displays of surface heat such as geysers, steam vents, and hot springs have captivated man's interest for centuries. Now, at several "hot spots" about the world, thermal energy has been put to work developing a total capacity of 1 million kw of electric power as of this date.

World Geothermal Development

The first harnessing of natural steam for electric power was accomplished at Larderello, Italy, a little more than 60 years ago. Production has now risen to 370,000 kw, and other thermal areas in Italy are being explored. At its Wairakei Hot Springs area on North Island, New Zealand has developed more than 150,000 kw capacity and expects to reach 250,000 kw in the near future. Other thermal areas of the North Island are also being explored. Some 50,000 people in the vicinity of Reykjavik, Iceland, are provided residential and building heat by natural hot water. Since Iceland has sufficient stream flow for economic hydroelectric power generation, there is no immediate need for geothermal power development; however, studies in this field have been made. Besides these three examples in foreign lands, exploration and development is going on also in Japan, Mexico, USSR, Central America, Kenya, Java, New Britain, and the Fiji Islands, and a number of other countries are beginning to look at their geothermal potential.

It has been only within the past 10 years that geothermal power has received serious attention in the United States. Increasing demands for energy have prompted the utilization of natural steam at The Geysers, Calif. This locality, which has long been known for its natural steam vents, is now operating at a capacity of 27,000 kw. A similar capacity has been produced recently from wells drilled about a mile to the west and an additional generating installation is planned. Exploration at Casa Diablo, Calif., and at Beowawe and Brady Hot Springs in Nevada indicate a power capacity

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which may be exploited in the near future. Unusual are the wells which have been drilled in the Niland, Calif., vicinity. Here a concentrated brine and steam mixture is produced which is very hot (450°F or more), and bottom-hole temperatures as high as 800°F have been measured. The brine alone may be valuable for recovery of its contained potash, lithium, copper, and silver.

Geologic Environment of Geothermal Areas

Most geothermal areas known today are associated with structural features which show both uplift and subsidence in the belts of recent volcanism. The movement of magma within the crust and to the surface is believed to be the major factor producing these structures. Several of the geothermal areas are located on primary rift zones of the world, where heat presumably is flowing up from greater depths within the earth. Many of these features have their counterparts in Oregon, as will be discussed later.

Although surface display of steam or hot water is a great aid in the location of geothermal reservoirs, it is not necessarily present in all reservoirs. Without surface indications, reliance must be placed first on finding geologically similar structures and then on measuring the geothermal gradient by the use of shallow drill holes. Much more needs to be learned about the relationship of geothermal sources and geologic structures to aid in the application of geothermal gradient surveys for these hidden reservoirs. As the science and technology improves, hidden sources of heat will provide an ever-larger part in the supply of geothermal energy.

Role of Geothermal Energy in Oregon

Recently the Bonneville Power Administrator stated that planning must go forward on steam plants for the generation of electric power, which will be needed in the Pacific Northwest after 1975. By that time, all the economic hydropower sites of the region will be under construction or in operation. These future thermal plants will require fuel, either fossil or nuclear. Except for some coal fields in central Washington which may prove economic, the fuel resources of the Northwest are scant. At present, oil and gas are transported into the region from outside sources and are costly for power production. Even discoveries of these hydrocarbons on land or off shore in the Pacific Northwest would not necessarily make them more economic. Under the current trend of capital and fuel costs for thermal power plants, nuclear power will in all probability be the preferred type for installation in the Northwest from 1975 on.

Largely ignored in this future power picture is the role which geothermal energy could play, especially in Oregon. Of all the western states, Oregon has been favored with the greatest amount of volcanism throughout the Tertiary and Quaternary periods. Therefore Oregon should have an excellent geothermal-energy potential. It is not unreasonable to expect that 20 years from now a share of the thermal power capacity will be supplied from geothermal sources. Coupled with this expectation is the evidence that geothermal electric power can be as low in cost or lower on the average than power generated by any other method. As the technology of finding and exploiting natural steam fields improves, costs should go down, which in turn will spur greater effort in producing this natural resource. Therefore, its potential should not be discounted at this time, since development of this energy is in the state of earliest infancy.

Conversion of the heat in natural steam to electric power is the most convenient method of utilizing the energy, because electricity may be transmitted considerable distances economically. Under some conditions, though, the steam could be more valuable when used in industrial heating. Large consumers of process steam, such as the pulp and paper industry or some types of chemical plants, might find it desirable to locate near a geothermal steam field, provided that other factors were favorable. Costs per unit of heat can be very low when geothermal steam is used in this manner.

Exploration for Geothermal Sources in Oregon

Initially, the groundwork for exploration of geothermal sources in Oregon will probably fall on the public agencies concerned with geology and minerals. Field studies, mapping where necessary, temperature measurements, well logging, photogeologic studies, limited geophysical surveys, and compilation of the data will need to be accomplished in order to provide fundamental information for private industry interested in Oregon's geothermal future. Some of this preliminary work is already in progress. For example, gravity data gathered from private and public sources is being plotted at the Oceanography Department of Oregon State University, and a gravity map of Oregon will soon be published. This map should be of considerable help in interpreting a number of structures that may be related to geothermal sources. Research in the use of electromagnetic methods for outlining higher temperature zones in the earth's crust is another example of geothermal studies now in progress. There is a paucity of basic heat-flow data concerning the western states and none at all for Oregon. Information of this sort can aid greatly in delineating the hyperthermal regions of the state on which the major development efforts should be brought to bear. It is hoped that research groups now engaged in this work elsewhere can be encouraged to do some of it in Oregon.

Private enterprise has been seriously hindered so far in geothermal exploration on public lands in the United States. Exploration and development work which has been done on federal lands proceeded either under the general mining laws or mineral leasing acts. Neither provides any clear-cut legal rights of ownership regarding geothermal steam or fluids. In 1964 the Eighty-eighth Congress sought to remedy this situation by instituting a geothermal steam-leasing act. It was passed by the Senate, but failed to make the floor of the House. An improved version of this leasing act has been again passed by the Senate in the present Congress and now awaits approval in the House. It is hoped that passage will be accomplished shortly. Upon establishing the statutes governing the production of natural steam from public lands, private developers should begin to take an ever greater interest in this form of energy. Passage of this legislation is particularly important to Oregon, since within the area favorable to geothermal exploration at least two-thirds of the land area is federally controlled.

Prospective Geothermal Areas in Oregon

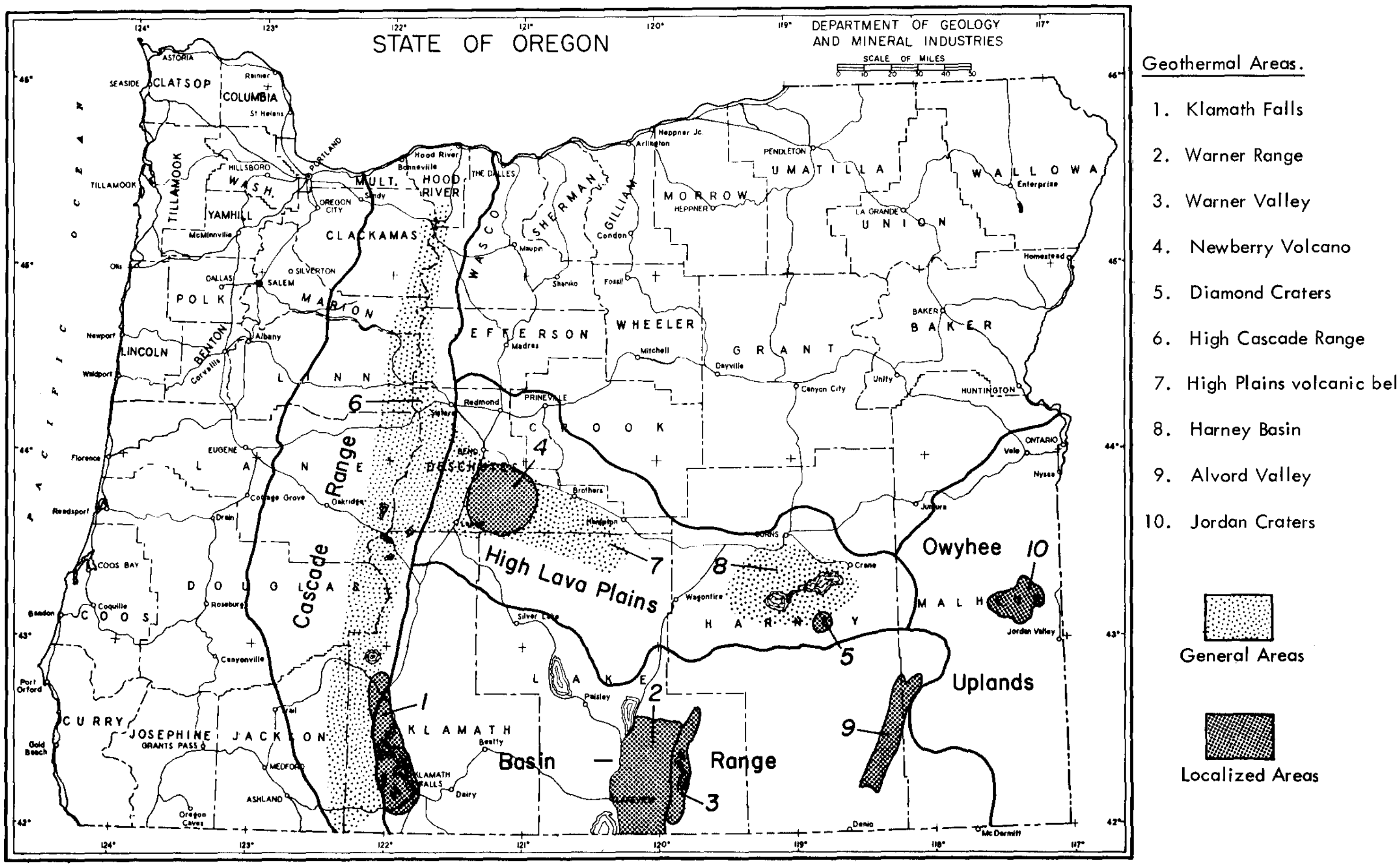
The possible geothermal areas of Oregon are, in general, within four contiguous physiographic divisions (see accompanying map): the Cascade Range, the High Lava Plains, the Basin-Range, and the Owyhee Upland. Together they form a region comprising more than 40 percent of the state's total area. Practically all of the late Cenozoic volcanic activity has occurred within this region. About 80 of the 100 thermal springs known in Oregon are found within its borders.

Some of the structural and volcanic features which appear attractive as possible geothermal sources are briefly described below.

Klamath Falls area

Within the city of Klamath Falls is Oregon's major geothermal display. The hot springs and wells drilled in the thermal area have been utilized for the space heating of many residences and other buildings since 1900. The thermal zone is located along one of the many northwest-trending faults prevalent in the Klamath Basin. To the north, a graben has formed and this major structural feature extends on towards Crater Lake. No thermal springs are present along the bounding faults of the graben; nevertheless, a geothermal potential is strongly indicated by this depression, which is believed to be associated with the volcanism in the Cascade Range to the west. Many of the faults in the Klamath Falls area have exposed slickensides indicating very recent movement. In these respects, the area resembles the Wairakei geothermal region of New Zealand, but smaller in area. The thermal fluid being discharged at Klamath Falls has a high sulphate - low chloride content which strongly suggests a volcanic origin for its heat. One is tempted to theorize on the possibility of a deeper thermal reservoir which may be leaking only a small portion of its heat upward along a fault. Mixing of this thermal fluid from depth with cool ground water may set up a near-surface convective circulation which provides the hot springs at Klamath Falls.

The large heat flow manifested in this area makes it the prime prospect in Oregon for eventual geothermal-power development. With large



PHYSIOGRAPHIC DIVISIONS AND PROSPECTIVE GEOTHERMAL AREAS IN OREGON.

power-transmission lines crossing the area already and an intertie line being built, there is no problem of a market for energy. Immediate work suggested for this prospect would be a detailed geologic field and photogeologic study, coupled with measurement of surface-heat flow. Gravity, and perhaps some seismic and electromagnetic, surveying would be the next step. Results from these investigations would determine if the risks of a full geothermal exploration program were warranted.

Warner Range

Standing as a horst bounded on the east and west by faults, this structure is of geothermal interest for the numerous hot springs along its margins. A thermal zone along the east side about 4 miles north of Adel was drilled by Magma Power Co. in 1959. Although the results were not satisfactory, the well did erupt as a continuous geyser for more than a year. Wells have been drilled and some steam produced on the eastern, or Surprise Valley, side of the extension of the Warner Range into California. On the western margin, an oil test well was drilled by Humble Oil Co. in 1961. Bottom-hole temperature at total depth of 9,564 feet was 295°F as recorded on the electric log. Since equilibrium conditions were not reached prior to the temperature measurement, true temperature is undoubtedly greater and signifies a high geothermal gradient. Near the Oregon border, late Tertiary silicic volcanic intrusions are exposed which are part of a group continuing into California. The Warner Range horst bears certain similarities to the geologic structure at The Geysers steam field. The structure at The Geysers has been attributed to upthrusting by a probable bathylithic intrusion, which may also be conjectured as a cause of the Warner Range feature.

Here, again, detailed geologic studies will be needed to appraise the potential of the area. Follow-up by geophysical surveys and, if favorable, ultimately by drilling must be done to give the answers on the geothermal potential this structure holds.

Warner Valley

This structural trough or graben lies on the east side of the Warner Range. The high scarps of Hart Mountain and Poker Jim Ridge border the graben to the east. It has a width of 5 to 6 miles and is more than 40 miles in length. A number of hot springs are present along the bounding fault zones. The close association of this feature of subsidence with its complement, the Warner Range horst, may indicate large-scale movement of magma at depth. Although much of the subsidence is Recent, the graben probably has been active since Pliocene time. This offers an opportunity for an accumulation of sediments in which the pervious beds may act as reservoirs for thermal fluids rising from depth. Again exploration of this structure will require the geological and geophysical studies mentioned for the

Warner Range. Part of the data gathered will be common to both features.

Newberry Volcano

During late Cenozoic time this immense shield cone, some 20 miles in diameter, was formed from innumerable eruptions of lava. In the latest Pleistocene a collapse of the summit began, probably from many flank eruptions which withdrew magma from the reservoir and, therefore, support from the roof. Collapse proceeded, along with some infilling by later volcanic action, to produce the caldera now called Newberry Crater. From the size of the caldera, about 4 miles wide by 5 miles long, it has been estimated that the magma chamber may lie at shallow depth, perhaps as little as 2 miles. Since the magma chamber was only partly emptied in the recent collapse, in all probability a very large body of hot magma underlies this feature. A great amount of heat must flow outward from the remaining magma and, if aided by thermal convection currents to higher levels, could offer a tremendous geothermal source. Several surface thermal indications are present within the caldera, and the caldera block would be most attractive for exploration. Because of its value for recreational purposes, the caldera is closed to any mineral exploration. Nevertheless, the great flanks of the shield are available. Although no surface thermal displays are known to exist on the flanks, this does not preclude the finding of vast quantities of heat at economic depths around the flanks.

Geothermal exploration of Newberry Volcano will require a heavy reliance on geophysical methods to seek out the hidden heat zones. There will probably be a great need for borehole surveys to determine geothermal gradients. Yet efforts may eventually prove a vast heat source.

Diamond Craters

This area is exceptionally inte esting, since preliminary study indicates that a laccolithic intrusion ha. taken place at shallow depth. After the extrusion of a lava field about 25 square miles in extent, intrusion of basaltic magma domed part of the area. An age of around 5,000 years is estimated for the intrusion. Except for the eruptive phenomena accompanying the volcanism and intrusion, no surface displays of thermal waters occurred or are evident now in the immediate vicinity. The only heat flow to the surface is by conduction alone and the intrusion should be still quite hot. The domed structure is probably a closed system. While nothing is known concerning the permeability of the laccolith, it is reasonable to expect that an influx of ground water through fractures could take place, generating a flow of steam when tapped by wells. If a natural flow did not take place or was insufficient, injection methods might be tried experimentally. Estimated thermal conditions of the Diamond Craters area do not appear to offer an immense heat source. Nevertheless, it remains as an intriguing area where high temperatures probably can be reached at a depth of around 1,000 feet. Exploration is needed to determine if an economic steam field can be developed.

High Cascade Range

Extending the length of Oregon from north to south, this volcanic pile represents part of the largest and latest extent of volcanism in the conterminous United States. The High Cascades division formed, from Pliocene time onward to the present, on an older Tertiary volcanic basement. The tens upon tens of thousands of separate eruptions required to build this volcanic chain must have resulted from a fundamental but as yet unknown process at work in the earth's interior. Obviously a great amount of heat has been brought near the surface by virtue of this activity.

Numerous hot springs are present in and about the High Cascades, although no unusual indications of heat are displayed. Yet it is difficult to believe that there are not innumerable bodies of hot rock and magma at shallow depths. The segment of the Cascades running from Mount Jefferson to Crater Lake is particularly impressive, since so much late Quaternary and Recent activity centered here. Many of the large cones very likely are underlain by large magma chambers at no great depth. Before some of this heat can be utilized, further progress in geothermal exploration and development will be needed. The area remains one of great potential for the future.

High Plains volcanic belt

A zone of intense Quaternary volcanism extends some 75 miles southeast from the Three Sisters in the Cascade Range. Within this belt is Newberry Volcano, previously described as an individual geothermal prospect. A dominant fault zone beginning in the neighborhood of Mount Jefferson curves off to the southeast towards the Harney Basin. The fault zone generally separates the older Cenozoic rocks to the north from the late Cenozoic rocks to the south. The High Plains volcanic belt seems to be strongly associated with the fault zone. Volcanism is confined to the south and parallels it. Because of the great amount of late Quaternary eruptive activity in this belt, it should be of future interest in geothermal exploration.

Harney Basin

A number of hot springs which occur in this area are no doubt a result of the volcanism of late Cenozoic time. Vast sheets of ignimbrites and tuffs surround much of the basin. In this respect, the basin may have a volcano-tectonic origin and be similar to some other localities of this type throughout the world where geothermal investigations are proceeding. Again, this is an area open to future study and possible exploration.

Alvord Valley

This graben is bordered on the west by the great Steens Mountain fault scarp and on the east by low fault scarps. The graben valley is from 6 to 9 miles wide and about 30 miles long. Several hot springs occur along the margins and also within the valley south of Alvord Lake. Although the amount of subsidence is unknown, the fault activity probably began in the Pliocene and has continued to Recent time. The valley may contain an accumulation of sediments in which thermal fluids could be trapped.

This structure resembles the previously described Warner Valley in many respects; studies suggested for that feature would also apply to Alvord Valley.

Jordan Craters

Northwest of the town of Jordan Valley, basaltic lavas of late Pleistocene to very Recent age have been extruded over an area of several hundred square miles. A few thermal springs occur within the general area. Below the lavas, older lacustrine and tuffaceous sediments are predominant. Laccolithic intrusions similar to those at Diamond Craters may penetrate these incompetent strata, making this area a geothermal prospect. Initially, photogeologic studies will be of greatest benefit with a follow-up by geophysical work on any suspected dome-like structure.

Summary and Conclusions

Earth heat energy has been harnessed at several places in the world to make electricity; the installations are economically successful, and this is spurring further exploration and development, such as at The Geysers, Calif. Geothermal regions appear to be intimately connected with certain structures in zones of late Cenozoic volcanism, and since Oregon has received as much late Cenozoic volcanic activity as practically any part of the world, it would seem to be in a most promising position for exploration and development. Those concerned with future power requirements of the Pacific Northwest have stated that after about 1975, new supplies of electric power in the Pacific Northwest will need to be generated from thermal plants, since all the satisfactory hydro sites will have been developed. Most of this new power capacity will be nuclear, because fossil fuels are scarce in the region. Economic studies of currently operating geothermal power plants show that they can produce power at a cost competitive with contemplated nuclear plants. In this light, it would seem that effort should be directed now towards finding geothermal resources in Oregon.

About 40 percent of the land area of Oregon has been subjected to late Cenozoic volcanism, and within this area a number of tectonic structures having uplift and subsidence exist. Of these, the Klamath Falls area, Warner Range, Warner Valley, Harney Basin, Alvord Valley, and Diamond Craters appear to be logical geothermal prospects. Other possible areas are the High Cascades Range, the High Plains volcanic belt with Newberry Volcano, and the Jordan Craters volcanic area.

Much of the preliminary work in geothermal exploration of these structures will consist of mapping, photogeologic studies, geophysical studies, and field observations. Most of this work will probably need to be done by public agencies in order to provide a foundation for exploration and development. From this point it is up to private industry to become interested and to take the risks inherent in the future development of this form of energy.

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MOUNT JEFFERSON PRIMITIVE AREA DESCRIBED

The U.S. Geological Survey has issued Bulletin 1230-D, "Mineral Resources of the Mount Jefferson Primitive Area, Oregon," by George W. Walker and Robert C. Greene of the U.S. Geological Survey and Eldon C. Pattee of the U.S. Bureau of Mines. The bulletin is one of a series of mineral surveys being made of primitive areas to determine their suitability for incorporation into the Wilderness System.

The Mount Jefferson primitive area, encompassing more than 150 square miles, extends for about 25 miles along the crest of the Cascade Range in Jefferson, Marion, and Linn Counties. The area is underlain by predominantly volcanic rocks which range in age from middle Tertiary to Recent and correlate with the older Western Cascades and younger High Cascades volcanic units. The only mineral deposits found in the area were small amounts of alunite and native sulfur near volcanic vents and scattered deposits of pumice and cinders, none of which were considered by the authors to be of commercial value.

The 32-page bulletin with geologic map may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. The price is 55 cents.

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SUPPLEMENT TO THESES BIBLIOGRAPHY PUBLISHED

The Department has issued "Bibliography of Theses and Dissertations on Oregon Geology, from January 1, 1959 to December 31, 1965," compiled by Miriam Roberts. This new publication is a supplement to the Department's Miscellaneous Paper 7, which lists theses on Oregon geology from the earliest known through 1958. The supplement lists 94 theses and includes an index map of the State showing location of theses that cover specific areas. Supplement to Misc. Paper 7 can be purchased from the Department's offices in Portland, Baker, and Grants Pass for 50 cents. Copies of the earlier report are still available, also at a price of 50 cents.

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LUNAR CONFERENCE BULLETIN REISSUED

The popular Lunar Geological Field Conference Guide Book, first issued last year, has been reprinted. The new issue contains the same material that appeared in the original printing, with additional photographs. Four Ranger Nine photographs of close-up views of the lunar surface have been added to show the close resemblance of the moon's surface to that of parts of the Bend area of Central Oregon. There are 18 colored geologic and index maps which accompany the detailed geologic descriptions of the five field trips to the unique volcanic features in the area. Copies are available from the Department's office in Portland at $3.50 per copy, postpaid.

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GEOLOGIC HISTORY OF FOSSIL LAKE PUBLISHED

"Fossil Lake, Oregon -- Its Geology and Fossil Faunas," by Ira S. Allison, has been published as Oregon State Monograph, Studies in Geology No. 9. The 48-page booklet is illustrated with sketch maps, diagrams, and numerous photographs. It contains an index and an extensive bibliography. The publication can be obtained from Oregon State University Press, Corvallis, Oregon, for $2.00.

Dr. Allison has studied the geology of the Fossil Lake area over a period of many years. In this monograph he has gathered together his own findings, along with those of other workers, and has come up with a comprehensive report on the Pleistocene lake beds and their relation to the abundant fossil fish, mollusks, birds, and mammals. In addition to their paleontological significance, the lake beds reveal a sequence of regional events dating back 100,000 years to include development and waning of large pluvial lakes and the final eruption of Mount Mazama.

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The ORE BIN
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STEIN'S PILLAR AREA, CENTRAL OREGON

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Introduction

Stein's Pillar * is an imposing natural column of light-colored rock, about 120 feet in diameter, that towers 350 feet into the air -- well above the ponderosa pines at its base. It lies about 17 miles east of Prineville, Oregon, and is easily reached by following U.S. Highway 26 nine miles to the east from Prineville, then turning north onto the Mill Creek Road near the east end of Ochoco Reservoir. The pillar is plainly visible on the east side of the Mill Creek road, 8 miles from its junction with U.S. Highway 26.

Southwest of Stein's Pillar, within a quarter of a mile, are two additional picturesque crags, eroded from the slightly sintered to moderately welded tuff (ignimbrite) that forms the pillar (see accompanying map). All three crags lie on the nose of a sharp ridge that dies out a quarter of a mile north of Stein's Pillar in the valley of Mill Creek, but which rises steeply to the south-southeast, culminating about $1\frac{1}{2}$ miles from Stein's Pillar in Rocky Butte (elevation 5,343 feet).

The ignimbrite from which most of this ridge is carved is water retentive, and supports a forest composed chiefly of ponderosa pine on the lower slopes, but with dense thickets of lodgepole pine and other trees on the higher summits -- especially on Wildcat Mountain about 4 miles to the northeast. By contrast, the slopes across Mill Creek to the north of Stein's Pillar are almost barren. The altered andesite flows and mudflows which

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* According to the Oregon Historical Society, Steins Pillar should more properly be Steens Pillar. It was probably named for Major Enoch Steen of the U.S. Army, who, with Captain A. J. Smith, explored this region in 1860 in search of a shorter military route between Fort Dalles and Great Salt Lake. Their route through central and southeastern Oregon became known as the "Steen's and Smith's Road," and various topographic features were named after them. Unfortunately, on some old maps and records, Steen became Stein. This misspelling was often applied to Steens Mountain, and it took an official proclamation by the U.S. Board of Geographic Names to correct it.

Stein's Pillar, composed of three layers of ignimbrite, stands 350 feet high and 120 feet in diameter on Mill Creek road, 8 miles north of U.S. Hwy. 26 east of Prineville. This pillar and two craggy rocks to the right are erosional remnants of once-continuous flows of welded tuff (ignimbrite) of the John Day Formation. This water-retentive rock supports a forest of ponderosa and lodgepole pine. (Oregon State Highway Department photograph.)

underlie them are nearly impermeable; most of the rain that falls runs off once. Therefore, these hills are clothed mainly by bunch grass, sunflower, and sagebrush, with scattered clumps of mountain mahogany, sparse junipers, and a few lone remnants of ponderosa pine.

This picturesque area contains a remarkable diversity of animals and plants. Deer, porcupine, groundhogs, golden-mantled squirrels, lizards, and rabbits abound. Coyotes, bobcats, skunks, raccoons, and black bear are less common; mountain lion have been seen in the dense thickets that cover Wildcat Mountain. A wide variety of both forest and upland birds nests in the open forests and grass-covered glades. Turkey vultures and several varieties of hawks patrol between Stein's Pillar and the craggy summits of Rocky Butte. Tiny burrowing owls hunt for grasshoppers and mice on the barren ridges to the north -- where seed-eating birds such as quail, prairie chickens, meadowlarks, and many kinds of sparrows and finches nest in the grassy glades and brushy canyons. Abundant wildflowers attract great hordes of butterflies.

Geology of the Area

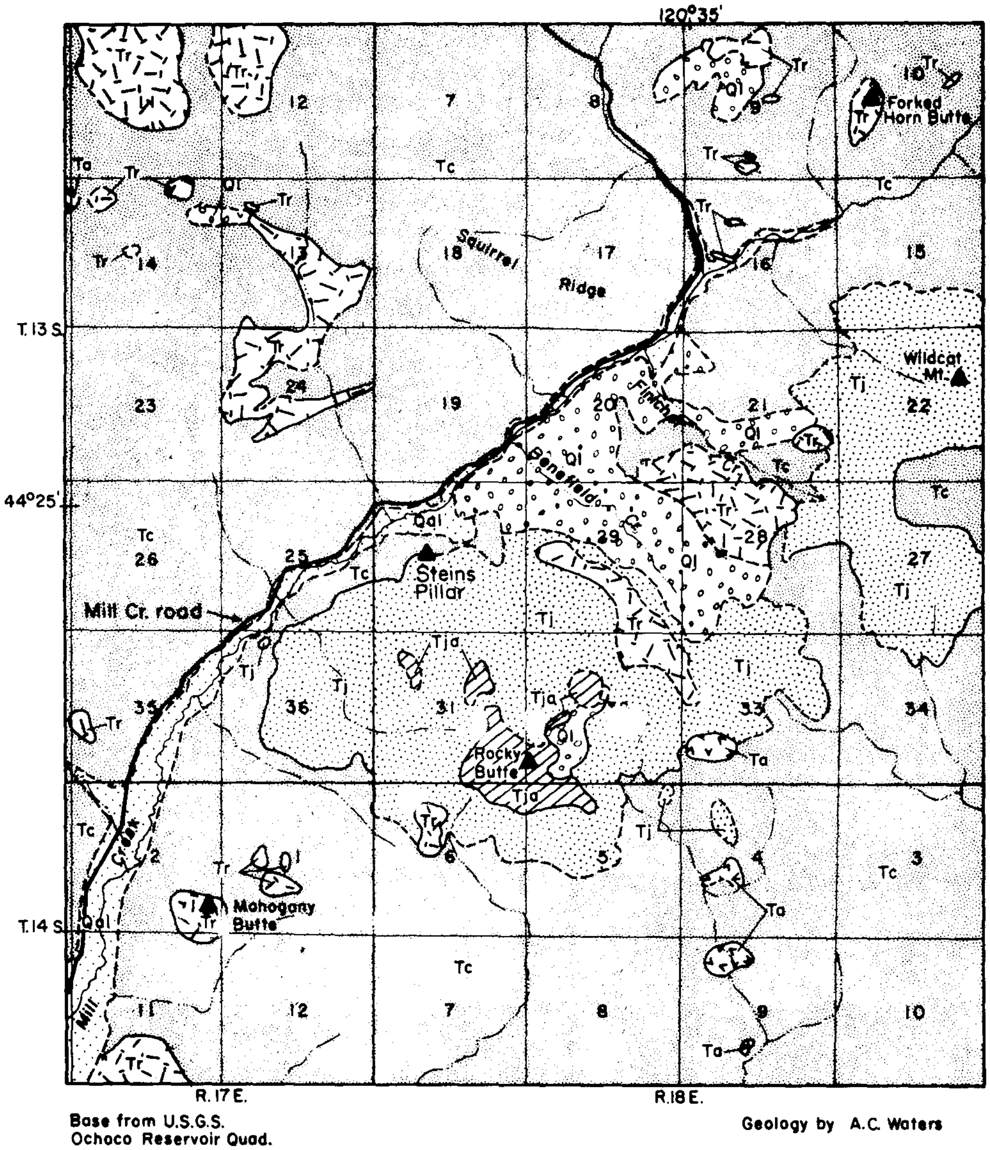
Clarno rocks

The oldest rocks of the Stein's Pillar area are lava flows, volcanic ash, and extensive volcanic mudflow deposits. These were spread from numerous volcanoes that dotted the area during the Eocene period, about 50 million years ago. The climate was humid and subtropical as reconstructed from fossil leaves and petrified wood found in thin beds of shale interbedded with the lavas. A semi-tropical climate is also indicated by the semi-lateritic weathering profiles that developed on the lavas and pyroclastics after their extrusion. Much of the area was apparently low and swampy, with numerous shallow lakes in which mud and plant debris accumulated. The rise of hot molten lava into and through these swamps and lakes caused explosive disruption of the water-soaked sediments and their intimate intermingling with the shattered lava. Extensive hot mudflows of shattered rock encased in a muddy matrix spread as tongues and lobes downslope from the volcanic conduits.

These mudflows, lava flows, and related sediments comprise the Clarno Formation, named by J.C. Merriam from Clarno's Ferry on the John Day River about 40 miles to the north.

Erosion and weathering of Clarno rocks

After several thousand feet of Clarno rocks had accumulated, a period of gentle folding and uplift ensured. Long-continued weathering and erosion then reduced the mountainous surface to an area of rolling hills, diversified by sharp buttes and ridges. The more resistant volcanic plugs,



GEOLOGIC MAP OF THE STEINS PILLAR AREA,

CROOK COUNTY, OREGON

EXPLANATION

Quaternary	Qal	Alluvium.	
Quaternary	Ql	Landslides.	

UNCONFORMITY

Oligocene	Tr	Rhyolite domes, plugs and flows.	John Day Formation
Oligocene	Tj	Welded tuff, sintered tuff, and tuffaceous clays.	John Day Formation
Oligocene	Tja	Andesite.	John Day Formation

UNCONFORMITY

Eocene	Ta	Andesite plugs.	Clarno Formation
Eocene	Tc	Andesite and quartz basalt flows, mudflows and tuffs.	Clarno Formation

Contact, well located.

Contact, inferred.

dikes, and thicker lava flows were left etched into relief as erosion wore away the easily removable mudflows, tuffs, and shales.

Tropical weathering still prevailed into Oligocene time -- about 25 to 30 million years ago -- when the next major period of volcanism began. This was the volcanism that produced the welded tuffs from which Stein's Pillar is carved, and the ash falls, tuffaceous clays, and occasional basalt flows that collectively make up the John Day Formation in this part of central Oregon.

Before John Day volcanism began, however, weathering of the Clarno rocks had produced a deep-red, alumina-rich, clay soil 2 to 100 feet thick over the well-drained uplands. In the ancient valleys this red, semi-lateritic soil graded laterally into yellow silts, or green and gray clays which record the former presence of swampy areas and of flood plains along sluggish streams. Even the craggy surfaces of the butte-forming volcanic plugs were reddened, discolored, and mildly silicified during this period of weathering.

John Day volcanism

The sudden onset of an exceptionally violent episode of John Day volcanism buried this soil and preserved it as a saprolite beneath a thick accumulation of hot pumice fragments, glass shards, and violently vesiculating lava that frothed from numerous volcanic orifices -- many of whose sites are now filled with plugs, domes, and dikes of rhyolite. Among these former centers of eruption are the ridges on either side of Benefield Creek, Forked Horn Butte, Mahogany Butte, and many unnamed sharp buttes both to the north and to the south of Stein's Pillar.

The flows of hot pumice fragments and glass shards pouring from these volcanic centers spread into and filled an ancient broad valley. Part of the valley, in the area between Wildcat Mountain and Stein's Pillar, now lies buried beneath as much as 1,000 feet of sintered and welded tuff. These hot avalanches of pumice and ash accumulated very rapidly; at many places an earlier deposit was still hot when the next searing cloud of pumice and dust arrived. Therefore, although most individual eruptions spread in broad lobes generally less than 200 feet thick across the nearly level surfaces of the next-earlier mass of ash and pumice, the cooling units as contrasted to the individual eruptive lobes were 500 or more feet thick. Cooling units formed when the successive lobes of two or more volcanic eruptions chilled together as a single unit -- in other words, the lower layer was still hot and plastic at the time it was overwhelmed and buried beneath the next hot avalanche of pumice and dust.

Stein's Pillar itself is a single cooling unit, but it is composed of at least three successive hot avalanche deposits, each of which must have arrived practically on the heels of its predecessor. Three of these units can be seen in the accompanying photograph of Stein's Pillar: The top of the lowermost unit is about one-third of the way up from the base of the pillar and is seen as a narrow ledge across the left side of it. A similar junction between two separate pulses of the pumice and ash is more clearly visible about a quarter of the distance downward from the top of the pillar as a series of ledges and cracks sloping across the face of the pillar toward the left. The top of the pillar also slopes in the same direction, and marks the junction with a fourth deposit of pumice and ash which has been completely removed by erosion. Its former presence is revealed, however, by the siliceous crusts that have leached down from it to cement the openings in the top of the unit beneath. This cementation formed the thin but strong overhanging ledge that caps Stein's Pillar. Note, however, that all of these separate pulses of frothy pumice and ash cooled as one unit, allowing vertical contraction joints to pass through them uninterrupted. This is shown even better in the massive crag just to the south (right in the photograph) of Stein's Pillar.

The slow loss of heat from these rapidly accumulated pulses of hot shards and ash produced notable changes in the rock during the cooling processes. Adjacent bits of frothy pumice were hot and plastic enough to stick together, flatten out, and lose most of their contained gases. Frothy filaments of glass forming the walls between tiny bubbles collapsed, welding their walls tightly together. Glass shards, still soft and plastic, draped over the sides of stronger minerals and tiny rock fragments. By these processes a highly inflated mass of hot rock froth collapsed and sintered into a coherent sheet of ignimbrite.

Still other changes occurred in much of this ignimbrite during the cooling process. Glass crystallizes into spherulitic bodies when cooled slowly. Much of the welded tuff of the Stein's Pillar - Wildcat Mountain area is crowded with whitish ball-like masses or spherulites ranging in size from tiny birdshot to spheres the size of a tennis ball. These are composed of thickly packed fibers of sanidine and cristobalite radiating outward from a common center. Still later in the cooling process, the vertical contraction joints split the rock into long, slender columns. Millions of years later, erosion progressing rapidly along these joints etched the outcrops into the numerous crags of which Stein's Pillar is one.

Alteration, weathering, and erosion

During the episode of burial in the ground, prior to this final period of weathering and erosion, further changes occurred in the rocks. Volcanic glass is inherently unstable. If exposed to water underground, it absorbs a part of this water, swells, and slowly recrystallizes into a mixture of clays and zeolites. The rock of Stein's Pillar contains abundant montmorillonite clay and several zeolites, among them clinoptilolite and mordenite. In the process of argillization and zeolitization, silica is released; it migrates into cavities and openings, sealing and hardening the rock. Some of the spherulitic forms described above were hollow and many of these have been filled with secondary opaline or chalcedonic silica forming small "thunder eggs" -- the official State Rock of Oregon.

On exposures to air, still other changes set in. Rainwater dissolved some of the soluble zeolites and other minerals in the rock, then concentrated them in hard crusts by evaporation on the rocks' surface. The walls of Stein's Pillar have been "case hardened" in this way, and in places are "painted" by a yellow-brown stain from the strong pigment formed by the oxidation of the few iron-bearing minerals in the ignimbrite. This case hardening of the outer surface of Stein's Pillar poses a particularly treacherous problem to rock climbers. It is easy to drive a piton into this apparently firm rock, but the piton shatters and peels loose the hard, thin crust for an inch or two, gripping only the soft, chalky rock beneath. Rock climbing on these treacherous crags should certainly be discouraged for anyone other than professionals thoroughly versed in the nature of rocks "case hardened" by weathering.

In addition to crags such as Stein's Pillar, the processes of weathering and erosion have produced other striking features. Where heavy basalt flows, welded tuffs, or other well-jointed rocks rest on the slippery saprolite beneath the John Day Formation, great landslides have developed. The vertically jointed rocks give way and skid downhill on the greasy material. The entire valleys of Benefield and Fintcher Creeks, north of Stein's Pillar, are choked with these hummocky landslides. Elsewhere, as along the contact between the Clarno and John Day Formations about a mile south of Rocky Butte, the red saprolitic clay has swelled up with each rain, and has been washed downhill by rainsplash and rills, spreading a paint of bright red or pink over the rocks and soils below the outcrops of saprolite.

Conclusion

The Stein's Pillar area contains a number of extraordinarily interesting geologic features, among which Stein's Pillar is the most spectacular. In addition to the geology, there is a remarkable diversity of plants and animals to be seen. All of these natural features make this locality well worth the eight-mile side trip up Mill Creek road off U.S. Highway 26.

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SEISMIC REFLECTION STUDIES OF BURIED CHANNELS OFF THE COLUMBIA RIVER

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ABSTRACT

Five continuous seismic reflection profiles were established between the Astoria Submarine Canyon and the mouth of the Columbia River. Subbottom geological structure to a depth of about 750 feet below the bottom was investigated. While presently there is no direct drainage system between the river and the submarine canyon, evidence for at least two buried channels was found. These channels may have linked the river and the canyon in the past.

Introduction

On June 23 and 24, 1963, five continuous seismic reflection profiles were established on the continental shelf 6 to 12 miles west of the Columbia River. Figure 1 shows the positions of the reflection profiles. Each traverse was between 8 and 10 miles in length, and is normal to the present trend of the Columbia River and Astoria Canyon. The most westerly line (Line E) was positioned across the head of the Astoria Submarine Canyon. This study was undertaken to determine if previous drainage patterns could be found.

Equipment and Procedure

The seismic reflection profiles were made using an acoustical sounding probe called the "sparker." A block diagram for this system is shown in Figure 2. For this work, two electrodes separated by one inch were towed 100 feet behind the ship at a depth of 15 feet, and 125 joules of electrical energy were discharged at a predetermined rate. The electrical energy was stored in capacitors until it was discharged by a trigger which was coupled to the recorder.

The spark discharge was approximately equivalent to the energy discharged by a conventional blasting cap. The pulse of sound energy spread spherically from the spark electrodes and energy was reflected (or echoed) from the bottom of the ocean and subbottom geological horizons to a depth of about 750 feet from the surface of the sea.

Reflections were received by a hydrophone which was towed 150 feet behind the ship at a depth of about 15 feet. The hydrophone consisted of pressure-sensitive piezoelectric crystals (rochelle salts) and a pre-amplifier.

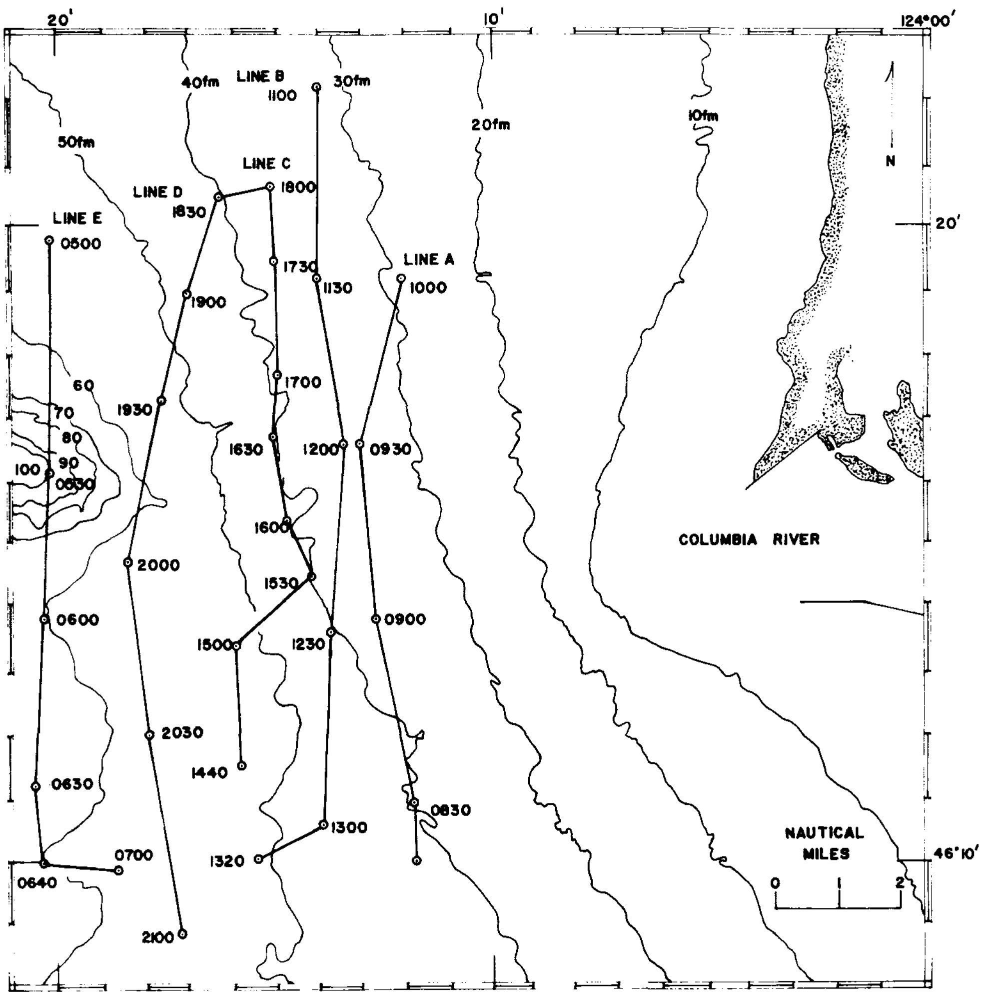

Figure 1. Index map showing ship track lines. Bottom contours from Byrne (1963).

A pressure pulse of reflected sound energy was transformed to electrical energy by the crystals. The electrical pulse was passed through filters and amplifiers and then recorded. For example, a filter setting often used for work of this nature would allow frequencies between 125 and 300 cps to be recorded, whereas the original pulse contained energy for frequencies between 50 and 1000 cps. The choice of filter settings is dependent on the spectra of the signal and noise.

Figure 3 shows a portion of a record, the northern half of Line E of Fig. 1, that was obtained during this work. The subbottom reflections representing a cross section of channel No. 1 and the bottom reflections from the Astoria Submarine Canyon are well displayed.

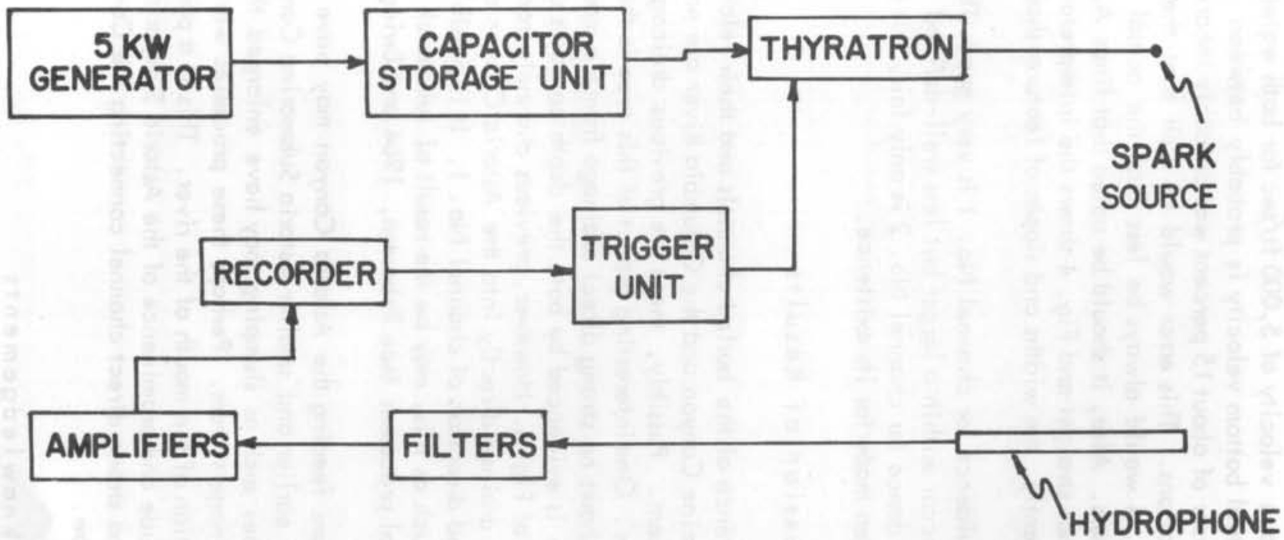

Figure 2. Block diagram of continuous seismic reflection profiler.

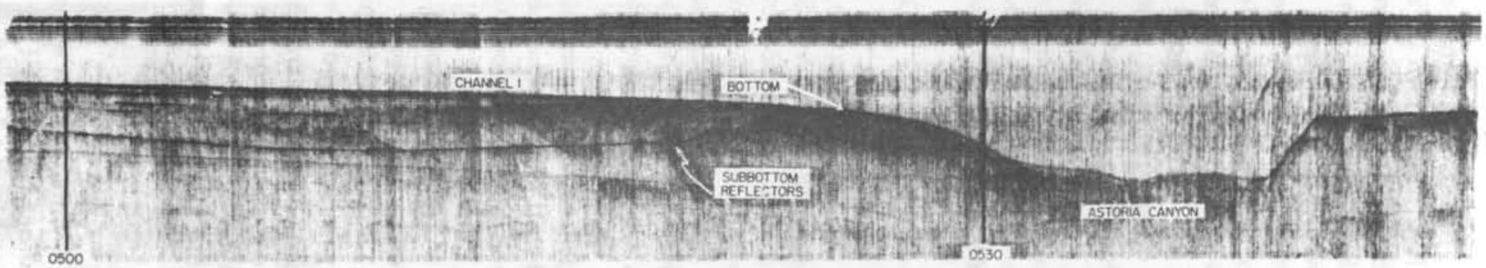

Figure 3. Example of portion of record along Line E showing buried channel 1.

Presentation of Data

Interpreted bottom and subbottom features for Lines A, B, C, D, and E of Fig. 1 are shown in Figure 4. The depths of reflecting layers were computed using a compressional wave velocity of 5,000 ft/sec for both water and bottom material. The actual bottom velocity is probably between 5,000 and 6,000 ft/sec. An error of about 15 percent was probably incorporated in the depth determinations. This error would be such that the computed depths shown in Fig. 4 would always be less than the actual depths of the subbottom reflectors. Also, it should be noted that lines A, B, C, D, and E of Fig. 1 are not straight and Fig. 4 shows the interpretation along the lines. Consequently, the widths and slopes of features shown in Fig. 4 are distorted.

The seismic reflection evidence for channel No. 1 is very good. This well-developed channel may occur within a larger but less well-defined channel (see Fig. 4). The evidence for channel No. 2 is only fair, but a tentative interpretation has been made for its existence.

Discussion of Results

The reasons for the existence of the buried channels and their relationships to the Astoria Submarine Canyon and the Columbia River are not completely understood at present. Possibly, these are previous drainage channels of the Columbia River. One interesting aspect of this area is that the Astoria Canyon currently shows no strong direct drainage from the mouth of the Columbia River, which is evidenced by both the depth contours of Fig. l and the bottom profiles of Fig. 4. However, previous channels from the Columbia River may have drained directly into the Astoria Canyon as evidenced by the proximity and direction of channel No. 1. It is possible that well-defined channels, such as this, may be the result of subaerial rather than submarine erosional processes (see Roberson, 1964 and Ewing and others, 1963).

Previous drainage systems feeding the Astoria Canyon may have undercut the head walls of an earlier and smaller Astoria Submarine Canyon. Other erosional processes such as slumping may have enlarged the canyon and changed the drainage system. Perhaps these processes were linked with a shift in the position of the mouth of the river. This is a possible explanation for the attitude and prominence of the Astoria Submarine Canyon even though there is no strong direct channel connecting the Columbia River to the canyon now.

Acknowledgements

This research was sponsored by the Office of Naval Research under contract No. 1286 (10) NR 083-102. James Whitcomb and Orin Knee helped in obtaining the data.

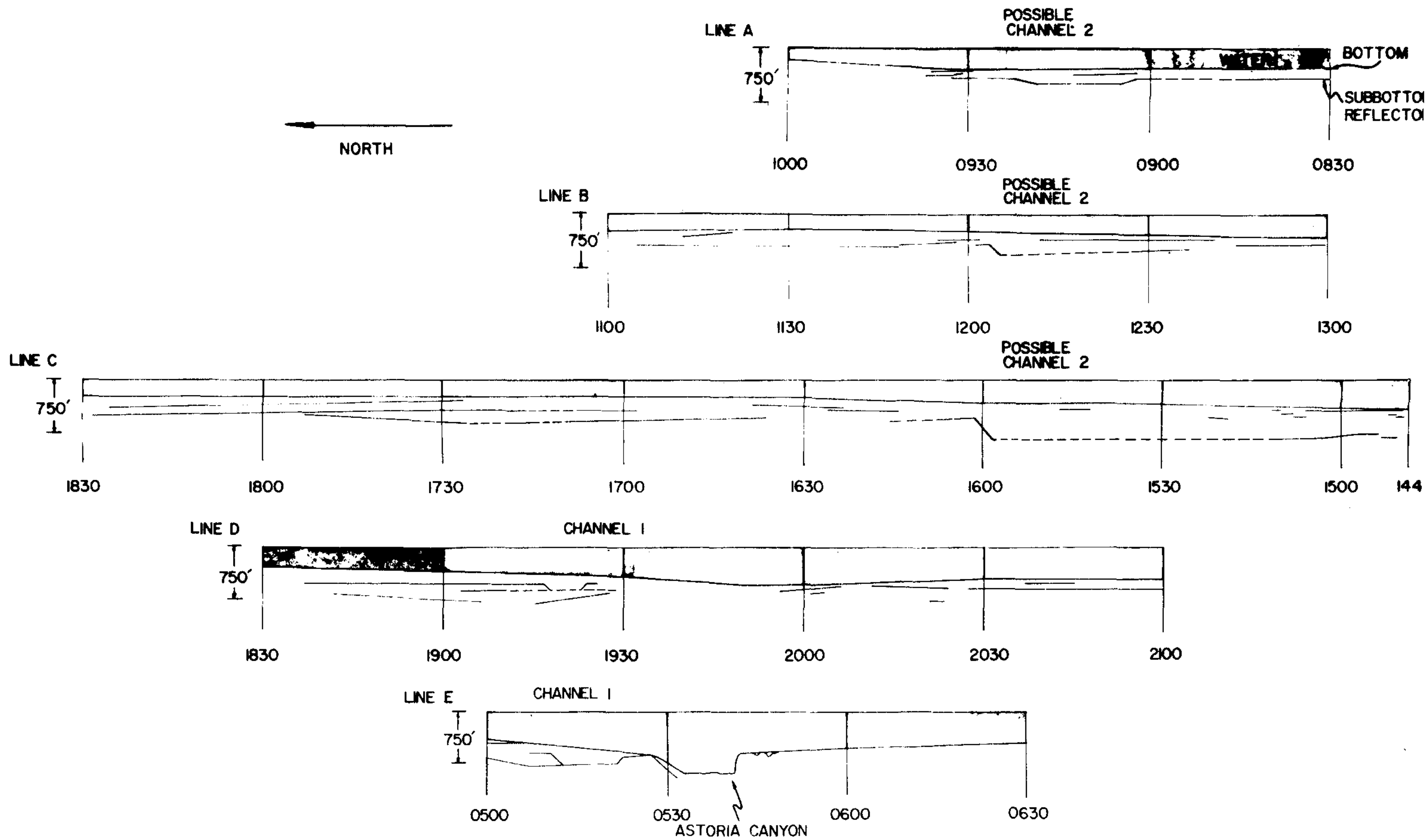

Figure 4. Interpretational cross-sections along ship track lines A, B, C, D, and E (Fig. 1).

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SENATE PASSES MINERAL EXPLORATION TAX BILL

On July 29 the Senate passed by voice vote the Senate Finance Committee version of H.R. 4665, relating to deduction of mineral exploration expenditures, after adopting an amendment to make the measure's provisions applicable also to coal. H.R. 4665 was introduced by Al Ullman, Congressman from Oregon.

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MONUMENT QUADRANGLE MAP FOR SALE

"Geologic Map of the Monument Quadrangle, Grant County, Oregon," by Ray E. Wilcox and R. V. Fisher, has just been issued by the U.S. Geological Survey as Map GQ-541. The multicolored map is accompanied by a descriptive text and cross sections. It may be obtained from the U. S. Geological Survey, Federal Center, Denver, Colo. The price is $1.00.

The Monument quadrangle lies in northwestern Grant County between 119°15' - 119°30' long. and 44°45' - 45°00' lat. All but the southwestern corner of the area is occupied by a thick series of nearly flat-lying Miocene and Pliocene basalt of the Columbia River Group (consisting of Picture Gorge Basalt with possible Yakima Basalt in the uppermost flows). Exceptions in these vast areas of flood basalt are small windows of John Day Formation and two isolated caps of Pliocene ash-flow tuff. In the southwestern part of the quadrangle, where rocks beneath the Columbia River Group are exposed in the valleys of Cottonwood Creek and North Fork of John Day River, basaltic and andesitic lavas of the Clarno Formation of Eocene age are overlain by (and in fault contact with) red, green, and buff tuffs of the John Day Formation of upper Oligocene and lower Miocene age. Penetrating these units are numerous basaltic dikes, sills, and masses related to the Columbia River Group.

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OREGON PETRIFIED LOG ON DISPLAY IN NEBRASKA

This 15-foot, 3-ton petrified log was discovered in Oregon in 1889. It was exhibited in two world fairs -- Chicago in 1893 and Omaha in 1898. About 10 years ago it was bought by Harry B. Cowles of Fremont, Nebraska, who now displays it on his front lawn. Cowles saw the log when he was a boy in Omaha. Later he became interested in rock collecting and succeeded in purchasing it from the owner, who "wanted $300 but finally accepted $50." The log has been identified as a white oak and is considered to be quite a rarity because it is hollow. The site in Oregon from which it came is not known. (Photograph courtesy of the Fremont Tribune.)

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U.S.G.S. ESTABLISHES MARINE PROGRAM OFFICE

The U.S. Geological Survey has established an Office of Marine Geology and Hydrology at its Research Center at Menlo Park, Calif. This office, headed by Parke D. Snavely, Jr., a veteran Survey geologist, will facilitate geological and geophysical investigations of the continental shelves and slopes -- work which has been under way in the Survey for several years. Dr. Joshua I. Tracey, Jr., will serve as deputy chief of the office in Washington, D.C.

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WHITE KING URANIUM LEASED

The White King group of uranium claims northwest of Lakeview was leased recently by the owners to Western Nuclear, Inc., of Denver, Color., it was announced by Don C. Tracy, a member of the ownership. The lease agreement includes an option to purchase, and its term is 11 years.

Western Nuclear, a Delaware corporation with principal offices in Denver, has not announced its plans, but Tracy said he was informed by representatives of the firm they plan to have a crew here about August 1 to begin exploration and possible development of the property.

The owners are John R. and Aleta Roush, Wayland Roush, Erma Roush, Don C. and Irma L. Tracy, W. H. Leehmann, Sr., Walter H. Leehmann, Jr., and Jean Leehmann. The White King, with the nearby Lucky Lass group, was the basis in 1958 for construction of the uranium reduction plant here by the Lakeview Mining Co., of which the late Dr. Garth W. Thornburg was president. The mine went to open-pit ore production in 1959 and was shut down in the fall of 1960. Since then there have been a few attempts at ore production there. The White King includes 19 claims on National Forest land, plus about 40 acres of adjacent deeded land.

Signing the agreement for Western Nuclear were Ralph H. Light, vice-president, and James T. Moran, secretary of the firm. (Lake County Examiner, July 28, 1966)

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HOUSE INTERIOR COMMITTEE REPORTS GOLD BILL

On July 22 the full House Interior Committee reported H.R. 11667, a bill designed to revitalize domestic gold production. This measure, originally introduced by Rep. Harold T. Johnson (Calif.), was favorably reported to the full committee on July 12 by the Subcommittee on Mines and Mining.

The legislation would authorize financial assistance payments to domestic producers of gold. Each domestic gold producer who has operated a gold mine continuously for one year prior to the effective date of the Act would be entitled to annual assistance payments of 6 percent of the value of its total gold bullion receipts produced in such year. The bill, as reported by the subcommittee, would have increased these payments at the rate of 1 percent for each one-point increase in the Consumer Price Index. However, the full committee deleted this provision on the basis that tying such an increase to the Consumer Price Index would inevitably invite a Presidential veto.

An operator who did not produce continuously for one year would be entitled to receive a payment of 125 percent of the total gold bullion receipts produced from his mine during the year immediately preceding the date of his application. The bill would also establish a Gold Mines Assistance Commission to administer the Act.

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FULGURITES FROM MOUNT THIELSEN, OREGON

By William B. Purdom
Southern Oregon College, Ashland, Oregon

Fulgurites are natural glasses formed where lightning strikes bare rock or sand. They are the result of a very large electrical discharge between the earth and clouds.

The potential difference necessary for such a discharge results when minute droplets of water condense on dust particles in the atmosphere. These droplets grow until the limit of cohesion is exceeded (when the drop has a diameter of about 4mm), after which they are torn apart by rapidly ascending air currents. The smaller, lighter fragments are carried to the top of the cloud, losing electrons as the result of friction. Thus the upper portion of the cloud becomes positively charged, and the lower portion negatively charged, and an electrical potential difference exists between the top and bottom of the cloud. The earth itself becomes charged by induction and the electrons in the earth become concentrated on any protuberances on the surface.

If the electrical potential difference between oppositely charged portions of the cloud or between the cloud and the earth become great enough, discharge occurs in the form of an immense spark. The critical potential difference is generally in the range of 20 to 30 million volts. It has recently been ascertained that these discharges occur in 10 microseconds or less (Orville, 1966). High-speed photographs reveal that the stroke starts as a thin leader passing between different parts of the cloud or between cloud and earth. Immediately after the leader a return stroke occurs, traveling in the opposite direction. This is usually followed by a number of discharges and return strokes, all taking place within a few microseconds. To the eye these appear as a single stroke, and during this brief discharge a current of 60,000 to 100,000 amperes may flow. The intense heat of the discharge creates an instantaneous and explosive expansion of the atmosphere along its path. The audible result of this expansion is thunder.

Approximately two-thirds of all lightning strokes occur between different parts of clouds. The remaining one-third occurs between clouds and the earth. Many of the cloud-to-earth discharges strike high buildings, trees, and in the United States about 200 unlucky people each year, but some strike barren rock or sand.

Location of Fulgurites

Where lightning strikes loose sand it fuses the sand grains to glass, creating a glass-lined tubular hole protruding several inches into the sand. These structures have been given the name "lightning-tubes" (Blitzröhren). Often these tubes branch irregularly downward, and are decorated with wispy threads of glass. Some tubes, while in the molten stage, cannot withstand the pressure of the surrounding sand and are found in various stages of collapse. The fused material has a glazed appearance; it is transluscent and colorless to faintly colored. Under the microscope the glass is seen to contain numerous small gas bubbles and occasional unfused remnants of quartz grains. Lightning tubes are most abundant in sand dunes, and if the loose sand is shifted by the wind they are sometimes left protruding above the surface of the dunes.

Other than sand dunes, the most common sites for the occurrence of fulgurites are high, sharp mountain peaks devoid of tall vegetation. Fulgurites on rock in such areas were recognized by European naturalists as long ago as the late 18th century. They have been reported from Mount Shasta in California, and on Union Peak and Mount Thielsen in Oregon. Fulgurites doubtless occur on many of the high, barren peaks in the western United States, but probably have gone largely unnoticed.

Mount Thielsen Fulgurite

In the summer of 1884 a party of the U.S. Geological Survey in the charge of J. S. Diller made a geological reconnaissance of the Cascade Range (Diller, 1884). One of the party climbed Mount Thielsen, situated about 15 miles north of Crater Lake (figure 1). Among the samples collected from the summit of Mount Thielsen were several of fulgurite. Mount Thielsen is a likely site for lightning strokes (figure 2). It has been referred to as the Matterhorn of the Cascades, and is, in fact, a nearly classic glacial horn. Its sides are precipitous and give way to well-formed cirques on all sides of the summit. The uppermost 100 feet of the peak are very steep and without vegetation.

The author ascended Mount Thielsen on a totally cloudless day in the summer of 1963 and collected several samples of fulgurite from the peak. The fulgurite is confined to the uppermost 5 or 10 feet of the summit. The material occurs as spattered patches of brownish black to olive-black glass scattered randomly over the basalt making up the summit pinnacle. These patches are generally between 2 cm and 10 cm in diameter, but some form a twisted path a few centimeters wide and up to 30 cm long (figure 3). Some of the patches are smooth, others have a bubbled or spongy appearance. The smooth, glassy fulgurite encrusting the basalt is generally 1 or 2 mm thick (figure 4), but occasionally bubbles 10 mm in diameter protrude above the encrusting material (figure 5). The specific gravity of the fulgurite is

Figure 1. Mount Thielsen in the Oregon Cascades, looking northeast.

Figure 2. Lightning strikes the summit of Mount Thielsen. (This photograph courtesy of F. Leroy Bond, Forest Supervisor, Umpqua National Forest.)

about 2.5 (Diller, 1884), and its hardness is $6\frac{1}{2}$ on the Mohs scale.

Diller reports the presence of lightning tubes on Mount Thielsen ranging from 10.5 to 20 mm in diameter, but no such glass-lined cavities were found by this author. Diller indicates that the lightning tubes he examined seem to have been formed by lining pre-existing cavities and that the rock material adjacent to the lightning tubes offered no evidence of having been compressed.

The unique nature of fulgurite can be seen more clearly under the microscope. The fulgurite coating the basalt is seen to be a homogeneous glass, entirely free of even the smallest crystallites, though occasional unfused crystals indigenous to the original basalt are enclosed. This total absence of crystallinity in fulgurite serves to distinguish it from obsidian, pumice, tachylite, and other natural glasses. However, the fulgurite is not totally structureless. The upper surface of the fulgurite consists of homogeneous glass containing minute bubbles. Between this layer and the unaltered basalt is a thinner zone of partial fusion, which contains mineral grains of various sizes in all stages of digestion. The most abundant crystal fragments are those of feldspar, pyroxene, and olivine -- the same minerals that make up the bulk of the crystalline portion of the unfused basalt.

Diller correctly attributes the total lack of crystals in the bulk of the fulgurite to its very rapid cooling and cites the existence of lightning tubes in loose sand to support this view. Many such lightning tubes solidify so quickly that the surrounding loose sand does not have time to collapse the tube.

Diller found that heating the fulgurite in the Bunsen burner flame for only two minutes produced minute crystals. Intense heating for a period of several hours produced a dark, stony material similar to basalt in appearance.

Index of Refraction

Another, less obvious, property of the fulgurite can be related to the basalt source rock. That property is its index of refraction. Several investigators have demonstrated the relationship between the indices of refraction of glasses and their silica content. The technique was first used to correlate refractive indices with natural volcanic glasses (George, 1924). More recently, powdered rock samples have been fused and the artificial glasses thus produced used for silica content-refractive index correlations (Callaghan and Sun, 1956; Wargo, 1960). Most investigators agree that good correlation exists between these parameters for rocks taken from the same petrographic province or suite. Kittleman (1963) has recently suggested that the relationship between the index of refraction and silica content is approximately linear. His points vary only $\pm$ 2 percent silica about a calculated line.

In order to determine whether the index of refraction of the Mount

Figure 3. The twisted structure is a fulgurite approximately 2 cm wide and 30 cm long.

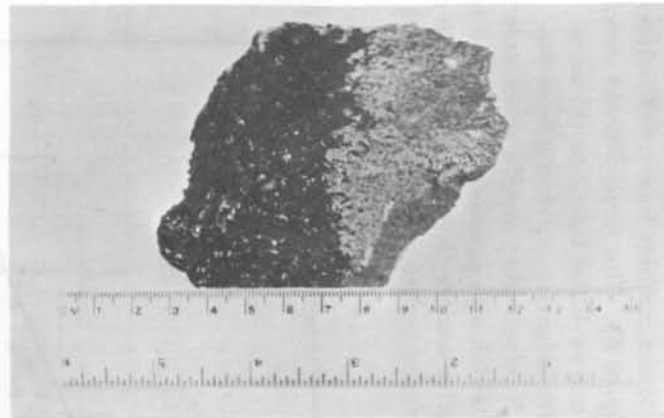


Figure 4. Fulgurite coating basalt from the summit of Mount Thielsen.

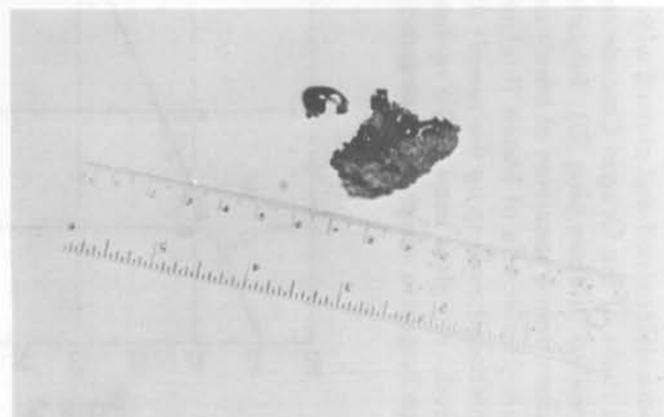
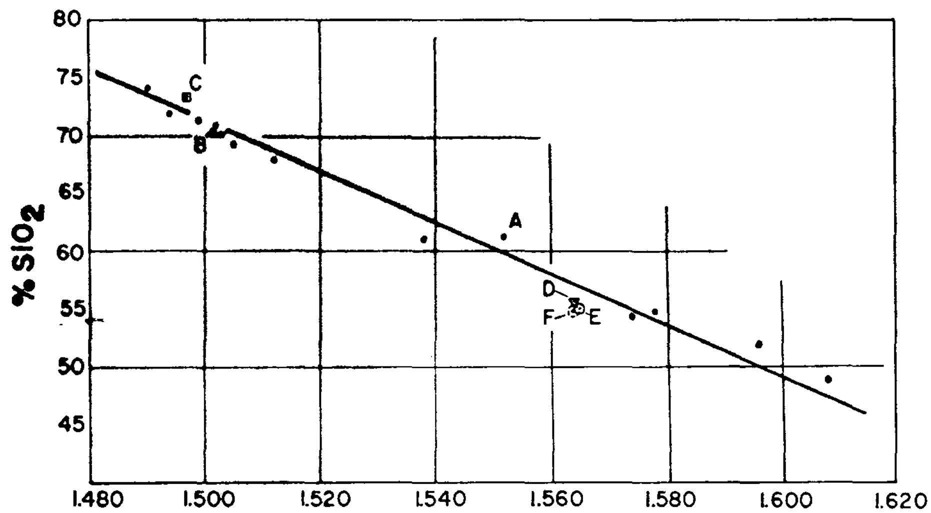


Figure 5. Bubbled fulgurite from Mount Thielsen.

Thielsen fulgurite might be indicative of its silica content, these values were determined and plotted with similar determinations from other volcanic rocks of the Oregon Cascade region (figure 6). The three plotted samples labeled Thielsen plug (D), fulgurite (E), and re-fused fulgurite (F) were taken from a specimen of basalt coated with fulgurite collected from the summit pinnacle of Mount Thielsen. The Thielsen plug sample represents the basalt making up the summit pinnacle which was powdered and fused to produce a glass bead. The re-fused fulgurite sample represents a portion of the fulgurite which was powdered and re-fused before determination of its



A = Thirteen volcanic rocks of Oregon's Western Cascades, chemical analyses and refractive index determinations after Peck, 1960.

B = Llao Rock obsidian, Crater Lake, chemical analysis after Diller and Patton, 1902, refractive index determination by Purdom.

C = Newberry obsidian, chemical analysis after Williams, 1935, refractive index determination by Purdom.

D = Thielsen plug, chemical analysis after Williams, 1933, refractive index determination by Purdom.

E = Thielsen fulgerite, chemical analysis after Diller, 1884, refractive index determination by Purdom.

F = Re-fused Thielsen fulgurite, refractive index determination by Purdom.

Figure 6. Comparison of silica content and refractive index of fused samples of volcanic rocks of the Oregon Cascades and of fulgurite from Mount Thielsen, Oregon.

refractive index. Samples were ground and fused using the method and apparatus described by Kittleman (1963). The fusion process consists of placing the powdered specimens in a carbon arc for several seconds.

The close fit of the fulgurite to the graph shown in figure 6 suggests that natural fulgurite has a refractive index correlative with its silica content and with the silica content of the basalt from which it was fused by lightning. The near coincidence of the points representing the natural fulgurite, the re-fused fulgurite, and the fused basalt indicates that the unusual mode of formation of the natural fulgurite did not induce chemical changes that altered its refractive index with respect to that produced by carbon arc fusion.

Acknowledgments

I wish to thank Dr. L. R. Kittleman for providing the apparatus used to fuse the powdered rock samples, and for his helpful suggestions.

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Gov. Mark O. Hatfield, Dr. Burt Brown Barker, and James H. McClain admire the bronze plaque honoring Herbert Clark Hoover. The plaque was presented by McClain, chairman of the Oregon Section of AIME, and dedicated by the Governor.

GOVERNOR HATFIELD DEDICATES HOOVER PLAQUE

A bronze plaque honoring Herbert Clark Hoover was dedicated by Governor Mark O. Hatfield at the late President's boyhood home in Newberg on August 11. The plaque was prepared by the Oregon Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers. Dr. Burt Brown Barker, President of the Herbert Hoover Foundation of Oregon, accepted the plaque from James H. McClain, chairman of the Oregon Section of AIME. McClain lauded Hoover as a foremost mining engineer, a philanthropist, and a humanitarian who brought the finest talents and skills of the engineering profession to bear on wide-spread suffering in many parts of the world. Governor Hatfield, a long-time admirer of Hoover, stressed his essential humanity which, combined with rare engineering and administrative talents, produced an outstanding citizen of the world. Hoover served as President of AIME in 1920. His boyhood home, the Minthorn House, has been carefully restored under the direction of Dr. Barker, and contains numerous mementos of his life.

ZONING IN AN ASH FLOW OF THE DANFORTH FORMATION HARNEY COUNTY, OREGON

By Ernest H. Lund
Department of Geology, University of Oregon

The Pliocene Danforth Formation, a heterogeneous rock unit in the Harney Basin, Harney County, Oregon, consists of lake-deposited sediments, basalt flows, and silicic pyroclastic members. It is underlain by the Miocene Steens Basalt and silicic volcanic rocks and overlain by the Harney Formation (Pliocene?), itself a heterogeneous unit consisting of basalt flows and tuffaceous sediments. The Danforth Formation was first described by Piper and others (1939) and was named for the Danforth Ranch. The type section is along Cow Creek in T. 22 S., R. 32½ E., in the northern part of Harney Basin.

Ash-flow Units

Several welded ash-flow units occur in the upper part of the formation of the basin. Erosion and faulting have produced prominent escarpments on these units in the higher land that borders the flat plain in the northern and western parts (figure 1). The escarpments and "rimrock" constitute a major feature on the Harney Basin landscape (figure 2).

Three ash flows are well exposed in the walls of Devine Canyon along U.S. Highway 395 a few miles north of this highway's intersection with U.S. Highway 20 (figure 3). The lowermost unit, exposed at the junction of Poison Creek and Devine Canyon about 5 miles north of the highway intersection, is a loosely consolidated tuff consisting of pumice and other rock particles, finer vitric particles, and crystal fragments. It is generally referred to as a crystal tuff because of its high content of crystalline material, a feature that readily distinguishes it from the overlying units. This unit is widespread, and, though only weakly indurated, it forms nearly vertical escarpments along stream valleys and in places where it is faulted.

The escarpments in the ash flows are maintained partly because of vertical jointing and partly because of a layer of very weakly lithified basal ash. This ash erodes more rapidly than does the overlying harder material, leaving a re-entrant at the base, thus removing support from the upper part of the unit. As long as mass movement extracts talus material from the base of the unit, the escarpment persists. Where talus accumulates and covers the basal ash layer, erosion of the ash stops and the escarpment is eliminated. The re-entrant at the base of the upper ash flow is shown in figure 4.

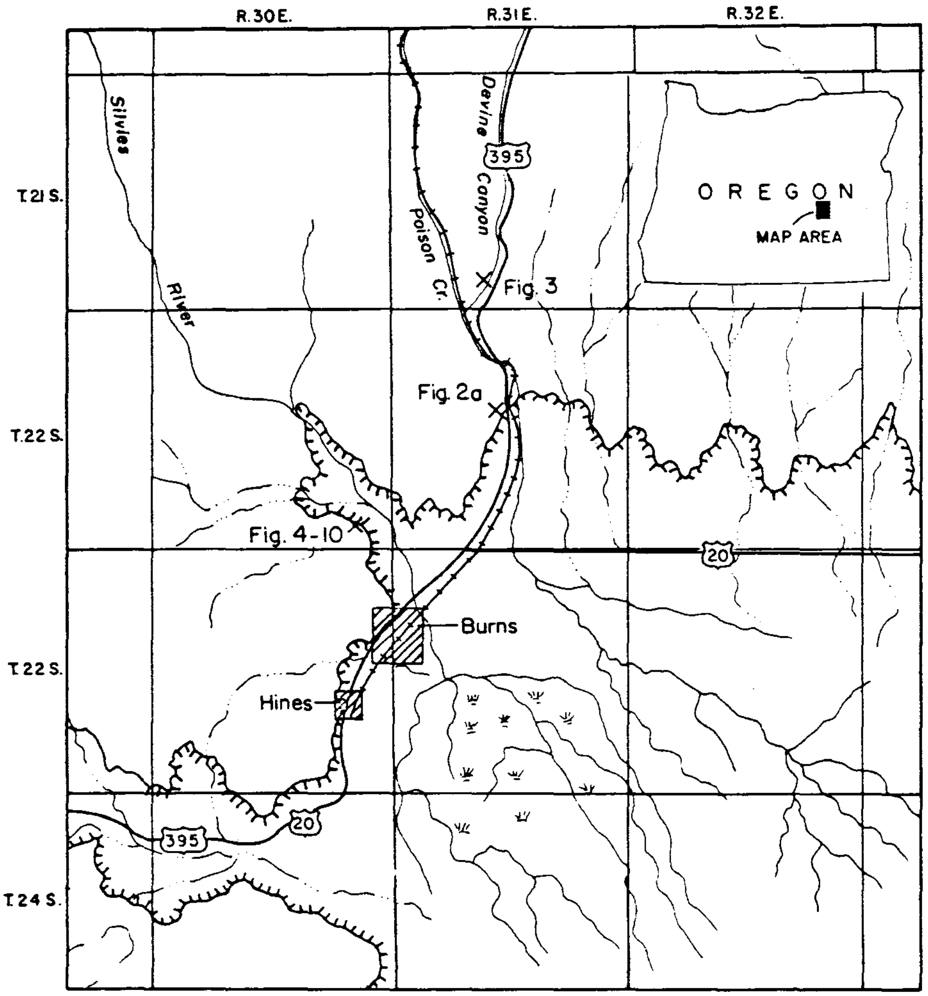

Figure 1. Index map of the Burns area showing the northwest margin of the Harney Basin. Figure numbers on map indicate location of photographs accompanying text.

The middle and upper ash flows consist mostly of fine vitric particles and small pumice fragments; they contain only small amounts of other rock fragments, and crystal fragments of anorthoclase, oligoclase, quartz, and green pyroxene. Both units are welded, but the upper one is particularly noteworthy because of the high degree of welding and the distinct zoning. The upper unit is described in detail below.

Upper Ash Flow

The upper unit underlies much of the area in the vicinity of Burns and is the source of the stone used in several of the local stone-block buildings.

Figure 2. Escarpments on ash-flow units in the Danforth Formation. Devine Canyon (above); along road to Frenchglen at milepost 39 (below).

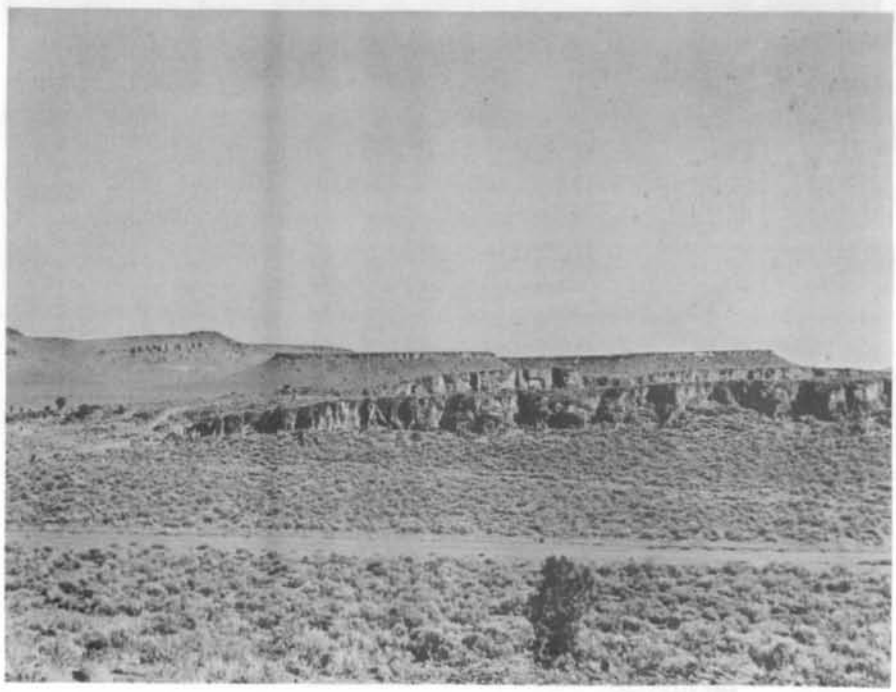

Figure 3. Three ash flows along Devine Canyon.

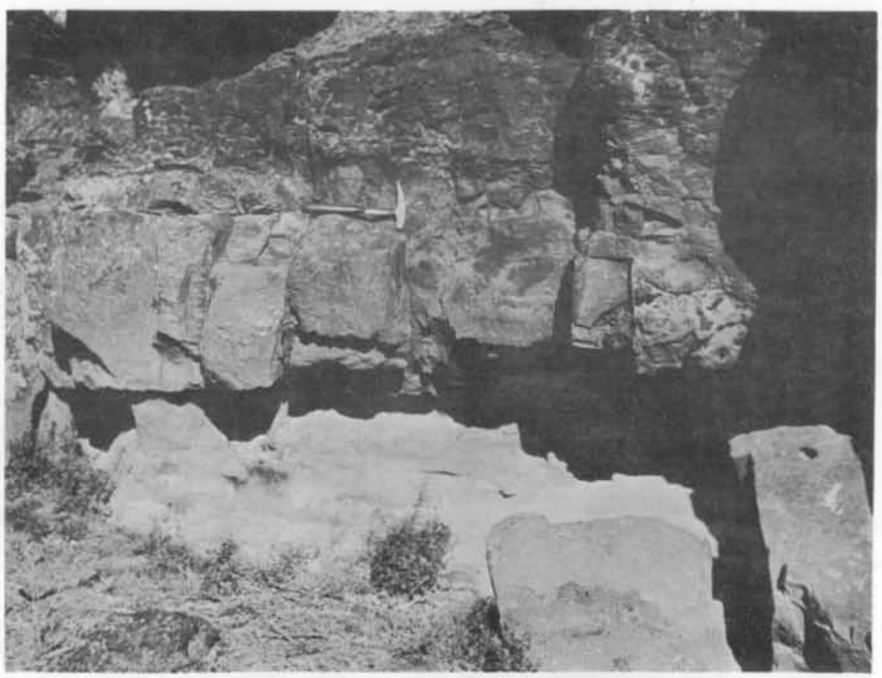

Figure 4. Base of upper ash flow in Silvies River locality, center of section 36.

It is well exposed in a number of places along Silvies River northwest of the town. There are two excellent outcrops in the bluffs on the southwest side of the river in sec. 36, T. 22 S., R. 30 E. Here the flow is about 50 feet thick and is exposed in its entirety except for an upper layer of nonwelded ash that probably was present originally but has been stripped. The rock in the outcrop near the road in the SE$\frac{1}{4}$ sec. 36, about half a mile north and west of the Indian Village, is described in the paper by Piper and others (1939, p. 43). The other and more extensive outcrop is a few hundred yards north of the road near Hayes Ranch and about in the center of section 36.

In the Silvies River locality the upper ash flow overlies sorted and stratified pumiceous ash and lapilli. A few feet of this material is exposed at the base of the escarpments in section 36, and it is separated from the overlying ash flow by a distinct disconformity.

At its base the ash flow is a gray, unstratified, and unsorted pumiceous tuff consisting mostly of ash but containing numerous pumice particles 2 inches or more in length. Scattered fragments of basaltic rock are also present here and elsewhere in the flow. This part of the flow is not welded but is weakly cemented, largely by fibrous aggregates of quartz and possibly other minerals that occur in isolated clusters through the rock. Because of its low resistance to erosion, the ash flow is marked where exposed by the re-entrant at its base (figure 4).

No distinct surface separates the nonwelded ash from the welded part. Rather, the amount of welding increases progressively upward in the unit through a thickness of about 5 feet (figure 4). This transitional zone of partial welding is characterized by an increase in density as pore space is reduced, flattening of glass shards (figure 5) and pumice fragments, a change in color from light, brownish gray through shades of brown to black, and a change from an earthy to a pitchy luster. The pumice fragments maintain their identity in this zone, but have been deformed into thin lenses oriented essentially horizontally. Some retain their gray color, but in the densely welded part most have become black.

The hard, densely welded rock in the upper part of this zone grades almost abruptly into rock with a pronounced perlitic structure that gives the rock a granular appearance. Because of the perlitic structure, this rock disintegrates easily, and its erosion has created a bench on top of the dense, compact underlying rock and a bulbous overhang in the more resistant material above it (figure 6).

Spherulites and lithophysae appear a short distance above the base of the perlitic zone and mark the beginning of a zone of gaseous activity. The perlitic structure continues upward into the spherulitic zone.

The spherulitic zone (figure 7) is about 30 feet thick, and the spherulitic and lithophysal structures make up about half the rock. Pumice particles, so prominent in the lower part of the flow, are inconspicuous in this zone. Lenticular masses of fragmented obsidian-like glass (figure 8), some more than a foot long, occur in the lower part of the spherulitic zone and

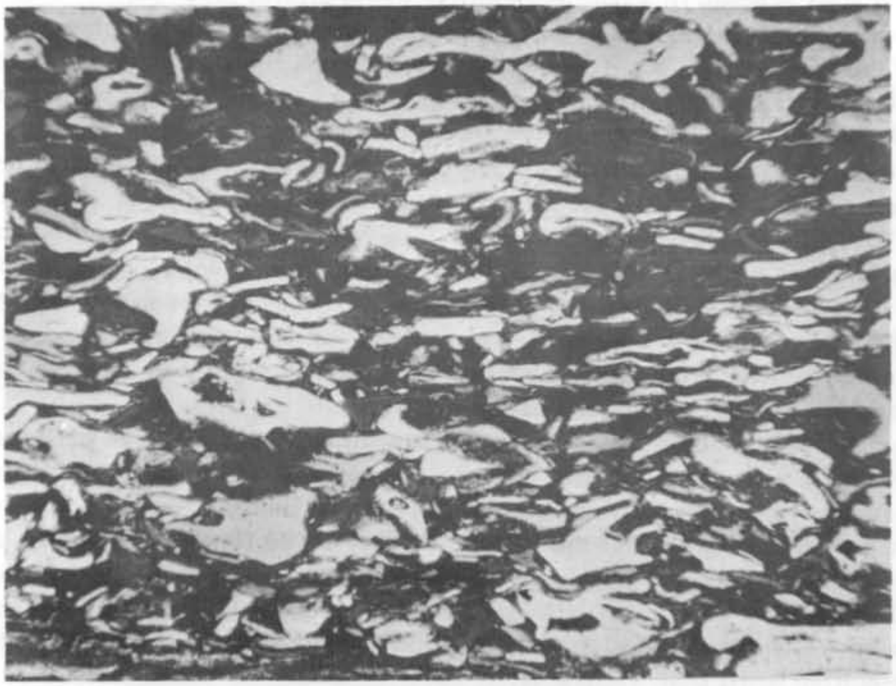

Figure 5. Flattened glass shards. Ordinary light. Mag. approx. X40.

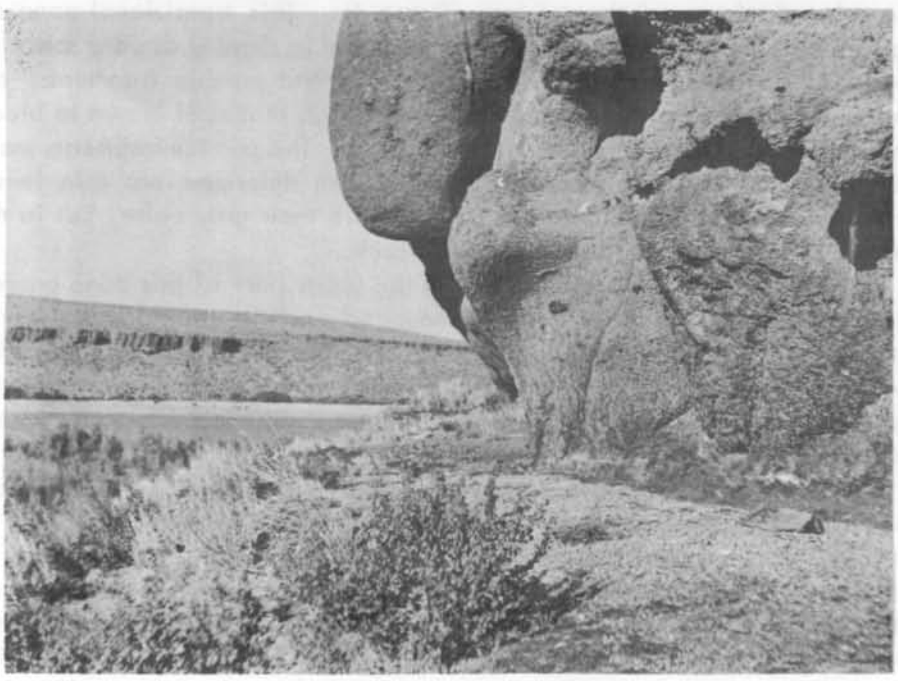

Figure 6. Bench on densely welded ash. Perlitic rock at base of overhanging spherulitic rock.

Figure 7. Spherulites and lithophysae.

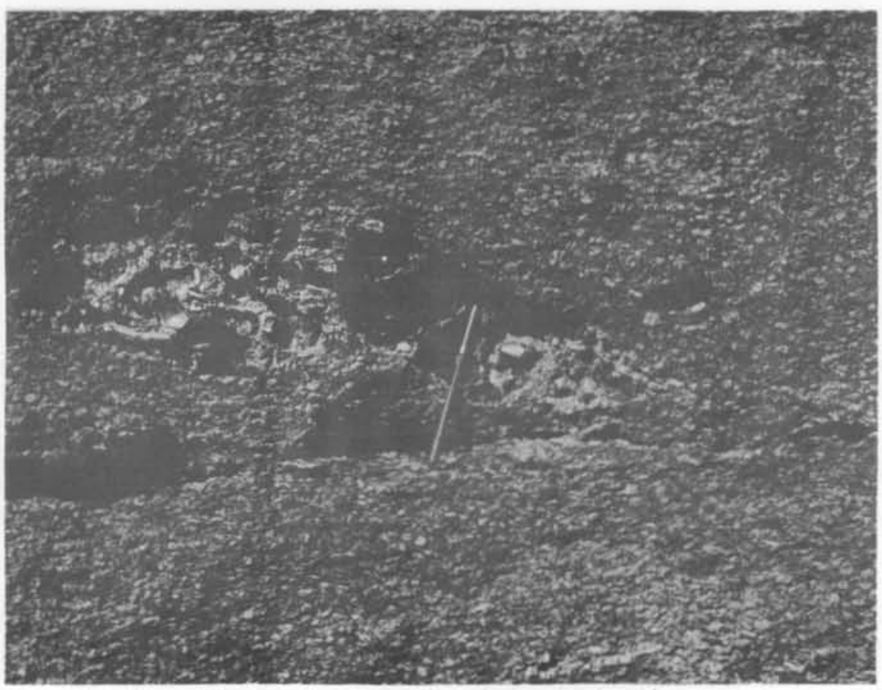

Figure 8. Fragmented glass lens in spherulitic zone.

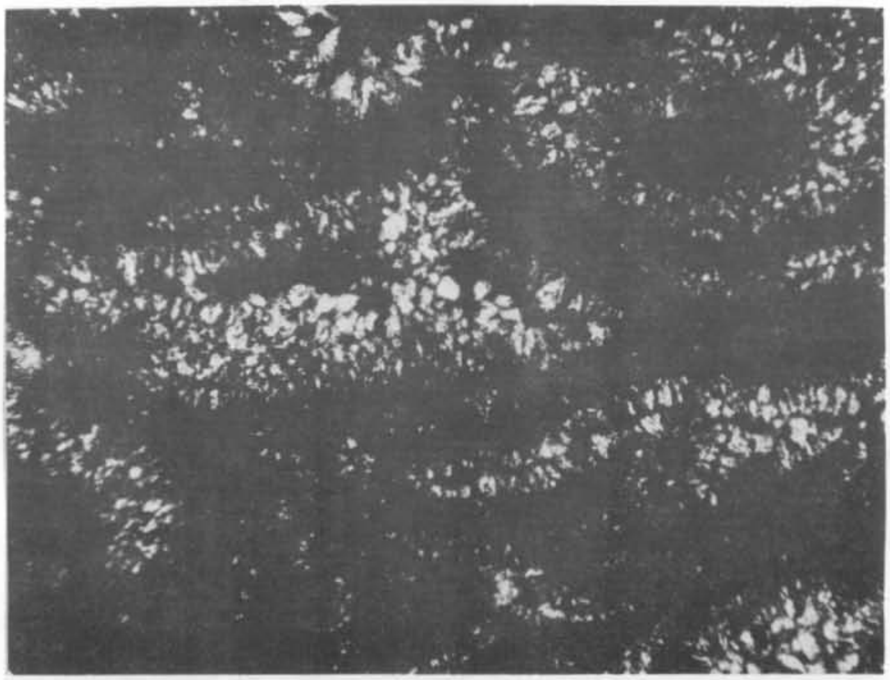
Figure 9. Axiolitic structure in devitrified tuff. Crossed polars. Magnification approximately X110.


Figure 10. Platy structure in porcelaneous rock.

may represent small local spots where the tuff was completely melted and resolidified, or they may be obsidian inclusions. The shard structure that characterizes the ash flow from bottom to top is absent in this glass. The glass separates into small fragments which have somewhat rounded edges and resemble the so-called "Apache tears." Particles of basaltic rock are essentially unchanged in the spherulitic zone.

In the upper part of the spherulitic zone the glass is devitrified, the glassy luster is lost, and the rock becomes "stony" and porcelaneous in appearance. The shard structure has been preserved in the devitrified rock, and the crystalline material formed through devitrification is arranged in axiolitic structure around the borders of the shards (figure 9). The minerals that were formed by devitrification of the glass are cristobalite, tridymite, albite, and anorthoclase. The same minerals line the cavities in the lithophysae of the spherulitic zone.

The spherulitic rock grades into a dense, pinkish-gray rock that makes up the top 10 feet of the flow in the Silvies River locality and elsewhere in the Burns vicinity. It is exposed in a number of road cuts west of Burns along U.S. Highway 20. The transition from the spherulitic rock to the porcelaneous rock is marked by many large, flattened gas vesicles. The number of vesicles diminishes upward in the zone of porcelaneous rock, and they are sparse in the upper few feet.

The porcelaneous rock is largely devitrified glass in which shard structure has been preserved. Numerous larger fragments, some several inches

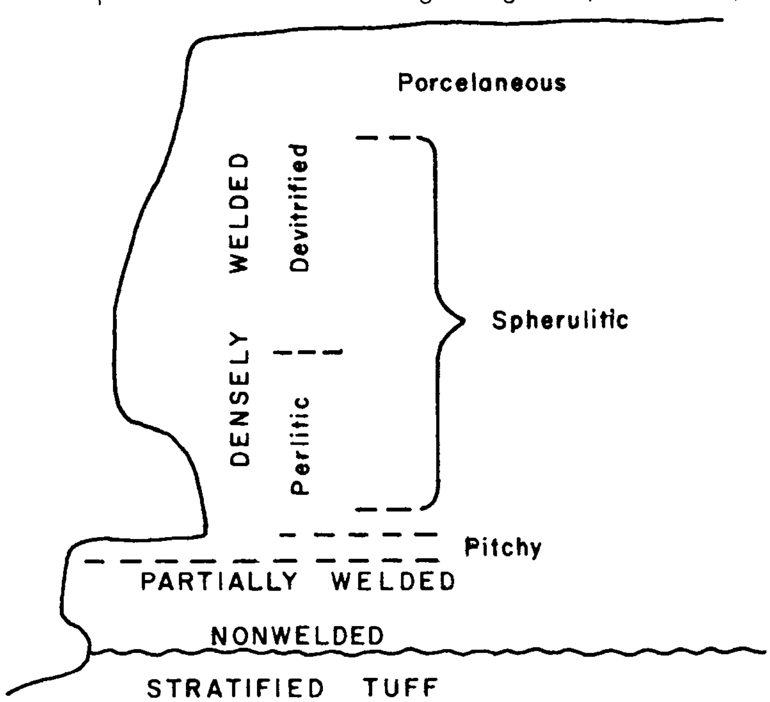

Figure 11. Diagram of zones in upper ash flow.

across, give the rock the appearance of a breccia in places, and it is commonly referred to as a tuff-breccia. These large flattened particles, composed of devitrified glass, are believed to be mostly original pumice fragments that became flattened by compression and oriented horizontally. Locally the rock of the porcelaneous zone is very platy (figure 10).

Nonwelded ash that usually occurs at the top of welded ash flows was not observed. From the amount of compaction in the uppermost part of the densely welded rock, it would seem that originally there was a layer of considerable thickness. Erosion has probably removed most of it, and where it is still present it is covered by soil.

Welding within the upper ash flow of the Danforth Formation ranges from no welding to dense welding, and the major part of the unit in the Silvies River locality and elsewhere is densely welded. Within the densely welded part different zones, as defined by Smith (1960), can be identified. The zone boundaries can be drawn in different places, however, depending upon which features of the rock are used as basis for zoning.

Figure 11 shows positions of significant characteristics in the rock as they exist in the Silvies River locality, section 36. A zone identified by one rock property overlaps zones identified by other properties. For example, the spherulitic zone overlaps a zone of devitrification in its upper part and a perlitic glass zone in its lower part. An initial division of zones is made on the basis of degree of welding. Further division is made within the densely welded zone on the basis of structural and mineralogic criteria.

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PERMIT ISSUED FOR CENTRAL OREGON DRILLING

The Department issued permit No. 57 to Central Oils, Inc., of Seattle, Wash., on August 31, 1966, to re-enter a hole it abandoned in December of 1960. The abandoned test hole, "Morrow 1," is located in the SW$\frac{1}{4}$ sec. 18, T. 12 S., R. 15 E., Jefferson County. Depth reached in the initial drilling was reported to be 3300 feet. The well site lies approximately 10 miles southeast of Madras, and a short distance east of U.S. Highway 26. The firm will attempt to test pre-Tertiary marine rocks underlying younger volcanics. Pre-Tertiary metasediments have been mapped on the surface approximately 5 miles northeast of the drilling site (Peck, U.S. Geol. Survey Bull. 1161-D, 1964).

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UDALL NAMES OCEAN RESOURCES TEAM

Secretary of the Interior Stewart L. Udall has named a top-level team to develop and coordinate the Department's many programs for utilizing the resources of the sea, including minerals.

Dr. Stanley A. Cain, Asst. Secy. for Fish and Wildlife and Parks, was named to head the team, which includes Dr. Thomas F. Bates, science advisor to the Secretary; Asst. Secy. J. Cordell Moore (mineral resources); Asst. Secy. Frank C. DiLuzio (water pollution control); Asst. Secy. Harry R. Anderson (public lands); and Asst. Secy. Kenneth Holum (water and power development). Dr. Water R. Hibbard, Jr., director, Bureau of Mines, was selected as program manager.

Udall pointed out that among Interior's key responsibilities under the Marine Resources Development Program are mining of minerals on and beneath the ocean's floor, mapping and structural studies of the continental shelf, and geology as related to earthquakes and mineral values.

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SENATE PASSES RESEARCH CONTRACTS BILL

On August 29 the U.S. Senate passed by voice vote and sent to the House S. 3460, a measure to authorize the Secretary of the Interior to enter into contracts for scientific and technological research.

Such authority presently exists for certain specific programs of the Department, such as for saline water, helium, and coal and water research. However, the Bureau of Mines and the Geological Survey do not have similar authority. This legislation would place all of Interior's programs on an equal basis with respect to use of nongovernmental research facilities, organizations and programs. The measure does not authorize any new programs or any additional appropriations.

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TOPOGRAPHIC MAP PRICES TO CHANGE

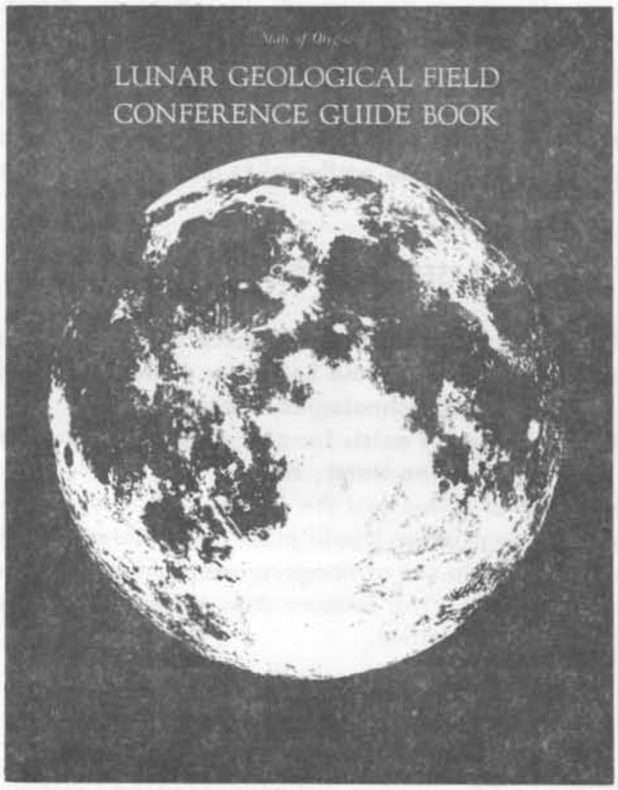
The U. S. Geological Survey has just announced new prices on all of its maps, effective October 1, 1966. The new list price of topographic quadrangle maps at scales 1:24,000; 1:31,680; 1:62,500; 1:63,360; and 1:125,000 is 50 cents each. The list price of topographic maps at a scale of 1:250,000 is 75 cents each.

National Park and other special topographic maps are individually priced. The Survey can provide a price list of these maps upon request. All maps for areas lying west of the Mississippi River should be ordered from the Survey's Map Distribution Office, Denver Federal Center, Denver, Colo.

Discounts on orders amounting to $20 or more at the list price are 20 percent; on orders of $100 or more 40 percent is allowed.

"MOON COUNTRY" BULLETIN REPRINTED

Despite its rather impressive title, "Lunar Geological Field Conference Guidebook," the Department's "Moon Country" bulletin has proven to be one of its most popular. Originally prepared for the use of the 85 space scientists attending the conference in central Oregon a year ago, the book, filled with photographs, maps, and line drawings, attracted wide interest. The first printing was rapidly exhausted and a second edition, with improved illustrations and additional photographs, has been published.



Interest in the bulletin stems from the fact that central Oregon contains a wealth of spectacular volcanic features which, in the opinion of many space scientists, closely resemble those to be found on the moon. The area has been studied by several teams of astronauts and lunar geologists. Five of the six "Lunar Standard" rocks used in lunar research are found in the area. Five field trips are described and illustrated in the bulletin, making it possible for individuals to conduct their own self-guided tours through a lunar-like countryside. The bulletins are also used as texts by the University of Oregon's summer workshop in volcanology. Copies of the bulletin sell for $3.50 postpaid.

The ORE BIN
Volume 28, No. 10
October, 1966

FOSSIL WOODS SUPPLEMENT KNOWLEDGE OF THE SUCCOR CREEK FOSSIL FLORA

By Wallace Eubanks*

The name Succor** Creek implies an area rich in fossil flora. It is, of course, the name of a drainage which arises partly in Idaho, flows in a northerly direction along the state line in Malheur County, Oregon, and finally crosses into Owyhee County, Idaho, where it empties into the Snake River (figure 1). The name Succor Creek also carries with it the association of other names such as Rockville School, McKenzie Ranch, Specimen Ridge, Fenwick Ranch, and Owyhee Reservoir, which in the past have been landmarks for the important fossil beds.

The Succor Creek Formation

The areas mentioned above are located within Miocene lake-bed sediments which crop out all along Succor Creek and are wide spread in the general area. These beds were named the Payette Formation by Lindgren (1900), and they retained this name for many years, but they are now referred to as the Sucker (Succor) Creek Formation (Kittleman, 1962; Kittleman and others, 1966; Baldwin, 1964; and Corcoran, 1965). This is the oldest Tertiary rock unit exposed in these parts of Oregon and Idaho.

The Succor Creek Formation consists of a thick series of tuffaceous sediments which are principally fine grained, thin bedded, and nearly white. In some areas, coarser tuffs of brown, yellowish, or greenish color are common. Basalt and rhyolite dikes and flows, also present within the series, evidently poured out during the deposition of the lake beds.

The age of the Succor Creek Formation is considered to be middle to late Miocene on the basis of fossil plants and vertebrates. Chaney and Axelrod (1959) and Graham (1962) correlate the leaves, fruits, and pollen

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* Supervisor of Timber Section, Oregon State Tax Comm., Salem, Oregon.
** Phil Brogan, Chairman of the Oregon Geographic Names Board, reports that "Succor" Creek is now official. Action reversing the earlier official spelling, "Sucker" Creek, was taken by the U.S. Board on Geographic Names in the spring of 1966 on recommendation of the Oregon Geographic Names Board, following considerable historical research. The reversal was one of the few ever made by the national board.

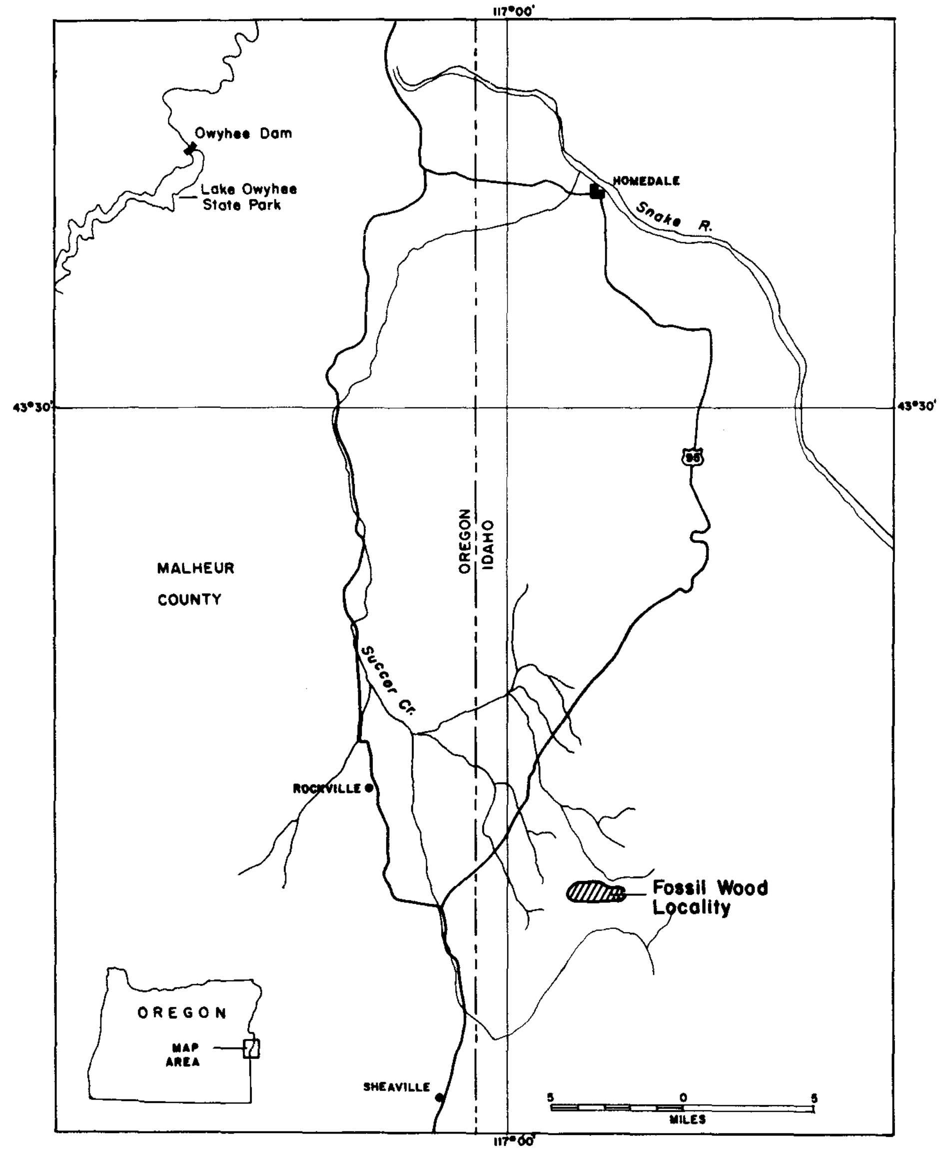

Figure 1. Index map of the Succor Creek area, Oregon-Idaho, showing fossil wood locale from which specimens were collected for study.

with those of the Mascall Formation of middle to upper Miocene age. Scharf (1935) concludes that the fossil vertebrates found in the lake beds are also generally equivalent to those in the Mascall Formation, and he assigns the strata to the middle Miocene or perhaps the early part of the late Miocene.

Studies of the Fossil Plants

Flora of the Succor Creek area first became known through Knowlton's study of Lindgren's collections (Lindgren, 1900). In Lindgren's report (p. 97-98), Knowlton lists more than a dozen types of fossil leaves. Since that time Chaney (1922), Berry (1932), Brooks (1935), Arnold (1936, 1937), and Smith (1938, 1940) gathered material from various parts of the Succor Creek area and analyzed it. A more recent work by Chaney and Axelrod (1959) presents a systematic study and correlation of the Miocene fossil floras of the Columbia Plateau, including the Succor Creek flora.

The most recent and the most comprehensive study of the Succor Creek flora is by Alan Graham (1962) for a doctoral dissertation. Graham gathered new specimens and analyzed them along with the previous collections and conclusions made by earlier workers. In addition to work with leaves, flowers, and fruits he made use of many thousands of pollen and spores to aid in identifying the various plants. As a result of this study, several plant types were renamed and new ones were added to the list. The trees and shrubs totaled 47 genera with 67 species. In addition several herbs, grasses, and ferns were found in the flora.

A summary of the tree and shrub genera from Graham is given below, with common names in parentheses. Some Asiatic forms have no common names in English.

Abies (white fir)
Acer (maple)
Alnus (alder)
Ailanthus (tree of heaven)
Amelanchier (serviceberry)
Arbutus (madrone)
Betula (birch)
Castanea (chestnut)
Carya (hickory)
Cedrela (cedar)
Crataegus (hawthorn)
Cornus (dogwood)
Diospyros (persimmon)
Ephedra
Fagus (beech)
Fraxinus (ash)
Ginkgo (ginkgo)
Glyptostrobus
Gymnocladus (coffee tree)
Hydrangea
Ilex (holly)
Juglans (walnut)
Lithocarpus (tanbark oak)
Mahonia
Magnolia (magnolia)
Nyssa (gum)
Oreopanax
Ostrya (hop hornbeam)
Pinus (pine)
Platanus (sycamore)
Populus (cottonwood)
Ptelea
Picea (spruce)
Pterocarya
Persea (avocado)
Pyrus (pear)
Quercus (oak)
Sassafras (sassafras)
Symphoricarpus (snowberry)
Shepherdia
Salix (willow)
Thuja (cedar)
Tilia (basswood)
Tsuga (hemlock)
Ulmus (elm)
Zelkova

These genera are represented by living trees and shrubs of three separate geographic regions. The principal group is found in the Appalachian Mountains of the eastern United States. Genera such as Carya, Fagus, Gymnocladus, Ostrya, Tilia, and Ulmus are now living in the eastern forests. Another group is represented by trees growing along the western slopes of the Cascade Mountains. This group includes Abies, Pinus, Quercus, Lithocarpus, and Picea. The third group is made up of plants currently found in Asia, such as in certain provinces of China. Examples are Ginkgo, Glyptostrobus, Ailanthus, and Zelkova.

These plant associations reveal the fact that the fossil flora of this period grew in locations which ranged from swamp to rocky mountain sides with considerable difference in elevation, and in a climate which varied from a winter low of 30° to summer highs of about 90°. Annual rainfall was probably on the order of 50 to 60 inches and well distributed throughout the year. The trees such as Cedrela and Oreopanax show that subfreezing temperatures occurred rarely.

Analysis of Succor Creek Woods

A study by the author in 1960-1961 of fossil wood structure and identification of woods from one portion of the Succor Creek area was made in order to supplement the knowledge of the flora as determined previously from leaves and fruit. Specimens were gathered at the head of a branch of Succor Creek at a spot in Idaho about one mile southeast of the crossing of U.S. Highway 95 with the state border (see figure 1).

This particular area has been the source of black, opalized wood encased in a white matrix. Rockhounds have mined several acres of the deposits in search of the material. However, miscellaneous pieces of wood not suitable for the collectors' purpose were more satisfactory for the study of wood structure. These pieces ranged in size from several hundred pounds to pieces of perfectly preserved twigs only an eighth of an inch in diameter. Wood structure of many specimens is excellently preserved, even to the details which are visible only at 200 magnification and greater.

The study of Succor Creek woods revealed that there is a considerable correlation between the genera identified from the leaves and fruits and genera identified from the wood structure. The wood, of course, did not yield all the different genera represented by the leaves, perhaps because the wood was more difficult to preserve than the leaves and perhaps because the wood sampled is not representative of as wide an area as the leaves, which could have been carried by the wind and water for long distances. One outstanding lack of wood genera is the oak or Quercus. Usually a fossil wood locality will yield oak if it is at all present. Perhaps it was just a quirk of fate that the author did not find a piece in that particular location.

Genera established through study of wood structure are as follows:

Acer (maple)
Alnus (alder)
Arbutus (madrone)
Betula (birch)
Castanopsis (chinquapin)
Celtis (hackberry)
Evodia
Fraxinus (ash)
Pinus (pine)
Platanus (sycamore)
Populus (cottonwood)
Prunus (wild cherry)
Sequoia (redwood)
Ulmus (elm)
Umbellularia (laurel)

Of these the Castanopsis, Celtis, Evodia, Prunus, Sequoia, and Umbellularia do not correspond to the genera named from the studies by Chaney and Axelrod (1959) and Graham (1962). However, all of these except Evodia are found in other portions of fossil forests of the Miocene epoch in Oregon.

It is not possible to determine species through fossil wood structure as it is from leaves and fruit or pollen, because many species of one genera having quite different leaves and fruits will have wood structure so similar that it is not practical to distinguish between them in the fossils. Consequently, in the above list only the genera are given. Woods not identifiable were also found in this location and perhaps future study will add to the list.

It is interesting to note that trees of past geological ages were also infected with insects, borers, and fungi as evidenced by the work of all three found in the fossil samples.

Method for Identifying Fossil Wood

Identification of trees by consideration of the wood is achieved through study of the cellular composition and arrangement within the wood. To the casual observer, or even to the cabinet maker and others familiar with the use of wood, it appears to be only a solid mass of fibres. With live woods the qualities of hardness, color, odor, and pattern of grain are apparent and are the means by which many people distinguish different kinds of wood.

Actually, wood is made up of many types of cells in many variations of arrangement. It is the systematic classification and knowledge of these variations that enable the identification of trees to be made through the structure of wood. This information concerning structure has been set up in the form of keys and lists for many of the trees and larger shrubs of the world. However, no such listing is available for fossil woods alone. Fossils are usually identified by relating them to living plants. By correlating the structure of fossil plants with the structure of living plants which are classified and named under uniform international rules, it is possible to achieve identification of the fossils even though they are several million years old.

In working with woods from the Oligocene, Miocene, and more recent epochs, it is not difficult to correlate the structure with present-day live

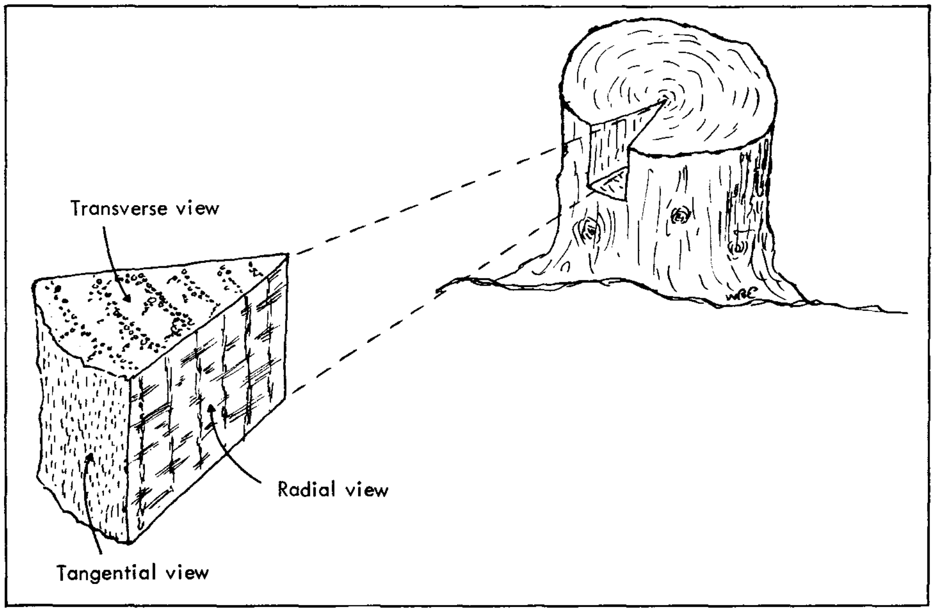

Figure 2. Sketch of tree stump and enlarged wedge of wood removed from it to show proper orientation of sections for microscopic identification.

woods. With wood from older geological periods, however, difficulty is experienced with correlation because of the greater changes in the plant structures during those millions of years.

Study of the minute structure of fossil woods from the Succor Creek area was made with polished pieces and by thin sectioning. Thin sections are made from the fossils by cutting very thin slices -- a sixteenth of an inch in thickness or less -- from properly oriented faces of the piece (figure 2). These slices are then polished on one side, fastened to a micoscope slide glass, and ground on a small lap or by hand until the light passes through the material and the cell structure becomes visible through the microscope. This technique is fairly simple for the hard, opalized or agatized woods but other techniques must be employed for the soft carbonized material.

By using the hand lens and microscope, the cell structure of the woods can be studied and the characteristics listed by standard definitions and terminology set up by the International Association of Wood Anatomists. After listing the characteristics of anatomy of each of the woods, a search is made of classified characteristics of live woods to find a correlation of live to fossil. The woods are considered to be similar if most characteristics correspond and none of the most important ones disagree.

An example may be made of the wood, Prunus -- one of the types found in the Succor Creek area. The thin section of this wood was made to show the tangential, radial, and transverse views of the structure (figure 3). Upon study of the wood by microscope, the following characteristics were listed:

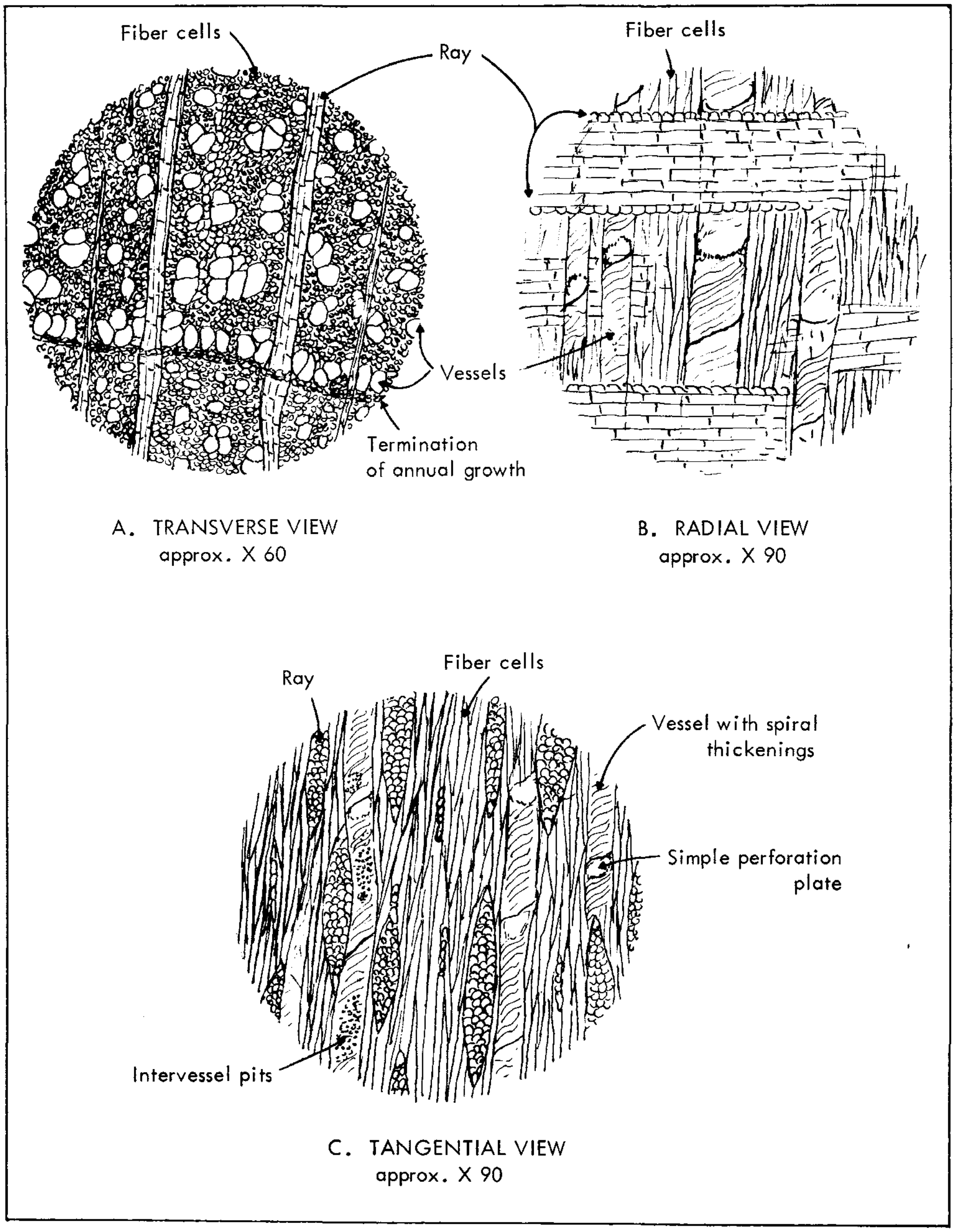

Figure 3. Microscopic structure of fossil Prunus from Succor Creek area.

Transverse view (figure 3-A)

Pore arrangement diffuse to semi-diffuse with pores small and indistinct to the naked eye. Those at the beginning of the growth season slightly larger than the late-year pores and aligned in a more or less uniseriate row, otherwise fairly evenly distributed. Growth rings are fairly distinct.

Parenchyma is not visible. Rays are plainly visible to the naked eye, are as wide as the vessels and occasionally wider. This piece of wood had traumatic resin ducts in a long, tangential string which did not show in the particular thin section.

Tangential view (figure 3-B)

Rays not storied, 2 to 4 seriate, mostly 3 seriate, homogeneous to heterogeneous type III; spiral thickening present in vessels; intervessel pits very small, crowded, orbicular; fibres not storied, not septate.

Radial view (figure 3-C)

Perforation plates simple; rays verified as to type; presence of spiral thickening in vessels verified.

A systematic check of these characteristics with the keys showed that the fossil wood agreed closely with the living Prunus, especially the North American representative of the genera. No significant differences between the fossil and live wood structures could be determined.

Summary

The writer has studied fossil woods from lake beds in the Succor Creek Formation and has added six genera of trees to the Succor Creek flora list. Previous workers based their studies on leaves, fruits, and pollen. Identification of the wood was done by examining thin sections under high magnification and comparing growth structures with those of living woods.

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REDRILL PERMIT ISSUED

The Department issued a permit on October 24, 1966, to Ivan J. Vojvoda of Los Altos, Calif., for the redrilling of Linn County Oil & Development Co. "Barr 1." Vojvoda will cut a window in the $5\frac{1}{2}$-inch casing, which was placed in the hole for testing purposes by Linn County Development Co. After the window is made, the new permittee will set a whipstock and redrill to a depth between 3,000 and 4,400 feet. Oil shows were reported in the original drilling, but subsequent testing resulted in only a small flow of gas.

Vojvoda is associated with the Supreme Oil & Gas Corp., Mountain View, Calif., and Ken Sills, geologist, who was the drilling contractor on the first hole. The official designation for the new permit is: Ivan J. Vojvoda "Madonna 1" (Linn County Development Co. Barr 1 Redrill, Permit 58 RD), located in the NW$\frac{1}{4}$ sec. 32, T. 11 S., R. 1 W., Linn County.

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BROKEN TOP BREAKS: FLOOD RELEASED BY EROSION OF GLACIAL MORAINE

By Bruce Nolf
Geology Department,
Central Oregon College, Bend, Oregon

A torrential flash flood swept $5\frac{1}{2}$ miles down the east and south sides of Broken Top Mountain on October 7, 1966. Flood waters carried mud, logs, and bouldery debris from this High Cascades peak west of Bend, Oregon, across the Cascade Lakes Highway into Sparks Lake meadow (figure 1). The highway was temporarily blocked, and irrigation structures and timber were damaged along the course of the unexpected deluge.

First reports blamed a cloudburst for the sudden surge of flow along the lower part of Soda Creek. However, Phil F. Brogan of the Bend Bulletin correctly inferred that the source of the flood lay in a high glacial lake. Forest Ranger David Rasmussen traced the route of the flood backward to its head in a small unnamed lake, 11 acres in extent, at an elevation of 8,000 feet on the east side of Broken Top Mountain.

This seldom-visited lake lies at the foot of Crook Glacier*, and also receives melt water from a part of Bend Glacier. A very recently abandoned terminal glacial moraine, averaging 100 to 150 feet high, acts as a gravity dam (figure 2). This moraine is built of unconsolidated sand, gravel, and boulders deposited by previous glacial action and now ponding runoff from these melting glaciers. The exact cause of the flood is uncertain, but Rasmussen suggests that sudden breaking off of glacial ice into the lake may have created a wave which overtopped the lake outlet, rapidly increasing downcutting by the outlet stream (figure 3). It is possible that little or no extra impetus was necessary to breach the moraine, and that slow but persistent headward erosion by the steep outlet stream cut this natural dam until it could no longer hold back the lake.

Whatever the triggering action, within a short time (probably a few hours) the lake level dropped $14\frac{1}{2}$ feet (figures 4 and 5), releasing about 50 million gallons of water into the small stream channel below the lake (figure 6).

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* Use of the name Crook Glacier is unclear. Older maps of the U. S. Geological Survey and current maps of the U.S. Forest Service apply the name Crook Glacier to the field of snow and ice on the east side of Broken Top. The 1959 U.S.G.S. 15-minute sheet applies the name Crook Glacier to the ice field on the south side of Broken Top, at the head of Crater Creek. This report follows the older U.S.G.S. usage.

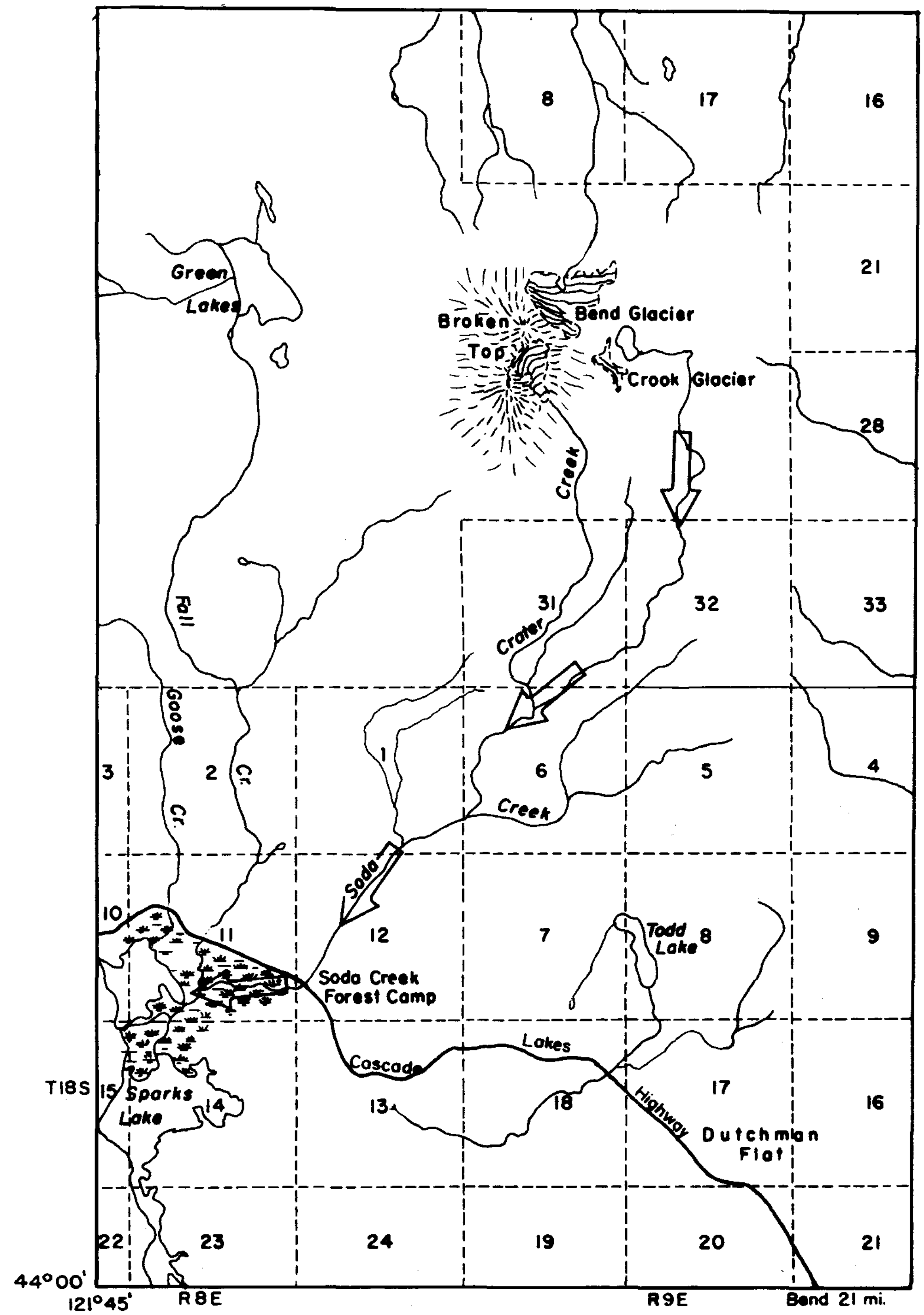

Figure 1. Map of the Broken Top area, showing location of the glacier, lake, and route of the flood waters (arrows).

Figure 2. East side of Broken Top, showing the terminal moraine which impounds the lake. Note the gap in the moraine, and boulders in the foreground which have been carried by flood water.

Figure 3. Outlet stream cutting through the moraine. The pre-flood level of the outlet was approximately at the shoulders of the notch, about 15 feet above the small waterfall.

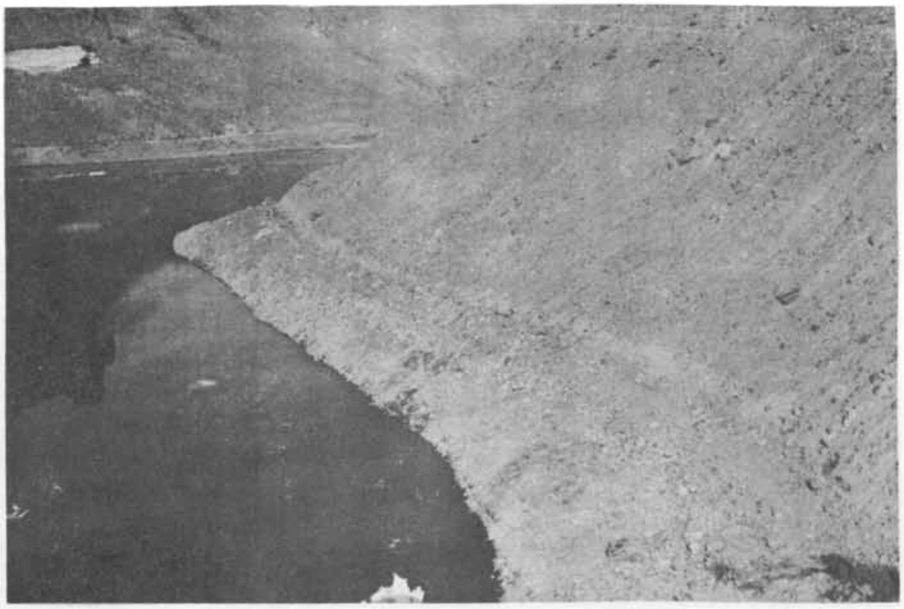

Figure 4. View to the north-northwest along the east shore of the unnamed lake, showing the old shoreline on the moraine, and in the lower right corner a part of the new outlet cut.

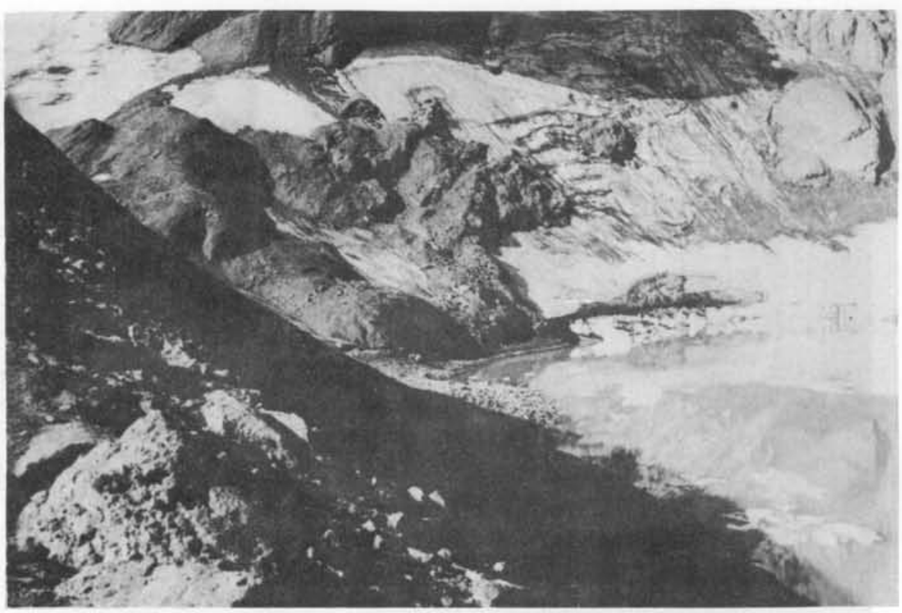

Figure 5. View along the southeast lakeshore, showing the old water line and part of the snow and ice of Crook Glacier.

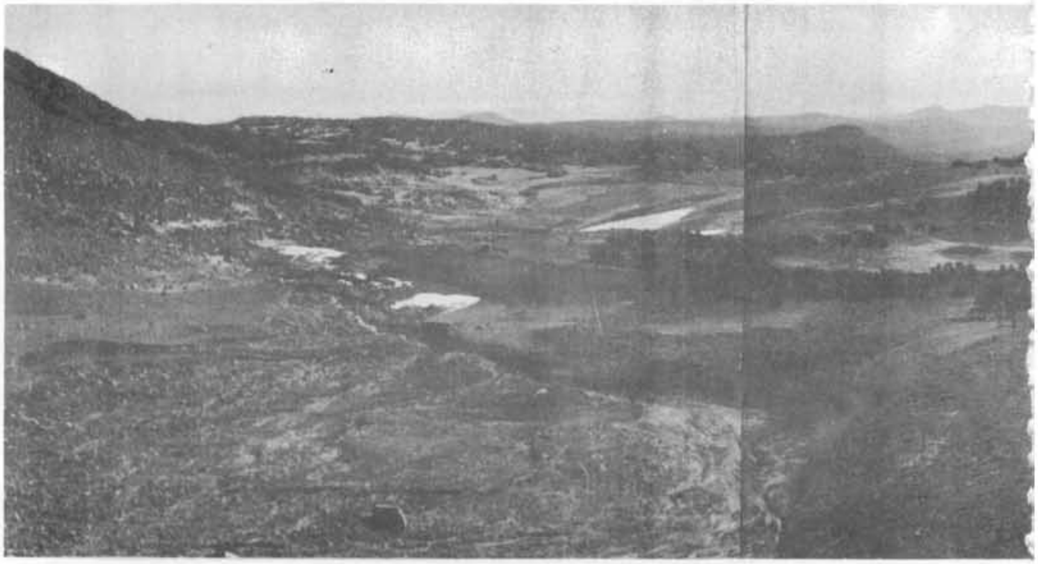

Figure 6. Panorama looking east and south from the moraine down the path of the and back to the right in front of Ball Butte.

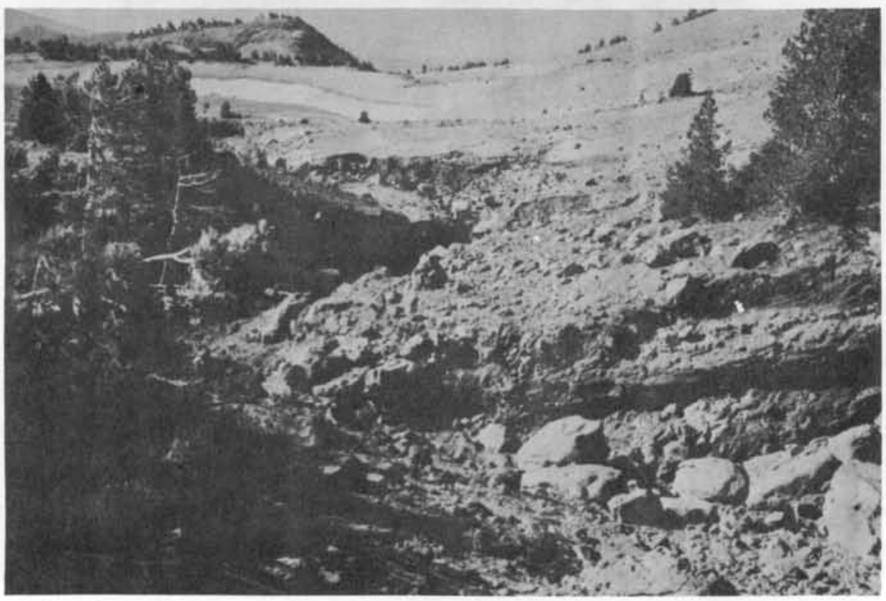

Figure 7. Typical erosion by the flood, approximately one mile down stream from the lake.

flood. The stream channel flows left around an old terminal moraine (with trees),

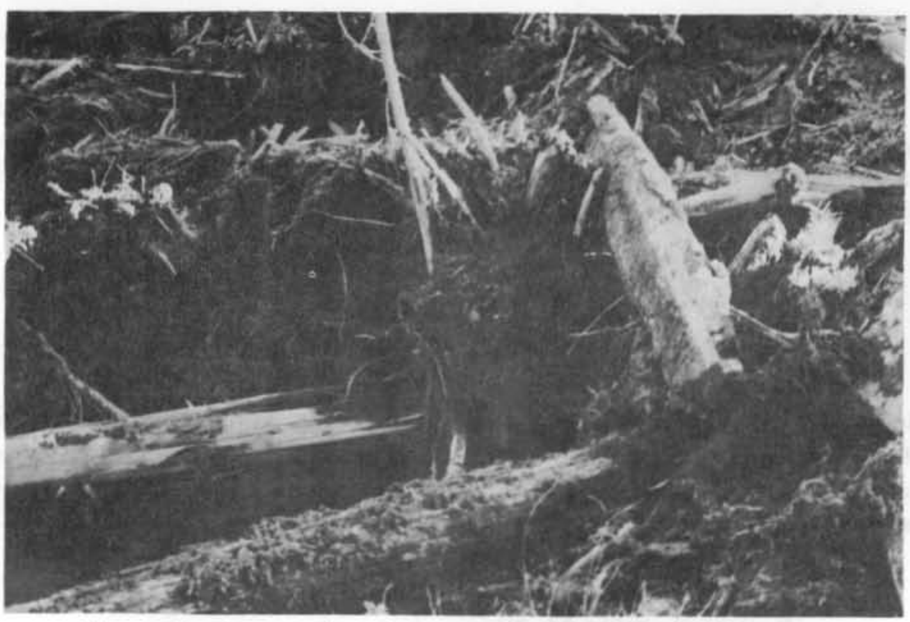

Figure 8. Logs and mud near Soda Creek crossing on the Cascade Lakes Highway.

The water line left by the flood indicates that flow was 10 to 15 feet deep at many downstream points, cutting large gullies and deluging meadows with mud, sand, and gravel (figure 7). The destructive flood waters dropped 2,600 feet in elevation down the east fork of Crater Creek and along Soda Creek before spreading out in the broad basin of Sparks Lake. Forest officials estimated that 35 percent to 45 percent of Sparks Lake meadow was covered by silt. At least 10,000 to 20,000 tons of sediment were carried into the lake and meadow by this flood (figure 8).

Floods of this sort are typical of alpine terrain. Mr. Brogan recalls similar and even larger floods in the Oregon Cascades, one of which swept down the north side of Mount Jefferson more than 35 years ago. Another famous alpine flood originated in a glacial lake near North Sister and reached the McKenzie River.

The author has studied similar flows of muddy debris in the Wallowa Mountains in northeastern Oregon. It is estimated that in the Wallowas the present rate of denudation by mudflows alone, averaged over the entire range, is between 10 and 16 inches per thousand years, considerably greater than the total rate in gentle terrain.

The small lake on Broken Top was only partly drained by the flood of October 7, and the moraine still impounds a large volume of water. Similar floods could occur again with rapid erosion of the moraine. An older, larger moraine, completely dissected by stream action, stands less than a quarter of a mile down stream from the one which impounds the lake.

Acknowledgments

The generous assistance of Phil F. Brogan and that of the personnel of the U.S. Forest Service, especially David Rasmussen, and of the Oregon Department of Geology and Mineral Industries is gratefully acknowledged in compiling this report. All photographs are by David Rasmussen.

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U. of O. MUSEUM ISSUES NEW BULLETIN SERIES

University of Oregon's Museum of Natural History, under the directorship of J. Arnold Shotwell, is now publishing a bulletin series, the first two numbers of which may be obtained, at the prices designated, from the Museum of Natural History, University of Oregon, Eugene, Oregon 97403:

Bulletin 1: Cenozoic stratigraphy of the Owyhee region, southeastern Oregon, by L. R. Kittleman and others; 45 pages, illustrated, price $1.50.

Bulletin 2: Notes on some upper Miocene shrews from Oregon, by J. H. Hutchison; 23 pages, illustrated, price $1.25.

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SOME REVISIONS OF THE GEOLOGY OF THE COOS BAY AREA, OREGON

By Ewart M. Baldwin
Department of Geology, University of Oregon

Introduction

This paper is a progress report on geologic mapping in part of the Coos Bay area (see Plate 1). The writer's interest in this area started in 1943 in connection with the State of Oregon-Coos County coal project (Allen and Baldwin, 1944) and has continued to the present. He is currently working toward a revision of the Coos Bay area, the area encompassed by the Coos Bay 30' quadrangle, as well as the Eocene stratigraphy of southwestern Oregon. The geology is complex and the area is thickly covered by alluvium, terrace deposits, and brush. Thus progress is slow and it may be some time until a more detailed revised map and report are published. The writer has been supported in this study by the Oregon Department of Geology and Mineral Industries, U. S. Geological Survey, and University of Oregon Faculty Research grants, and aided by graduate students at the University of Oregon who have mapped areas near Coos Bay.

Pioneer mapping by Diller (1901) and a later work by Turner (1938) added much to the knowledge of the Coos Bay area. More detailed bibliographic references as well as a revised geologic sketch map is given by Baldwin (1964). A recent paper by Dott (1966) describes the interesting internal structures in the Coaledo Formation and gives petrographic data. Regional mapping by Allen and Baldwin was done prior to detailed microfaunal studies, and such data came later (Detling, 1946; Cushman, Stewart, and Stewart, 1947; and Stewart, 1957). Unpublished data from R. E. Stewart and W. W. Rau have been helpful in dating formations.

Stratigraphy

Pre-Tertiary rocks

Jurassic and Cretaceous strata are present at the southern and southwestern margins of the Tertiary depositional basin. Formations are poorly defined and previous designations may be more confusing than helpful. Many of the strata containing greenstone, chert, and graywacke have been assigned to the Dothan Formation. However, a revised interpretation of coastal geology near Port Orford by Koch (1966) indicates that these beds are likely a northern extension of the Otter Point Formation of late Jurassic age. Koch also describes the lower Cretaceous Humbug Mountain Conglomerate and Rocky Point Formation, neither of which is known to be present in the Coos Bay area.

Rhythmically bedded turbidites of probable late Cretaceous age crop out at Fivemile Point north of Bandon and at the mouth of Crooked Creek south of Bandon. These strata are similar to beds north of Cape Blanco referred to by Dott (1962) in which he found belemnoids, a form that occurs mostly in Mesozoic rocks. Small spherical clay balls encompassed in the sandstone at both Fivemile Point and beds at the mouth of Crooked Creek weather light gray. They were noted in beds along upper Twomile Creek in secs. 33 and 34, T. 29 S., R. 14 W. mapped as lower Umpqua. Late Cretaceous strata such as those at Cape Sebastian (Howard and Dott, 1961) resemble Umpqua strata and are similarly deformed and would be difficult to separate in the field. There was apparently no significant break in deposition at the end of the Cretaceous, and the youngest Cretaceous strata are included in the lowest part of the Umpqua by Baldwin (1965).

Umpqua Formation

The oldest Cenozoic formation is the Umpqua, which has been divided into three mappable formations (Baldwin, 1965). These are to be named and described in a later publication (manuscript in preparation). The oldest of the Umpqua units apparently includes latest Cretaceous beds, Paleocene and early Eocene volcanic flows, and early Eocene eugeosynclinal sedimentary rocks. Although complete sections are not known, at least 10,000 feet is believed to be present where it crops out along Oregon Highway 42 between Coquille and Myrtle Point. A minimum of 8,000 feet of sedimentary rock is present in this section, and the volcanic and prevolcanic rocks probably exceed 2,000 feet. Small isolated patches of Umpqua basalt and tuffaceous sedimentary rocks of the lower unit crop out at the Forks of Coos River and along Willanch and Kentuck Creeks (Pl. 1).

The middle Umpqua unit occurs only along Bear Creek drainage southeast of Bandon and along Catching Creek west of Myrtle Point. It is made up of 5,000 feet of thin, rhythmically bedded graywacke and siltstone, including a variable thickness of basal conglomerate and pebbly sandstone. The basal beds seldom exceed 100 feet in thickness along Bear Creek but total more than 400 feet along Catching Creek. It rests unconformably upon the lower Umpqua at both places.

The upper Umpqua unit is present east of Remote along the Middle Fork of the Coquille River and east of the axis of the Coast Range, but is absent in the Coos Bay area.

Tyee Formation

The Tyee Formation, made up of massively bedded micaceous sandstone, crops out in the central part of the Coast Range and forms the hills in the eastern part of the Coos Bay area along the Coos and Millicoma Rivers. It grades upward into the Elkton Siltstone Member near Elkton northeast of the map area. Massive Tyee was mapped along the western edge of the Coos Bay coal field in Bear Creek drainage southeast of Bandon by Baldwin (manuscript in press). Along tributaries of Bear Creek the beds are overlain unconformably by the lower Coaledo and no siltstone is present. However, micaceous siltstone and thin-bedded sandstone crop out at Sacchi Beach 8 miles north of the nearest known Tyee exposure along the Coquille River. The massive phase of the Tyee does not crop out along the coast but is presumably downdropped against older strata a short distance north of Fivemile Point.

The beds at Sacchi Beach were called the Sacchi Beach Member of the Tyee Formation by Baldwin (1964) and apparently bear the same relationship to the more massive Tyee that the Elkton and Lorane Siltstone Members do at Elkton and west of Eugene. In both instances the massive Tyee sandstone grades upward into the siltstone members.

Pre-Coaledo - Post-Tyee beds

Allen and Baldwin (1944) and others have suggested that the sea withdrew and regional erosion occurred prior to the return of the Coaledo seas, and others have postulated a break at the base of Spencer and Cowlitz Formations to the north. Dott (1966) questions this and postulates little if any break at the base of the Coaledo. Yet one need not leave the Coos Bay area to prove the unconformable relationship, because the Coaledo Formation rests on eroded Tyee and in proximity with lower Umpqua basalt at the forks of Coos River and on a much thicker section of Tyee a few miles to the south or north. No trace of the Sacchi Beach or Elkton Siltstone Members is present at the base of the Coaledo other than at Sacchi Beach. At the south end of the basin along the tributaries of Bear Creek the basal Coaledo conglomeratic and pebbly sandstone beds rest in turn from south to north on lower Umpqua, middle Umpqua, massive Tyee, and then, with a terrace-covered gap of 7 to 8 miles, on the Sacchi Beach Member. It is reasonable to carry the unconformity northward to Sacchi Beach, where the break would be of lesser duration.

Baldwin (1961) mapped beds in the center of the Coast Range south of Elkton as Coaledo (?). These beds cap Old Blue, Rainy Peak, and Soup Mountain in the Elkton and Scottsburg quadrangles. Similar strata were found at Bateman Lookout and southward in the Tyee and Ivers Peak quadrangles. Although in many places they are parallel, on the regional basis the beds show some overlapping from the underlying Elkton Siltstone

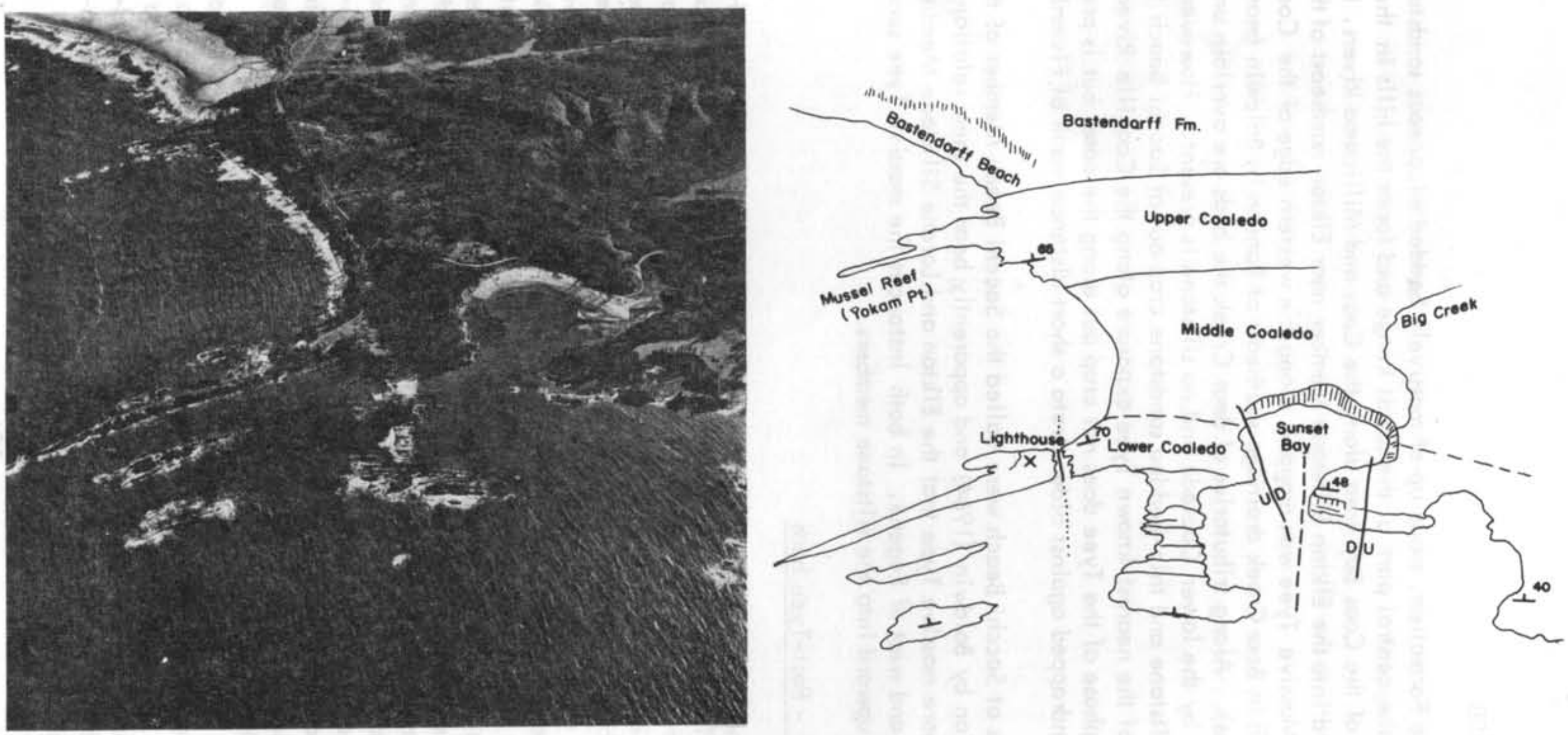

Figure 1. Aerial photograph and sketch of Sunset Bay and vicinity. (Photograph: University of California, Hydraulic Eng. Lab.)

Member toward the more massive Tyee and thus may be slightly disconformable.

Work in the Tyee and Ivers Peak quadrangles has led the writer to consider these beds pre-Coaledo and post-Tyee. The beds, although micaceous, lack the rhythmic bedding of the Tyee and instead include some coal beds. They were evidently laid in deltaic conditions where marine and nonmarine strata interfingered -- conditions similar to those of the Coaledo Formation. The sandstone was probably laid down during an offlap of the Tyee seas. Fossils are not abundant, but Venericardia califia was collected from these beds in the center of sec. 13, T. 25 S., R. 9 W. at the head of the North Fork of Bottom Creek. This distinctive fossil is abundant in the Tyee but has not been reported from the Coaledo. The beds mapped as Coaledo (?) in the Elkton and Scottsburg quadrangles are to be described and named as a new formation. These beds are not recognized in the Sacchi Beach area, where that part of the section is likely missing. R. E. Stewart and W. W. Rau considered the Sacchi Beach fauna to be late middle or early upper Eocene, a part of the B-1A stages of Laiming.

Coaledo Formation

The Coaledo Formation is made up of approximately 6,000 feet of coal-bearing beds of late Eocene age that was first divided into lower, middle, and upper members by Turner (1938). These subdivisions were mapped regionally by Allen and Baldwin (1944), the latest regional mapping of the Coos Bay field. Coal is present in both the lower and upper members, but the middle member is more argillaceous and not coal bearing. Later work in the Coos Bay area has not changed this concept appreciably. It is possible that the base of the upper Coaledo in the coastal area should be drawn somewhat lower at the expense of the middle Coaledo and this is done on Figure 1. The units are transitional and there is a zone about 400 feet thick in which about equal amounts of sandstone and siltstone are present. If encountered inland, the contact would probably be placed lower at the base of the sandstone. Thus some of the differences in thickness cited regionally may be due to interfingering of sandstone and siltstone along strike. An adjusted thickness for the upper Coaledo in the coastal section is 1,715 feet and for the middle Coaledo 2,525 feet.

The middle Coaledo appears to thin at the southern and eastern margins of the basin, as would be expected during an onlap followed by an offlap of seas to the west. The middle Coaledo likely graded laterally into sandstone along the margin of the basin, beds of which are now removed by erosion.

The tip of Cape Arago is labeled as upper Coaledo on the map (Allen and Baldwin, 1944), but this was a mechanical error, for it was considered to be lower Coaledo even at the time of mapping (see page 23).

Turner (1938) considered the channeling in North Cove to represent

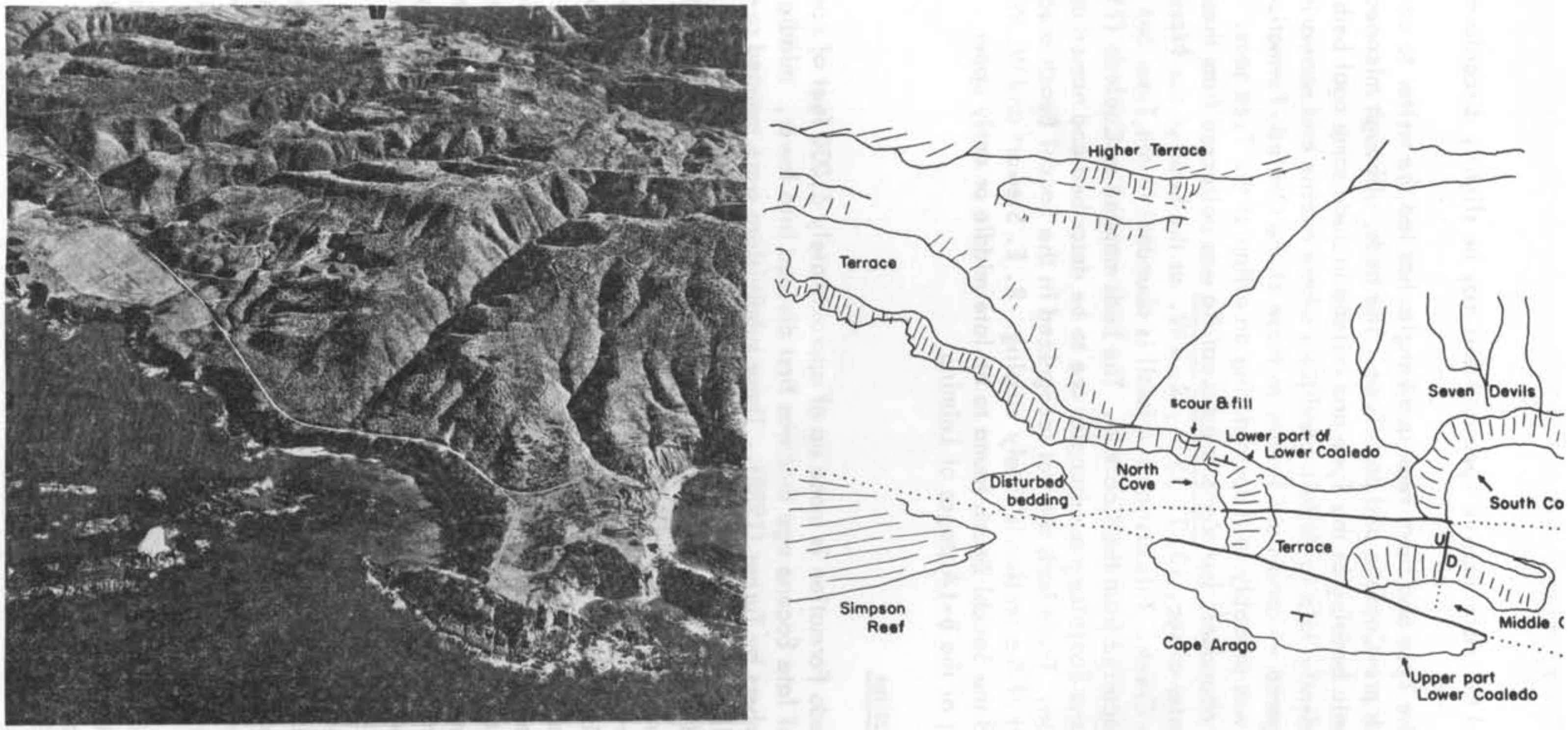

Figure 2. Aerial photograph and sketch of Cape Arago and vicinity. (Photograph: University of California, Hydraulic Eng. Lab.)

the basal unconformity of the Coaledo Formation. Further study of the Cape Arago area (Fig. 2) as well as the Coaledo Formation indicates that the formation was laid down as deltaic shallow-water sediments with swampy margins and interfingering continental beds in which primary sedimentary features such as cross-bedding, scour and fill channeling, and slump structures occurred. Channeling such as that seen in North Cove is now considered by the writer to be intra Coaledo and does not represent the bottom. Beds in the fault zone at Cape Arago, formerly mapped as Umpqua by Allen and Baldwin (1944), are now considered by the writer to be Coaledo, and their greater steepness is attributed to disturbance along the fault or faults. Lithologically they are more similar to the thin-bedded micaceous and carbonaceous sandstone in the Coaledo than to beds in the Sacchi Beach Member of the Tyee.

Bastendorff Formation*

The Bastendorff Formation is conformable upon the Coaledo Formation. It consists of 2,900 feet of shale which crops out at Bastendorff Beach. Stewart (1957) shows that the formation is both upper Eocene and lower Oligocene. The upper 700 feet of the section is comparable to the Refugian stage of California, according to Stewart.

Tunnel Point Formation

The Tunnel Point Formation crops out between the Bastendorff Formation and the Empire Formation southwest of the Coos Bay Jetty near the east end of Bastendorff Beach. The upper part of the section is not exposed, but it may grade upward into siltier beds much as the Yaquina Formation of comparable age apparently interfingers and grades upward to the Nye Mudstone at Yaquina Bay (Snavely, Rau, and Wagner, 1964). The cross section of the South Slough syncline (Fig. 3) shows that there may be room for the Nye Mudstone to be present and still leave space for an appreciable thickness of both the Tunnel Point and Miocene beds.

The Tunnel Point Formation on the geological map (Allen and Baldwin, 1944) was shown extending northward under the broad beach to the jetty. Actually, it should not extend north of the cliff line. The eastern margin as shown on the 1944 map is too close to the south end of the jetty, which is against beds of the Empire Formation (see Plate 1 of the current report).

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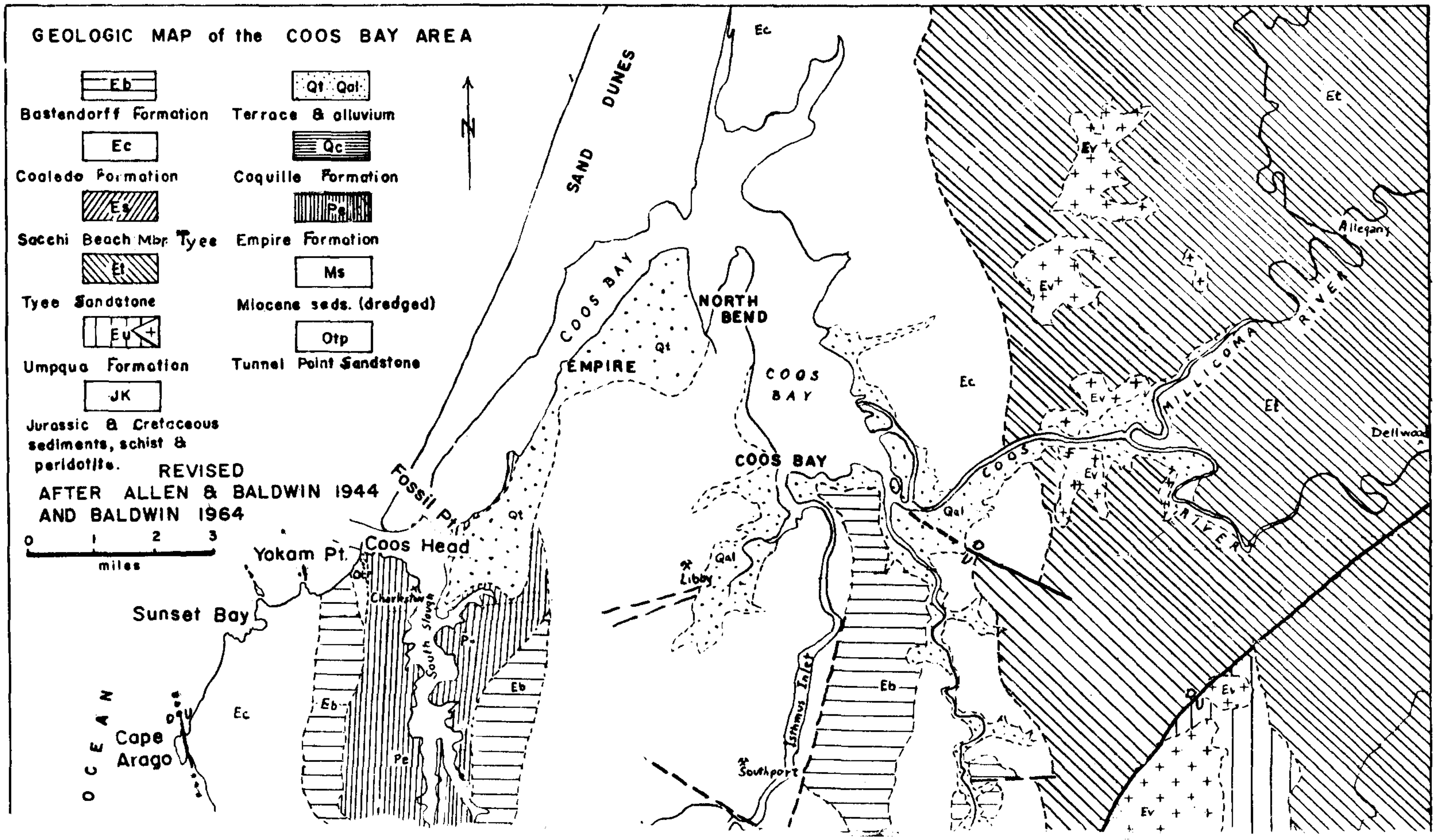
* The correct spelling of Bastendorff, according to the U. S. Board of Geographic Names.



GEOLOGIC MAP of the COOS BAY AREA
Eb
Bastendorff Formation
Qt Qal
Terrace & alluvium
Ec
Coaledo Formation
Qc
Coquille Formation
Es
Sacchi Beach Mbr. Tyee
Pe
Empire Formation
Et
Tyee Sandstone
Ms
Miocene seds. (dredged)
Ev
Umpqua Formation
Otp
Tunnel Point Sandstone
JK
Jurassic & Cretaceous sediments, schist & peridotite.
REVISED
AFTER ALLEN & BALDWIN 1944
AND BALDWIN 1964
0 1 2 3
miles
N
SAND DUNES
COOS BAY
EMPIRE
NORTH BEND
COOS BAY
COOS BAY
Fossil Pt.
Coos Head
Yokam Pt.
Sunset Bay
Cape Arago
OCEAN
South Slough
Isthmus Inlet
Libby
Southport
MILLICOMA RIVER
COOS RIVER
Allegany
Dellwood

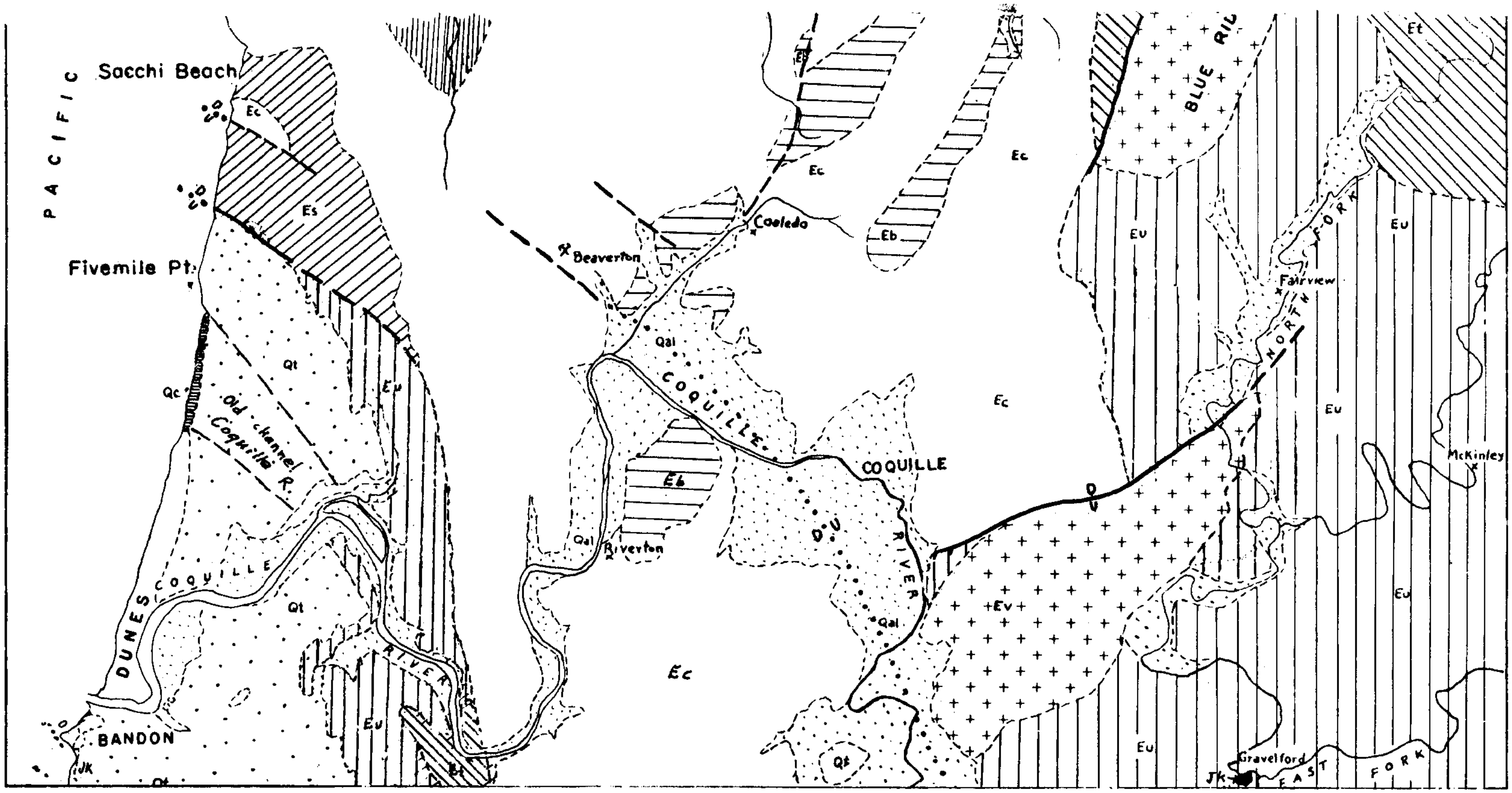
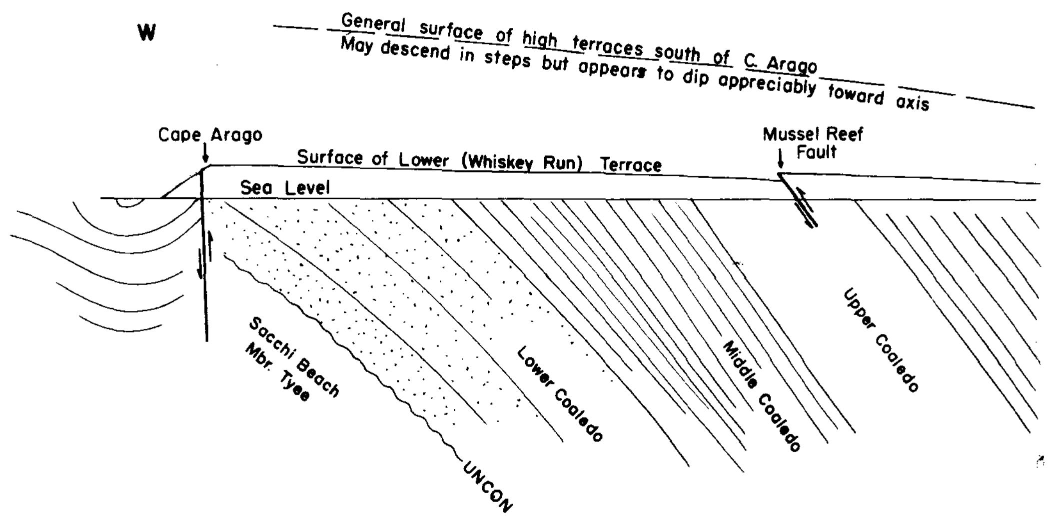


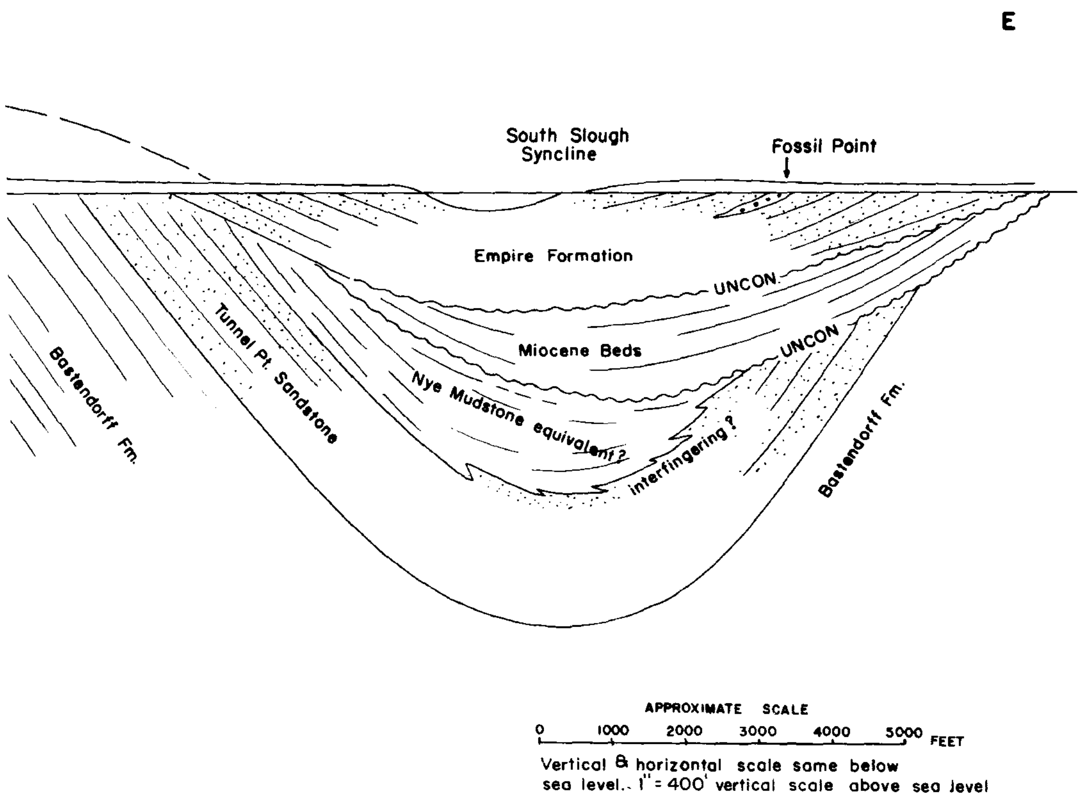
PLATE 1. GENERALIZED GEOLOGIC MAP OF PART OF THE COOS BAY AREA, OREGON.



igure 3. Schematic cross section through a part of the South Slough syncline from vicinity of Cape Arago to a point near Empire, showing progressive deformation along axis of syncline.

1. Late Oligocene to early Miocene deformation involving Tunnel Point and older Eocene beds.
2. Implied deformation during late Miocene involving Miocene beds.
3. Post Empire Formation deformation during middle and late Pliocene.
4. Deformation of older terraces with dip toward axis (may be in part steplike withdrawal of sea).
5. Inclination of Whiskey Run terrace toward axis during late Pleistocene.
6. Post terrace (late Pleistocene) fault at Mussel Reef indicating continued compression.

As shown, there is ample room in center of syncline for beds equivalent to the Nye Mudstone which may interfinger with the upper part of the Tunnel Point Sandstone and for a thickened section of Miocene beds which are not exposed at the western edge of the basin but which have been found in restricted area by Armentrout at eastern margin.



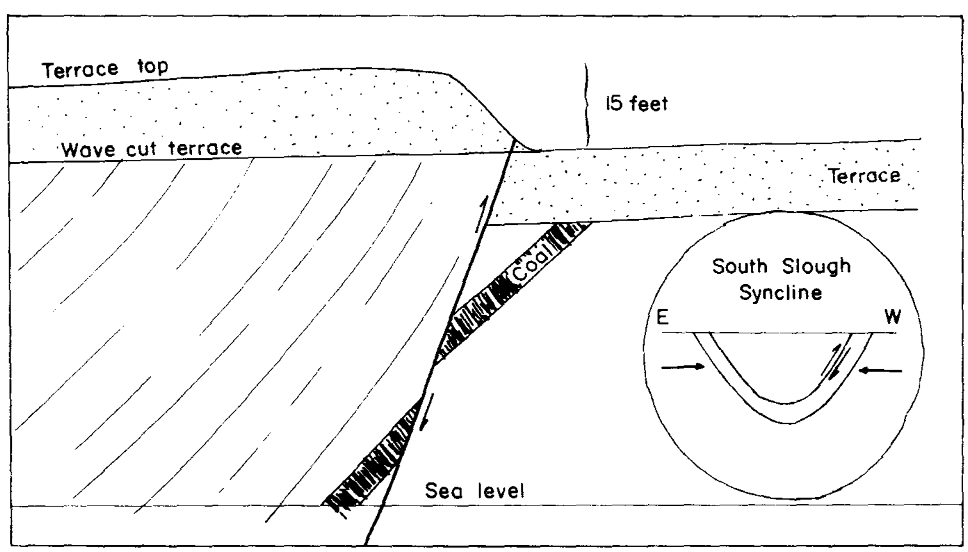


Figure 4. Small fault at Mussel Reef offsetting the late Pleistocene terrace. Continued compression is implied. Relation to South Slough syncline is shown in inset.

Miocene beds

Miocene beds were discovered during dredging of Coos Bay by the U.S. Corps of Engineers. The dredgings contained abundant fossils which were described by Moore (1963). She concluded that the fossils are lower to middle Miocene and in beds generally equivalent to the Temblor of California but not closely resembling Oregon Miocene faunas. The fauna in the dredgings contained numerous specimens of the genus Dosinia. None of this genus has appeared in the younger Empire Formation at Fossil Point where fossils in blocks are obviously reworked. It seems evident that the reworking is within the Empire Formation and did not affect older Miocene beds. A projection of older formations in the South Slough syncline indicates that there is room for a considerable thickness of Miocene strata in the center. John Armentrout (oral communication, September 1966) has found a thin section of the Miocene beds cropping out along the northeastern margin of the basin. The beds are only a few feet thick where exposed and dip gently at about the same angle as the overlying Empire beds.

Empire Formation

The Empire Formation occupies the center of the South Slough syncline, and is made up of as much as 3,000 feet of massive sandstone. It contains the well-known Fossil Point locality. The Empire Formation was dated as lower and middle Pliocene with a possibility of uppermost Miocene (Weaver, 1942, 1945). Armentrout is currently restudying the Empire fauna. Loose fossils similar to those in the Empire Formation are relatively common along the beach at the mouth of the Coquille River. One of the few outcrops of the Empire Formation between Coos Bay and Cape Blanco occurs at the mouth of China Creek 3 miles south of Bandon. Poorly exposed beds at the Fish Hatchery on Ferry Creek a mile east of Bandon are tentatively considered to be Empire by the writer.

Coquille Formation

The Coquille Formation of late Pleistocene age was named and described by Baldwin (1945, 1964). It is best exposed north of the present mouth of the Coquille River between the mouths of Whiskey Run and Cut Creeks and it represents the position of the river mouth at the time of deposition. The formation contains semiconsolidated conglomerate, sandstone, and mudstone with numerous stumps and logs, all of which were deposited in a bay during a stage of alluviation similar to that taking place today.

Pleistocene terraces

Pleistocene events were confined largely to terrace formation. A series of terraces reaching as high as Blue Ridge at 1,500 feet has been described by Griggs (1945). In the South Slough area higher terraces are almost 600 feet high south of Cape Arago but dip noticeably toward the axis of the syncline, pointing to definite tilting eastward. The latest terrace, the Whiskey Run terrace of Griggs (1945), has been warped (Baldwin, 1945). It is 125 feet at Cape Arago, lower at Shore Acres and Sunset Bay, and approximately 25 to 30 feet at Fossil Point (Fig. 3).

Structural Geology

Faulting

Several prominent faults have been discovered since 1944. Baldwin (1964) has shown a fault contact between the lower Coaledo and the Umpqua along Hall Creek west of Myrtle Point and another northeast-trending fault paralleling the north side of the Umpqua basalt east of Coquille, where the Coaledo is faulted against the basalt. He would now add a prominent parallel fault along the northwest side of Blue Ridge and continue it northeast to Coos River about a mile east of the margin of the Coos Bay 15' quadrangle (Pl. 1).

Geophysical work by H. R. Blank (U.S. Geological Survey open-file report, 1965) indicates that a northwesterly trending fault is buried beneath the Coquille River sediments. The basalt mass south of Coquille drops abruptly to the southwest. This fault is parallel to smaller faults in the Beaver Hill area and along the coast at the south end of Sacchi Beach and with the larger one a short distance north of Fivemile Point.

A prominent fault through Cape Arago with a branch in Middle Cove was mapped by Allen and Baldwin (1944). The block between Middle and South Coves has many subsidiary fractures with small displacement. In the cape there is little evidence for other than simple dip slip. However, where the fault zone cuts diagonally northwest across Simpson reef, at the north tip of the cape, considerable brecciation and drag on beds suggest that there may be some strike slip (Fig. 2).

Nearly all small coves are located where erosion has been aided by existing faults, many of them with only a few feet of displacement. The entrance to Sunset Bay represents erosion along an intersection of several parallel and intersecting faults (Fig. 1). On an areal photograph the various resistant beds may be traced across the entrance to the bay even though offset by faulting. Vertical movement on dipping beds can give an apparent horizontal offset, but this is often more apparent than real, and that is perhaps the case at Sunset Bay where small horizontal separation may be seen.

Terraces in the Cape Arago area are particularly well displayed, for many of the bays give a three-dimensional view of both the terrace surface and the wave-cut platform upon which the terraces lie. Several post-terrace faults have been observed. The most distinctive is at the coal bed along the west side of Mussel Reef (Yokam Point). At this place the strike of the fault is parallel to the beds, although the dip may be somewhat steeper. It appears to be a steep reverse fault roughly parallel to the beds (Fig. 4).

Folding and warping

The principal structure in the Coos Bay area is the north-plunging coal basin that extends from Grigsby Rock west of Myrtle Point to the Coos Bay area. Within it are subsidiary folds of which the South Slough syncline is one of the best known (Pl. 1 and Fig. 3). Cape Arago is on the western limb in an area of the best exposures. Folding followed the build-up of more than 10,000 feet of late Eocene to middle Oligocene strata. The Coaledo Formation commonly dips 60° to 70°, much steeper than the older Tyee Formation a short distance to the east in the Coast Range. The Bastendorff and Tunnel Point Formations share this steep dip. An unconformity between the Tunnel Point and the Miocene beds is implied and still another is indicated beneath the Empire Formation, for it laps onto the Tunnel Point, Bastendorff, and Coaledo Formations (Pl. 1 and Fig. 3).

The evidence suggests that there has been intermittent folding along the South Slough synclinal axis ever since deposition of the thick section of Eocene and Oligocene beds. Recurrent folding is shown by progressive deformation of each succeeding formation, by tilting of the terraces, and by the small dip-slip fault offsetting the youngest terrace. Folding is attributed to continued, although intermittent, compression.

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LUNAR CONFERENCE TRANSACTIONS PUBLISHED

The Department of Geology and Mineral Industries has published "Transactions of the Lunar Geological Field Conference," a companion publication to the Lunar Geological Field Conference Guide Book which was printed a year ago. The Transactions volume contains 11 papers and 7 abstracts prepared by lunar geologists and geophysicists who attended the conference. The 100 pages of articles are illustrated with 46 photographs, tables, and line drawings. The publication was sponsored by the University of Oregon Department of Geology and by the New York Academy of Sciences. Copies of the Transactions are available from the Department of Geology and Mineral Industries for $2.00 postpaid.

* * * * *

U. O. MUSEUM ISSUES THIRD BULLETIN

The University of Oregon Museum of Natural History has issued Bulletin No. 3 entitled "A New Archaic Cetacean from the Oligocene of Northwest Oregon," by Douglas Emlong. The author discovered this unusual fossil whale in March 1964 in the Yaquina Formation near Seal Rock State Park, Lincoln County. The bulletin may be obtained from the Museum of Natural History, University of Orégon, Eugene, Oregon. The price is $1.50.

* * * * *

GUIDE TO MINERAL INDUSTRY EDUCATION PUBLISHED

The American Mining Congress has published a guide to mineral industry education in American universities entitled "Profiles in Mineral Industry Education." It describes university programs in 21 American mining schools. Purpose of the publication is to help increase the enrollment in the technologies which serve the mining industry -- mining engineering, geology, metallurgy and others. Presently there is a critical shortage of university-trained technical personnel but, while the demand is rising for people with this training, enrollment has declined.

Copies are available without cost to high school and university guidance counselors and industry officials engaged in counseling young people for a future in the mineral industry; write to the American Mining Congress, 1100 Ring Building, Washington D.C. 20036.

* * * * *

MOUNT VERNON QUADRANGLE MAP FOR SALE

"Geologic Map of the Mount Vernon Quadrangle, Grant County, Oregon," by C. Ervin Brown and T. P. Thayer, has just been issued by the U.S. Geological Survey as Map GQ-548. The multicolored map is accompanied by cross sections and a descriptive text outlining the geologic history of the area. It may be obtained from the U.S. Geological Survey, Federal Center, Denver, Colo. The price is $1.00.

The Mount Vernon quadrangle lies in the west-central part of Grant County between long 119°00'-119°15' and lat 44°15'-44°30'. The southern half of the area is underlain almost entirely by Paleozoic and Mesozoic rocks of late Permian to Early Jurassic age which, in some places, have been intruded by diorite or granodiorite stocks of Late Jurassic or Early Cretaceous age. In the northern half of the quadrangle, these older rocks are overlain unconformably by Cenozoic non-marine sediments and volcanics.

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A MAGNETIC SURVEY OFF THE PACIFIC NORTHWEST COAST

By

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Introduction

Since 1963 the Geophysics Research Group of the Department of Oceanography, Oregon State University, has been conducting regional magnetic studies off the coasts of Washington, Oregon, and northern California. One of the purposes of these studies is to extend into the coast the data of Mason and Raff (1961) and Raff and Mason (1961) in order to determine whether their anomalous north-south lineations continue to be evident. We also desire to locate more localized magnetic anomalies and to determine their depth, bottom expression, and relationships with the continental mass and shelf.

Instrumentation and Procedure

The total intensity magnetic field was measured using a ship-towed proton precession magnetometer, of ± 5 gamma accuracy, constructed at Oregon State University in 1962.

Figure 1 shows the survey area, the ship's track lines representing 11 cruises and 10,000 miles, and the ships used. Comparison at each of the 223 cruise crossings was made and the absolute mean difference was 6.1 gammas with a standard deviation of 38.4 gammas. This is quite reasonable considering the instrument error of ± 5 gammas and the diurnal variation of 30-40 gammas for which no correction was made.

Magnetograms from Tucson were compared with our records to determine the effect of magnetic storms. No significant effect was found.

The Data

Figure 2 shows the total magnetic intensity off the coast of Washington. A main feature of this map is the north-south lineation at 126° which is consistent with the map of Raff and Mason (1961). Closed highs and lows

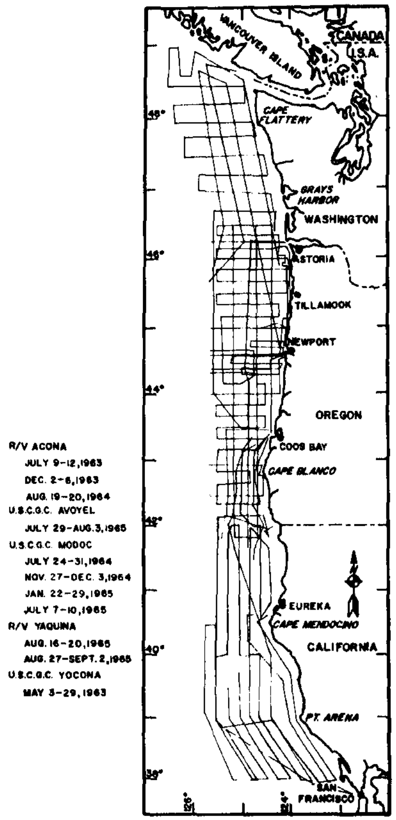

Figure 1. Ship track lines for magnetic measurements.

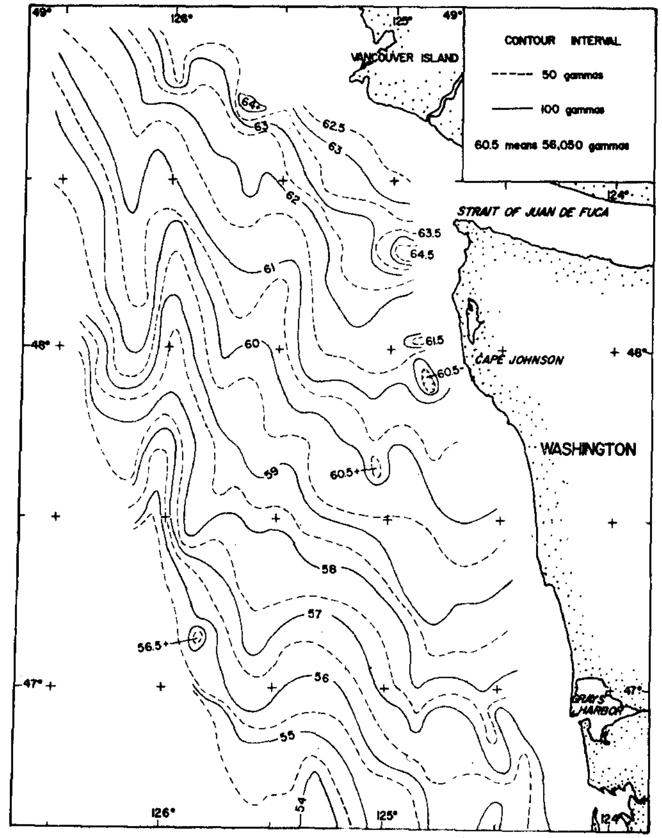

Figure 2. Total magnetic intensity off the coast of Washington.

are not as evident in this area as off Oregon and northern California. Hence, the northwest to southeast trend of the earth's dipole field is clearly seen.

Figure 3 shows the total intensity off the coast of Oregon. The most interesting areas of this map lie just off shore where many strong highs and lows are evident. One of these areas in particular, just south of Newport, was studied by Whitcomb (1965). Combining magnetic data with that from gravity and sparker work, Whitcomb concluded that the coastal geologic structures probably do continue to the west, although this may not always be evident from the sea-floor geology and topography. We feel this to be representative of the other near-shore anomalous areas off northern Oregon.

Figure 4 shows the total intensity off the coast of northern California. Much magnetic character is evident here, with the main points of interest being opposite Cape Mendocino and Point Arena. Off Cape Mendocino indications are that the Mendocino Anomaly continues to the continent. This is an excellent extension of the maps of Mason and Raff (1961) and a confirmation of their later findings based on two magnetometer lines run in this area. Off Point Arena there is what very well could be an extension coastward of the subtle Pioneer Anomaly of Mason and Raff. This anomaly vanishes as it approaches the coast.

Work Being Done

Anomaly maps have just been completed and calculations of depths to anomaly sources are being made using the methods of Peters (1949), Vacquier and others (1951), Henderson and Zietz (1948), and Smellie (1956).

Acknowledgments

We would like to thank Happy T. Holden, Jeremy R. Hutt, Timothy Long, William R. McKnight, and William A. Rinehart for assisting with the field work and data reduction. The U.S. Coast Guard provided ship time on the U.S.C.G. cutters AVOYEL, MODOC, AND YOCONA. The National Science Foundation and Office of Naval Research sponsored this work under grants GP 2186, GP-5581 and Nonr 1286(10) NR 083-102.

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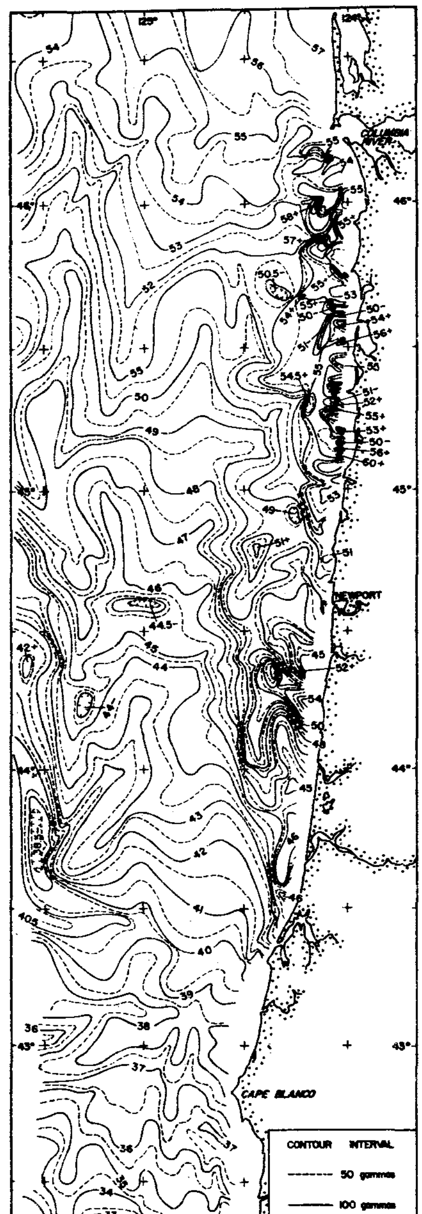
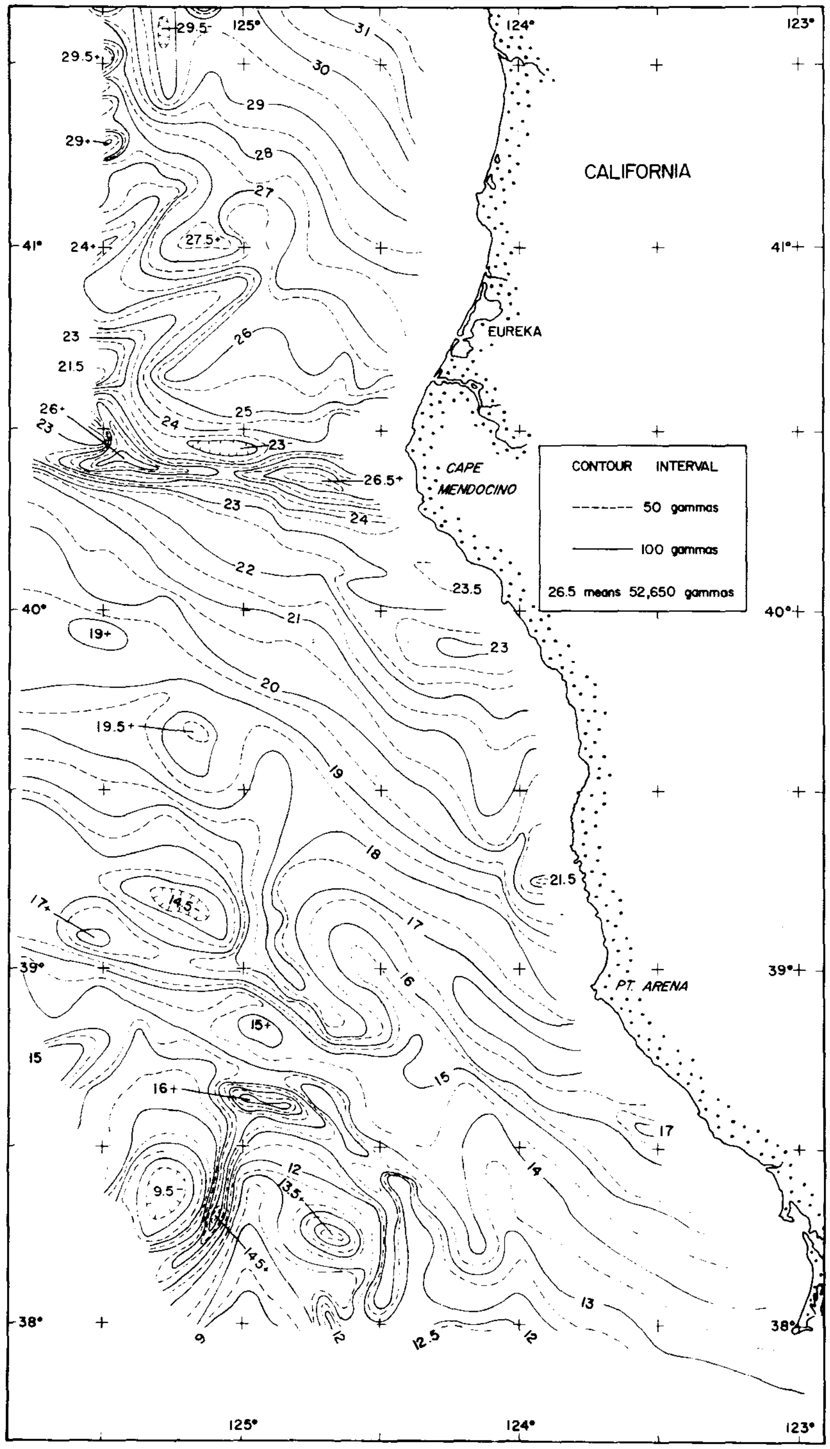


Figure 3. Total magnetic intensity off the coast of Oregon.



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Vacquier, V., and others, 1951, Interpretation of aeromagnetic maps: Baltimore, Maryland, Geol. Soc. America Memoir 47, 151 p.

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FOSSIL LEAVES FROM CENTRAL OREGON EXHIBITED

A fossil leaf collection from the Dick Ranch near Post southeast of Prineville in Crook County, Oregon, is on display at the Department's Portland office. The fossils occur in the John Day Formation of late Oligocene to early Miocene age. Leaves and seeds are numerous, varied, and beautifully preserved. They represent more than 30 different kinds of trees and shrubs growing today in moist temperate climates. The flora has been described in a Carnegie Institution publication by noted paleobotanist Ralph Chaney, who considers it to be identical to the Bridge Creek flora at Painted Hills State Park. Associated with the plant remains at Dick Ranch are skeletons of tiny fish. The Dick Ranch leaves were collected and loaned by Lee Jenkins of Portland. The Department also has fossil leaves from this site that were collected and donated by Leonard Wilkinson of Prineville. The Jenkins collection will be on display through January, 1967.

* * * * *

OREGON ACADEMY OF SCIENCE ELECTS OFFICERS

The Oregon Academy of Science has elected the following officers for 1966-67. President: Dr. Wendell Slabaugh, Department of Chemistry, Oregon State University; Secretary, Dr. Keith Oles, Department of Geology, Oregon State University; Treasurer, Dr. Alan Kays, Department of Geology, University of Oregon. The next annual meeting will be held on February 25, 1967. The meeting place will be announced in the near future.

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THE ARMSTRONG NUGGET

By N. S. Wagner*

On Thursday, June 19, 1913, George Armstrong and his partner recovered the gold nugget pictured in figure 1 from the gravels of their placer mine located approximately three miles from Susanville, Grant County, Oregon.

By early the next morning news of the discovery was made public and spread like wildfire. First a Susanville correspondent interviewed Armstrong in Susanville and telephoned his account to the Baker Herald, Baker, Oregon. A few hours later another correspondent interviewed Armstrong and his associates in Austin and telephoned in a report to the Baker Herald. In some way news of the discovery reached Ed Hendryx, editor of the Blue Mountain American, Sumpter, in time for him to meet the train and interview Armstrong and his entourage in the Sumpter Valley Railroad depot in Sumpter that same afternoon.

The reports submitted by the Susanville and Austin correspondents were printed in the Baker Herald, Friday, June 20, the same day the correspondents interviewed Armstrong and submitted their stories. Hendryx missed out on a scoop, however, because his Blue Mountain American was a weekly paper published each Thursday; hence, his article did not appear in print until June 26, even though his interview with Armstrong took place on the same day as the other interviews.

Because these published reports were based on first-hand interviews with Armstrong at a time when the novelty of the discovery was still fresh and uppermost in his mind, they probably chronicle the circumstance of the discovery accurately. In addition, they provide an interesting side light into the manner in which each reporter handled the story. For these reasons the full text of each of these articles is reproduced. First, however, there is another thought that it might be best to mention. This is that in evaluating these reports, the reader should remember that the Susanville and Austin reporters were faced with the cost of long-distance tolls and the urgency of meeting a press deadline. Their stories are, therefore, probably shorter and less detailed in their coverage than they would have been had they had more time for preparation. Hendryx, on the other hand, was faced with the fact that the news was already old by the time he could publish his article; hence, he did not elaborate on the subject to the extent that he might have done had he not been scooped by the Baker newspapers.

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* Department Geologist, Baker Field Office.

Undoubtedly each of the reporters deplored the circumstances which prevented him from writing a detailed, blow-by-blow account of the discovery, but perhaps this was for the best, because what we now have in these particular articles conceivably comes closer to being a straight recitation of essential fact than might otherwise have been the case. In any event, and in the order in which the interviews were held, these articles are as follows:

Baker Herald, Friday, June 20, 1913

$1500 NUGGET IS PICKED UP AT SUSANVILLE

"Largest find of the kind in eastern Oregon was made yesterday
"Three men bring it to this city
"George Armstrong and Dick Stuart make discovery while working in their placer mine in Dutch Gulch
"May be the largest found in the Northwest"

"Susanville, June 20: To find a $1500 nugget, after picking up three pieces of gold worth $10 to $11 each, was the good fortune which befell George Armstrong and Dick Stuart in their Dutch Gulch placer claim three miles from Susanville yesterday.

"The nugget is solid gold, no quartz being mixed with it, and weighs about six and three-quarters pounds. The gold is worth about $17.50 an ounce.

"The men have been working the claim irregularly the past four years but have found it paying a handsome profit for the little time spent on the property. While mining by hydraulic pressure yesterday the big find was unearthed.

"The nugget is the largest ever found in Eastern Oregon and perhaps in the entire Northwest, being of solid gold. A few years ago a specimen was found in that same district worth $728, and about two years ago, one was found in the Humboldt placers worth $720.

"The two men and a companion left this morning for Austin to take the Sumpter Valley train for Baker."

* * *

Baker Herald, Friday, June 20, 1913

"Special to Herald

"Austin, June 20: On their way to Baker with the $1500 nugget the three men stopped in Austin today. When asked about the find, Armstrong said: 'It was almost unbelievable yesterday when we washed that chunk out, we were so surprised. We have been working on the claim only at intervals, but we have been well repaid for our work. Three of us comprise a party, guarding the metal, and will reach Baker this evening on the Sumpter Valley. There has been a number of people to see the find, several being

Figure 1. The famous Armstrong nugget found in placer gravels near Susanville, Grant County, Oregon, in 1913.

Figure 2. Medal won in 1915 at the Panama Pacific Exposition in San Francisco for being the largest quartz-free nugget exhibited.

from Susanville and Austin. All are of the same accord that it is one of the greatest finds in Eastern Oregon'."

* * *

Blue Mountain American, June 26, 1913

"A NEAR RECORD GOLD NUGGET

"A gold nugget worth $1408.75, weighing a fraction over 80 ounces, is some piece of gold, a sight for sore eyes. Those at the S. V. depot last Friday afternoon were treated to a sight of this kind. The nugget was the property of D. I. Stewart and George Armstrong, and was found by them in their placer mine near Susanville. They were taking it through to Baker to place it in the First National Bank of that place.

"The nugget takes its place among the large pieces of native gold that have been found in Eastern Oregon, and calls to mind other big chunks of the yellow stuff that have been found. These range in value from a few hundred dollars to up in the thousands. One story we remember is of the finding of a chunk worth $10,000.00 by a Chinaman, in the Greenhorn mountains many years ago. This, if authentic, was doubtless the largest nugget ever found in the state."

* * *

Today there are several stories about how the nugget was found at the instant of discovery. One is that a large chunk of mud stuck to the heel of Armstrong's son's boot when they started back to the cabin for lunch. This revealed the nugget which the father, walking behind, picked up. Whether it is true, or just fanciful, this version of the actual discovery is mentioned in print in a Democrat Herald article as early as October 25, 1934 and is credited to one of the old First National Bank officials who presumably knew the story from first-hand acquaintanceship with the principals.

Another version of the discovery is given by O.H.P. McCord of Baker, who was bookkeeper at the First National Bank at the time Armstrong brought the nugget in. McCord's version of the discovery is that Armstrong left the giant trickling at reduced pressure against the face while the crew went to lunch. When they returned to the pit, the nugget lay there on the pit floor as a result of having been washed out during the lunch hour.

Despite the fact that this aspect of the discovery is not mentioned in any of the foregoing articles, either of these stories can represent a true account of the actual circumstance which took place at the instant of discovery. For example, a nugget of this size would not likely be washed to the sluice boxes by ordinary hydraulic means. Instead, it would hang back nested in the mud in the bottom of the pit near the face from which it had been washed. Thus it would be available to be stepped on and tripped over and there is no real reason to disbelieve the mud-on-the-son's-heel story. On the other hand, McCord's story is equally sound as leaving the giant in operation at reduced pressure, temporarily, was a common practice at all hydraulic operations.

The articles disagree on the name of Armstrong's partner, which is spelled "Stuart" in the report datelined Susanville, and "Stewart" in the Hendryx article. What the correct spelling of the partner's name is we don't know and haven't taken the trouble to investigate. Of more importance, Armstrong's placer is described in the Susanville article as being located in "Dutch Gulch." However, the location is universally accepted as having been in Buck Gulch and this is a situation that can be attested to by numerous individuals, still living, who resided in Susanville and knew Armstrong at the time the nugget was discovered. This discrepancy was investigated and it can be stated that the location of the Armstrong placer is given as being on Buck Gulch in a report published by the Oregon Bureau of Mines and Geology in 1914, to wit -- "Buck Gulch, below Deep creek, years ago had one $800 (nugget), but on June 19, 1913, George Armstrong found another on Buck gulch weighing 80.4 ounces."

Why the Susanville article cites the location as "Dutch gulch" is difficult to explain. One possibility is that the gulch may have been known locally by two names in 1913. Another more likely explanation is that during the course of relaying the story between the reporter in Susanville and the Herald editor in Baker, the name became garbled due to poor connections. After all, long-distance communication by telephone during 1913 often left much to be desired in terms of today's standards, so that, conceivably, the word "Buck" could have come through as "Dutch" to the ears of the listener.

How contagious "gold fever" can be is amply illustrated by the editorial the editor of the Baker Herald saw fit to publish on June 21, 1913. This was the day after Armstrong arrived in Baker with the nugget and whereas the editor does not say so explicitly, we can be virtually certain that before composing his editorial he had visited the bank, talked with Armstrong, drooled over the nugget, and probably also hoisted a few convivial drinks with the assembled throng in line with the general spirit of "celebration" which is rumored to have taken place. In any event, the editorial which followed the original discovery articles is as follows:

Baker Herald, Saturday, June 21, 1913

"PICKING UP $1400

"How would you like to pick up a house and lot? Or a small store? Or a four-passenger automobile? Maybe a trip around the world? A nice little farm? A college education? A team of find horses? A band of sheep? A bunch of cattle? Or a little library?

"That is just what George Armstrong and Richard Stuart did when they found a nugget worth $1,408.75 near Susanville. Any of these things they could buy with the find and many more.

"While placer mining, the big piece of gold was picked up and when brought to Baker last night safely deposited in a bank after being weighed.

"This probably gives Baker County the added distinction of producing another largest nugget in the Northwest. It makes the strides of placer mining in this county even greater than before -- and placer mining here has given indications before that it would take the lead in the state in every way.

"In making this find and advertising Baker County as a mining community these two men have paid themselves for much work they have done in the past. It is their reward for perseverance. While it may seem easy to pick up $1,400 there is always the unrewarded work of the years gone by that evens the so-called 'luck.' So they are receiving their just reward.

"However, wouldn't it be a happy little party if each of us could go out and do the same?"

* * *

The Herald editor was carried away by his own enthusiasm, forgetting that Susanville is located in GRANT COUNTY -- many miles from the Baker County border. Thus his remarks about how the find advertises "Baker County as a mining community" and gives Baker County the added distinction of producing "another largest nugget in the Northwest" must be recognized as editorial exuberance, if not, indeed, too much celebrating. Just the same it is interesting to note the list of everyday items he saw fit to equate with the value of the nugget -- a four-passenger car, a team of fine horses, a band of sheep, a farm or a small store, a college education, the cost of a trip around the world, and so forth. The importance of the find is thus well illustrated in terms of the economy of the period. In this connection the reader must remember that gold was priced at only $20.67 per fine ounce in 1913. However, at today's price of $35 an ounce the nugget is worth approximately $2,500 in terms of its gold content. Its value as a specimen is many times greater.

Perhaps on Thursday, June 26, the Oregon Daily Journal was motivated by a case of sour grapes when it came to news of eastern Oregon (a not-unprecedented situation). Or perhaps it correctly interpreted this eastern Oregon editorial about the nugget as being due to "gold fever." In any event, the only coverage they gave to the nugget story (that we found) was a short four-line comment on an obscure, back page and without a headline. This reads:

Oregon Daily Journal, Portland, Thursday Evening, June 26, 1913

"That $1,500 Baker County nugget will probably have the usual result in stimulating a toilsome and expensive search for other big nuggets that aren't there."

* * *

No bull could have been more enraged by a red flag than was the Baker Herald editor by the Journal's comment. As a result we have one final editorial with which to conclude this presentation of news articles inspired by the discovery of the Armstrong nugget. Even yet the editor still disdains to give Grant County credit for being the county in which the nugget was found, to wit --

Baker Herald, Saturday, June 28, 1913, Editorial column

> "How does the Portland Journal know that there are no more big nuggets? Large nuggets, some worth nearly $3,000, some worth $700, have been found in Baker County before. Why cannot there be more? Many men have searched for gold and have failed but their efforts made them better men -- better at least than those who do not try but instead scoff at those that do. The men who found the $1,500 nugget got it by systemmatic and persistent work. Others will do the same.
>
> "Were the Portland Journal, usually fair and often flippant, to investigate it would find that mining in Eastern Oregon, great as it is, is only on the threshold of its possibilities. Today the figures that once startled the world are commonplace in comparison with what is being accomplished now. Baker County mines this year are to make the state greater than ever before. Baker County mines this year will make the nation wealthier.
>
> "There are plenty of nuggets in Baker County for the man who wants them enough to work for them."

* * *

Now that 53 years have passed, we can look back on history and make an independent judgment of our own. One thing we find is that placer mining did continue in both Grant and Baker Counties. Furthermore, it expanded appreciably as is shown by records covering an output since 1912 of nearly 640,000 fine ounces of gold and 126,000 fine ounces of silver from placer sources in the two counties.

At the current price of $35 per fine ounce for gold and $1.29 per fine ounce for silver, this amounts to a combined value of approximately $32,500,000 for the gold and silver output recorded since 1912. If the value of gold and silver produced from lode sources during the same period is added to that of the placer output, the total value of the gold and silver produced from these two counties since 1912 then amounts to nearly $56,500,000 even though precious metal mining has been at a virtual standstill in both counties since 1942, at which time gold mines were shut down by governmental decree for the duration of World War II -- a set-back from which the industry has never recovered because of continued governmental maintenance of the pre-war price of gold despite the ever-inflating trend of post-war operating costs.

The bulk of the afore-mentioned production was achieved during the 30-year period immediately following 1912 rather than between 1912 and

Figure 3. Gold collection owned by the United States National Bank of Oregon and displayed at its branch bank in Baker includes the Armstrong nugget.

1966. Thus, in all fairness, and as we see it, the Baker Herald editor's optimism concerning the gold-silver potential of Baker and Grant Counties cannot be regarded as altogether unfounded, even though he did commit a major sin by not giving Grant County recognition as the parent county in which Susanville is located.

As for the Armstrong nugget -- in 1915 it won a medal at the Panama Pacific Exposition in San Francisco for being the largest essentially quartz-free nugget of its type exhibited. Insofar as is known, this record still stands. The medal that was won is pictured in figure 2. It is owned, along with the nugget itself, by the United States National Bank of Oregon, and both items are part of the bank's famous gold collection on exhibit at its branch bank in Baker, Oregon (figure 3).

Acknowledgments and References

Except for the Blue Mountain American article of June 26, 1913, and the Democrat Herald article of October 25, 1934, both of which are in this Department's files, all press quotations originate from microfilm files in the archives of the Oregon Historical Society, Portland.

Data confirming early use of the name "Buck" gulch originated from A. M. Swartley's report entitled "Ore Deposits of Northeastern Oregon," published by the Oregon Bureau of Mines and Geology, Mineral Resources of Oregon, Volume 1, Number 8, 1914.

Production statistics (ounces) originate from U.S. Bureau of Mines records tabulated in the date range used here by Howard Brooks, geologist with the Department.

Finally, credit is due the United States National Bank of Oregon, and especially John R. Hilsenteger, Press Relations Officer, Portland, and to F. W. Johnson, Thomas Hunt, and Jyme Stoner of the Baker Branch, for assorted data relating to the nugget and medal, and for permission to photograph them; to Lester Hansen, former manager of the Baker Branch of the same bank, and to O. H. P. McCord, former bookkeeper at the old First National Bank of Baker, for supporting data; and to Oscar Nygord for photographs of the nugget and medal.

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IGNIMBRITE IN JOHN DAY FORMATION DESCRIBED

Pyroclastic ignimbrites, sometimes referred to as welded tuffs or ash-flow tuffs, are extensively displayed throughout large areas of central and eastern Oregon. The state has come to be considered a classic region for the study of these interesting volcanic rocks, because of the wide diversity of petrologic types and the areal extent.

Richard V. Fisher describes the mineralogy and petrology of a distinctive rhyolitic to dacitic ignimbrite sequence which occurs in the middle part of the John Day Formation of eastern Oregon. Field evidence indicates that the flow probably had its source somewhere west of the John Day basin, and poured out over 1200 square miles of the land surface before coming to rest.

The report, entitled "Geology of a Miocene ignimbrite layer, John Day Formation, eastern Oregon," is published by the University of California Press as University of California Publications in Geological Sciences, volume 67. Copies of this report may be obtained from the University of California Press for $2.50.

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REPORTS ON OREGON GEOLOGY RECEIVED IN 1966

The following published and unpublished reports on Oregon geology and mineral resources were added to the Department's library during 1966. The list does not include papers appearing in technical journals or trade magazines.

United States Geological Survey

Geologic maps

Brown, C. E., and Thayer, T. P., 1966, Geologic map of the Canyon City quadrangle, northeastern Oregon: USGS Map I-447.

Brown, C. E., and Thayer, T. P., 1966, Geologic map of the Mount Vernon quadrangle, Grant County, Oregon: USGS Map GQ-548.

Thayer, T. P., and Brown, C. E., 1966, Geologic map of the Aldrich Mountain quadrangle, Grant County, Oregon: USGS Map GQ-438.

Walker, G. W., and Repenning, C. A., 1966, Reconnaissance geologic map of the west half of the Jordan Valley quadrangle, Malheur County, Oregon: USGS Map I-457.

Wilcox, R. E., and Fisher, R. V., 1966, Geologic map of the Monument quadrangle, Grant County, Oregon: USGS Map GQ-541.

Mineral resources

Cornwall, H. R., 1966, Nickel deposits of North America: USGS Bulletin 1223.

Walker, G. W., and Greene, R. C., 1966, Mineral resources of the Mount Jefferson Primitive Area, Oregon: USGS Bull. 1230-D.

White, D. E., 1965, Geothermal energy: USGS Circular 519.

Young, L. L., and Colbert, J. L., Gaskill, D. L., and Piper, A. M., 1965, Water power resources in Nehalem River basin, Oregon, with sections on geology of sites: USGS Water-Supply Paper 1610-C.

Stratigraphy and paleontology

Addicott, W. O., 1966, Late Pleistocene marine paleoecology and zoogeography in central California: USGS Prof. Paper 523-C (includes Bandon, Oregon area).

Bingham, J. W., and Grolier, M. J., 1966, The Yakima Basalt and Ellensburg Formation of south-central Washington: USGS Bulletin 1224-G (correlates with Oregon).

Jones, D. L., Murphy, M. A., and Packard, Earl L., 1965, The Lower Cretaceous (Albian) ammonite genera *Leconteites* and *Brewericeras*: USGS Prof. Paper 503-F (central Oregon).

United States Bureau of Mines

Peterson, E. C., 1966, Titanium resources of the United States: USBM Inf. Circ. 8290.

Walker, F. E., and Hartner, F. E., 1966, Forms of sulfur in U.S. coals: USBM Inf. Circ. 8301.

United States Air Force

Skehan, J. W., 1965, A continental-oceanic crustal boundary in the Pacific Northwest: Air Force Cambridge Research Lab. Scientific Rpt. No. 3.

University of California

Fisher, R. V., 1966, Geology of a Miocene ignimbrite layer, John Day Formation, eastern Oregon: Univ. California Publications in Geol. Science, vol. 67.

Oregon State Engineer

Price, Don, and Johnson, Nyra A., 1965, Selected ground-water data in the Eola-Amity Hills area, northern Willamette Valley, Oregon: Oregon State Engineer, Ground-Water Rept. 7.

Sceva, Jack E., 1966, A reconnaissance of the ground-water resources of the Hood River Valley and Cascade Locks area, Hood River County, Oregon: Oregon State Engineer, Ground-Water Rept. 10.

Sceva, Jack E., 1966, A brief description of the ground-water conditions in the Ordnance area, Morrow and Umatilla Counties, Oregon: Oregon State Engineer, Ground-Water Rept. 11.

Oregon State University

Allison, Ira S., 1966, Fossil Lake, Oregon -- its geology and fossil faunas: Oregon State Monograph, Studies in Geology No. 9.

University of Oregon Museum of Natural History

Emlong, Douglas, 1966, A new archaic cetacean from the Oligocene of northwest Oregon: Univ. Oregon Museum of Natural History Bulletin 3.

Hutchison, J. H., 1966, Notes on some upper Miocene shrews from Oregon: Univ. Oregon Museum of Natural History Bulletin 2.

Kittleman, L. R., and others, 1965, Cenozoic stratigraphy of the Owyhee region, southeastern Oregon: Univ. Oregon Museum of Natural History Bulletin 1.

Kansas Geological Survey and University of Kansas

Merriam, D. F., Ed., 1964, Symposium on cyclic sedimentation: Kansas Geol. Survey Bull. 196, vols. 1 and 2. (Vol. 1 contains paper on Coast Range by Snavely, Wagner, and MacLeod; Vol. 2 contains paper on southwestern Oregon by Dott).

Skinner, J. W., and Wilder, G. L., 1966, Permian fusulinids from Pacific Northwest and Alaska (Part 2 - Permian fusulinids from Suplee area, east-central Oregon): Univ. Kansas Paleontological Contributions, Paper 4.

Unpublished Theses

Dodds, R. Kenneth, 1963, Geology of the western half of the Svensen quadrangle, Oregon: Univ. Oregon master's thesis.

Engelhardt, Claus L., 1966, The Paleozoic-Triassic contact in the Klamath Mountains, Jackson County, southwest Oregon: Univ. Oregon master's thesis.

Fairchild, R. W., 1966, Geology of T. 29 S., R. 11 W., in the Sitkum and Coquille quadrangles, Coos County, Oregon: Univ. Oregon master's thesis.

Heinrich, M. A., 1966, Geology of the Applegate Group, Kinney Mountain area, southwest Jackson County, Oregon: Univ. Oregon master's thesis.

Helming, Bob Hager, 1966, Petrology of the Rogue Formation, southwest Oregon, Univ. Oregon master's thesis.

Magoon, L. B., 1966, Geology of T. 28 S., R. 11 W. of the Coquille and Sitkum quadrangles, Oregon: Univ. Oregon master's thesis.

Morrison, R. F., 1963, Pre-Tertiary geology of the Snake River Canyon between Cache Creek and Dug Bar, Oregon - Idaho boundary: Univ. Oregon doctoral dissertation.

Trigger, J. K., 1966, Geology of south-central part of the Sitkum quadrangle, Coos County, Oregon: Univ. Oregon master's thesis.

Wolff, E. N., 1965, Geology of the northern half of the Caviness quadrangle, Oregon: Univ. Oregon doctoral dissertation.

OLD MINING PROPERTIES PROVIDE RECREATION SITES

Two more withdrawals of federal lands from mineral entry have been announced by the U.S. Bureau of Land Management. Both actions stem from requests made by the U.S. Forest Service. One 52.5 acre withdrawal, located in southern Umatilla County along the banks of the North Fork of the John Day River, is scheduled for development into a recreational site. The second area is in central Josephine County, where 60 acres will also be developed for recreational purposes.

The Umatilla withdrawal site occupies old dredged ground which produced a large quantity of placer gold many years ago. The Josephine County area was once occupied by a brick and tile quarry and plant. The two withdrawals serve to point up the often-overlooked fact that old and abandoned mining properties can be rehabilitated and restored to an additional period of usefulness.

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REYNOLDS ALUMINUM ENLARGES TROUTDALE PLANT

The Reynolds Metals Co., which recently celebrated the 20th anniversary of the establishment of its reduction works at Troutdale, has embarked on an expansion program which will ultimately provide for a yearly total production of 140,000 tons of primary aluminum. Reynolds began operating the Troutdale plant in 1946 and acquired ownership from the federal government in 1949. The increased capacity at the plant will require the construction of one new potline plus additional furnaces, casting units, and ancillary equipment and buildings.

The economic impact of the Reynolds Troutdale plant on the local economy can best be gauged by the $88 million payroll and $200 million in taxes, supplies, utilities, freight, and other expenses incurred during the past 20 years. The Troutdale plant currently employs an average of 800 employees on a year-around basis.

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JOHN DAY MAMMALS EXHIBITED

Some exceptionally fine specimens of fossil mammal skulls, jaws, and a foot are on display at the Department's Portland office. The fossils include two oreodons, two sabre-tooth cats, a rhino, a peccary, and a coyote (skull and foot). All are from the John Day Formation and were collected and prepared by David Taylor of Portland. The specimens are on indefinite loan while Taylor is in the service.

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INDEX TO THE ORE BIN

Volume 28, 1966