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Mining Geology of the Seven Devils Region

by

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SUMMARY

During the summer of 1953, most of the mines and prospects of the Seven Devils and Cuddy Mountain mining districts were examined by the Idaho Bureau of Mines and Geology. These two districts, in west central Idaho, have had an estimated production of over $1,000,000 in copper with some silver, lead, gold and tungsten, since development began in 1888.

Contact copper deposits of the Seven Devils district, in which the primary minerals are chalcopyrite and bornite, have been the most productive of the several types of ore deposits in the region. The ore occurs in irregular, discontinuous bodies within a garnet-rock or tactite which rims blocks of metamorphosed limestone enclosed in quartz diorite. Most of the easily found ore, enriched by secondary sulphides, has been mined. Oxide minerals persist in the lowest workings; consequently, the ore must be shipped directly to a smelter. The ore usually has been upgraded to about 20 per cent copper by handpicking. A little high grade (10-20%) and considerable low grade (3-10%) ore remains in sight, but to prove any important reserves extensive development or drilling is required.

Among the more promising of the region's mines are two disseminated copper deposits which have never produced any ore, the Red Ledge in the northern part of the Seven Devils district, and the I X L on the south side of Cuddy Mountain.

The Red Ledge mine is in tuffaceous andesitic and rhyolitic rocks which have suffered intensive hydrothermal alteration; primary minerals consist of pyrite and chalcopyrite, with subordinate sphalerite, galena, other sulphides, and sparse gangue minerals. About 2,400 feet of underground workings and 16,000 feet of diamond drilling have revealed several ore bodies in mineralized shear zones, estimated to contain 1.0 to 2.5 per cent copper and some zinc, silver, and gold. Because of the nature of the ore bodies, tonnage estimates vary greatly, but it seems likely that about two million tons of 1.0 per cent copper ore could be developed. Exploration below the present workings might greatly increase this estimate.

The I X L mine, a disseminated deposit in fractured granitic rock, has been developed by about 900 feet of underground workings. The primary minerals are pyrite, chalcopyrite, pyrrhotite, and molybdenite. No data are available on which to base tonnage or grade estimates, but there appears to be a considerable body of low-grade ore.

Tungsten, known in this region for some years, was first mined in 1952 and several shipments of ore containing 1.0 to 2.2 per cent WO_3 have been made from the Alaska mine. The mineral is a high-molybdenum scheelite, approaching powellite in composition, and occurs in the tactite of the contact copper area. Deposition was apparently controlled by shear zones in the tactite and was not contemporaneous with the copper mineralization. Despite high transportation costs, penalty charges for the high molybdenum content, and a lack of underground exploration, the possibilities for developing a good tungsten mine appear excellent.

Some pyritic gold-quartz veins have been exploited in the Seven Devils region but none is now being worked. In addition, a number of fractures in andesitic rocks contain irregular deposits of chalcocite and other sulphides in a sparse gangue of quartz; none of these deposits appears likely to yield ore of high enough grade to ship to a smelter without milling, and the proved reserves do not warrant installing a mill.

Three carloads of high-grade lead ore have been shipped in the past four years from the Lead Zone mine on Cuddy Mountain. Workings are within the zone of oxidation on a galena vein in faulted and metamorphosed volcanic rocks. Good ore is in sight and, although the vein is narrow, further exploration may reveal a worthwhile tonnage.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The area covered by this report borders the Snake River in west central Idaho and includes the western part of Adams County and the northernmost portion of Washington County (Fig. 1). The Seven Devils region as here defined includes both the Seven Devils and the Cuddy Mountain mining districts. The only towns within the area are Bear and Cuprum, 29 and 38 miles, respectively, from Council, Idaho.

Graveled and dirt roads lead into the region from Council and Cambridge, Idaho, and Homestead, Oregon (Fig. 2). Most of the roads of the Seven Devils and Cuddy Mountain areas are unsuitable for large trucks and are closed by snow for varying periods during the winter. A network of trails, many of them in need of maintenance, affords access to the mining properties not reached by roads. Railpoints nearest the Seven Devils district are Council, Idaho, and Robinette, Oregon, both on the Union Pacific Railroad and each 38 miles by road from Cuprum. Council is also the shipping point for the north side of Cuddy Mountain, about 25 miles away; mines on the south side of this mountain would be served through Cambridge, 15 to 20 miles distant.

FIELD WORK AND ACKNOWLEDGMENTS

The field work on which this report is based was done during the months of July and August, 1953. About four weeks were spent in the Seven Devils area, three weeks on Cuddy Mountain and vicinity, and one week in reconnaissance southward to Iron Mountain and northward to Riggins.

During this time the writer was ably assisted in the field by Raymond E. Marshall, and, during July, by James V. McDonald.

The geologic map of the Seven Devils mining district included in this report is the work of a U. S. Geological Survey field party headed by Ralph S. Cannon, Jr., and is published by permission of the acting director of the U. S. Geological Survey.

The wholehearted cooperation of property owners and lessees is gratefully acknowledged.

PREVIOUS WORK AND SCOPE OF PRESENT WORK

Both the Seven Devils and Cuddy Mountain districts have previously been examined by the Idaho Bureau of Mines and Geology, the former in 1919 by D. C. Livingston and F. B. Laney, the latter in 1920 by Livingston. The results of these surveys were published by the Bureau in 1920 and 1923. Beginning in 1938 field parties of the U. S. Geological Survey worked in the Seven Devils district for several seasons, and the geological map prepared by them is included in the present report (Fig. 4).

Because of the extensive work already done by the U. S. Geological Survey and the limited time available, field work in 1953 was largely confined to the examination of mines and prospects. The previous publications allowed an additional limitation: Only those properties were examined on which work had been done since the publication of the two reports in the early 1920's. For information on properties which have lain idle these thirty years readers are referred to the earlier publications by Livingston and Laney.

GENERAL GEOLOGY

ROCK UNITS

Seven Devils volcanics

The oldest rocks in the region, Permian to Triassic in age, comprise a thick series of clastic and volcanic rocks, including andesitic flows and tuffs metamorphosed to greenstones, rhyolitic flows, waterlaid volcanic grits and conglomerates, quartzites, lenses of impure limestone, and small intrusive bodies. Because the metamorphosed andesitic rocks predominate, the most common rock colors are dark green to black; some of the tuffs are reddish purple, the quartzitic rocks are pale green or gray, and the rhyolites are gray to almost white. The thickness of this group is difficult to estimate; it probably exceeds 10,000 feet.

In northeast Oregon similar rocks are known as the Clover Creek greenstone; in the Seven Devils, Livingston and Laney mapped this group of rocks as andesite; and in the lower Salmon River country, Wagner (1945, p. 4)* named the same rocks the Seven Devils volcanics. None of these names suggests the large proportion of clastic sedimentary material within this rock group; however, Wagner's name is here used because his Seven Devils volcanics can be traced into the Seven Devils mining district.

Representative rock types of this sequence are exposed along the road between Cuprum and Homestead: greenstones, both dense and porphyritic; tuffaceous rocks, probably in great part waterlaid; conglomeratic beds; and, near the foot of the grade, well-bedded argillaceous quartzites. Limestone within the Seven Devils volcanics is exposed on the trail between the Snake River and the Red Ledge mine; near the mine, bold bluffs of light-colored rhyolite (called "Cordwood" rhyolite because of its columnar structure) represent interbedded acidic flows in the dominantly andesitic series.

The upper part of the Seven Devils volcanics appears to be largely of sedimentary origin for it consists of varicolored, rounded-pebble conglomerate in the northern Seven Devils; pale green, subangular pebble to boulder conglomerate near Smith Mountain and on Cuddy Mountain; gray siltstone, sandstone, and fine conglomerate near Sheep Rock; and water-laid tuffaceous grit at Big Bar.

Metamorphism of the Seven Devils volcanics is largely hydrothermal. No evidence of tight folding was seen during the field work; on the contrary, in localities where attitudes can be determined, the folding appears moderate. Alteration of the original rocks, then, has not been accomplished by recrystallization under stress during strong folding, but by hydrothermal replacement (metasomatism). Guided by fractures, mineralizing solutions permeated the rocks, transforming lava flows and tuffs into greenstones, gabbro into granodiorite, and sediments into quartzitic rocks. The principal new minerals produced by this hydrothermal metamorphism were feldspar, quartz, chlorite, epidote, sericite, pyrite, and relatively minor amounts of other metallic sulphides.

Silification is most intense along the northeast-trending shear zones which cut the older rocks of the region. Development of pyrite has, in many places, accompanied the silification of these shear zones, and the iron-stained oxidized outcrops have attracted many a prospector. Only where later shearing has allowed the introduction of solutions bearing other metallic sulphides, however, are these silicified and pyritized shear zones—or "iron dikes"—likely to reward the miner.

The Seven Devils volcanics are largely the result of submarine volcanism and sedimentation near the source of the volcanic debris. Toward the close of Seven Devils time part of this thick volcanic accumulation apparently rose out of the water and shed coarse material from which were formed the conglomerates of the upper part of the series.

Fossil collections made by Cannon and his associates show that the Seven Devils volcanics range in age from Permian to Upper Triassic (Cannon, personal communication).

Rhyolite or quartz latite

On Cuddy Mountain an iron-stained, white to yellowish rhyolite flow overlies metamorphosed conglomerate and greenstone of the Seven Devils volcanics. According to Livingston (1923, p. 6) this flow is from 200 to 600 feet thick in the Min-

* Refers to publication listed in the bibliography at the end of this report.

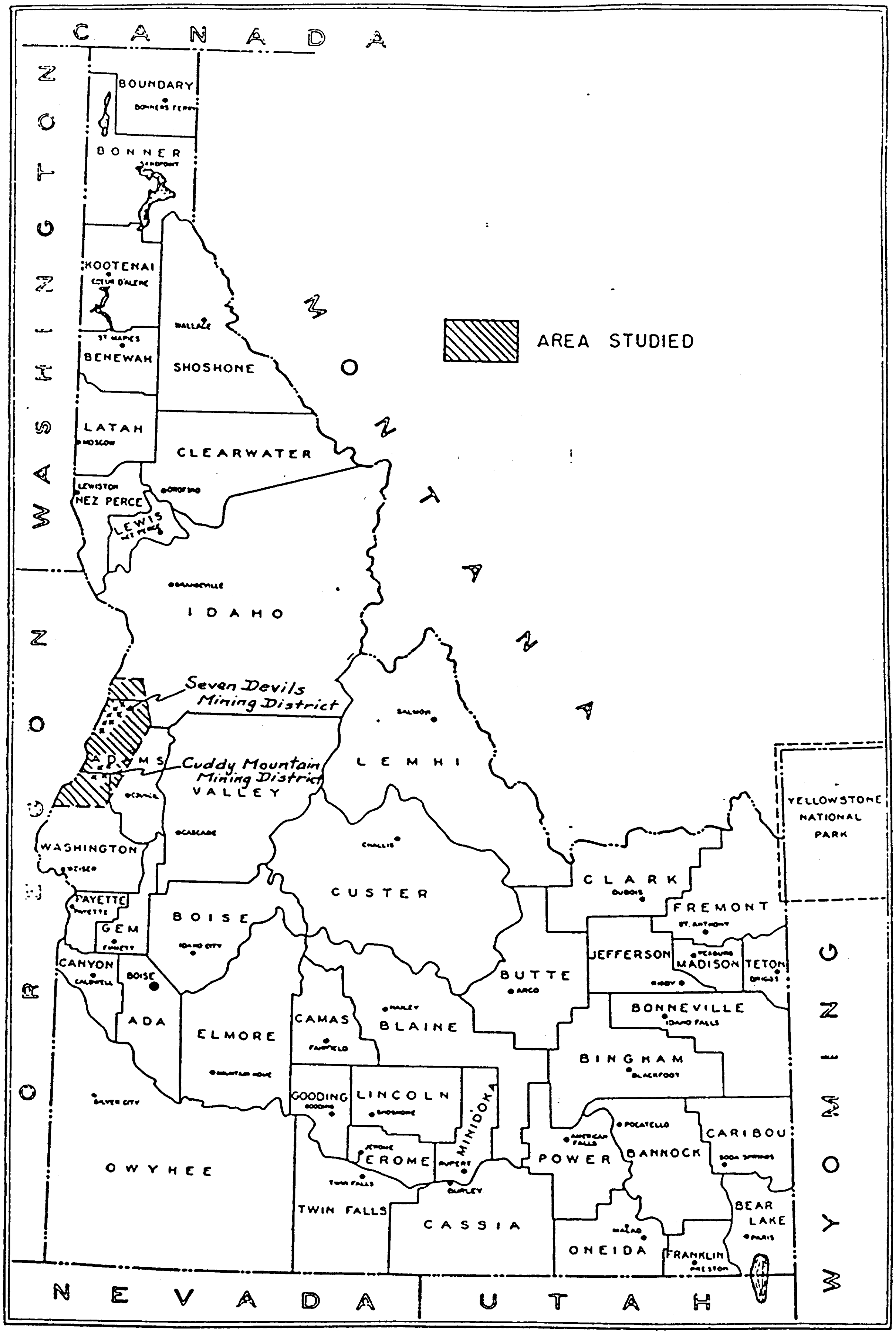


Fig. I. INDEX MAP OF AREA STUDIED

eral-Cuddy Mountain area; he thought, because some veins in the Mineral district cut the underlying volcanics but do not penetrate the rhyolite, that the latter was probably Triassic in age; Anderson and Wagner (1952, p. 5) later included this flow, mapped as quartz latite, with the Permian (?) volcanics.

Triassic shale and limestone

Unconformably overlying the Seven Devils volcanics is a thick sequence of shales and limestone, locally metamorphosed to phyllites and marble. In the northern Seven Devils these rocks, called the Lucile series by Wagner (1945, p. 5), can be separated into three members: a lower graphitic and calcareous shale member 0-1000 feet thick; a middle gray limestone member 50-500 feet thick, containing Upper Triassic fossils; and an upper phyllitic member over 2,000 feet thick. As these units are traced into the southern Seven Devils the lower shale becomes thin or absent, the limestone member thickens to 1000 feet, and the upper phyllitic member disappears.

The limestone unit, 1000 feet thick, dense, gray, and fossiliferous, forms cliffs at Big Bar, where it lies directly on tuffs of the Seven Devils volcanics. A quartz diorite intrusion in the Seven Devils mining district has engulfed large blocks of this limestone, caused its recrystallization, and formed rims of lime silicate minerals around the resulting marble; fragments of argillaceous and carbonaceous shales found with these marble blocks probably represent the lower member of the Lucile series. The limestone member of the Lucile series is apparently the equivalent of the Martin Bridge formation (Ross, 1938, p. 32) of northeast Oregon.

On Cuddy Mountain, banded silty shales several thousand feet thick are tentatively correlated with the Upper Triassic Lucile series, although they may be equivalent to the Jurassic shales and tuffs reported by Livingston (1932, p. 34) in the Mineral district. In fact, in several localities shales unconformably overlie the Lucile (Martin Bridge) limestone and even cut it out completely, as on the south side of Cuddy Mountain; this suggests that some of the shales and phyllites previously assigned to the Upper Triassic series may be Jurassic.

Granitic rocks

Granodiorite and metagabbro

Irregular, elongated outcrops of a pale gray-green, igneous-appearing rock trend northeast through the higher parts of the southern Seven Devils. Recognizable minerals are feldspar, quartz, and chlorite, but the appearance and composition of the rock vary irregularly. In some places this rock appears to grade into the Seven Devils volcanics, but Cannon (personal communication) thinks it is metamorphosed gabbro, approaching granodiorite in composition. Gilluly (1937, p. 32) describes similar rocks in the Baker quadrangle, Oregon, formed from from gabbro from additive hydrothermal metamorphism.

Livingston and Laney (1920, p. 25) were of the opinion at one time that this granodiorite was closely associated with the Seven Devils volcanics, but finally decided that it was just an earlier, finer-textured phase of the quartz diorite. Today the evidence against consanguinity appears conclusive; appearance and composition are different; the granodiorite is locally sheared, silicified, and epidotized whereas the quartz diorite is fresh and relatively unaltered; different structures controlled the emplacement of the two rocks; the granodiorite is cut by the quartz diorite and fragments of the former are found in the latter.

Quartz diorite

The intrusive rock of the contact copper deposits is a gray, rather coarse-textured quartz diorite. Well-shaped crystals of plagioclase feldspar, biotite, and hornblende are set in a finer-grained groundmass containing some quartz and a little orthoclase. More regular in grain size than the granodiorite, the quartz diorite also lacks the greenish color imparted to the granodiorite and metagabbro by chlorite and epidote.

Far from being stock-like in form and comprising the core of the uparched Seven Devils Mountains as Livingston and Laney pictured it, the quartz diorite appears to narrow downward and disappear at a shallow depth. Indeed, the headwaters of Granite Creek north of Smith Mountain have just about cut through the intrusive rock to the underlying Seven Devils volcanics. The attitude and position of the included blocks of marble near the periphery of the quartz diorite, dipping in toward the axis of the body, suggest an intrusion which came in along the contact between the Seven Devils volcanics and the overlying Triassic sediments in a place where this contact and overlying rocks were downfolded into a syncline.

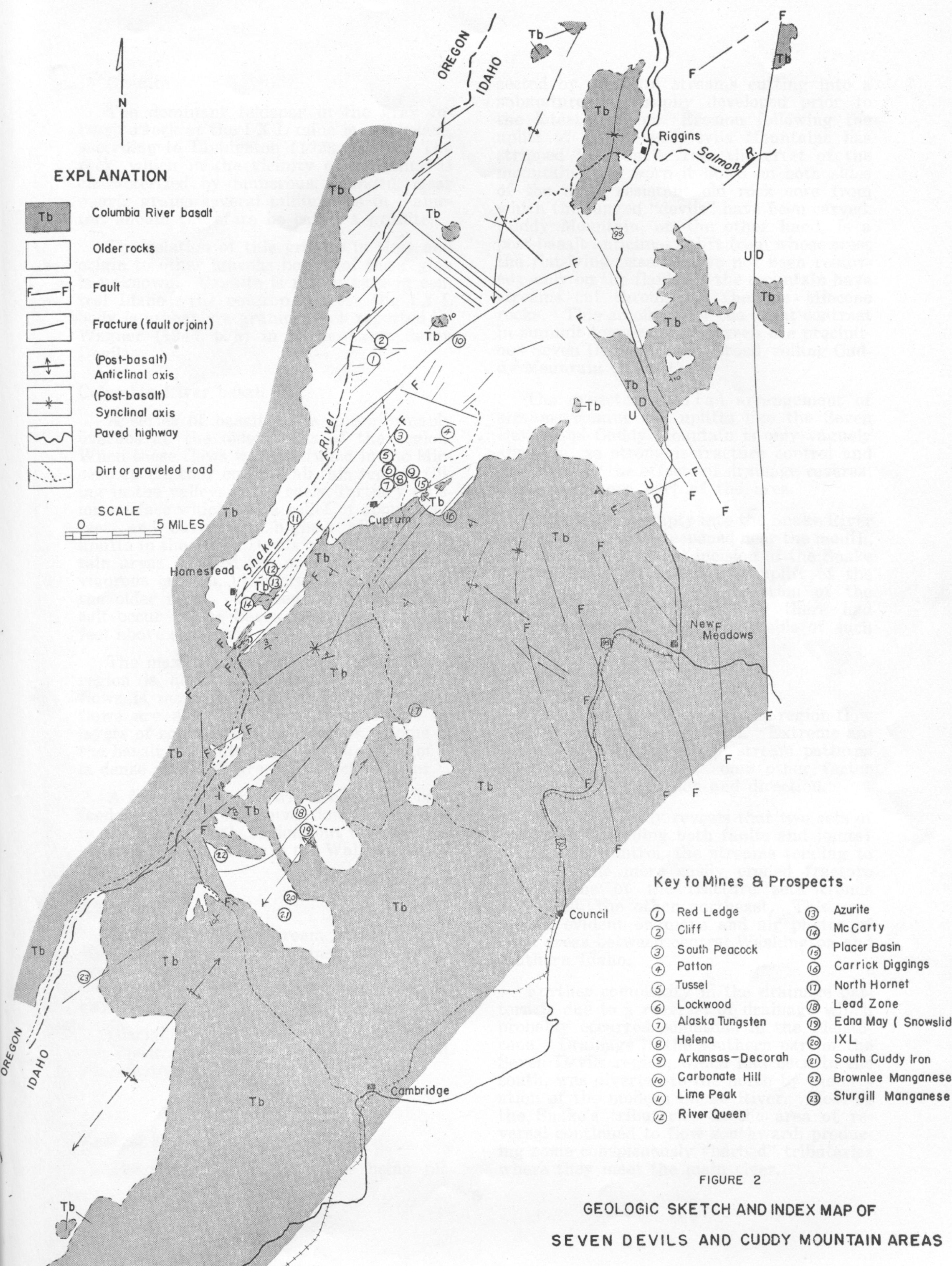


FIGURE 2

GEOLOGIC SKETCH AND INDEX MAP OF SEVEN DEVILS AND CUDDY MOUNTAIN AREAS

Granite

The dominant feldspar in the gray intrusive rock at the I X L mine is orthoclase, according to Livingston (1923, p. 10). The rock, which in the vicinity of the mine is characterized by numerous, rounded, clear quartz grains several millimeters in diameter, should therefore be called a granite.

The relation of this granite in time and origin to other igneous bodies of the region is unknown. Granite is rather rare in central Idaho; the outcrop nearest the I X L body is probably a granite stock reported by Wagner (1945, p. 8) in the northern Seven Devils.

Columbia River basalt

A series of basalt flows unconformably overlies all the older rocks of the region. When these flows were extruded in the Miocene epoch, they covered all this region, filling in the valleys of an early Tertiary erosion surface which had a relief of about 2000 feet, and buried the highest hills. Later uplifts in the Seven Devils and Cuddy Mountain areas exposed the uparched basalts to vigorous erosion, uncovering large areas of the older rocks. Isolated remnants of basalt occur in the Seven Devils up to 8,150 feet above sea level.

The maximum thickness of basalt in the region is about 2,500 feet. None of the flows is more than 100 feet thick; many flows are separated from those above by layers of soil or weathered basalt. Some of the basalt is highly vesicular but most of it is dense and dark-green to black in color.

A few basalt dikes, which may have been feeders for the extensive flows, are found in the Seven Devils region, but they are not nearly so numerous as in the Wallowa Mountains.

Alluvium

Landslide debris, stream alluvium, and glacial drift are relatively insignificant features of the surface geology of this region, for rapid erosion removes such material swiftly from the valleys and canyons.

Glacial deposits and some terrace gravels are Pleistocene; stream alluvium and landslide material is Recent.

GEOMORPHOLOGY

General statement

The Seven Devils region is being dissected by youthful streams cutting into a submature topography developed prior to the latest incision. Erosion following the uplift of the Seven Devils Mountains has stripped the basalt from the crest of the mountains and worn it down on both sides of the more resistant old rock core from which the jagged "devils" have been carved. Cuddy Mountain, on the other hand, is a post-basalt anticlinal uplift from whose crest the flat-lying basalts have not been removed; only on the flanks of the mountain have streams cut through to the pre-Miocene rocks. This accounts for the great contrast in summit topography between the precipitous Seven Devils and the broad, rolling Cuddy Mountain (Plate 1).

The expected radial arrangement of streams coming off uplifts like the Seven Devils and Cuddy Mountain is only vaguely apparent, so strong is fracture control and so confusing the effects of drainage reversal in the southern part of the area.

Creeks which empty into the Snake River commonly are oversteepened near the mouth, an indication of recent incision of the Snake itself. This was not due to uplift of the area, but to the sudden creation of the Snake River where previously there had been only small streams, incapable of such rapid downcutting.

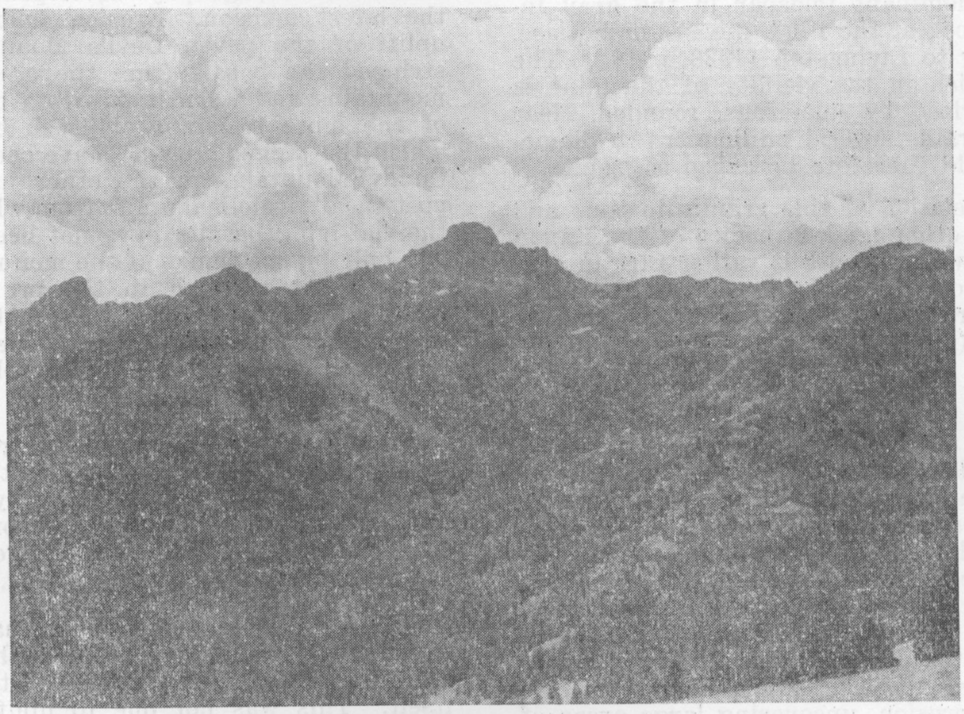
Drainage control

In general the streams of the region flow away from the axes of uplift. Extreme angularity and parallelism in stream patterns suggest, however, that some other factor controls stream position and direction.

Structural study reveals that two sets of fractures (including both faults and joints) provide the control, the streams tending to seek out the more easily eroded fracture zones. One of the fracture sets trends northwest, the other northeast. This system is evident on maps and air photos of most areas between central Washington and southern Idaho.

Further complexity in the drainage pattern is due to a reversal of drainage which probably occurred sometime in the Pleistocene. Drainage in the southern part of the Seven Devils region, which had been to the south, was diverted to the north by the creation of the modern Snake River. Most of the Snake's tributaries in the area of reversal continued to flow southward, producing some conspicuously "barbed" tributaries where they meet the main river.

PLATE 1



A. **Rugged topography of central Seven Devils Mountains, south of Heavens Gate.**

B. **Rolling summit topography of Cuddy Mountain, from Lead Zone mine.**

Pre-basalt erosion surface

It has been postulated that the Snake River flowed northward through this region before the Miocene basalt floods, that it was dammed or pushed eastward by the basalt, and that it later found an outlet northward over a low place in the basalt. A study of the surface on which the basalt poured out suggests that this is not so, but that the drainage in pre-Miocene times was westward or southwestward, strongly controlled by the structure of the pre-basalt rocks.

Where ridges and valleys of the old surface can be recognized, they generally strike east-west or northeast-southwest, transverse to the present Snake River. Near the Oxbow an ancient stream channel filled by basalt descends toward the southwest. The indications are, therefore, that drainage was toward the southwest before the basalts covered the early Tertiary erosion surface.

In most places the old surface is thinly mantled with gravel. Gold is widespread in this gravel in noncommercial amounts. Gold-bearing boulders from this gravel, located by probing through the surface vegetation with iron bars, are said to have been milled at Placer Basin.

High places on the old surface tend to be coincident with structural highs today and some valleys of the old surface are sites of post-basalt structural saddles. In general, the old surface slopes away from the Seven Devils and Cuddy Mountain uplifts at a greater inclination than do the overlying basalt flows. In some places there are exhumed portions of the old landscape, but nowhere is there a pre-basalt surface which has remained uncovered by basalt to the present day.

Snake River history

It will be shown elsewhere (Wheeler and Cook) that Livingston's hypothesis (1928) of initiation of the present Snake River in post-Miocene time by capture of southward drainage by a tributary of the Salmon working headward to the south, has much to commend it. The straight-line segmentation, deeply incised channel, steeper gradient, and lack of barbed tributaries of the Snake River in Hell's Canyon north of the Oxbow contrast enough with the barbed tributaries, flatter gradient, shallower and more curved canyon south of the Oxbow to suggest a different history for the two parts of the river.

It is thought that the first capture occurred a few miles north of the Oxbow and that, subsequently, an arm of the rising, early Pleistocene Lake Idaho, extending northward from the main lake in southern Idaho, spilled over a drainage divide at the Oxbow. Idaho Lake then had an outlet and rapid downcutting drained the lake, reversed the drainage south of the Oxbow, and cut the inner, deeper part of Hell's Canyon. As the new Snake River reduced the size of Lake Idaho, the lessened evaporation from the smaller lake surface increased the discharge, which further accelerated the downcutting. Idaho Lake probably formed as a result of uplift gradually blocking the old Snake River passage to the sea, which may have been via northern California. At its maximum, Lake Idaho probably lost more water by evaporation than the Snake now carries; in order to make the lake overflow at the Oxbow, then, the climate must have been considerably more humid than it is now. This conclusion, and the occurrence in several places of abundant glacial outwash gravels just above the highest lake level (3,000-3,500 feet), suggest that the spillover of Lake Idaho occurred during one of the Pleistocene stages of continental glaciation preceding the latest (Wisconsin) stage.

Glaciation

Like other mountainous regions of central Idaho the Seven Devils and Cuddy Mountain have supported alpine glaciers during the Pleistocene epoch. J. V. McDonald has made a study of glaciation in the Seven Devils and this brief summary has been taken largely from his thesis now in preparation at the University of Idaho.

The evidence of the latest (Wisconsin) glaciation is plain—in cirques, tarns, and U-shaped valleys. Actual moraines are rare and even glacial striae not too abundant, because of rapid post-glacial erosion. Most of the high lakes of the Seven Devils are tarns, lakes which occupy the low parts of glacial cirques. Emerald Lake is the only lake in the Seven Devils which is dammed by a moraine. None of the glaciers of the latest glaciation advanced much more than six miles from its source nor descended much below 5000 feet elevation.

The glaciers accumulated to a greater extent on the northeast slopes because of the greater sunshine and melting on the southwest. The regional fracture system was a secondary control of glaciation direction; a number of cirques face northwest or southeast (instead of northeast) and reflect directional control of pre-glacial valleys by northwest-southeast faults and joints, some of which are strikingly exposed in the high mountains.

High-level outwash gravels which cannot be correlated with the late Wisconsin glaciation and some U-shaped valleys which were not occupied by glaciers during the latest glaciation are indirect evidence of an earlier and more extensive glaciation in the Seven Devils.

STRUCTURE

In the Seven Devils volcanics structure is difficult to interpret because of the scarcity of bedded rocks and the metamorphism of the entire series. Structural features in the Upper Triassic sediments are easier to map, although faulting, metamorphism, and intrusion introduce many uncertainties even in these bedded rocks.

The Upper Triassic limestone at Big Bar is an erosional remnant in a syncline plunging southwest. A mile or two east of Big Bar, quartz diorite appears to have been intruded at the base of the Upper Triassic in a syncline with a twisted east-west axis. This may be an extension of the Big Bar syncline, separated from it by an upfaulted block of Seven Devils volcanics. The Upper Triassic rocks in the Little Salmon River drainage are folded, in general, along north-south axes.

The pre-basalt rocks of the Seven Devils region, with the exception of the quartz diorite, are cut by a subparallel set of silicified, locally brecciated and mineralized shear zones (Fig. 2) which strike N. 30-40° E. and dip steeply west. The width of some of these zones, for instance at Stevens Saddle on Carbonate Hill where the sheared zone is 200 feet wide, would not only seem to indicate considerable displacement of the rocks by faulting, but would also lead one to expect the fault lines to be sharply etched in the topography by differential erosion. However, these fracture lines are not apparent in the topography, due largely to the widespread silicification which has recemented and hardened the sheared rock. It is impossible to determine displacement because of the absence of stratigraphic markers in the faulted rocks. The hydrothermal solutions which produced the locally intense feldspathization of the older rocks probably were guided by these shear zones.

Faults of the northeast set in some places cut the granodiorite, but nowhere cut the quartz diorite. One of these faults does limit the quartz diorite on the west in the vicinity of Helena, but this appears to be a pre-intrusion fault which stopped the advance of the magma. Greenstone inclusions in the quartz diorite at the Tussel property support this conclusion. Some of these northeast, pre-basalt faults were reactivated during post-basalt time, but displacements and fractures produced were small.

In the basalts, the structural picture is much simpler. The Seven Devils Mountains and Cuddy Mountain are essentially doubly plunging anticlinal uplifts separated by a broad syncline. These two anticlines, with northerly striking axes, are anomalous tectonic features in the regional pattern, because most of the deformation of the same age is along east-west axes: e.g., the Lewiston downwarp, the Blue Mountains uplift, and the Snake River downwarp. An answer is suggested by the fact that these anticlines roughly parallel the pre-basalt fault trend. During the broad regional folding along east-west axes, fault blocks may have been squeezed upward between the older, northeast faults, uparching the overlying basalts and eventually breaking them. Small-scale movements on these northeast faults merely caused the basalts to updrape over the block in a flat-crested anticlinal fold; Cuddy Mountain is an example.

GEOLOGIC HISTORY

The geologic history of the Seven Devils region as interpreted from the evidence of the rocks within its borders, is given in tabular form on page 9.

Deposition of the volcanic debris, flow rocks, and sediments which make up the Seven Devils volcanics apparently continued from the Permian period into the late Triassic; this deposition took place mainly in shallow water. Volcanism then ceased, the region was gently folded and rose from the sea. Some of the previously deposited sediments and volcanics were eroded away before the land again sank beneath the sea, still in the late Triassic, to receive a thick accumulation of muds and limy sediments.

Non-volcanic marine sedimentation probably continued, with one or two interruptions because of temporary emergence, into the Jurassic period. Since some time in the Jurassic, the Seven Devils region has been above sea level and subject to erosion.

The intrusions of gabbro in the Seven Devils are tentatively placed in the Jurassic by Cannon. Support for this age assignment is the fact that Lupher (cited in Gilluly, 1937, p. 41) has found in the western Blue Mountains of Oregon (west of the

Seven Devils region) definite evidence of an intrusion of gabbro during late Jurassic time.

An extended period of folding, strong faulting, and hydrothermal metamorphism began in the late Jurassic or Cretaceous, causing the partial metamorphism of the gabbro to granodiorite and of the volcanic rocks to greenstones and dioritic rocks.

Toward the close of this orogenic period, and presumably still in the Cretaceous period, quartz diorite was intruded into a structure formed during the preceding folding and faulting. This quartz diorite body is apparently an extension of the Idaho batholith. It is interesting to note that the granodiorite batholith of the northern Wallowa Mountains also intruded along the same horizon, below the Upper Triassic shales and limestone and above the volcanic sequence (Smith, 1941, p. 16).

Widespread metallization, in the late Cretaceous or early Tertiary, followed the quartz diorite intrusion. The source of the metallizing solutions is unknown.

During the early Tertiary this uplifted Seven Devils region was worn down by erosion, exposing the plutonic rocks. By the time the first basalts of the Miocene were extruded, the erosion surface had a relief of about 2000 feet, and the granitic rocks were deeply eaten away.

For a considerable time, judging by the evidence of deep weathering between successive flows, the Columbia River basalts continued to pour out, eventually covering all the old land surface and producing a new, monotonously flat surface with scattered lakes and marshes.

Two periods of deformation, culminating in the late Pliocene and early Pleistocene, formed the Seven Devils and Cuddy Mountain uplifts and caused the damming of southern Idaho drainage to form Lake Idaho,

Age	Event
Quaternary	Rapid erosion, continuing to the present; glaciation; start of modern Snake River.
Quaternary	Folding and faulting, uplift of Seven Devils and Cuddy Mountain.
Tertiary	Eruption of Columbia River basalt.
? — ?	Regional uplift and erosion.
Cretaceous	Widespread metallization.
Cretaceous	Intrusion of quartz diorite.
Cretaceous ? — ?	Strong folding and faulting, with metamorphism of gabbro to granodiorite and volcanic rocks to greenstone.
Jurassic	Intrusions of gabbro.
Triassic, Upper	Marine sedimentation, forming shales and limestone; one or more epochs of emergence and erosion.
Triassic, Upper	Gentle folding, erosion, then subsidence.
Triassic, Upper/Lower	Deposition of gravels, tuffs, and (possibly) rhyolite extrusion in south.
Triassic, Lower ? — ? Permian	Intensive submarine volcanism and marine sedimentation.

which in the Pleistocene spilled over at the Oxbow into a northward-flowing tributary of the Salmon, thus starting the modern Snake River.

During two stages of the Pleistocene there were alpine glaciers in this region. Although there is no evidence of a third glaciation (indeed, there is very little evidence of the second), it may well have occurred, for there are deposits of three glaciations in the Council Mountain - Long Valley region just east of the Seven Devils region (J. H. Mackin, personal communication).

The main geologic process now active is erosion, kept vigorous by rapid downcutting of the streams.

ORE DEPOSITS

INTRODUCTION

The ore deposits of the Seven Devils region have been under development since about 1888 and have a total production estimated at over $1,000,000 in copper with some lead, tungsten, gold, and silver. The first ore was shipped from the mines near Helena and Landore to Bear by pack horse and thence in wagons to Weiser. Great activity took place in the 1890-1900 period with the building of the Kleinschmidt grade from Helena past Cuprum to the Snake River near Homestead, the partial grading of a railroad from Helena eastward, and the erection of smelters at Landore and near Weiser.

Production declined in the early 1900's. Following this decline, attention was redirected to the region about 1925 by the activities of the Idaho Copper Corporation, controlled by George Graham Rice, Dr. Walter Harvey Weed, and associates. In 1928, Rice and the corporation were convicted of using the mails to defraud in connection with this promotion (Ross, 1941, p. 7). In 1931, the principal properties of the defunct corporation (including the Red Ledge mine) were taken over by Cooley Butler and are now held by the Butler Ore Company.

During recent years, mining has been mainly by leasers. For several years, the Placer Basin operation made gold an important factor in the region's production. The copper properties ceased production in 1951, but the following year tungsten began to be produced from the Seven Devils district and is now (1953) the principal metal produced in the region. Three carloads of high-grade lead ore have been shipped from Cuddy Mountain since 1950. Production statistics of the region for the period 1936-53 have been compiled in tabular form on Page 11. Figures for 1936-49 are taken from the Minerals Yearbook of the U. S. Bureau of Mines; figures for later years have been gathered by the author from operators in the region.

The most productive deposits have been the contact copper deposits of the Helena-Landore area; these are irregularly shaped deposits within masses of lime silicate minerals which surround blocks of limestone enclosed in quartz diorite. In some of these deposits the principal primary metallic mineral is chalcopyrite; in others, bornite. In certain of the lime silicate masses, tungsten in the form of scheelite-powellite occurs in concentrations up to 2.4% WO_3. Although no copper is now being mined in this area, tungsten production in 1953 from one deposit exceeded in value the copper production of any year since 1937. Oxidized copper minerals persist to the deepest workings, about 300 feet below the surface; consequently, the copper ore must be shipped directly to a smelter and must be upgraded by hand-sorting to offset transportation costs. Much of the readily accessible high-grade ore has been mined out; in some mines considerable low-grade (3 - 10% Cu) and some high-grade (10 - 20% Cu) remains in sight. Because these deposits are typically irregular in size, shape, and tenor, extensive development or drilling is required to determine their value. No underground exploration and little surface stripping has been done at the tungsten deposit, but there is a good chance that a considerable tonnage of high-molybdenum tungsten ore may be developed.

The Red Ledge mine and several prospects in the region are disseminated pyritic deposits in tuffaceous rhyolitic and andesitic rocks that have undergone zones in which chalcpyrite and smaller amounts of sphalerite, galena, and other sulphides have been deposited. Secondary minerals, mainly chalcocite and covellite, have enriched the ore in the upper part of the deposit. Esti-

METAL PRODUCTION, SEVEN DEVILS REGION, 1936 - 53

from Minerals Yearbooks, 1936 - 49, other sources 1950 - 53

YEAR	Number of Mines	Tons of ore	Gold (oz.)	Silver (oz.)	Copper (lbs.)	Lead (lbs.)	Total Value	Principal producing properties
1936	2	883	1291	757	759	525	$ 45,815	Placer Basin
1937	7	4224	3984	1775	74843	——	149,869	Placer Basin
1938	5	227	274	379	17745	——	11,574	River Queen, Lockwood, Helena, Placer Basin
1939	2	401	507	358	14154	——	19,460	Placer Basin, Helena
1940	3	442	303	436	23000	——	13,514	Placer Basin, Helena, S. Peacock
1941	4	294	241	647	37000	100	13,267	Placer Basin, Helena, S. Peacock
1942	4	89	16	547	35900	——	5,293	Helena, S. Peacock
1943	2	88	9	959	37200	——	5,833	South Peacock, Helena
1944	3	203	7	426	48000	——	7,028	Arkansas-Decorah, Helena, Lockwood
1945	3	68	3	329	22600	——	3,390	Arkansas-Decorah, Lockwood, S. Peacock
1946	2	28	4	198	13500	4000	2,923	Helena, Lead Zone
1947	3	124	8	505	42000	——	9,557	Arkansas-Decorah, Helena, S. Peacock
1948	1	13	2	95	6400	——	1,545	Helena
1949	2	54	5	326	29000	——	6,183	Helena, South Peacock
1950	1	44	——	182	——	30850	4,032	Lead Zone
1951	2	116	4	381	18000	24830	8,502	S. Peacock, Lead Zone
1952	2	73	——	108	——	16800	4,621*	Alaska Tungsten mine, Lead Zone
1953	1	241	——	——	——	——	14,183**	Alaska Tungsten mine

* Includes value of 1312 pounds WO_3

**Value of 8878 pounds WO_3

mates of reserves vary greatly, but there are probably two million tons of at least 1.0 per cent copper ore in this unexploited deposit. Ross (1941, p. 7) says some of the ore zones are 60 to 150 feet wide and contain 1.5 to nearly 2.5 per cent copper and small amounts of silver and gold. In at least one ore body, sphalerite is important.

The I X L mine is also a disseminated copper deposit in which metallization is controlled by fractures, but with a mineralogy and country rock different from those of the Red Ledge. The ore minerals are a high temperature (hypothermal) assemblage of molybdenite, pyrrhotite, chalcopyrite, and pyrite filling fractures in granite.

Several mines and prospects have been opened on small fractures in andesite and andesitic tuff in which there has been irregular deposition of chalcocite and other sulphides in a sparse gangue. The amount of ore in such deposits appears small. A similar deposit, but in a more persistent fracture, with better prospects for development, is the galena deposit of the Lead Zone mine.

In addition there are some fissure gold-quartz veins with minor amounts of sulphides. None of these is now being developed.

Small lenticular pods of manganese oxides in sheared phyllites and of iron oxides along an igneous contact have attracted prospectors to the south side of Cuddy Mountain, but there is no evidence of a tonnage of either type sufficient to justify much expenditure for exploration.

Throughout the Seven Devils region, surface indications of mineralization are abundant, but only a few of the many mineral occurrences appear to warrant further development.

COPPER DEPOSITS

"Contact" Deposits

The Seven Devils "contact" deposits are located in the southern part of the Seven Devils Mountains, between the ghost camps of Helena and Landore. The primary ore minerals are largely chalcopyrite and bornite, in a gangue of lime silicate minerals, mainly garnet, with subordinate epidote, diopside, termolite, actinolite, hedenbergite and minor amounts of many other minerals. These lime silicate or tactite masses occur around blocks of limestone which have been engulfed by quartz diorite. The tactite has been subjected to post-intrusion fracturing which allowed the introduction of the copper sulphides (as well as a tungsten mineral, scheelite - powellite) which formed pods, chimneys and irregular masses in the fractured tactite. Oxidation has affected the deposits to varying degrees with development of much azurite, malachite, and chrysocolla. Supergene sulphides below the oxidized zone are chalcocite, covellite, and bornite.

Lindgren (1899, p. 125) said, "The copper deposits of the Seven Devils are typical contact metamorphic deposits formed by the chemical action of the diorite on the limestone when the former was intruded in a molten state into the sedimentary series." Livingston and Laney (1920, p. 65) demonstrated that the ore solutions came after the solidification of the diorite, and thus disproved Lindgren's assertion insofar as it concerned the ore minerals.

Ore deposition in these deposits was controlled largely by the location of fractures produced by post-intrusion tectonic movements. The limestone did not yield to stress by fracturing, but recrystallized and remained relatively impervious to the ore solutions; the diorite fractured in widely-spaced clean breaks with little open space; the tactite, however, broke irregularly and left many open spaces to accommodate ore solutions. The migrating solutions, therefore, found the limestone or marble inpenetrable, the granite inhospitable, and accordingly chose an irregular pathway through the tactite, depositing bunches and pockets of ore minerals in favorable places.

The word "contact" carries the idea of formation during intrusion by pyrometasomatic processes. The Seven Devils deposits occur along an igneous contact, but were formed from hydrothermal solutions after the solidification of the intrusive mass; therefore, they would be better classified as hypothermal (high-temperature, hydrothermal) deposits.

The recrystallized limestone or marble comprises a dozen or so "lime dikes", tabular masses standing on edge, the largest of which is about a mile long and 300 to 1000 feet wide. In some places there has been little or no tactite development along the blocks of marble; in other places masses of limestone up to 300 feet across have been completely replaced by lime silicate minerals. A great part of the tactite is barren or devoid of ore of commercial value.

The Alaska and Lockwood mines, although copper producers in the past, will be discussed as tungsten properties in this report.

South Peacock mine (3)*

The South Peacock mine, southeast of the ghost town of Helena, at an elevation of just under 7000 feet, was opened in 1897 or 1898 and has been operated intermittently since that time, attaining the greatest depth below the surface of any mine in the area, 325 feet. Shipments since 1940 total about 160 tons of 20 per cent copper ore. The latest shipment, in 1951, is the most recent copper ore shipment from the Seven Devils region.

Mine workings consist of a 325-foot vertical shaft connecting four levels, at 42, 100, 200, and 300 feet, the lowermost now flooded. In recent years a new shaft has been started about 250 feet southeast of the large one and is now down 50 feet below the surface, the lower 20 feet being flooded. Some ore was taken from a level extending off this small shaft at a depth of 20 feet, but the 1951 shipment came from the 200-level in the old shaft. There are about 1700 feet of unflooded underground workings.

The primary ore minerals are bornite and chalcopyrite, with abundant minerals of oxidation, especially cuprite, chrysocolla, and malachite, and considerable secondary chalcocite, covellite, and bornite. The ore occurs in irregular masses, stringers, and crush zones in a large tactite mass. There is no limestone in the mine, the tactite being surrounded by quartz diorite. The tactite body, composed mainly of garnet, is about 300 feet across and apparently was formed by the complete replacement of a block of limestone. The body is elongated east-west and both foot and hanging walls dip steeply southward except in places where the hanging wall is a flatly southward-dipping thrust fault.

The ore minerals have been deposited in pre-mineral fractures in the tactite. However, post-mineral dislocations are the most striking; instances of ore minerals smeared along faults and mixed with broken garnet and other lime silicate minerals in crush zones are common. Most of the faults exposed underground fall into one of the three following sets: (a) thrust faults striking east-west, dipping 20° - 35° south; (b) a steeply dipping set of faults striking about east-west; and (c) a set which cuts the other two sets, striking about north-south and generally dipping 75° - 90° either east or west.

There is some ore in sight in the South Peacock, and a program of exploration on and near the surface in the vicinity of the small shaft might have good results. Ore showings are more widespread in the upper levels than on the extensive 200-level; exploration might, therefore, be more productive near the surface than on or below the 200-level.

Tussel prospect (5)

On Tussel Ridge south of Kinney Point is an irregular tactite zone on the quartz diorite-greenstone contact. The tactite contains bornite, somewhat oxidized to malachite, and quartz veinlets carrying sparse scheelite-powellite.

Workings consist of a caved adit, two open cuts, and the beginning of a new adit. In 1937, 55 tons of ore were shipped. Smelter returns on a 19-ton portion of this yielded 7.25 per cent copper, 4.75 ounces of silver and 0.25 ounces of gold per ton. There is no ore in sight.

Helena mine (8)

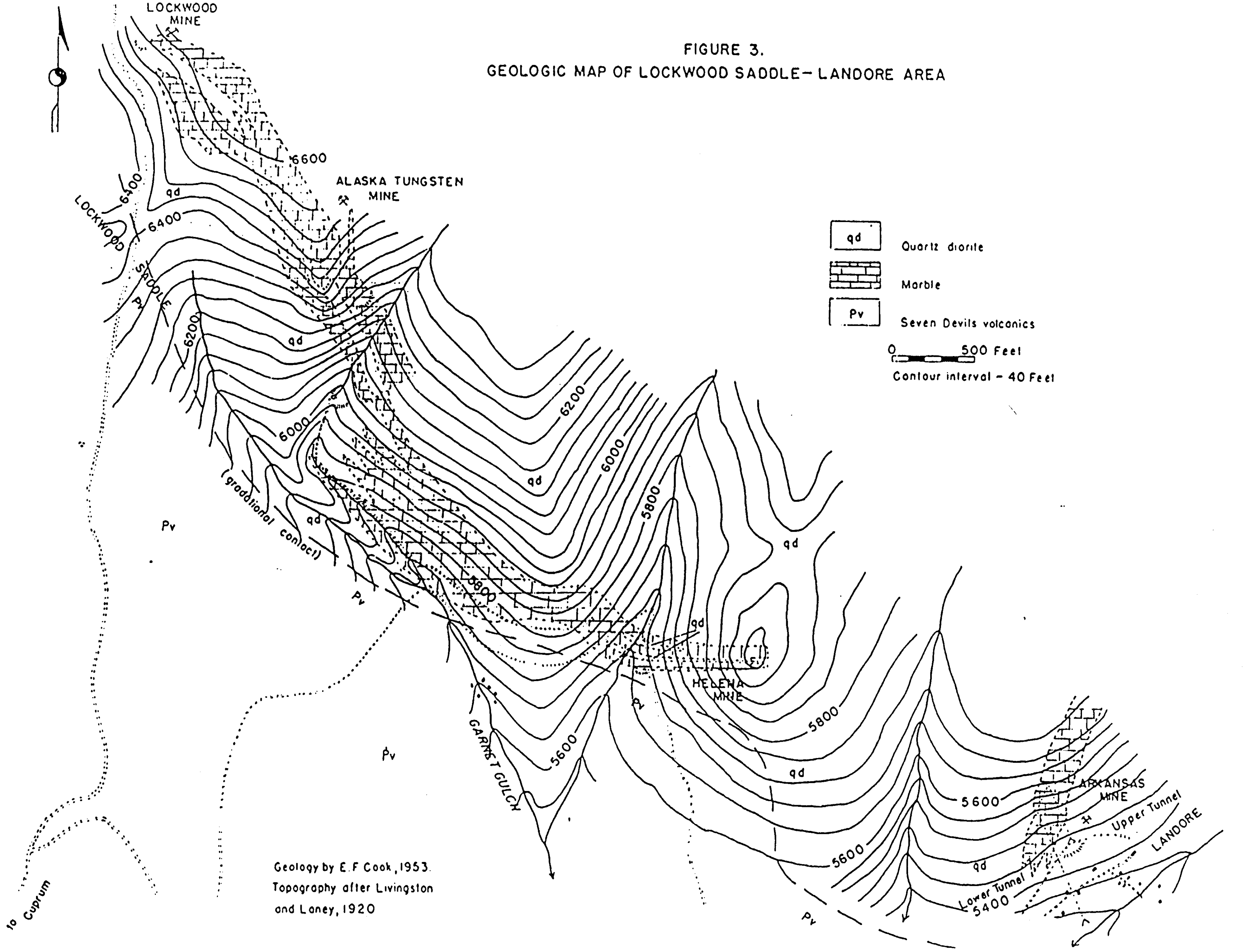
This mine, about one mile northwest of Landore, has an estimated production of 450 tons in the past 20 years. Quartz diorite has surrounded and injected sills into a limestone body (Fig. 3), forming several tabular tactite zones in which pockets and bunches of rich bornite ore were found. The mountain in which the mine is located has been honeycombed with workings and no ore remains in sight.

The mine has not been operated since 1949. Ore shipped in recent years contained about 24 per cent copper, one shipment in 1948 assaying 24.57 per cent, with 6.7 ounces of silver and 0.125 ounces of gold per ton.

A width of about 14 inches of tactite in the back end of a short adit showed good fluorescent scheelite - powellite mineralization in 1953 but no sample was taken. Lindgrenite, a rare hydrous copper molybdate of supergene (secondary) origin has been found in the Helena mine and described by Cannon and Grimaldi (1953, p. 904-906, who also noted molybdenite replaced by supergene powellite, as well as scheelite-powellite partially altered to cuprotungstite, a hydrous copper tungstate.

* Numbers refer to the geologic sketch and index map, Figure 2, and the Seven Devils geologic map, Figure 4.

FIGURE 3.
GEOLOGIC MAP OF LOCKWOOD SADDLE — LANDORE AREA



Arkansas and Decorah mines (9)

Shipments by leasers from these two properties at Landore ended in 1947 after about 300 tons of 9 per cent copper ore had been shipped in the ten years preceding.

The ore, chalcopyrite with chrysocolla, chalcocite, covellite, and bornite, occurred in scattered masses in tactite near the borders of a limestone body which strikes N. 15° E. and dips 45° west (Fig. 6). The workings were once extensive but most are now caved. Some low-grade ore remains in sight.

Disseminated deposits

Red Ledge mine (1)

The Red Ledge mine, on Deep Creek about two miles above its mouth, is reached by a 19-mile company-owned road down the Snake River to Eagle Bar and a 5-mile jeep trail from Eagle Bar to the mine. The property consists of 23 patented and a large number of unpatented lode and millsite claims, covering over 1500 acres.

No ore has been produced, but exploration which began in the early 1900's has produced about 2,400 feet of underground workings and 16,000 feet of diamond drilling, at a cost in excess of a million dollars.

The ledge is a mass of porphyritic and tuffaceous rhyolite and andesite rising 3,500 feet above Deep Creek, red to orange yellow in color because of the oxidation of pyrite which is thoroughly disseminated through the ledge. The rhyolite and andesite are apparently flows and tuffs within the Seven Devils volcanics.

Copper, lead, and zinc sulphides were deposited later than the pyrite along northeast-striking shear zones in the sericitized, silicified, and pyritized volcanic rocks. Some silver and a little gold occur in all the ore. The ore minerals are chalcopyrite, galena, sphalerite, and tetrahedrite, with a sparse gangue of quartz and barite. Below the zone of oxidation supergene enrichment is prominent, the principal secondary minerals being chalcocite and covellite. More or less complete oxidation ceases at a depth of 120 feet and below this the secondary sulphides are abundant for another 50 feet, then begin to decrease.

Known ore bodies are confined to an area of about 2,000 by 3,000 feet. The ore zones appear to be lenticular both in plan and section, with maximum widths of 60 to 150 feet. Copper is reported to run as high as 3.6 per cent over a 50-foot width in the zone of enrichment; silver values go to 8 ounces per ton in this zone. One ore body reportedly contains zinc values up to 8 or 9 per cent. Below the zone of secondary enrichment the metal content of the ore falls to about a third of the values given above. Gold appears to be associated with pyrite whereas the silver is contained in tetrahedrite. Silver values, therefore, vary directly with the copper content of the ore, because tetrahedrite and chalcopyrite were deposited in the same stage of mineralization. Gold values, on the other hand, do not vary in proportion to the copper content because the pyrite was deposited in an earlier stage of mineralization.

Probable ore reserves depend upon the grade of cut-off. For example, from the incomplete data available, it appears that about half a million tons of ore containing 1.4 per cent copper, 3 per cent zinc, and 1.8 ounces of silver and 0.03 ounces of gold per ton is probable; however, if the cut-off is lowered to 1.0 per cent copper, probable ore reserves are raised to two million tons. Exploration has not extended much below the level of Deep Creek. Some of the known ore bodies may extend to considerable depths; consequently, the possible ore in the Red Ledge mine may greatly exceed the probable reserves estimated above.

I X L mine (20)

On the south slope of Cuddy Mountain about 15 miles northwest of Cambridge, is the I X L mine, a low-grade disseminated copper deposit in fractured and mineralized granite. The area of mineralization, according to Livingston (1923, p. 12), is about 8,000 feet long by 4,000 feet wide, elongated northeast. Very little discoloration marks the outcrop of the mineralized zone, in contrast to the brilliant colors of the Red Ledge; this is probably due to less pyrite in the country rock at the I X L.

The Bear Creek Mining Company, a subsidiary of the Kennecott Copper Corporation, at present has a lease and option on the property and is doing sampling and exploration. A road has recently been bulldozed to the property.

The ore minerals, deposited in small faults and fractures, are pyrite, chalcopyrite, pyrrhotite, a little bornite, and considerable molybdenite. The only gangue is a small amount of quartz. In the 844-foot adit which is the main development on the property there is no sign of enrichment by secondary sulfides. Oxidation has apparently been on a small scale and, consequently, enrichment is minor. The granitic country rock is sericitized and silicified. Two stages of mineralization are evident, molybdenite and pyrrhotite being earlier than the chalcopyrite. Quartz - molybdenite veinlets are cut by quartz - chalcopyrite veinlets.

An interesting feature of the faults mapped in the adit is that none of them has a dip in the range 45°-60°; all are either flatter (18°-44°) or steeper (60°-80°). Mineralization seems to be associated with the flatter fractures.

The best mineralized area begins about 500 feet in from the portal of the adit and continues irregularly for about 200 feet. The west side of this zone has been exposed by laterals 76 feet north and 81 feet south of the main adit.

No assays are available, but the copper values appear to be in the 1-2 per cent range, with some molybdenum. Because the mineralization is hypothermal (high-temperature, hydrothermal) and because the fractures with which the ore minerals are associated appear to be of deep-seated compressional origin, the prospects for downward extension of the mineralization are good.

Vein deposits

Lime Peak mine (11)

At the Lime Peak mine, in the Snake River Canyon about five miles north of Homestead, irregular breccia zones in red tuff and porphyritic tuffaceous greenstone of the Seven Devils volcanics have been mineralized by chalcocite and a sparse gangue of quartz and epidote. The quartz is crystalline and vuggy. The chalcocite, deposited by cavity filling, has been slightly oxidized to malachite and azurite.

A 175-foot adit and several surface pits in red - purple tuff have exposed the chalcocite mineralization. A 350 - foot adit in somewhat sericitized, porphyritic, tuffaceous greenstone shows no mineralization. These two adits were driven eastward into the mountain from near river level. A few hundred yards to the east and several hundred feet above the Snake River, a 1500-foot adit was driven through porphyritic and tuffaceous greenstone, allegedly in an attempt to intersect at depth the Lime Peak limestone which forms a prominent landmark on the hill above. Neither limestone nor mineralization was encountered.

The Lime Peak fault (Fig. 4), cuts between the two smaller adits and the large one, striking N. 42° E. and dipping 65°-80° west. The downthrown side is on the west, with a probable throw of several hundred feet.

The amount of ore in sight at the Lime Peak mine is small. Future exploration should explore the known mineralization.

River Queen mine (12)

The River Queen mine, about three miles north of Homestead, has produced an estimated $20,000 in copper ore. The latest production was in 1936-40; about 200 tons of hand-sorted ore containing 15-17 per cent copper were shipped. The mine has been developed by several hundred feet of workings on three levels.

A series of northeast fractures cut altered andesitic tuffs, rhyolite, and sedimentary rocks of the Seven Devils volcanics and these fractures are irregularly filled with chalcopyrite and some bornite. There is no gangue. The rhyolite appears to be associated with the chalcopyrite and is full of pyrite crystals and grains (Laney and Livingston, 1920, p. 24). Some of the greenstone is silicified and the rhyolite probably is also.

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.

Azurite mine (13)

Workings at the Azurite were not accessible during the summer of 1953. The mine has a vein striking N. 60° W., dipping 65° northeast (Livingston and Laney, 1920, p. 40), carrying pyrite, galena, chalcopyrite, sphalerite, and tetrahedrite in a gangue of quartz, dolomite and siderite. The country rock consists of sediments and tuffs of the Seven Devils volcanics. There has been no recent production.

TUNGSTEN DEPOSITS

Alaska mine (7)

The only producing mine in the Seven Devils region during 1953 was the Alaska tungsten mine, located just southeast of Lockwood Saddle about 5 miles by road north of Cuprum. The Alaska claims were patented as copper claims in the 1890's, but no copper has been produced in many years. Production of tungsten ore began in 1952 with the shipment of 36 tons of ore containing 1.84 per cent WO_3 (tungstic oxide). In 1953, 241 tons of 1.57% WO_3 ore were shipped. Because of the high content of molybdenum, the ore is subject to a price penalty. To compensate for losses during milling, only 80 per cent of the tungsten content is paid for. Despite these factors the production of the two summers yielded $16,650 before transportation and milling charges.

Production is from a new opening on a hillside a few hundred feet from the nearest copper workings. Here a slab of limestone at least 60 feet wide, striking N. 5° W. and dipping 78° east, has been engulfed in quartz diorite with the formation of tactite zones in which the tungsten is found. The tungsten mineral is a molybdenum-rich scheelite of the isomorphous scheelite-powellite series. Powellite, the molybdate end of the series, was first reported from the Peacock mine of the Seven Devils (Melville, 1891), having never before been found in nature.

A face 40 feet wide was opened on the hillside, showing alternating bands of tactite and marble from one to 15 feet in width. Of the 40 feet in the face, 6 to 10 feet are marble, the rest tactite. The tungsten values are limited, however, to one of the tactite bands, about five feet wide, which was sampled by the Idaho Bureau of Mines and Geology and found to contain 2.2 per cent WO_3. A 24-foot sample across most of the remainder of the exposed tactite gave only 0.05 per cent WO_3. A stringer of copper mineralization, mainly malachite and azurite, occurs along one of the tactite-marble contacts. Other assays across this same face give 2.40 per cent WO_3 for the ore zone and from 0.01 to 0.88 per cent for other parts of the face. A tactite zone forty feet wide at the level of the access road and within the "lime dike", yielded assays of 0.32 to 0.91 per cent WO_3, the weighted average being 0.53 per cent.

Examination of a rock thin section shows scheelite-powellite filling interstices between garnet, epidote, and diopside crystals. The scheelite-powellite is later than the lime silicates and has apparently deposited in fractured tactite, largely replacing residual calcite. Cannon and Grimaldi (1953, p. 909-910) apparently believe that much of the powellite in the Seven Devils is of secondary origin, having replaced molybdenite, the primary mineral. The copper mineralization is much later than the tungsten and has been guided by post-tungsten fractures. Therefore, the only relationship between the two is that they both occur in the tactite. Locally, there is considerable coarsely crystalline quartz and secondary calcite in the tactite, both very late, low-temperature minerals. Some post-copper fractures are filled by epidote or quartz-epidote veinlets.

The geologic map of the property (Fig. 5) shows that the limestone slab of the mine area is probably a faulted-off portion of the large "lime dike" which forms a conspicuous ridge southeast of Lockwood Saddle. The chances of extension of this tabular block along strike appear excellent but the persistence of the tungsten, controlled as it is by local fractures in the tactite, is unpredictable. Only more exploration, which is certainly justified and necessary, will tell the story.

This is an excellent prospect and may develop into a good mine. At present, the operators are having difficulty finding a buyer who will accept the high-molybdenum ore, but this should be only a temporary setback. The need is for exploration to develop enough ore reserves to justify a mill in order to reduce transportation charges which, during the summer of 1953, amounted to $23 per ton of ore.

Lockwood mine (6)

The Lockwood mine, just north of Lockwood Saddle, was an intermittent copper producer from the 1890's to 1944. About 20 tons of 20 per cent copper ore were shipped in 1943-44 by leasers. This ore reportedly ran high in tungsten, although no assays of the shipment are available. The property was leased as a tungsten prospect in 1953.

There are two adits, one about 150 feet above the lower. The upper adit is 140 feet long and the lower 290 feet. The lower adit had been caved but was reopened during August, 1953. One hundred ten feet in from the portal of the lower adit a raise goes up at least 50 feet. This was developed as a stope in mining out a chimney of copper ore. The dump of the lower adit contains rocks which have abundant fluorescent scheelite-powellite and the lower adit was reopened to search for the source of this material.

The mine is in a tactite body (Fig. 5) along the northern end of the great "lime

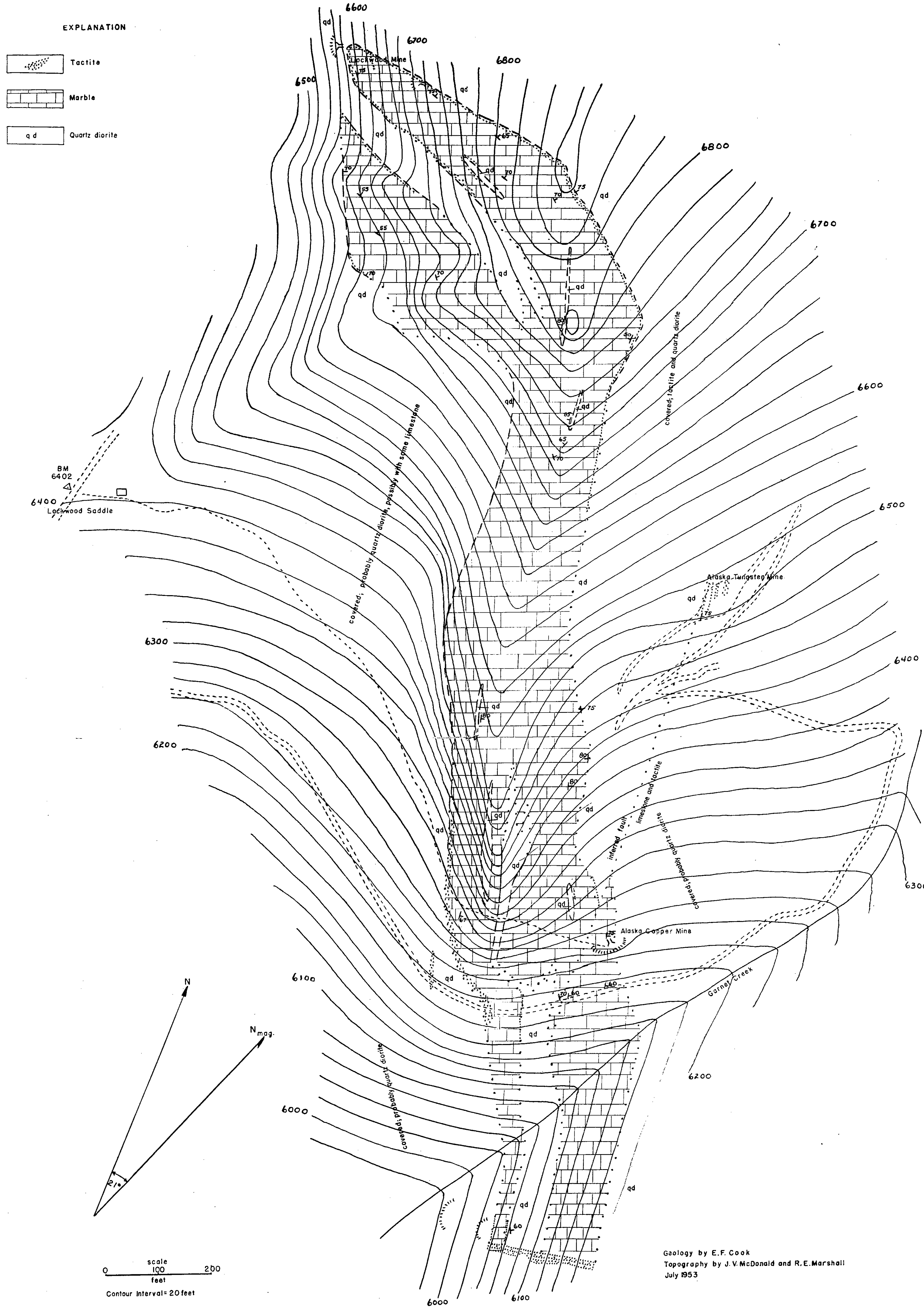


FIG. 5. GEOLOGIC AND TOPOGRAPHIC MAP OF LOCKWOOD SADDLE TUNGSTEN AREA

16a

dike" which extends northward from the Helena mine. The primary copper mineral is bornite, with malachite and chrysocolla as oxidation products. The tactite includes the usual lime silicate minerals, garnet dominating.

A sample taken from fluorescent rock near the end of the upper adit assayed 0.65 per cent WO_3 over an 18-inch width. A sample was taken across seven feet of the main fluorescent zone in the lower adit, with a result of 0.05 per cent WO_3. Under ultraviolet light, this zone, which extends up the raise as a shell of the mined-out copper chimney, fluoresces well and apparently contains good ore. The reason for the disappointing yields in tungsten became apparent when the samples were assayed for molybdenum. It was found that the rock contains much more molybdenum than tungsten. The fluorescent mineral is, therefore, close to powellite in composition, a calcium molybdate with some tungsten. All scheelite containing over 4.8 per cent included molybdenum fluoresces a golden yellow and the only way to determine the relative percentages of the two elements is by chemical assay, a slow and costly process for the prospector. Under present conditions, scheelite-powellite is valuable only as an ore of tungsten, not as a source of molybdenum.

The potential value of the Lockwood mine appears to depend upon the exploration and development of a cylindrical shell of ore surrounding an inclined shaft about 400 feet above the Kinney Point road. This shaft, about 30 feet deep and five feet in diameter, is the highest working on the ridge. The shaft was sunk to stope out the core of a high-grade copper ore shoot. The shell of low-grade ore which remains was channel-sampled by Cannon (personal communication) in 1941 and assayed in the U. S. Geological Survey laboratory; the sample, taken where the shell is 16 inches thick, was found to contain 9.95 per cent copper, 2.24 per cent WO_3, and 0.85 per cent MoO_3.

Unlike the Alaska occurrence the Lockwood scheelite-powellite is closely associated, in space, with copper mineralization. There is little doubt, however, that this is a structural coincidence, the later fractures which guided the copper solutions having broken tactite in the same place as the earlier fractures which controlled the tungsten-molybdenum mineralization.

A study of assays from the Alaska and Lockwood mines (below) suggests that the proportion of molybdenum in the scheelite-powellite decreases as the amount of the mineral in the rock increases. For example, in the good ore from the Alaska mine (Sample No. 2) the molybdenum and tungsten are about equal, but in the poorly mineralized tactite of the same deposit (Sample No. 3) there is about ten times as much molybdenum as tungsten. The sample from the upper Lockwood adit illustrates the intermediate situation where sub-marginal tungsten ore contains about twice as much molybdenum as tungsten.

Sample	Location	Width of sample	WO_3	Mo
No. 1	Lockwood upper adit	1.5′	0.65%	1.0%
No. 2	Alaska ore body	5.2′	2.2 %	1.8%
No. 3	Alaska tactite	24.0′	0.05%	0.4%
No. 4	Lockwood lower adit	7.0′	0.05%	

Assayed by C. R. Kurtak, Chemist, Idaho Bureau of Mines and Geology.

Patton prospect (4)

Near the head of Deep Creek about two miles northwest of Smith Mountain is a small limestone lens on the contact between quartz diorite and granodiorite. The limestone has been recrystallized and tactite has developed. Within the tactite is some scheelite, which, judging by its pale fluorescence color, has a low molybdenum content. High assays are reported, but the samples were probably taken parallel to a mineralized shear and thus are deceptively high. Most of the tactite contains no scheelite and the prospect cannot be regarded as containing tungsten ore under present conditions.

LEAD DEPOSIT

Lead Zone mine (18)

For many years, a lead deposit near the summit of Cuddy Mountain has been known and sporadically developed. The property has been called the Keystone and the Galena; since 1950 it has been known as the Lead Zone mine. Workings include some surface cuts along the outcrop and a 600-foot adit from which branch three short laterals.

Small shipments are reported through the years. Recent production, by the Lead Zone Mining Company, is as follows:

Year	Tons	Copper	Lead	Zinc	Silver	Gold
1950	44.4	0.05%	34.75%	0.4 %	4.1 oz./ton	0.01 oz./ton
1951	42.3	0.05%	29.35%	0.55%	3.53 " "	0.05 " "
1952	37.3	—	22.5 %	0.8 %	2.9 " "	0.0075" "

A narrow, pinching, swelling, and branching vein strikes N. 45°-65° E. and dips 53-70° north. Galena is the only primary ore mineral, much oxidized to anglesite and cerussite; a minor amount of quartz is the only gangue. Near the surface manganese oxides are prominent in brecciated zones. The ore has been formed by filling and replacement in shears and breccia zones. The wall rock which is predominantly andesite and locally tuffaceous, is hydrothermally altered. In one place an isolated block of banded shale or argillite about ten feet thick is included in the hanging wall of the vein. The principal alteration effects are bleaching and silicification, producing a hard, light-colored rock which looks like a rhyolite.

The andesitic rocks are probably part of the Seven Devils volcanics of Permian to Upper Triassic age, but the age of the other rocks in the vicinity is largely in doubt. A northeast-striking, west-dipping rock sequence is apparently interrupted by faulting in the vicinity of the mine. To the east of the mine are the andesitic conglomerates of the upper Seven Devils volcanics, overlain by a thick rhyolite flow, which is cut off along the valley of Galena Creek (Fig. 6) by a strike fault; west of this fault is a complex zone of faulted, sheared, altered, and locally mineralized rhyolite and andesite; in the vicinity of the mine the andesite becomes tuffaceous and grades westward into waterlaid grit and boulder conglomerate. These clastic sediments are apparently overlain by a thick sequence of platy, banded, fissile, gray to black shales with some interbedded sandstone and conglomerate. The shale sequence is overlain in turn by a conglomerate about 150 feet thick, characterized by shearing around pebbles, lithologic heterogeneity, pyritization of both matrix and pebbles, and poor sorting. Some of the fragments up to a foot long are of stretched and twisted pink limestone—a rock type which does not occur in the rocks which lie structurally beneath the conglomerate. Because boulders occur in the top of the conglomerate, and because overlying it is a thin, pink crystalline limestone, lithologically similar to the limestone fragments within the conglomerate, there is a suggestion that this entire sequence from the mine west may be overturned and have been brought against the Seven Devils volcanics by faulting in the vicinity of the mine. Furthermore, if this is an essentially conformable sequence from Permian volcanics to Upper Triassic shales, the absence of the Lucile (Martin Bridge) limestone is difficult to explain, for it outcrops in Wildhorse Canyon three miles west of the mine and again on the south slope of Cuddy Mountain. Whatever the nature of the faulting at the Lead Zone mine, it probably has a displacement measured in hundreds and perhaps thousands of feet.

Ore exposed in the present workings is considerably oxidized. In an attempt to get below the zone of oxidation and develop reserves of milling ore, an adit called the Bruce Tunnel has recently been started from a point near Galena Creek 300 feet below the present portal. This adit will not only have to be driven about 1,200 feet to strike the vein, which is dipping away from it, but will probably pass through barren rock. The Bruce Tunnel was started in a bleached shear zone but will soon be out of it if driven further (See map, Fig. 6).

The galena vein is nowhere over 5½ feet wide and probably averages about two feet. Tenor also varies greatly, and generally in-

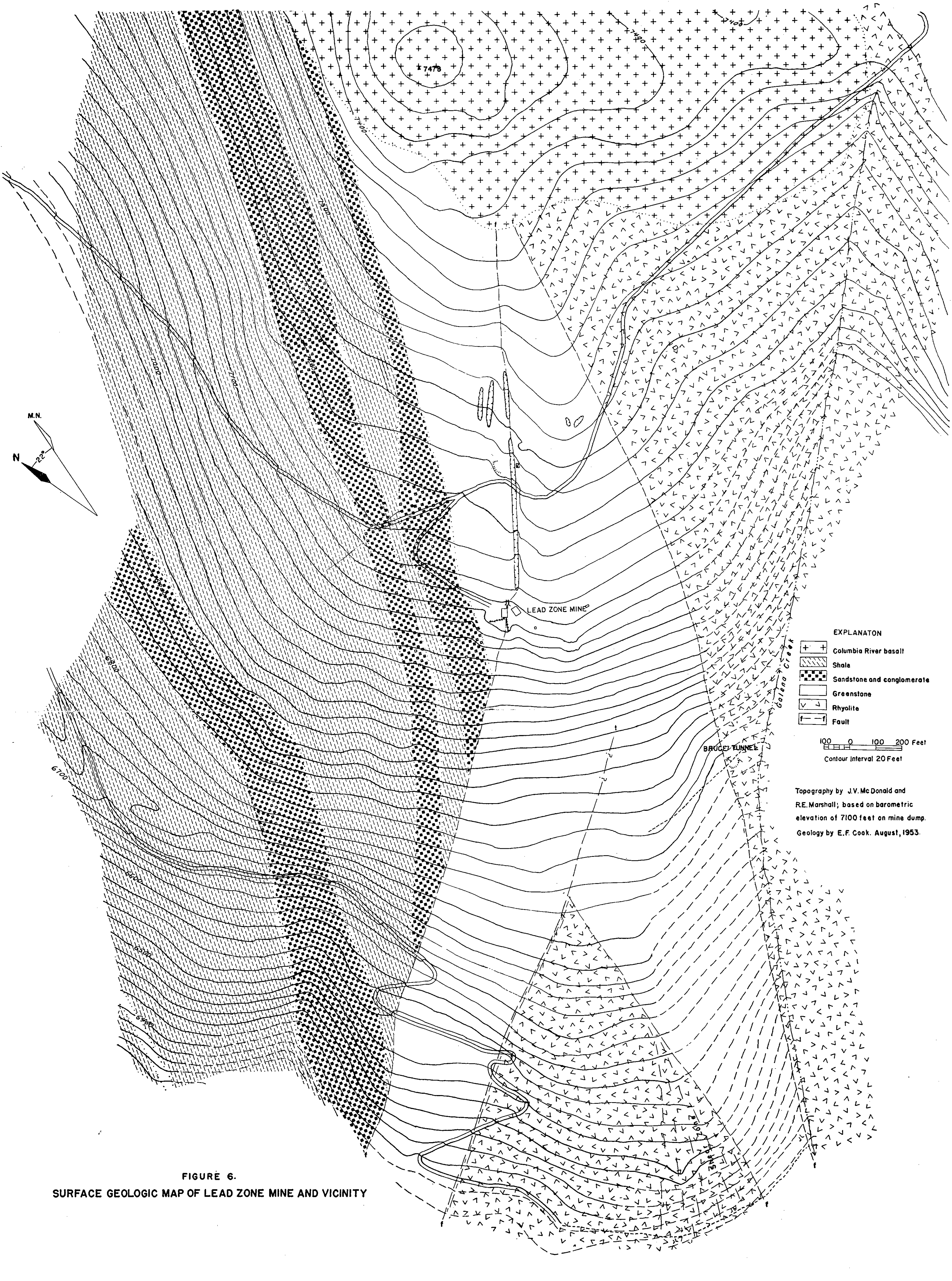


FIGURE 6.

SURFACE GEOLOGIC MAP OF LEAD ZONE MINE AND VICINITY versely with the width. Widths of 0.5 to 2.0 feet contain 17 to 50 per cent lead, whereas widths of greater than two feet assay only 2 to 5 per cent lead. There are, of course, higher grade lenses along the vein where 30 per cent ore can be found over a width of three feet, but these places are exceptional. Most of the ore shipped in 1950-52 came from a winze below the adit level, 150 feet in from the portal. A weighted assay across 5.5 feet in this winze gave 12.6 per cent lead and one ounce of silver per ton.

The chances of persistence in depth of this mineralization appears good and further exploration by sinking the winze a hundred feet and then drifting on the vein or by starting another adit 100 to 200 feet below the present one, but on the trace of the vein, would seem justified by the showings in the present workings.

GOLD DEPOSITS

Quartz vein deposits

Cliff mine (2)

High above Oxbow Creek, about one mile north of the Red Ledge mine, an adit has been driven 370 feet into the side of Cliff Mountain following a quartz vein, the outcrop of which can be traced far up the flank of the mountain. The vein fills a fracture, one of a prominent set; its hanging and footwalls are sharply defined. The vein is 8 inches to 44 inches wide, strikes N. 10°-15° W. and dips 40° east. The wall rock is dark tuffaceous andesite of the Seven Devils volcanics. The hanging wall is locally bleached and pyritized as much as two feet from the vein; the footwall up to four feet from the vein is bleached to a sugary, granitic-looking rock.

The ore minerals are pyrite, bornite, and chalcopyrite in small, irregular masses within the quartz, which is locally vuggy and coarsely crystalline. There is little oxidation. Gouge one to two inches thick is persistent on the footwall. The vein has been given a banded appearance by recurrent fracturing, the bands being about one quarter-inch apart. Quartz veins in other fractures of this same set which lack the banding are barren; recurrent fracturing, then, was a prerequisite to the introduction and deposition of the ore.

The vein, which averages about 16 inches in width, has been thoroughly sampled, by W. H. Hill in 1915 and Clayton Robbins in 1947. Weighted averages of the 1947 assays are: gold, 0.26 ounces per ton; silver, 1.6 ounces per ton; and copper, 2.46 per cent. At present prices, this ore would yield $25 per ton. Despite the apparent persistence of the vein, its narrowness seriously reduces its potential value.

Carbonate Hill area (10)

Pyritic gold-quartz veins in sheared and altered greestóne and tuffs of the Seven Devils volcanics outcrop on the south side of Carbonate Hill on the crest of the Seven Devils Mountains about ten miles by trail north of Black Lake.

Auriferous pyrite is the only ore mineral, set sparsely in quartz gangue. Shear planes strike about N. 40° E. and dip steeply southeast. The veins, whose position is controlled by the shears, have a similar attitude. The country rock north of the shear zone is unbrecciated, dark purple tuff; within and south of the shear zone, it is silicified greenstone containing sparse lenticles of limestone. This shear zone is apparently part of a large fault which extends southwestward toward the Snake River, one of a number of northeast faults in the area (see map, Fig. 2).

There is no recorded production from these veins and the few workings are caved.

Placer Basin mine (15)

A gold-bearing, quartz-pyrite vein was mined at Placer Basin, on the Bear-Black Lake road, until 1941. The workings, which included a 600-foot inclined shaft and 6 levels, are now caved, and the surface plant which for several years featured a 25-ton cyanidation plant, has been dismantled. The peak period of production was 1935 - 37. Thirty-four hundred tons were milled in 1937 and made up a large part of the district's $150,000 production that year. During this period a little ore was hauled from the Black Lake deposits, which are also pyritic gold-quartz veins.

Placer deposit

Carrick Diggings (16)

Rumored to have produced several hundred thousand dollars 40-50 years ago, and worked by one man in 1945-9, the Carrick Diggings are about 8 miles up Bear Creek from Bear Post Office. A deposit of coarse, angular gravel about five feet thick over an area of perhaps two acres has been worked for gold, which is reported to be concentrated in the lower two feet, just above the granitic bedrock.

The gravel, which has many angular fragments of white quartz, was deposited by a stream coming into Bear Creek from the east, and apparently has stimulated prospecting over the years for the lode source of the quartz and gold. The gravel cannot have traveled very far, but the source of the gold is still undiscovered.

MANGANESE DEPOSITS

Brownlee deposit (22)

A manganese deposit was discovered in 1953 about three miles east of the mouth of Brownlee Creek. The deposit is on the southwest side of Cuddy Mountain at an elevation of about 5,000 feet. A bulldozer cut has exposed a lenticular mass of pyrolusite about 20 feet long, with a maximum thickness of five feet, associated with quartz in gray, sericitic phyllites. The structure of the phyllites dips flatly west. Only where the phyllites have been brecciated is there quartz and manganese mineralization.

The manganese body exposed is discontinuous and holds no promise in itself of providing enough tonnage to justify a mining operation. The grade is probably not much over 25 per cent manganese, silica being the main impurity.

Sturgill deposit (23)

About three miles east of the mouth of Sturgill Creek, high on the north side of its valley, is another manganese deposit (Livingston, 1919, p. 32) similar to the Brownlee occurrence. Three pits have been opened in a 500-foot strike distance.

Lenses of pyrolusite and quartz occur in a brecciated siliceous, Sericitic phyllite, the structure of which strikes N. 65° E. and dips 60-80° northwest. The phyllite, which locally contains lenses of limestone was originally a calcareous shale, then was transformed into a phyllite and subsequently faulted with local brecciation. The breccia zones have been the loci of quartz and manganese oxide deposition.

Only a small tonnage of 25 per cent manganese ore is probable in these lenticular masses, whose maximum thickness is four feet. Vertical dimensions are unknown, but the bodies will probably pinch out downward within a few tens of feet. There is a good possibility of other bodies being found by subsurface exploration, but the expense probably would not be justified under present conditions.

IRON DEPOSIT

South Cuddy area (21)

A flurry of claim-staking on the south side of Cuddy Mountain, below the I X L mine, in the past three or four years, was occasioned by the discovery of some outcrops and considerable float of magnetite and hematite along a contact between granodiorite or quartz diorite and greenstone of the Seven Devils volcanics.

A few small pits and a bulldozer trench comprise the total development. The masses of magnetite and hematite are quite pure, containing only a little quartz and, locally, feldspar. Specimen assays have yielded 63 to 69 per cent iron.

The largest body, much of which appears not to be in place, occurs at the highest outcrop, just below a basalt cap. Here some of the iron is oxidized to limonite and the cellular limonite contains quartz-pyrite veinlets and disseminated pyrite cubes. This is probably in large part a residual concentration of iron boulders weathered from an outcrop during pre-basalt time and then buried by the basalt in the Miocene epoch. The pyrite mineralization occurred while the deposit was still covered by hundreds of feet of basalt. Thus is found the phenomenon of a cellular mass of limonite containing fresh, shiny cubes of pyrite. Post-basalt pyritization in the region is known from drilling at the Oxbow.

The iron apparently occurs in discontinuous, mainly small, pods along the granodiorite-greenstone contact. A four-foot thick hematite pod was the only iron seen in place by the field party. The abundance of float in this area is not indicative of large ore bodies, but rather of extensive pre-basalt erosion. Places in which these iron boulders are found are usually places from which the Columbia River basalt cover has just been stripped, exhuming the early Tertiary erosion surface upon which these boulders were scattered. The boulders are not found in areas from which the basalt capping is long gone because the vigorous erosion of the present day has taken them away.

The South Cuddy iron deposits appear to be of only scientific interest.

OTHER PROPERTIES

McCarty mine (14)

One mile south of Homestead, Oregon, on the Idaho side of the Snake River, are four short adits, totaling about 250 feet, driven into complexly faulted and irregularly mineralized volcanic rocks. 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 narrowness and discontinuity of the veins, and the small amount of ore in sight make the prospect a poor one.

North Hornet mine (17)

Mineralization in the vicinity of the headwaters of Hornet Creek, about five miles north of the Hornet Creek Ranger Station, has been known for over fifty years. The only production, however, seems to be 65 tons of gold ore which were milled about 1931 for a gross yield of $200. A few years later a camp and mill were built, a vertical shaft was sunk 140 feet, and stock was sold, but no ore was mined or milled. Present activity is based largely upon the alleged occurrence of samarskite (a niobate and tantalate of iron, uranium and the cerium metals) in a pegmatitic specularite-quartz veinlet in weathered quartz diorite.

Low-grade, gold-bearing quartz and barite veins cut argillites, tuffs, and some greenstone of the Seven Devils volcanics, which are here intruded by quartz diorite in which have developed specularite-quartz veinlets up to two or three inches wide. Boulders of specular hematite to two feet in diameter lie on the surface north of the camp, their source undiscovered.

The pegmatite from which the samarskite is said to have come was thoroughly investigated by the author with a Geiger counter, with negative results. There is no evidence of radioactive minerals in this deposit. With the possible exception of one barite vein, the sole present value of the property appears to be as a source of road material. A large borrow pit in the weathered diorite has been the source of much of the road surfacing material of the vicinity.

Edna May (Snowslide) mine (19)

The Edna May mine, relocated as the Snowslide, is on Edna May Creek at the head of No Business Canyon. A road has been bulldozed to the property from the top of Cuddy Mountain. Work done years ago consists of one 80-foot adit (drift) and one 420-foot adit (crosscut) with two lateral drifts where the adit cuts a vein 150 feet from the portal. One lateral has been driven 60 feet northward, the other 95 feet southward. These are on a N.20° W. vein, apparently the same one on which the shorter adit was opened, higher and to the southeast.

The minerals are pyrite, chalcopyrite, and galena, in a sparse gangue of quartz and feldspar, replacing rocks of the Seven Devils volcanics along a shear zone. Mineralization appears too poor to warrant much exploration.

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MAPPING IN COOPERATION WITH IDAHO
BUREAU OF MINES AND GEOLOGY

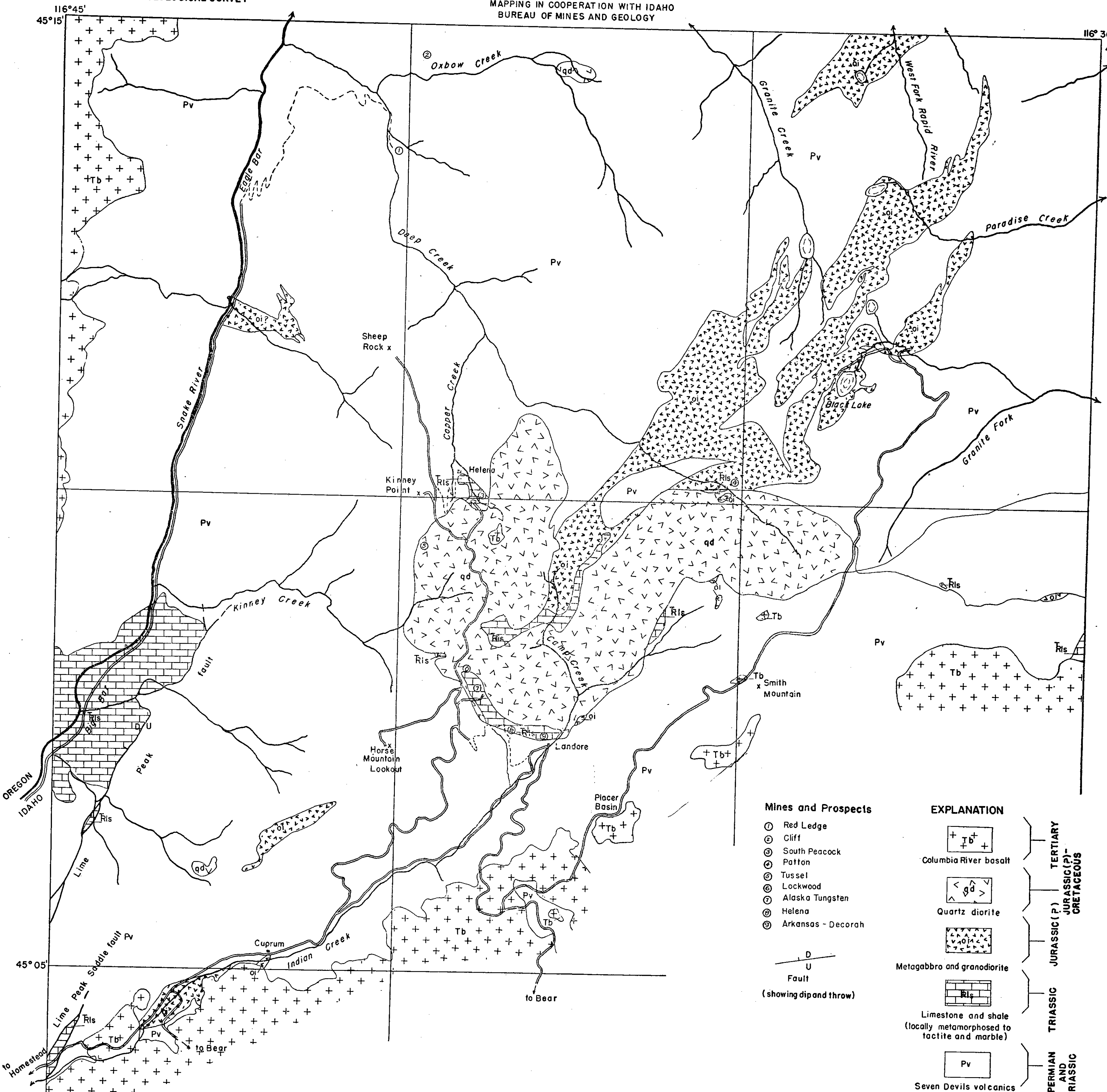


FIGURE 4.

GENERALIZED BEDROCK GEOLOGIC MAP OF THE SEVEN DEVILS MINING DISTRICT QUADRANGLE, IDAHO

SCALE 1: 48,000

1 0 1 2 3 MILES

Geology from mapping by R.S. Cannon, Jr., F.W. Cater, J.R. Cooper, G.H. Espenshade, Carl Fries, Jr., and B.K. Thomas. 1938-1949

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