ECONOMIC GEOLOGY OF THE BRATTEIN
MINING AREA, PAGELAY, ORGON

by

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A THESIS

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and Geography and the Graduate School
of the University of Oregon
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Master of Science

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(For the Committee)
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ECONOMIC GEOLOGY OF THE BRATTAIN MINING
DISTRICT PAISLEY, OREGON

ABSTRACT

South central Oregon is the northern extension of the Basin and Range Province, and consists topographically of a series of alternating mountains and valleys that owe their origin in large part to faulting. One of the valleys, Chewaucan Marsh, is thought by the writer to be of the keystone type of faulting.

Chewaucan Marsh is bordered on the west by an uplifted fault block, the Paisley Mountains, which consist of a series of dacite and andesite flows, tilted to the west at thirty-five to forty degrees. The oldest flows are soda dacite, dacite, and basic andesite, and are pre-Pliocene in age, possibly being deposited in late Eocene times. Basalt dikes and sills are common throughout the mountains, and a number of small vents near the crest of the mountains have erupted vesicular glassy basalt, probably in Pleistocene times.

Hydrothermal solutions of mid-Tertiary age have penetrated the faults and joints of the older flows precipitating base metal sulfides, gold, silver and small quantities of copper.
The deposits are in fissure veins, and are classed as mesothermal deposits. Because of the occurrence of small amounts of copper, the zonal theory may be applicable to these deposits, and an increase in the amount of copper may be encountered at a greater depth.

Development work consists of a number of discovery pits, and several shafts that may have been sixty to eighty feet deep originally, but are now caved in. Exploration work has been carried out recently in the Daylord tunnel, and much of the information concerning the deposits was collected there.

It is believed that it will not be profitable to mine in the Brattain Area until arrangements are made to concentrate the ore near Paisley, thus eliminating a large part of the cost of transportation.
INDEX MAP
SHOWING AREA STUDIED
AND SURROUNDING REGION
INTRODUCTION

Location and Accessibility

The mineralized district to be discussed in this paper will be called the Brattain Mining Area, after Brattain Canyon, which heads in the center of the area. The area is five miles south of Paisley, in an uplifted fault block, which will be called the Paisley Mountains. The fault block, trending somewhat west of north, is bounded on the west by the Chewaucan River, and on the east by the Chewaucan Marsh. As can be seen from the accompanying map (fig. 1), the Chewaucan River flows north from its source for a distance of twenty miles, then reverses its direction, and empties into Abert Lake, which is temporary base level for streams of this region, being surrounded in all directions by higher ground.

Gaylord tunnel, the center of the area from the standpoint of development, is at an elevation of fifty-eight hundred and fifty feet, and is fifteen hundred feet above Paisley. An unimproved dirt road, unsuitable for truck traffic in its present condition, extends from state highway 30 at Paisley, to the tunnel.
Lake County is sparsely settled, having a population density of less than one person for each square mile. The two largest towns are Lakeview, the county seat, with twenty-five hundred persons, and Paisley with two hundred and fifty persons. The Northern part of the county is part of the Eastern Oregon high plateau, whereas the southern part of the county is the northward extension of the Basin and Range province. The topography is that of a series of northward trending fault blocks, with alternating uplifted and downdropped blocks. The average elevation of the valley is four thousand feet, with some of the higher mountains reaching eighty-five hundred feet.

State highway 80, a surfaced highway, connects Lakeview with Paisley, and extends north until it joins U. S. 99E three miles south of Lapine. Travel to the east and west from Paisley is a little more difficult, it being necessary to go to Lakeview, where paved highways may be found that extend east and secondary roads that extend to the west. The only railroad within the county comes from the south and terminates at Lakeview. Another railroad terminal is found at Lapine in Deschutes County, ninety miles northwest of Paisley.

Sixty percent of the income of this region is derived from the sale of sheep and cattle. A small amount of field
crops are grown for local use, and some logging is carried on in the western part of the county. Some of the logs are transported to adjoining areas for processing, but sawmills are located at Lakeview, Paisley and Silver Lake.

Mining has provided very little income, although considerable prospecting has been done. Small amounts of gold in quartz veins are found at New Pine Creek, Coyote Hills, and Rabbit Hills. A cinnabar occurrence has been reported in a masters thesis by Johns (1949), and some quicksilver has been marketed from the Currier Mine on the west edge of Summer Lake.
Figure 2

Panoramic view of Brattain Mining Area looking north. Gaylord tunnel is right of center. Chewaucan Marsh in the distance.
Figure 3

Brattain Canyon near the eastern edge of the mapped area, showing the beginning of the steep gradient.

Figure 4

The Paisley Mountains from Chowaucan Marsh. Brattain Canyon in the center.
Climate and Vegetation

As part of the high plateau region, Lake County experiences a cold steppe climate. The winters are cold with a mean January temperature less than 32°, and the summers are quite warm, the mean July temperature being about 60°. Precipitation varies from fifteen inches annually in the western part of the county to ten inches or less in the eastern part. Records at Paisley for the period 1934-1939, show a mean annual precipitation of nine inches.

Somewhat greater extremes of temperature will be found in the Paisley Mountains and probably also a greater amount of precipitation, with a large proportion being snow. In the Paisley Mountains snow usually covers the ground from December to April, reaching a maximum depth of five or six feet.

Following Merriam's (1898) system of "Life Zones", the area around Paisley is classified as Arid Transition. Sage brush (Artemesia tridentata) and rabbit brush (Chrysothamnus nauseosus) are most common with interspersed Rocky Mountain juniper. Mountain mahogany and quaking aspen are common in the ravines and along creek banks at the higher elevations. In the Paisley Mountains at an elevation of sixty-
five hundred feet a few scattered Ponderosa pine are found indicating a gradual change to a typical Arid Transition yellow pine forest.
Field Work and Acknowledgements

The district was first visited in May 1948 in the company of Dr. L. W. Staples and Dr. E. M. Baldwin, Professors of Geology at the University of Oregon and Mr. W. R. Johns, graduate student of Geology, also at the University. The purpose of this trip was to determine the suitability of the area for a thesis problem.

Field work was started in mid-July when the author, assisted by Mr. Johns spent a week mapping the district topographically. The map was made by plane table methods, augmented by pace, compass, and aneroid traverses, and later checked with a map made by photogrammetric methods from aerial photos furnished by the U. S. Forest Service. In the latter part of August, the author visited the district for a period of three weeks, when the area was mapped geologically, specimens were collected, and various aspects of the problem were studied.

The writer wishes to thank Dr. Staples, under whose careful guidance this thesis was completed, and Dr. Baldwin who suggested the problem, and has freely given needed counsel. The advice and help of Dr. Anna Hakala, petrographer and Assistant Professor of Geology at the University
of Oregon, has been of great aid in solving petrographic problems. Mr. Johns, who aided in the preliminary field work, has also been of great assistance in the laboratory.

Mr. Frank Hoswell, and Mr. and Mrs. Russell Goger, owners of several mining claims in the district, have kindly allowed the author access to their property, and have rendered assistance in many ways.
Regional Geology and Previous Work

The general geologic picture of south central and southeast Oregon is of Tertiary flows and tuffs, dominantly basaltic and andesitic, broken by north trending faults. Along the faults considerable movement has taken place, resulting in horst and graben structure in some places, and tilted fault blocks in others. Faulting probably commenced in early Tertiary times when orogenic movements were taking place to the south, and when the coastal region to the west was uplifted slightly. Nolan (1943, P. 183) states:

"The best conclusion that may be reached from present information therefore is that block faulting as a process probably began in early Oligocene time and has been more or less continuous ever since. Topographically expressed faults, however, probably date back only to late Pliocene or early Pleistocene time, though there may have been still earlier movement along such faults."

Fuller and Waters (1929, P. 210) recognize seven north trending tectonic depressions in southern Oregon. One of them is the Summer Lake - Chewaucan Marsh - Goose Lake Valley depression, which they recognize as a graben. They believe that this type of structure is far more typical of southern Oregon than is the true tilted fault block.

Russell (1885, P. 448) had previously recognized faults
bounding the east and west sides of the Chewaucan Basin, but did not term the marsh a graben.

Saring (1908) recognized three general groups of rocks which he termed; older acidic effusives, older basaltic effusives, and recent eruptive material. Noting the extent of basalt flows he concluded that they are roughly contemporaneous with the Columbia River basalt, and tentatively dated them as Miocene, although later workers have shown them to be Pliocene. Saring visualized a great basalt plateau, after the cessation of the basalt flows, with remnants of the former land surface projecting through. The projections are the older basaltic and acidic effusives, and are located at the Coyote Hills, Rabbit Hills, and creek near Lakeview, at the head of the Chewaucan River, and between Silver and Summer Lakes.

Saring (1906, p. 23) mentions the area covered by this paper saying:

"A thick tuff bed also exists in the mountains south of Paisley and is well exposed in the Chewaucan River Canyon a short distance above the town. This tuff, which is colored various shades of red and blue, and has been mineralized to some extent by quartz and calcite, towards its southern end considerable prospecting for gold has been done, and good values are reported to have been found in some places. The remains of an old erastre, half a mile below these workings show that for a number of years the locality has been prospected for the precious metal."
Along the base of most of the fault scarps, alluvial fans have formed and the valley floors are covered to unknown depths with lake sediments and alluvium from the mountains. Shrock and Hunzicker (1935) studied the lake sediments and reached the conclusion that the lakes were much larger in the Pleistocene, and that the basins are filled with as much as eight hundred feet of sediments. Carl Williams, a well driller, who formerly lived in Lakeview is reported to have drilled as deeply as two thousand feet before encountering bed rock.

Among other geologists who have worked in south central Oregon, may be included Allison (1945) who has described pumice beds in the Summer Lake Basin, which he believes originated from the Pleistocene eruption of Mt. Mazama, and Ross (1941), who has described the quicksilver deposits at the Currier Mine on the western edge of Summer Lake. He states that the deposit is in an andesite flow and is overlain by a basalt flow, both of which are nearly horizontal.
QUATERNARY

PLEISTOCENE P

PLIOCENE P

PRE PLIOCENE

ALLUVIUM

GLASSY BASALT

INTRUSIVE BASALT

BASIC ANDESITE

DACITE

CONTOUR INTERVAL 50'
<table>
<thead>
<tr>
<th>Age</th>
<th>Formation</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent</td>
<td>Alluvium</td>
<td>0-25</td>
</tr>
<tr>
<td>Pleistocene</td>
<td>Glassy basalt</td>
<td>0-100</td>
</tr>
<tr>
<td>Pliocene or</td>
<td>Intrusive basalt</td>
<td></td>
</tr>
<tr>
<td>earlier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Pliocene</td>
<td>Basic Andesite</td>
<td>2000 (?)</td>
</tr>
<tr>
<td></td>
<td>Dacite</td>
<td>2500 (?)</td>
</tr>
<tr>
<td></td>
<td>Soda Rhyolite</td>
<td>500 ($)</td>
</tr>
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CHART OF GEOLOGIC FORMATIONS
GENERAL GEOLOGY

Stratigraphy

The rocks found in the four sections surrounding Gaylord tunnel can be separated into three distinct lithologic units; dacite, basic andesite, and glassy basalt. In addition, there are small patches of alluvium and intrusive basalt. East of the area that was mapped are outcrops of an older flow of soda dacite that will be included in this study.

For convenience in treatment of the rocks of this area, the flows of soda dacite, dacite and basic andesite will be grouped together under the name "The Silicic Flows", and a discussion of their age and correlation will be deferred until the occurrence, distribution and lithology of each of the three flows has been discussed. The flows cropping out in the Brattain Area are found in the following sequence:

Alluvium
Glassy basalt
Intrusive basalt
Basic andesite

{ Dacite

Soda dacite

} The Silicic Flows
Soda dacite — Underlying the dacite flows, and cropping out on the eastern side of the Paisley Mountains is found a flow of soda dacite the lower part of which is buried beneath the alluvium found at the foot of the mountains. The exposed portion of the flow is estimated to be five hundred feet thick. The outcrop noted is found in Brattain Canyon about a mile west of the highway and while other outcrops are not definitely known they would undoubtedly be revealed by further field work.

The flow is uniformly light gray in color and hand specimens are fine grained and slightly porphyritic. Jointing is well developed, which together with a natural tendency to platyness or flow structure causes numerous small fragments to fall at the base of the outcrops forming long talus slopes.

Under the microscope the specimens have a hypocrystalline groundmass, and a few phenocrysts of plagioclase. The groundmass is composed of feldspar, quartz, glass, remnants of a ferromagnesian mineral and magnetite. As far as can be revealed by the microscope the feldspar is entirely oligoclase, but it would be necessary to have a chemical analysis before saying definitely that no potash feldspar existed in the rock. The presence or absence of potash feldspar is important in the classification of this flow, for if orthoclase or sanidine were present in amounts
exceeding five percent, the rock would be classed as a soda rhyolite, but if the analysis showed no potash feldspar, or amounts less than five percent, a classification as soda dacite would be correct.

The mineralogic composition of this rock is:

- Oligoclase \((\text{Ab}_{18}\text{An}_{12})\) 40%
- Quartz 20%
- Glass 30%
- Ferromagnesian Mineral 8%
- Magnetite 2%

The effects of alteration are minor, five to ten percent of chlorite being the only alteration mineral. Calcite, which is present in most specimens from the overlying flows, is lacking entirely.

**Dacite** - Outcrops of dacite are found along the eastern face of the mountains, and roughly cover the eastern one quarter of the area mapped. One third of a mile southwest of Gaylord tunnel is a patch of dacite that possibly owes its position to faulting, and will be treated in more detail later. The greatest series of outcrops are found in the northeastern and east-central portions of the mapped area. The former is a ridge more than a thousand yards long, where dacite and several minor basalt intrusions are the sole rock types. The latter is exposed on both sides of Brattain Canyon. A reconnaissance along the Chewaucan River disclosed no outcrops of dacite, and it is believed that the flow dips
Figure 7

Photomicrograph showing basic andesite. Crossed nicols. X 55.

Figure 8

Photomicrograph showing dacite. Crossed nicols. X 106.
under the river. Another reconnaissance across the southern part of the fault block near Clover Flat, four miles south of the Brattain Area, led to the discovery of a thinner dacite flow which is continuous, or at least contemporaneous with the outcrops in the Brattain Area. Observations of the eastern side of the Paisley Mountains from the highway, for a distance of nearly ten miles, discloses outcrops along that side that appear to be dacite.

On the basis of measurements taken in Brattain Canyon, the dacite flows are estimated to be twenty-five hundred feet thick. Other measurements tend to substantiate this figure, but it is probably not too accurate as faulting has perhaps given the impression of greater thickness than originally existed. As will be explained in more detail later, most topographic forms that resulted from faulting within the area covered by the map have since been obliterated by erosion, and a definite idea of the amount of displacement is difficult to obtain.

Dacite is the most distinctive in appearance of the flows, being colored various shades of red and yellow. As in the case of the soda dacite, outcrops of dacite have well developed jointing, and long talus slopes are formed beneath them. It is often possible to predict the occurrence of dacite before actually sampling the outcrop because of the
color and the talus slopes. Outcrops of the upper part of
the flow are commonly agglomeratic, containing fragments
up to five feet in length. More specifically they are classi-

cified as flow breccia, with the fragments originating from
collapse of the surface crust of solidified lava, together
with fragmental ejecta thrown out from the parent volcano.

The dacites are porphyritic, with phenocrysts of
plagioclase, and a few of quartz. Poorly defined flow lines
are present in the groundmass which is partially hyaline,
partially cryptocrystalline.

Essential primary minerals are plagioclase, quartz, and
a ferromagnesian mineral. Accessory magnetite is always
present in varying amounts. An average specimen contains:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andesine (Ab85An25)</td>
<td>58%</td>
</tr>
<tr>
<td>Quartz</td>
<td>20%</td>
</tr>
<tr>
<td>Ferromagnesian Mineral</td>
<td>10%</td>
</tr>
<tr>
<td>Magnetite</td>
<td>13%</td>
</tr>
</tbody>
</table>

Hydrothermal solutions have altered these rocks, but
not as strongly as the overlying basic andesite. Most
specimens contain chlorite, and in some it is found in
polygonal outlines, showing that chlorite has replaced a
primary mineral. In some cases the primary mineral was
biotite, but more often a pyroxene as shown by the octagonal
outline (section cut parallel to the c01 face) or hexagonal
outline (section cut parallel to the O10 face). A few grains of epidote are found with the chlorite. The felds-
pars are clouded by kaolinite, and a little sericite. Limonite is scattered rather plentifully throughout most sections and hematite derived from the oxidation of magnetite is common. Calcite is found in all specimens, but is not as abundant as in basic andesite.

**Basic Andesite** - The basic andesite series is composed of several flows and interbedded layers of tuff. The flows are similar to each other in appearance and composition and no attempt was made to distinguish between them, as for the purpose of mapping they could be treated as one unit.

The central portion of the mapped area, from the northern to the southern border is basic andesite with basalt intrusions. The flows crop out along the north trending crest of the Paisley mountains beyond the borders of the mapped area for an undetermined distance. On the western side of the area are found several outcrops of basic andesite surrounded by glassy basalt. These occurrences are in the nature of fensters, being located near the head of small streams where erosion has been active and has stripped away the overlying basalt.

During the reconnaissance along the Chewaucan River,
it was found that most of the outcrops there could be placed in the basic andesite category, and examination of the outcrops near the crest of the southern part of the Paisley Mountains near Clover But showed them also to be basic andesite.

A superficial examination of the Clover But mine, near the base of Winter But, disclosed rock quite similar to the basic andesite of the Trattain area. Ross (1941 p. 29) examined the mine and states:

"The workings are in a flow of andesite that is nearly black when fresh, and is overlain by a basaltic flow; both are essentially horizontal."

It is quite possible that this andesite is a continuation of the basic andesite series.

The basic andesite flows are estimated to be two thousand feet in thickness, but faulting has perhaps given the impression of greater thickness than actually exists.

Outcrops of basic andesite are dark in color, varying from dark red to black. Many specimens have a greenish tinge due to chlorite in them. This series is considerably less resistant to weathering and erosion than dacite or basalt, and as a result there is a tendency for the depressions and low areas to be andesite, while the peaks and ridges are the less easily weathered dacite and basalt. An exception to this rule is found in the area south of the head of Trattain
Canyon, but faulting is thought to have elevated this block.

The texture of all specimens from the basic andesite series is porphyritic, with a trachytic groundmass. The phenocrysts are usually plagioclase, but a few corroded remnants have the crystal outline of pyroxene.

When fresh the rocks in this series were mineralogically simple, containing only plagioclase, small amounts, of biotite, a pyroxene, and accessory magnetite, apatite and titanite. The original composition of the average rock from this series is:

<p>| | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Plagioclase</td>
<td>70%</td>
</tr>
<tr>
<td>Ferromagnesian minerals</td>
<td>12%</td>
</tr>
<tr>
<td>Magnetite</td>
<td>17%</td>
</tr>
<tr>
<td>Other accessories</td>
<td>1%</td>
</tr>
</tbody>
</table>

In all sections that were studied, plagioclase was determined to be very close to the andesine–labradorite border, ranging from \( \text{Ab}_{44}\text{An}_{56} \) to \( \text{Ab}_{34}\text{An}_{66} \). This percentage of the anorthite molecule, together with the restricted amount of ferromagnesian minerals will account for the classification, for even the specimens containing the most basic plagioclase (\( \text{Ab}_{44}\text{An}_{56} \)) could not be considered true basalt because of the lack of dark minerals. Concerning the classification of basalt and andesite, Grant (1932, p. 92) remarks:
"Different petrographers use different features to distinguish andesites from basalts. Rosenbusch, Kemp, Pirsac, and Daly describe basalt as having olivine, andesite lacking it. Washington says it is best to restrict basalts to rocks with more than 50% mafic minerals, andesites to those with less than 50% mafic."

It is interesting to note the abundance of plagioclase in these rocks, not only in the basic andesite series, but also in the dacite. An amount as low as sixty percent is rare, and seventy to seventy-five percent is common. This is strongly suggestive of anorthosite, the intrusive rock which has seventy percent or more plagioclase feldspar. If an anorthosite magma had been proved to exist, it is possible that some of the rocks from this area could be classified as extrusive andesinites or labradoritites. However, most petrologists think that anorthosite is derived by gravity settling in a magma of a different composition. Shand (1947, p. 282) remarks:

"N. L. Bowen contends that no such thing as an anorthosite magma ever did or could exist, basing his argument on the high melting point of the lime-rich plagioclases, and that all anorthosite rocks must have been formed by the separation of plagioclase crystals from gabbroic magma. Bowen conceives that in such a magma the heavy phases such as pyroxene will first sink to the bottom of the magma-chamber, forming a basal sheet of pyroxenite, and that when the residual magma is sufficiently lightened by this process the plagioclase crystals will also sink and give rise to a body of anorthosite, leaving the uppermost portion of the magma with syenitic or granitic composition."
Figure 9

Photomicrograph showing altered basic andesite. Crossed nicols x 47.

Figure 10

Photomicrograph of andesite, showing relic olivine at the center. x 49.
other geologists are convinced of the existence of anorthosite magma. In summarizing the argument Chand states:

"Spear certainly seems to have the better of this argument, and until somebody discovers a lava with the composition of anorthosite it will be difficult to believe in the existence of a completely liquid plagioclase magma."

It seems possible that a more detailed petrographic study of the rocks of the Brattle area will help solve this problem.

Since the time that the basic andesite flows were deposited, they have been subjected to the action of hydrothermal solutions that preceded and accompanied the deposition of ores, and consequently the original minerals have been altered considerably. Basic andesite has been affected more strongly than dacite, because of the higher content of ferromagnesian minerals in the andesite. The small amount of pyroxene and biotite has been altered to chlorite and minor amounts of epidote, kaolinite and some sericite cover the plagioclase. Some primary magnetite is present, but most of it has been oxidized to hematite and limonite. Calcite is found in all specimens in considerable amounts. It is usually scattered through the specimen as metasomatic replacement of the primary minerals, but is sometimes found filling amygdules.
Age and correlation of the andesitic flows - Soda dacite, the oldest member of this series is overlain by one or more dacite flows. It is not known if the contact is conformable or not. The dacite flows in turn are overlain, apparently conformably, by a series of andesitic flows and tufts. An absence of paleontologic evidence complicates the problem of age relationship, but it can be said with assurance that the flows were extruded in Tertiary times, and prior to the uplift that gives the mountain their present relief.

The conclusion that the flows are post-Mesozoic is based partly upon the scarcity of exposed pre-Cenozoic rocks in south central and south eastern Oregon, for rocks of Paleozoic or Mesozoic age have been covered by the extensive flows of Tertiary times, and partly upon the morp- hologic and microscopic appearance of the flows. Neither the outcrops nor thin sections exhibit to any degree the metamorphism or other signs of diastrophism that would be expected of pre-Cenozoic rocks of the Basin and Range Province which have been subjected to intermittent tectonic movement since pre-Cambrian times.

The fact that the flows were extruded before uplift of the mountains seems obvious, and if we are to accept Solon's statement (1943, p. 163) the uplift took place in late
Pliocene times or earlier, and consequently the time of extrusion of the flows was pre-Pliocene.

Additional proof that the silicic flows are pre-Pliocene is that the basalt flows which are widespread throughout this part of Oregon are not found in the Paisley Mountains, and therefore Waring's theory (1908) that the basalt flowed around certain elevated areas is thought to be applicable to the Paisley Mountains. One understandable error that Waring made was in tentatively dating the basalt flows as Miocene, and correlating them with the Columbia River basalt. As pointed out by Russell (1928, P. 417) in a discussion of the relation of the Warner basalt to the Columbia River series, basalts that are lithologically similar to the Columbia River series were common throughout Tertiary time, and in the Pleistocene and Recent epochs. Williams (1946, P. 38) considers the Steens Mountain basalts and the other widespread basalt flows in the region to be middle Pliocene.

It appears, therefore, that the time of deposition of the silicic flows may reasonably be restricted to either the Eocene, Oligocene, or Miocene epochs. Closer dating than this cannot be done with accuracy, but in a region that is dominated by basaltic lavas and tuffs, outstanding is the occurrence of a series of acid flows more than three thousand feet thick, overlain by twenty-five hundred feet of andesite.
A similar occurrence is described by Fuller (1931, p. 87-90) from the Steens mountain area, where the Pike creek volcanic series (more than two thousand feet of flow rhyolite, interbedded acid tuff and biotite dacite) is overlain by the Steens mountain andesite series, which reaches a thickness of seventeen hundred feet. These two series of flows are overlain by the Steens mountain basalt, thought by Williams to be middle Eocene, and underlain by the Almond creek beds, which are tentatively correlated with the Eocene Neskow formation on the basis of a small flora that was found in them.

Although the distance between the Steens mountains, and the Malheur mountains is too great to allow direct correlation, the two occurrences are remarkably similar, and it is quite possible that future work may show a connection between them, or at least that they were extruded during the same epoch of volcanism.

Most of the mineralized areas of Oregon are in rocks of the late Eocene series, or equivalent formations. This is not an infallible rule, but it does suggest that the rocks of the Malheur mountains may have been deposited during the same epoch of volcanism. Williams (1949, p. 59) mentions that rocks of the Almond formation were deposited in Lake and Harney counties, but does not state the localities. For the purpose
of comparison, the work that Wilkinson (1932) had done on the
Clarno formation was consulted, and considerable similarity
was found between that formation and the silicic flows of
the Paisley Mountains.

If the rocks of the Paisley Mountains are Clarno, or
an equivalent formation, there is reason to suspect that
the Pike Creek Series and the Steens Mountain Andesitic Series
may have been misdated. However, before making a definite
statement to that effect, it would be necessary to attempt
a closer correlation between the rocks of the two areas.

Intrusive basalt - Throughout the area covered by the
map are found sill like bodies and dikes of basalt. In
contrast to the glassy basalt they are quite thoroughly
crystallized, though aphanitic. In many places the intru-
sions form ridges and peaks, because basalt is considerably
more resistant to weathering than basic andesite.

The texture of the intrusive basalts is porphyritic,
with phenocrysts of plagioclase reaching lengths of 5mm.
The texture of the groundmass was originally ophitic, with
the interstices of plagioclase laths being filled with
anhexal pyroxene. The original composition was:

Plagioclase \((\text{Ab}_{38}\text{An}_{62})\)  \(50\%\)
Pyroxene (now altered)  \(25\%\)
Magnetite  \(15\%\)
Olivine  \(10\%\)
Hydrothermal solutions have also affected these rocks, altering the pyroxenes to chlorite and epidote, and depositing calcite throughout the specimens. Plagioclase has not been kaolinized very much, and only a few specks of sericite are present. Olivine has been completely altered to antigorite, with magnetite occurring along the fractures as a secondary mineral. Primary magnetite has altered very little.

There is very little evidence upon which to base an age determination, except that the dikes and sills are younger than the silicic flows, and older than the glassy basalt. As the silicic flows are pre-Pliocene, intrusive basalt will be tentatively dates as Pliocene.

Glassy basalt - earlier in this paper, page 19, it was stated that glassy basalt is one of three distinct units. However, it is believed that this is not one flow originating from a volcano or fissure outside of the area, but is formed by the coalescing of flows from a number of small cones and fissures found along the western and north central part of the area. Outcrops of this type were not noticed along the lower part of the canyon of the Chewaucan River.

Specimens of this unit have the black color, glassy
texture, and vesicular structure of the typical basaltic lava. The flows are of the jagged, broken type that is styled as lava. Examination of thin sections of this rock prove of little value because of the vitreous texture. A few poorly defined phenocrysts of labradorite \((\text{Ab}_{34}\text{An}_{66})\) were found.

The maximum thickness is approximately one hundred feet near the vents, and in a short distance away may be less than five feet thick, giving the impression of an extremely viscous lava that chilled very close to the vent. Several fensters are found on the west side of the map which are partly erosional, but probably also due to the thinness of the basalt at these points.

There is no regular dip present in these flows. Instead they seem to conform to the erosion surface of the mountains, increasing in angle of dip as the slope of the mountains increases to the west. Because of this, it is believed that the basalt was extruded after the mountains were uplifted and, for that matter, after the mountains had been eroded sufficiently to approximate their present form, probably early Pleistocene.

**Detrital material** - Alluvium is not extensive in the mountains, being confined dominantly to the foot of the range along Chewaucan Marsh. However, small patches are found adjacent to creek beds, and in some of the dry gullies.
Figure 11

View looking north from Saylord Tunnel. Small knobs in the distance are glassy basalt.

Figure 12

Brattain Canyon in the center of the mapped area. Saylord tunnel in the center.
most cases alluvium was not mapped as the underlying rock was known.

Talus caused a little more difficulty in mapping, most of the steep slopes being covered with it, particularly underneath outcrops of dacite and basalt. It was necessary in many cases to map the underlying rock type by tracing float found in the talus. This may lead to minor inaccuracies in the location of contacts, but it is believed that their general position is sufficiently exact.
Structure

Chenoweth Marsh is bordered on the east by Coplan
Hill, and on the west by the Rainey Mountains. Both the
east and west borders are due to faulting, and define the
"Marsh" as a graben. The fault on the west edge of the
marsh undoubtedly parallels the face of the mountains,
which trend slightly west of north near Claver Point, ten miles
south of Rainey, and curve further to the west upon approach-
ing the town. Coplan Hill is roughly parallel to the Rainey
Mountains, and both are dipping away from the marsh, the
latter from thirty-five to forty degrees, the former approxim-
ately twenty-five.

There is some disagreement among geologists as to the
type of deforming stress that has caused the east and
west graben structure of south central Oregon, proponents of the
rift theory calling for lateral compression, and those
believing in the rift theory advocating lateral tension.
In the opinion of the writer, the fault blocks on either
side of the Chenoweth Marsh, dipping in opposite directions
at something approximating equal angles is strongly suggest-
ive of keystone faulting, which is attributed to stretching
during folding.
FIGURE 13

ORIENTATION DIAGRAM OF THE FAULT SYSTEM
In the Brattain Mining Area, a number of faults are found that have had their surface expression eroded away. It is these faults that contain the veins, and were it not for the great number of pits and trenches dug by prospectors many of them would not be noticed. The possibility exists that they are small fractures that formed during the uplift of the mountains, and with such a small throw that erosion could erase surface expression easily. This possibility is borne out to some extent by the distribution of rock types, which provides no evidence of major displacement along any of the topographically erased faults. In many cases the veins show evidence of movement by fault breccia and as much as six inches of gouge. However, as noted by McKinstry (1943, p. 352) the amount of fault gouge is not a true indication of the amount of displacement, rather, it is merely an indication that there has been movement.

In figure 13 the strikes of all the known faults within the Brattain Area have been plotted. An attempt has been made to quantitatively represent the magnitude of the fault by the length of the line. The longest lines represent those faults with the greatest amount of gouge, breccia, and the most noticeable sheet structure. The shortest lines represent those faults that have a minimum of these effects. Dotted lines represent faults wherein the strike could not
be measured with less than a twenty degree error in either direction. The solid line on the east shows the approximate strike of the main fault and has been moved to the west from its true position for the purpose of comparison. All other strikes have been taken directly from the map. In all cases the faults are vertical, or have less than a ten degree deviation from the vertical.

The two westerly trending dashed lines on the diagram are located respectively along Jones Canyon and Brattain Canyon, and represent possible faults. The only evidence for this is the difference in rock types (fig. 5); the north wall of Jones Canyon is dacite, the south wall is basic andesite. Brattain Canyon is just the opposite; the north wall is basic andesite, the south wall is dacite. The canyon floors are covered with alluvium so a definite contact could not be located.

By examination of the diagram it can be seen that the faults within the district showing the greatest movement are oriented N 45 W, at an angle of 35 degrees west of the main fault along the east side of the mountains. This pattern does not seem to be one that can be attributed to the period of uplift of the mountains, for whether Cretaceous Marsh graben is attributed to keystone type faulting or simple down drop-
Figure 14

Uplifted block on south side of Brattain Canyon is on the right. Light colored patch in left center is dacite.

Figure 15

View looking south at the uplifted block south of Brattain Canyon.
ping of the earth, vertical stresses are necessary, and the
result should be faults more nearly parallel to the main
one.

In all probability, the faults found within the district
date from some period of crustal unrest prior to the first
uplift of the mountains.
ECONOMIC GEOLOGY

History and Development

The first observation of metallization within the Paisley Mountains was in 1975, when a member of a passing army patrol found a trace of gold in one of the creeks on the eastern side of the mountains. The report brought to the area a number of prospectors, who hunted throughout the mountains in search of gold, for at this time they were uninterested in lead and zinc. One man, Rev. Saylor, evidently was more successful than the others, for according to local historians he mined gold in the Butte area for several years, digging the tunnel that is named after him, as well as three or four shafts reported to be sixty to eighty feet deep originally, but now caved in. From the proceeds of his mining activities he was able to hire the assistance of a crew of men, and to support himself and family.

In the forty years that have elapsed since Rev. Saylor ceased operation, little has been done other than location and assessment work. A number of persons have held mining claims in the area, but after performing the assessment work
for a few years, have allowed them to lapse.

At the present time a group of mining claims surrounding Gaylord tunnel are held by Mr. Frank Boswell, Mr. and Mrs. Russell Cogar, and Mr. L. E. Cooch, who have maintained the annual assessment work, but as yet have not marketed any ore.
Description of Deposits

Hydrothermal solutions have permeated most of the area that was mapped. The pre-uplift fault system has furnished channels for the solutions, all the faults examined being mineralized to a greater or lesser extent. The veins are closely spaced, in many places being less than one hundred feet apart, and in all cases that are definitely known, the veins are nearly parallel, striking from E 45° W to S 30° E. They are all vertical, or inclined not more than ten degrees from the vertical. The majority of the veins do not exceed two feet in width, and many are less. The Gaylord vein has the greatest width of any of the veins that were examined, measuring as much as three and a half feet in places.

The veins can sometimes be traced on the surface by the altered wall rock which is often distinctively colored a light brown and occurs as float in many places. Outcrops of the vein minerals usually show quartz and limonite, with occasional small amounts of calcite or siderite. In one case, the calcite occurred as large euhedral scalenohedrons.

The Gaylord vein is the only one that is well exposed, as the other tunnels, adits, and discovery pits within the area are either caved in, or too dangerous to allow explora-
tion. For this reason, most of the information about the deposits has been taken from the Gaylord tunnel, and closely adjacent discovery pits. The conclusions reached by a study of this vein were not disproved by any evidence found in the surrounding veins, and it is believed that all the veins in the area have a common source and belong to the same metallogenic epoch.

The Gaylord vein, in common with the surrounding veins, is nearly vertical. The walls are marked by layers of fault gouge five or six inches thick, and are quite irregular, ranging from three and a half feet to less than two. Displacement is thought to be small, perhaps not more than two hundred feet. The wall rock is basic andesite, extensively replaced by calcite, chlorite, and some cryptocrystalline quartz.

In addition to the main tunnel and crosscut shown in figure 17, five shafts or discovery pits have been excavated along the top of the vein, none of them more than eight feet deep at the present although they originally were deeper.
VERTICAL SECTION ALONG LINE A-A' (FIG. 17)

GAYLORD TUNNEL
Classification of Deposits

The deposits are classified according to the Bateman system (1942, p. 364) as simple fissure veins, due to cavity filling. Bateman (p. 116) remarks:

"The filling of openings by precipitation may at the same time be accompanied by some replacement of the walls of the opening. If precipitation is subordinate and replacement predominant, the resulting deposit is a replacement deposit, but if replacement is subordinate to the filling of open spaces the deposit is a cavity filling."

Metasomatic replacement of the wall rock minerals by calcite and chlorite is extensive, and undoubtedly replacement has been responsible for the deposition of some of the ore minerals. However, the lack of definite evidence of replacement within the veins, such as the preservation of structures and phenocrysts of igneous rock, leads to the conclusion that this process is minor and that cavity filling predominated.

In classifying the deposits according to the Hindgren system, siderite was used as the index mineral, for this is the only mineral of the deposits that is thought to be restricted to one class of deposit. Each of the other minerals has been variously described in other localities,
but siderite is common only in the anatexial class,
although it is sometimes found in the lebathothermal class.
Therefore, the deposits are thought to be lebathothermal, a
class to which Malinverno ascribes a high pressure condition
of formation, and temperatures between two hundred and three
centred degrees centigrade.
<table>
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<th>Mineral</th>
<th>Hypothermal</th>
<th>Mesothermal</th>
<th>Leptothermal</th>
<th>Epithermal</th>
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<td>Pyrite</td>
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<td>X</td>
<td>X</td>
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</tr>
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<td>Galena</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<td>Sphalerite</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
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<td>X</td>
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<td>X</td>
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<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
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<td>Tourmaline</td>
<td>X</td>
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<td></td>
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</tbody>
</table>

Minerals of the deposits as they occur in other localities.¹

¹Modified after McKinstry (1948 p. 380)
Mineralogy of the Deposits

The dominant ore minerals are galena and sphalerite. The former occurs as small cubic crystals, and is usually argentiferous. Sphalerite is massive, and almost always is in slightly greater amounts than galena. Assays show that copper is found in a few specimens, but polished sections show no primary copper, and it is revealed microscopically in only the richest samples, where it occurs as malachite. A small amount of smithsonite is found as colloform crusts. Some pyrite occurs in the unoxidized portions of the vein. Gold is often reported from assays, but has not been noticed in polished sections.

Gangue minerals are calcite and quartz in approximately equal amounts, and a little siderite. Tourmaline has been found as float along Brattain Canyon at the foot of the mountains, but has never been found in place.

Paragenesis - A definite sequence of deposition is revealed by a study of polished sections of the ore. Quartz and calcite were the first to be deposited, and were precipitated from solution at nearly the same time. These minerals were followed closely by minor amounts of siderite. The first of the ore minerals to be deposited was galena.
which was later invaded by sphalerite. Sphalerite is found to penetrate the cleavage cracks in galena in a few places, and sometimes has formed around galena, which then takes the form of outliers. Pyrite, and a little quartz were the last minerals to be deposited. They are both found enclosed by galena and sphalerite, and no evidence was found that would give a clue as to which came first.

The order of deposition is as follows:

Quartz and Calcite
Siderite
Galena
Sphalerite
Pyrite and Quartz

Oxidation and enrichment - The deposits are located within the zone of oxidation, but oxidation generally has not been very active because of the arid climate, and the scarcity of ground water. Some limonite is present near the surface, but easily leached minerals such as pyrite and calcite are also found there, showing the oxidation is not complete.

Because of the incomplete oxidation, and general absence of leaching, supergene enrichment is thought to be practically nonexistent at depth. Iron sulfide is not present in amounts large enough to form sufficient sulphuric acid as a solvent,
even if ground water were abundant.

One of the few oxidized occurrences is in Gaylord vein where surface water has selected the vein as a channel, and has caused the oxidation and leaching of half of the width of the vein, leaving the other half relatively fresh and unoxidized. This selective oxidation as it might be termed, has an important bearing on the metallurgy of the ores, which will be discussed in more detail later. Assays show that the two types of ore differ considerably in value (cf. assay no. 12, unoxidized and assay no. 13 oxidized) the difference being in part that very little gangue is found in the oxidized ore.

Assays - The assays listed in this section were made by the State of Oregon Department of Geology and Mineral Industries. Samples from assays number one to nine (fig. 21) were collected by the Oregon Department of Geology and Mineral Industries, and the rest were collected by the writer.

Grab sampling was the only type undertaken throughout the area adjacent to Gaylord tunnel, and was performed with the idea of obtaining the most heavily mineralized specimens possible. The reason is that if high values resulted from such a procedure, the localities might be revisited and sampled with greater care, but if only mediocre values or
<table>
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<tr>
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<th>Lead</th>
<th>Zinc</th>
<th>Copper</th>
<th>Type of Sample</th>
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<td>12.49%</td>
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<td>Channel</td>
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<tr>
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<td>14.29%</td>
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<tr>
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<td>Trace</td>
<td>Trace</td>
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</tr>
<tr>
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<td>0.14 oz.</td>
<td>0.30 oz.</td>
<td>0.96%</td>
<td>1.24%</td>
<td>Trace</td>
<td>Grab</td>
</tr>
<tr>
<td>22</td>
<td>0.06 oz.</td>
<td>Nil</td>
<td>0.34%</td>
<td>Trace</td>
<td>Nil</td>
<td>Grab</td>
</tr>
<tr>
<td>23</td>
<td>0.05 oz.</td>
<td>0.50 oz.</td>
<td>0.42%</td>
<td>0.45%</td>
<td>1.08%</td>
<td>Grab</td>
</tr>
<tr>
<td>24</td>
<td>Nil</td>
<td>Nil</td>
<td>0.54%</td>
<td>1.56%</td>
<td>Trace</td>
<td>Grab</td>
</tr>
<tr>
<td>25</td>
<td>Nil</td>
<td>Nil</td>
<td>Trace</td>
<td>Trace</td>
<td>Trace</td>
<td>Grab</td>
</tr>
<tr>
<td>26</td>
<td>0.06 oz.</td>
<td>Trace</td>
<td>Trace</td>
<td>Trace</td>
<td>Trace</td>
<td>Grab</td>
</tr>
</tbody>
</table>

Figure 21 Continued
traces were found, much time has been saved. This method proved worth while, for most of the samples taken from the veins on the eastern side of the area were shown by assay to contain not more than one percent of lead or zinc, and in many cases only a trace was reported. Gold values were much the same as in the Gaylord vein, ranging from $1.50 to $4.50 a ton. Most of these samples were taken near the surface and may have been leached away to some small extent, but Gaylord vein which is the same type, and has been exposed to the same conditions of weathering, has some high grade ore quite near the surface.

Because of the obviously greater values exposed in Gaylord tunnel, sampling was done with greater care. One grab sample (no. 4) was taken from the shaft on top of the vein, and the rest were channel samples from the cross cut. Three samples (nos. 10, 11, 12, 13) were taken along the vein by the writer, for which is recorded the width of cut and distance between samples. The other two were taken by the Oregon Department of Geology and Mineral Industries, and while the distance between them is known the width of cut had to be estimated.

\(^2\text{Assays no. 12 and 13 are from the same channel, but were separated into oxidized and unoxidized samples.}\)
In order to determine the average grade of the exposed ore, the following calculations were made using the five channel samples that were taken from anylrod vein, and according to the formula:

\[
\text{Average} = \frac{\text{Interval} \times \text{Width} \times \text{Assay}}{\text{Interval} \times \text{Width}}
\]

<table>
<thead>
<tr>
<th>Assay No.</th>
<th>Interval</th>
<th>Width</th>
<th>I x W</th>
<th>Assay</th>
<th>Lead</th>
<th>I x W x A</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 &amp; 13</td>
<td>24'</td>
<td>2.0'</td>
<td>48.0</td>
<td>0.33%</td>
<td>258.0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>20'</td>
<td>2.0'</td>
<td>40.0</td>
<td>12.49%</td>
<td>500.0</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10'</td>
<td>2.0'</td>
<td>20.0</td>
<td>2.55%</td>
<td>51.0</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>15'</td>
<td>3.5'</td>
<td>52.0</td>
<td>0.75%</td>
<td>37.5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>32'</td>
<td>2.0'</td>
<td>64.0</td>
<td>0.55%</td>
<td>35.2</td>
<td></td>
</tr>
</tbody>
</table>

Total 11.5' 224.5 891.7

Similar computations were performed for zinc, gold, and silver, the results were substituted in the formula, and the average assay was determined to be:

<table>
<thead>
<tr>
<th>Lead</th>
<th>Zinc</th>
<th>Gold</th>
<th>Silver</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.93%</td>
<td>0.25%</td>
<td>0.10 oz.</td>
<td>1.68 oz.</td>
</tr>
</tbody>
</table>

This assay is representative of the ore that has been mined, and of closely adjacent parts of the vein. In addition it is an indication of the tonor of the reserves,
probably representing a minimum figure for the indicated reserves. (fig. 12)

It was estimated in February 1949, that ore of the average assay contains $16.00 a ton of recoverable metals. From this amount the smelter would deduct smelting charges and rail transportation.

It will be noticed in figure 17 that the tenor of the ore decreases upon following the vein to the northwest from the face of the southeast drift, the values shown in sample number 2 being nearly as low as those from veins to the east, while on the surface, fifty feet above the northwest drift, assay number 4 shows very good values. It is possible that the shaft containing sample number 4 and the south east drift have intercepted an ore shoot pitching to the south east, and that higher grade ore would be found upon extending the face of the south east drift, or upon stoping upward from any point in the south east drift.

**Lateral and vertical extent of the ore** - It has been observed that a definite relationship often exists between the depth of a fissure vein, and its length. An old mining rule is that the depth is equal to the length, but this is an empirical statement, and doesn't always hold true. According to Bateman (1946, p. 131) the depth is more often equal to some fraction of the length, usually one half.
In determining the length of Gaylord vein, an investigation was made of the five discovery pits scattered along the outcrop of the vein for a distance of three hundred yards. Sample number 4 was taken from the roof of the tunnel, and shows very good values. The pits contained only gangue minerals. This decrease in grade away from the location of the tunnel indicates that the lateral extent of metallization probably does not exceed two hundred yards. Examination of the northwest drift in Gaylord tunnel lends to the conclusion that the northwest limit of the ore shoot may be near at hand.

If the length of the vein is two hundred yards, then the depth can be assumed to be half of that, which is three hundred feet, or two hundred and forty feet below the bottom of the drift.

Zoning - Development of the deposits of the Seward mining area has not been carried deep enough to find evidence of a zonal arrangement of the minerals, but the possibilities of such an arrangement should not be disregarded. According to the ideal sequence of metals in a zoned deposit as presented by Muns (1930) lead and zinc minerals may be expected to give way at depth to copper, which in turn may give way to the hypothermal minerals of bismuth, tungsten and tin.
However, the ideal sequence of metals is never found complete in one district, but examples of lead-zinc ores changing at depth to copper ore are numerous. Among the better known examples of this are Butte, Montana and Bingham, Utah.

Other possibilities of zoning to be considered, are that silver may become the dominant mineral at depth, or that the ore will become richer in galena and sphalerite upon approaching more closely to the source. Finally, there is the chance that galena and sphalerite will give way at depth to worthless pyrite.

Of all the possibilities, the strongest one in the opinion of the writer is that with an increase in depth, the amount of copper in the ore will increase, and if the vein persists to a great enough depth, may become the dominant ore mineral. This change may be foreshadowed by the traces of copper that is shown in many samples of the lead-zinc ore.

The genesis - As the silicic flows of the Bretthain Mining Area are pre-Pliocene in age, and may have been extruded as early as late Pliocene, or early Pleistocene times it is probable that the mineral deposits were formed during a middle or late Tertiary period of metallization.

A late Tertiary metallogenic epoch is recognized in the western United States by Batchan (1942, p. 321) during which
the quicksilver deposits of Oregon were formed, but according to Bateman, the deposits rarely contained lead, zinc, or copper.

It is more probably that the deposits of the Brattain Area are connected with the lead-zinc deposits of the Cascade Range, although the two areas are more than eighty miles apart. Callaghan and Buddington (1938) think the Cascade Range deposits are related to a diorite intrusive body of upper Miocene age. Baldwin (1947), in reviewing the age of the Cascade intrusives, concluded that the diorite is pre-middle Miocene in age, more likely upper Oligocene.

Reserves - The classification of ore reserves that is followed in this thesis is that which is used by the U. S. Geological Survey, and the U. S. Bureau of Mines, and defined by McKinstry (1948, p. 472) as:

"Indicated ore is ore for which tonnage and grade are computed partly from specific measurements, samples, or production data, and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to outline the ore completely or to establish its grade throughout."

Inferred ore is ore for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed geologic evidence; this evidence may include comparisons with deposits of similar type. Bodies that are completely concealed may be
included if there is specific geologic evidence of their presence. Estimates of inferred ore would include a statement of the special limits within which the inferred ore may lie."

Under this classification, the ore that lies between the back of the drift and the surface is termed indicated ore (fig. 22), and a strip fifty feet deep underneath the bottom of the drift is termed inferred ore. An additional strip of inferred ore, twenty-five feet wide is located next to the face of the south east drift. No reserves were calculated for that part of the vein beyond the face of the northwest drift, as the value and extent of that ore is dubious.

The tenor of each class of reserves has been indicated by the average assay, although it is believed to be higher in the case of the indicated ore.

The amount of reserves was calculated by the formula:

$$\text{Tons of ore} = \frac{V \times G \times 62.5}{2000}$$

where \(V\) is the volume of the vein, using 2.3 feet as the average width of the vein, \(G\) equals 3.4, the average specific gravity of the ore, 62.5 is the weight in pounds of a cubic foot of water.

The ore reserves are:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indicated ore</strong></td>
<td><strong>940 short tons</strong></td>
</tr>
<tr>
<td><strong>Inferred ore</strong></td>
<td><strong>1564 short tons</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2504</strong></td>
</tr>
</tbody>
</table>
Economics

Transportation is the largest single cost item that would be encountered in developing the Brattain Area as it would be necessary to haul the ore by truck a distance of fifty-five miles to Lakeview, and then ship it by rail from four hundred to seven hundred miles, depending upon which smelter is selected. The cost of hauling to Lakeview by truck was estimated in the summer of 1949 to range from seven and a half to ten dollars a ton, depending upon the size of the truck used; and rail transportation at that time was approximately two cents a ton mile. Therefore, the total transportation cost would probably not be less than fifteen dollars a ton, and could easily exceed twenty.

The majority of smelters that are able to process lead ores, are not able to recover any of the zinc. Milling that would produce separate lead and zinc concentrates would ordinarily prevent the complete loss of the zinc, but the officials of the International Smelting and Refining Company have stated that there is no known method by which zinc can be separated from lead in complex oxidized ores such as those from the Gaylord vein. It would be possible to separate lead and zinc in the unoxidized ore, but the cost of milling
would probably exceed the payment for zinc.

If it were possible to concentrate the ore in a mill located close to Paisley, a considerable saving in transportation cost to the smelter would be effected. Unfortunately however, the only flotation plants that are able to accept custom milling are located in Idaho or Utah, and so are close to the smelters that nothing would be saved.

Smelters are located at Salt Lake City, Utah; Kellogg, Idaho; and Selby, California. The plant at Selby is one that is owned by the American Smelting and Refining Company, and by reason of its comparative nearness is probably the one to which the ore should be shipped. They will charge a penalty for zinc content that will amount to thirty cents a unit in excess of seven percent.

If development work is undertaken in the Brattain Area, it will be necessary to improve the road from Paisley to the Gaylord tunnel. A week's work with a bulldozer should make the road suitable for dry weather use. Replacement parts for machinery, and the services of a mechanic will be available, possibly in Lakeview, or certainly in Klamath Falls. A small stream with a year around flow runs by the Gaylord tunnel, and would furnish sufficient water for mining and camp use as long as operations are in the development stage, but if full scale operations were undertaken it would
probably be necessary to pipe water from one of the surrounding springs, at least a half a mile away. The sawmill at Paisley would be able to furnish lumber for timbering, and food and other basic supplies could be purchased in the town.

Because of the relatively severe winters that are experienced in the Paisley Mountains, it is believed that year around mining of the deposits would be impractical, unless further development should expose ore of a much greater extent and tenor than is believed to exist.
Conclusions

In the opinion of the writer, if further development work is undertaken, it should be done with the idea of determining the feasibility of installing a small concentrating mill in the area. The extent of ore in Gaylord vein should be determined more closely by a raise in the south east drift, and by extending the face of the drift. By following this course, it would be possible to learn more about the occurrence of the ore, and at the same time to defray a portion of the expenses by the sale of the ore, which in the south east drift is thought to be of higher tenor than is indicated by the average assay.

A later course of action should include exploration of the outcrop of the vein to determine the lateral extent, and if these preliminary developments should indicate worthwhile values, the adjoining area should be explored in greater detail. Prior to exploration of the veins surrounding Gaylord vein, additional claims should be staked out, and the boundaries of the established claims should be examined, for they are neither uniform in width nor direction, and between them are found unclaimed areas that are potential
nuisance claims if they should be taken up by persons other than operators.

Exploration work in the area would probably have to be done by actual mining, for the occurrence of the veins in thin vertical fissures eliminates the value of drill exploration.

The deposits of the Brattain Area will probably not be workable, and hence will not contain ore in the strict sense of the word, until a concentrating mill is available within a short distance of the area. The possibility of the construction of a mill within a hundred miles of Paisley is practically nonexistent as no deposits within that range are known that are large enough to pay for the cost of construction. Therefore, the deposits will probably not be mined unless enough reserves can be shown to warrant construction of a concentrating mill.

Another factor that would tend to induce development of the Brattain Area, would be a return to the high price that was paid for lead and zinc in the winter of 1948-1949, but accompanied by a stable market, for in a marginal deposit a high price accompanied by an unstable market is little better than a low price.
BIBLIOGRAPHY


Typed by Alice H. Stankey