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

By

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

Introduction

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

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

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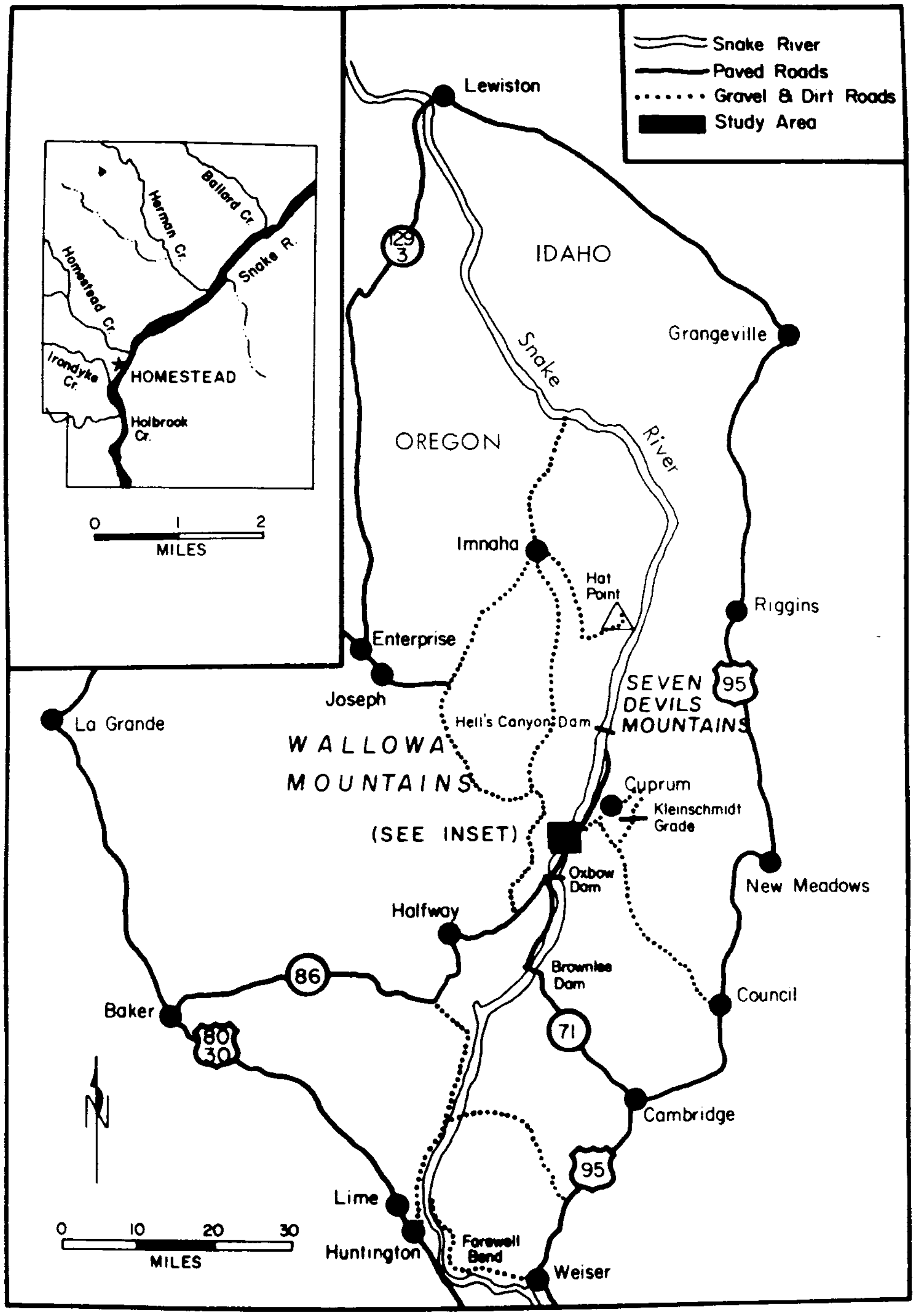


Figure 1. Index map of the Snake River Canyon area, Oregon and Idaho, showing detail of the Homestead area.

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

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

Stratigraphy

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

Permian rocks

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

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

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

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

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

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

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

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

Triassic rocks

Rocks of Middle and Late Triassic ages (Ladinian, Karnian, and Norian Epochs) are exposed in the Snake River Canyon (figure 5). In the Homestead area, Triassic rocks, informally named the Grassy Ridge formation, are preserved in a complex graben and are separated from the adjacent Permian strata structurally by steeply dipping boundary faults and stratigraphically by an unconformity. Fossils, identified by Dr. N. J. Silberling, are late Middle Triassic (latest Ladinian) and early Late Triassic (earliest Karnian) ages. Age assignments depended on the presence of the flat clam Daonella cf. D. indica and an ammonite Trachyceras (sensu stricto).

At least 500 feet of strata are exposed in the graben. Volcaniclastic rocks predominate but limestone, chert, limy shale, and conglomerate also occur.

Farther north in the Snake River Canyon equivalent rocks are well exposed, particularly along Squaw and Saddle Creeks, about 10 and 20 miles north, respectively, of the Homestead area. At these localities, thicknesses approach 3000 to 4000 feet and rocks include pillow lava, limestone, and graded beds of volcaniclastic sediments. These Triassic rocks also have been metamorphosed to the greenschist facies and major mineralogic changes are similar to those which occurred in the Permian rocks.

Provenance studies indicate that the contributing volcanic terranes were of basaltic composition. This is in stark contrast to the source areas for the Permian, which contained volcanic rocks of andesitic composition and also plutonic rocks. Apparently, the older Permian rocks had subsided before Middle Triassic volcanism began or perhaps they were covered by Triassic lava flows and did not contribute debris to the Middle Triassic basins.

The Middle Triassic rocks are of particular interest for any regional geologic interpretations because they are the only known strata of that age in the Cordilleran eugeosyncline of Oregon and Idaho.

Tertiary rocks

Overlying the pre-Tertiary rocks unconformably are the cliff-forming basalt flows of the Columbia River Group. West of Homestead these essentially flat-lying flows are more than 2000 feet thick and farther south thicknesses approach 3000 feet. The basalt flows poured out from fissures onto a terrain that had a minimum relief of 1500 to 2000 feet during Miocene-Pliocene time. Basalt dikes cut the older rocks near Homestead and in some places the dikes follow pre-Tertiary faults. Widths of dikes range from 2 to 40 feet in the map area.

Intrusive Rocks

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

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

Structural Geology

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

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

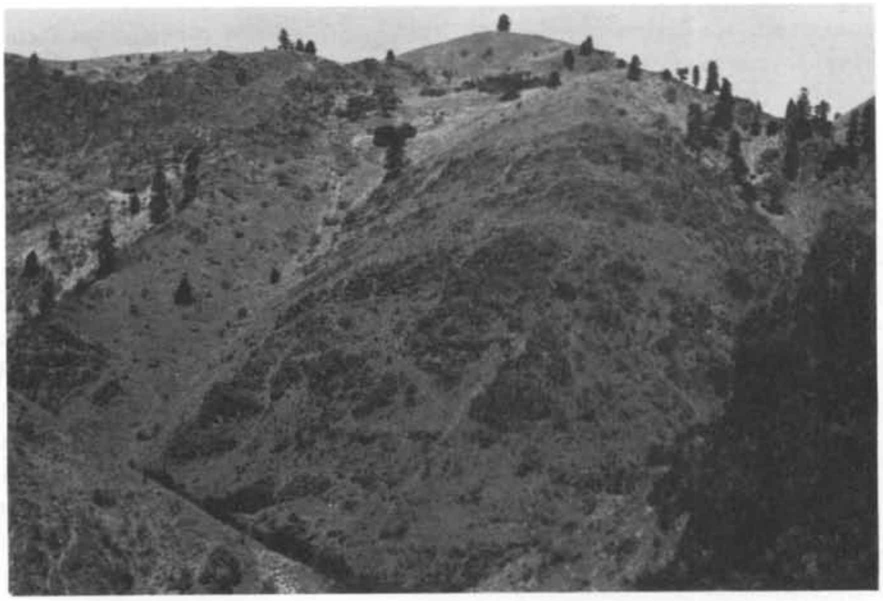


Figure 4. Permian rocks exposed in Homestead Creek. The more rugged and thicker outcrops are conglomerates and coarse breccias.

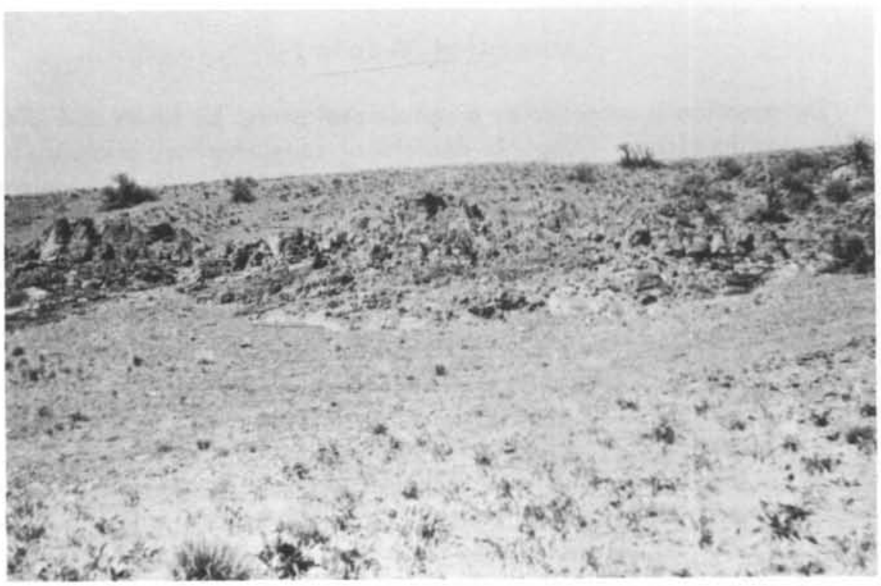


Figure 5. Middle Triassic rocks exposed along the ridge north of Homestead Creek. Volcanic graywackes are interbedded with thin bedded limestones which contain the flat clam Daonella.

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

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

Copper Deposits

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

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

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

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

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

Iron Dyke mine

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

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

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

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

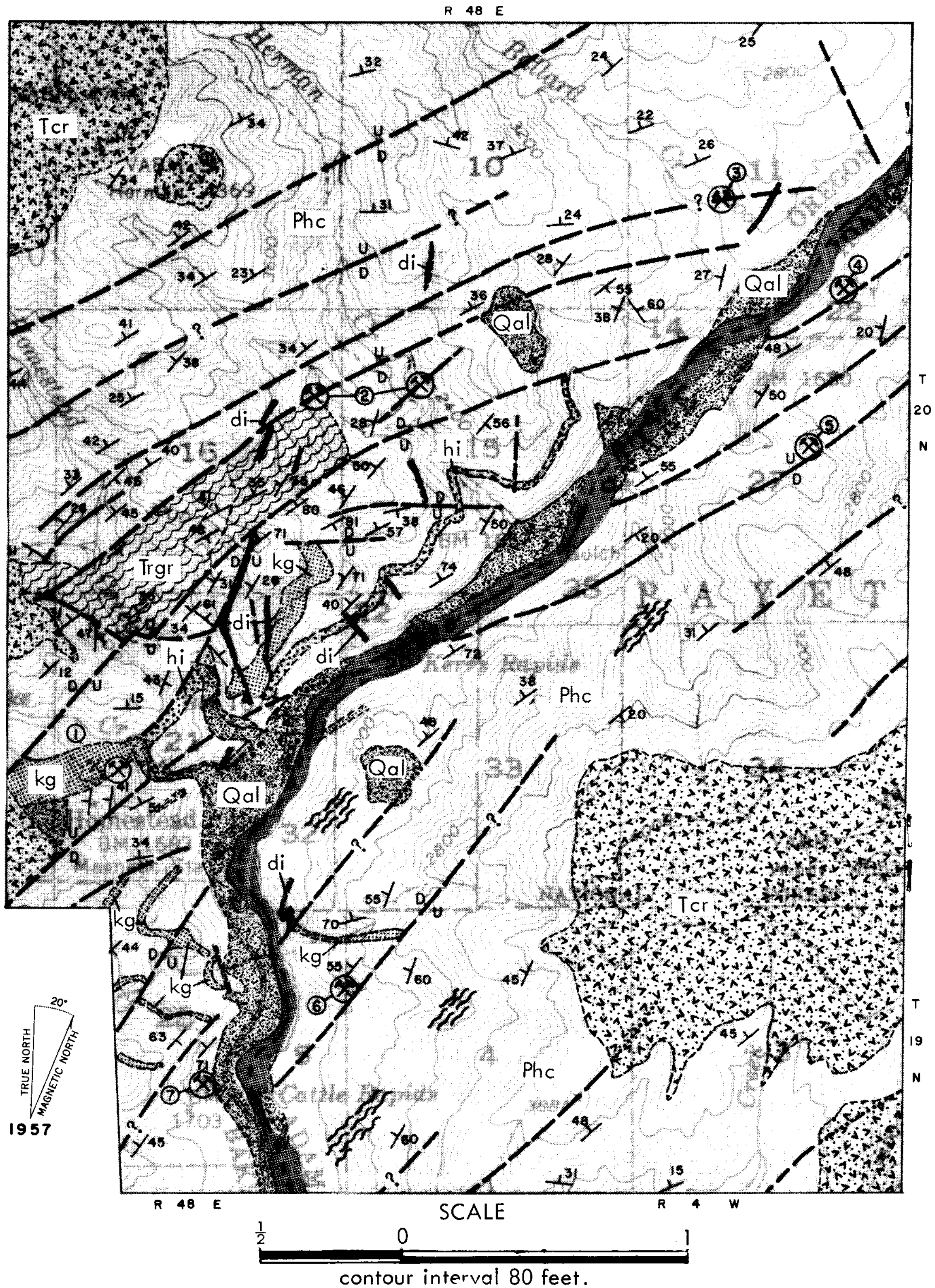
1/ Total ore milled and smelted. 2/ Bullion produced.

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

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

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

PLATE 1. GENERALIZED GEOLOGIC MAP OF THE HOMESTEAD AREA, OREGON AND IDAHO



Explanation

Qal — Quaternary alluvium and landslide debris.

unconformity

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

unconformity

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

unconformity

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

* Formation names are informal.

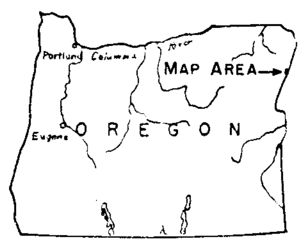
Fault, dashed where inferred.
Contact, dashed where inferred.

Strike and dip of bedding.

Shear zone.

Mines and prospects described in the text.

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



Topographic base from
USGS 15' Homestead quadrangle, 1957.

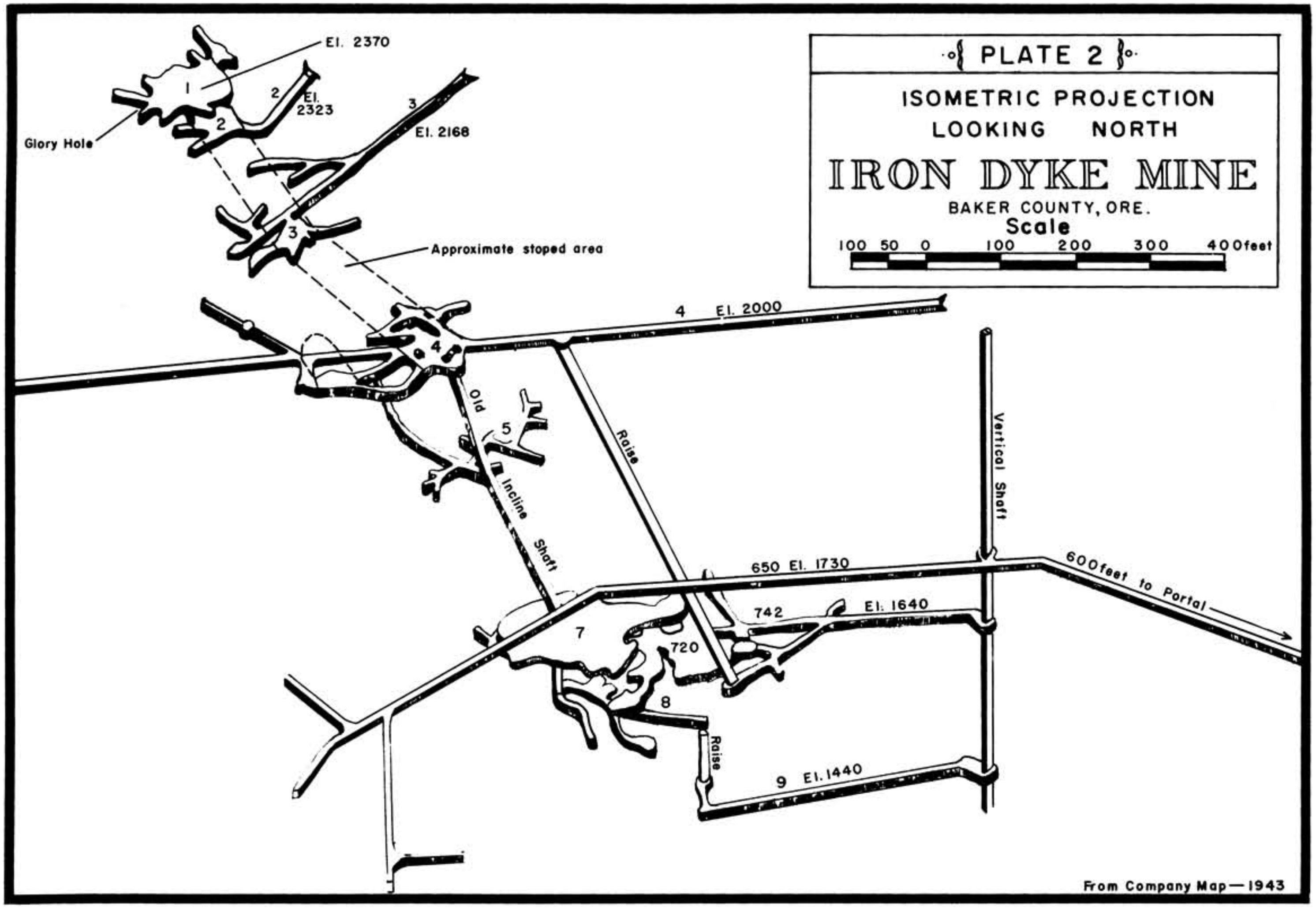


PLATE 2
ISOMETRIC PROJECTION
LOOKING NORTH
IRON DYKE MINE
BAKER COUNTY, ORE.
Scale
100 50 0 100 200 300 400 feet
El. 2370
Glory Hole
1
2
El. 2323
3
El. 2168
Approximate stoped area
4 El. 2000
Old Incline Shaft
5
Raise
Vertical Shaft
650 El. 1730
600 feet to Portal
742 El. 1640
7
720
8
Raise
9 El. 1440
From Company Map—1943

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

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

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

Rand-McCarthy prospects

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

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

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

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

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

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

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

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

Ballard group

Prospects located in 1899 by E. F. Ballard are on the north wall of Ballard Creek canyon about a quarter of a mile west of Hells Canyon Reservoir in the SW$\frac{1}{4}$ sec. 11, T. 6 S., R. 48 E., Oregon. Development includes three short adits, all caved.

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

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

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

River Queen prospect

The River Queen prospect is about 100 yards east of the Hells Canyon highway in the S$\frac{1}{2}$ sec. 22, T. 20 N., R. 4 W., Idaho. Much of the following description is from Cook (1954, p. 15).

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

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

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

Ants Creek prospect

The Ants Creek prospect in the SW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 27, T. 20 N., R. 4 W., Idaho, is on the north wall of Ants Creek canyon between 500 and 600 feet in elevation above the first switchback in the Kleinschmidt grade. Two accessible adits having a total length of about 200 feet are the principal workings.

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

A drift about 40 feet long in the upper adit prospects narrow quartz lenses included in a fault zone several feet wide in which the host rocks have been sheared, partly altered to clays, and locally limonitized. The zone strikes east-northeast and dips 40° to 60° N. Tetrahedrite clots in the quartz are partly altered to malachite and azurite. Small amounts of pyrite and sericite are accessory minerals. Local prospectors report that sphalerite also is present, although none was observed by the writers. At the portal of the lower adit, about 50 yards to the west, badly fractured and altered rocks contain irregular quartz stringers. No sulfides or oxide copper minerals were observed here. Structural continuity of this altered zone with that in the upper adit has not been proven.

McCarty prospect

The McCarty prospect is about one mile south of Homestead in the NW¼ sec. 4 and NE¼ sec. 5, T. 19 N., R. 4 W., Idaho. The prospect is developed by four short adits totaling about 250 feet. The adits are open at the portals. Local prospectors report that a small amount of ore was shipped from this property in the early 1920's.

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

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

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

Thorne Flat prospect

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

Outlook

Available data do not warrant predictions regarding the possibilities of future copper production from the Homestead area. Prospecting has not been sufficiently extensive to nullify the changes of discovering either new high-grade deposits similar to the Iron Dyke or lower grade deposits amenable to large-scale mining methods. With the exception of the work done at the Iron Dyke mine, there has been little prospecting to depths greater than 100 feet. In much of the area, bedrock is masked by soil or talus; thus the use of the more sophisticated prospecting tools available today might reveal the existence of buried deposits of economic importance.

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DRILLING RECORDS GET COMPUTER NUMBERS

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

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

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WORLD SUBSEA MINERAL RESOURCES OUTLINED

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

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WE MUST CONSUME, WE MUST CONSERVE

By Ralph S. Mason*

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

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

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

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

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

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

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

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COURSE IN ENVIRONMENT SCHEDULED

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

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THESES ON OREGON GEOLOGY RECEIVED IN 1968 AND 1969

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

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

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

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

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

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

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

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

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

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

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

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

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

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

AVAILABLE PUBLICATIONS

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

BULLETINS

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

GEOLOGIC MAPS

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

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Available Publications, Continued:

SHORT PAPERS

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

MISCELLANEOUS PAPERS

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

MISCELLANEOUS PUBLICATIONS

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

OIL and GAS INVESTIGATIONS SERIES

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