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GEOPHYSICAL SURVEYS IN THE OCHOCO QUICKSILVER DISTRICT OREGON

A PRELIMINARY REPORT

By
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Prepared in cooperation with the
STATE OF OREGON

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ABSTRACT

Three geophysical surveys were made in 1941 in the Ochoco quicksilver district in central Oregon by the Section of Geophysics of the Geological Survey, United States Department of the Interior, in cooperation with the Oregon State Department of Geology and Mineral Industries. The primary purpose of the surveys was to determine the value of magnetic and electrical measurements for assisting immediate mine development. Interpretation of the field data is still in progress, but it has proceeded far enough to justify this preliminary report, which will indicate some localities that may be favorable for further prospecting.

Tertiary formations of volcanic origin predominate in the district. They consist of basaltic, andesitic, and rhyolitic lavas, tuffs, agglomerates, and volcanic ash, and intrusive igneous rocks. All of the quicksilver deposits occur in the Eocene and Lower Oligocene Clarno formation along complex systems of faults. Cinnabar has been deposited in these fault zones, particularly at fault intersections. The cinnabar is erratic in localization, and most of the ore bodies are small.

Most of the mineral properties are located in the central part of the district along two main fault zones, the Johnson Creek zone and the Ochoco Creek zone, but other mines and prospects, including two major mines, the Horse Heaven mine near the north edge of the district and the Maury Mountain mine near the south edge, lie outside these zones. Geophysical surveys were made in the Johnson Creek zone, in the Ochoco Creek zone, and at the Maury Mountain mine.

Because of the physical nature of cinnabar and the small size of the ore bodies, the successful use of geophysical methods in finding cinnabar deposits depends on the detection and delineation of geologic bodies or structures associated with the ore. In the Ochoco district many of the rocks are paramagnetic, and detailed magnetometer surveys, supplemented by resistivity measurements, were made in order to map the ore-bearing fault systems.

The surveyed areas are magnetically variable and show many magnetic anomalies. Some of the anomalies appear to depend on differences in type of rock; but groups of definite magnetic patterns are found that, in the light of available geologic information, appear to be largely determined by the fault systems.

Suggestions for prospecting are based largely on the magnetic results. Structural trends and intersections are inferred from these results, and favorable localities are

indicated along the inferred major faults and intersections, considered in connection with known cinnabar-bearing zones or trends, but there is no certainty that cinnabar actually exists at these localities.

INTRODUCTION

During the fiscal year 1941-42 the Section of Geophysics of the Geological Survey, in cooperation with the Oregon State Department of Geology and Minerals Industries, made a series of geophysical surveys in selected mining districts in Oregon. The geophysical surveys here discussed were made in the Ochoco quicksilver district in central Oregon, where active development work and mining affords geologic information to correlate with the geophysical data. The field work, which occupied the period from July 13 to December 8, 1941, was done by E. L. Stephenson, of the Geological Survey, assisted by G. D. Bath, of the State Department of Geology and Mineral Industries. For a short period in October J. H. Swartz, of the Section of Geophysics, also was in the field.

The primary purpose of the surveys was to determine the value of electrical and magnetic measurements for furthering immediate development of quicksilver, chromite, manganese, and other mineral deposits. As the work is still in progress, interpretation of the results has not been completed. Field measurements, however, have been completed in three mining areas in the Ochoco quicksilver district, and, as quicksilver is an important strategic metal, this preliminary report has been prepared to present in a general way the features of the geophysical information now in hand. Although detailed interpretations are beyond the scope of this report, maps and other illustrations are presented that show the location and nature of the data, and certain suggestions for prospecting are made. Later a final report will be prepared giving detailed interpretations of the geophysical data and the geologic conditions that they indicate.

Magnetometer surveys were made at the Number One and Blue Ridge mines in the Johnson Creek area, at the Taylor Ranch mine in the Ochoco Creek area, and at the Maury Mountain mine. A standard Askania vertical magnetometer with temperature compensation was used. Resistivity measurements were made in the Johnson Creek area and at the Taylor Ranch mine by the Lee partitioning method. A few natural-potential measurements were made in the Johnson Creek area. To supplement the geophysical surveys a topographic map was made of the Taylor Ranch area, and surface and underground geologic mapping and sampling were done at all the properties.

Acknowledgments

Throughout the course of the surveys friendly assistance was given by many people. Particular mention should be made of Mr. Earl K. Nixon, Director, Oregon State Department of Geology and Mineral Industries, who sponsored the work, and of the able staff of that department, who gave valuable aid and information. At the Number One and Blue Ridge mines of Cinnabar Mines, Inc., Col. J. A. Maller, vice president and manager, and A. V. Quine, superintendent, gave cordial cooperation as well as full access to maps, assays, and other pertinent information. Ray Whiting, owner and operator of the Taylor Ranch mine, kindly furnished copies of maps and other mining data, and J. Gilkason assisted in underground work. At the Maury Mountain mine F. D. Eickemeyer and H. W. Eickemeyer furnished maps, field assistance, and living quarters, and Frank Towner kindly gave access to his property and to data used in geologic correlations. Thanks also are due to other residents of the district for help of various kinds. The magnetometer measurements and most of the geologic determinations at the Maury Mountain mine were made by G. D. Bath.

GEOGRAPHY

The Ochoco quicksilver district has been defined by Schuette[1] as the area within a half circle of 35-mile radius

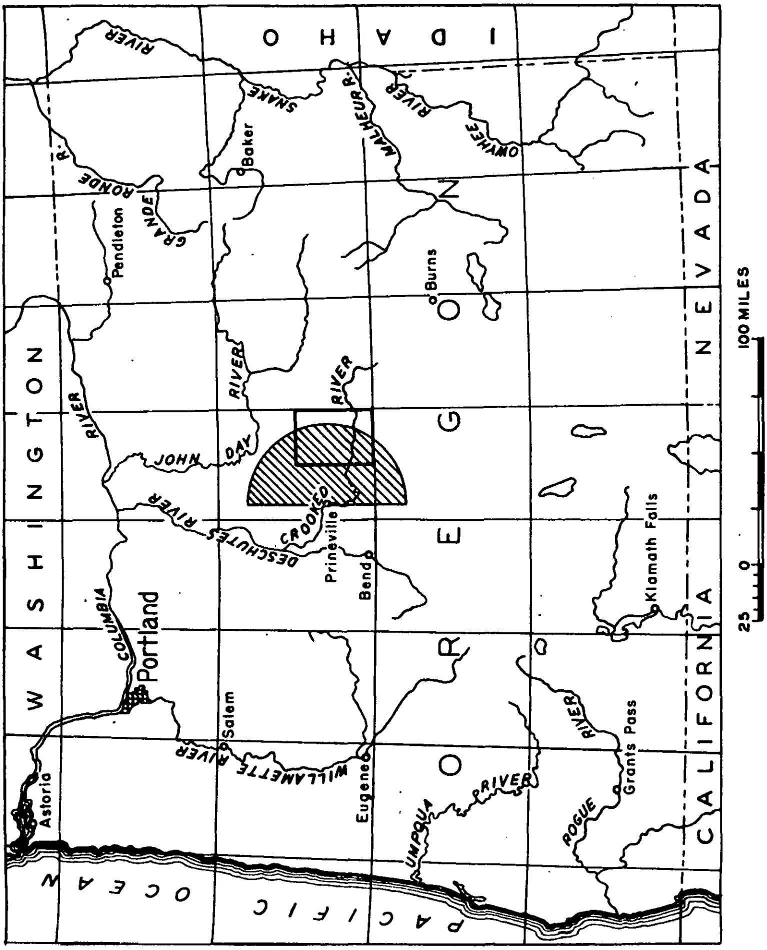

Figure 6.--Index map of Oregon showing the Ochoco quicksilver district and the Round Mountain quadrangle.

centering in and lying east of Prineville (fig. 6). It includes parts of Crook, Wheeler, Jefferson, and Deschutes Counties. All of the geophysical surveys were made in Crook County, within the Round Mountain quadrangle. Most of the following notes on geography and geology are taken from a

1/ Schuette, C. N., Quicksilver in Oregon: Oregon Dept. Geol. and Min. Industries, Bull. 4, p. 88, 1938.

discussion by Wilkinson[2] of the features of the Round Mountain quadrangle, a part of which lies within the district and which contains the three areas covered by the geophysical surveys.

The dominant topographic features of the Ochoco district are the Ochoco Mountains and the Maury Mountains, although only parts of these ranges lie within the district. The Ochoco Mountains, in or near which are located most of the quicksilver mines and prospects, lie north of Crooked River, and the Maury Mountains lie south of Crooked River. Most of the district is rugged, although the areas underlain by late Tertiary lavas present some broad, relatively flat surfaces.

Most of the major mines and prospects in the district are located along two more or less distinct fault zones, the Johnson Creek zone and the Ochoco Creek zone. Both of these are reached from Prineville on U. S. Highway 28. The Johnson Creek zone has a known length of about 4 miles. It is in the west-central part of T. 14 S., R. 20 E., trends about N. 60° E., and from southwest to northeast includes the following properties: Mother Lode, Independent, Devilsfood, Johnson Creek, Number One, Blue Ridge, and Westerling. Lookout Mountain, the most prominent peak of the district, is at the southwest end of the Johnson Creek zone, and to the northeast the trend of the zone leads into the broad flat of Big Summit Prairie. The Ochoco Creek zone, in Tps. 13 and 14 S., R. 19 E., and T. 14 S., R. 18 E., is roughly parallel to Ochoco Creek and has a known length of 6 or 7 miles. It trends about N. 50° E., and from southwest to northeast it includes the following properties: Johnson Brothers, Byram and Oscar, Staley and Barney, Ontko, Champion, Taylor Ranch, and Little Hay Creek. The zone may continue 5 or 6 miles farther

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2/ Wilkinson, W. D., Geologic map of the Round Mountain quadrangle, Oregon (with text): Oregon Dept. Geol. and Min. Industries, 1939.

northeast to include the Bear claims and the Beaver Guard Station prospect.

There are other prospects in the district that are not definitely associated with the two major zones, and the large Horse Heaven mine and the Maury Mountain mine are definitely isolated from these zones. The Maury Mountain mine, in T. 17 S., R. 19 E., is in the northern foothills of the Maury Mountains, about 4 miles southeast of Post. A side road leads to the mine from the Crooked River highway at the bridge half a mile east of Post.

Geophysical surveys were made (1) on the adjoining claims of the Johnson Creek, Number One, and Blue Ridge mines in the Johnson Creek zone; (2) at the Taylor Ranch mine in the Ochoco Creek zone; and (3) at the Maury Mountain mine.

GEOLOGY

The geology of the Ochoco quicksilver district, though relatively simple in its broad outlines, is complicated in detail, both stratigraphically and structurally. Some of the formations that have been identified in the district contain many members or phases that vary considerably in their physical properties. The geologic structure, simple in a regional sense, is locally very complex, especially in the mining areas. Extensive local cover masks much of the bedrock. It is not the purpose of this report to describe the geology, except as it bears directly upon the geophysical investigations, but a brief summary of the geologic background, taken largely from the work of Wilkinson,[3] is given here.

Rocks.--The exposed rock formations in the district range in age from Cretaceous to Recent, but Tertiary formations of volcanic origin predominate. The Tertiary section, the lowest part of which belongs to the Eocene and lower Oligocene Clarno

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3/ Wilkinson, W. D., op. cit.

formation, consists of a complex series of basaltic, andesitic, and rhyolitic lavas, together with tuffs, agglomerates, volcanic ash and various intrusive igneous rocks. The relations between the formations in the east-central part of the district are well shown on the geologic map of the Round Mountain quadrangle.[4] As all of the quicksilver deposits occur in the Clarno formation, and as only rocks of the Clarno formation and the Ochoco lavas of Wilkinson occur within the areas covered by the geophysical surveys, only these two formations are described here.

The Clarno formation in this area consists largely of basalt, andesite, rhyolite, and tuff. The andesites occur near the base of the Clarno section, and in places they are seen to lie unconformably upon Cretaceous conglomerate. Their weathered surfaces are green, drab gray, or nearly black. Their texture is generally fine, but striated plagioclase feldspar, augite, and greenish hypersthene can be observed. The basalts, which are black and flinty in appearance, contain striated plagioclase feldspar crystals in a glassy groundmass, although in places the phenocrysts are lacking. Rhyolite flows occur near the top of the Clarno section. Their color in the outcrops ranges from red to white. They are mostly fine-grained, but they contain a few recognizable crystals of quartz and feldspar. They are associated with tuffs, some of which have been so silicified as to resemble closely the rhyolitic lavas.

Field observations and tests made in the course of the geophysical surveys indicate that the Clarno rocks vary widely in their physical properties. Much of the variation is probably due to the original nature of the rocks as deposited, but weathering, deformation, and probably hydrothermal alteration appear to have exerted a strong influence in places,

4/ Wilkinson, W. D., op. cit.

particularly on the electrical and magnetic properties of these rocks. In general the Clarno rocks are paramagnetic,[5] but they vary widely in magnetic permeability. Their electrical conductivity appears to be more uniform, although strong local differences are found, especially in areas of structural deformation or strong alteration.

The name Ochoco lavas has been given by Wilkinson to a series of relatively late flows of upper Pliocene age or later. They are gray, fine-grained, equigranular basalts having a groundmass composed of plagioclase and glass. Augite is the chief dark mineral and there is some yellowish-green olivine. In places these lavas are vesicular and contain phenocrysts of plagioclase.

Near the eastern end of the Johnson Creek zone, east of the Blue Ridge shaft, Ochoco lava lies unconformably on the Clarno formation. Field tests indicate that the Ochoco lava is here strongly paramagnetic, in marked contrast with the predominately lower magnetic permeability of the Clarno rocks near the shaft. Only a small part of the edge of the lava was surveyed magnetically, and it is not certain that high magnetic permeability is characteristic of the Ochoco lavas in general; but, as these lavas are basaltic and young and have been very little altered by weathering, structural deformation, or other factors it seems probable that they may be generally characterized by relatively high magnetic permeability.

The other rocks exposed in the district, including Cretaceous conglomerate, and the Tertiary John Day formation, Columbia River basalt, Mascall (?) formation, and Rattlesnake (?) formation, do not occur in the areas covered by the geophysical surveys, and no further mention need be made of them in this report.

5/ A paramagnetic material is one having a magnetic permeability greater than unity.

Structure.--The general structural trend of the district is northeasterly. The major structural features are anticlines and synclines having subparallel axes bearing northeastward and faults or fault zones of northeastward strike. Certain major structural features, as the Ochoco fault, trend more nearly east or north, but the northeasterly trends largely predominate. The three geophysical surveys were made in structural zones of the northeasterly trend. For the purposes of this report no long general descriptions are necessary, but local details of structure having a direct bearing on the geophysical measurements are described under the respective areas.

As is natural, the Clarno formation exhibits a more complex structure than the younger Tertiary formations. The Tertiary history of the district is one of volcanism, and stresses accompanying the volcanic activity produced successive periods of folding and faulting. Thus the earlier Tertiary formations have undergone structural deformation at several periods, each probably characterized by new faulting and renewed movement along pre-existing faults. The early fault structure of the ore-bearing zones, which apparently were mineralized in early Tertiary time, has been altered and complicated, as the ore bodies have, by these successive periods of deformation.

The mineralized zones in general occur in definite structural patterns, and most of the observed and inferred faults are more or less parallel to one or the other of several specific fracture trends. In the Johnson Creek zone Wilkinson[6] notes the existence of series of faults trending N. 62° E., N. 10° E., and N. 45° E., and evidence at one place of faults striking northwestward. At the Taylor Ranch mine there are at least three definite fault trends, striking

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6/ Wilkinson, W. D., op. cit.

approximately N. 75° E., N. 31° E., and N. 72° W. There is also indication of a weaker northerly trend. At the Maury Mountain mine the rock is especially shattered by closely spaced fractures, but there are three definite trends striking approximately N. 74° E., N. 13° W., and N. 75° W., and two less definite trends striking approximately N. 40° E. and N. 38° W.

The Ochoco lavas for the most part are undeformed. Their chief structural features are varying initial dips, most of them low, that were determined by the slopes of the surfaces over which they were extruded. At one or two places faults have been observed in these lavas, but in large part they constitute undeformed sheets overlying all other formations except the late valley fill.

Ore deposits.--All of the quicksilver deposits of the Ochoco district, including the deposit at the large Horse Heaven mine, are in the Clarno formation. Some of the mines, such as the Blue Ridge, lie within areas mapped as the younger Ochoco lavas, but their ore occurs in the underlying Clarno formation. Wilkinson[7] states that the mineralization occurs only in the Clarno formation and seems to be associated with basaltic or andesitic intrusions, mainly dikes or plugs. The mineralization probably occurred in early Tertiary time.

The ore was deposited along certain fault zones, particularly at intersections of faults that are within the same zone but different in trend. The cinnabar is very erratic in its localization, and most of the ore bodies are small. The ore apparently tended to form in more or less vertical shoots, which, although they may go to considerable depth, have small lateral extent. In most of the ore zones long relatively barren stretches alternate with short productive stretches, although streaks or very small veins of cinnabar may extend

[7] Wilkinson, W. D., op. cit.

long distances. Mining is accordingly uncertain, but as the ore tends to be localized at fault intersections, mapping of the intricate fault patterns should be of great help in mine development.

GEOPHYSICAL SURVEYS

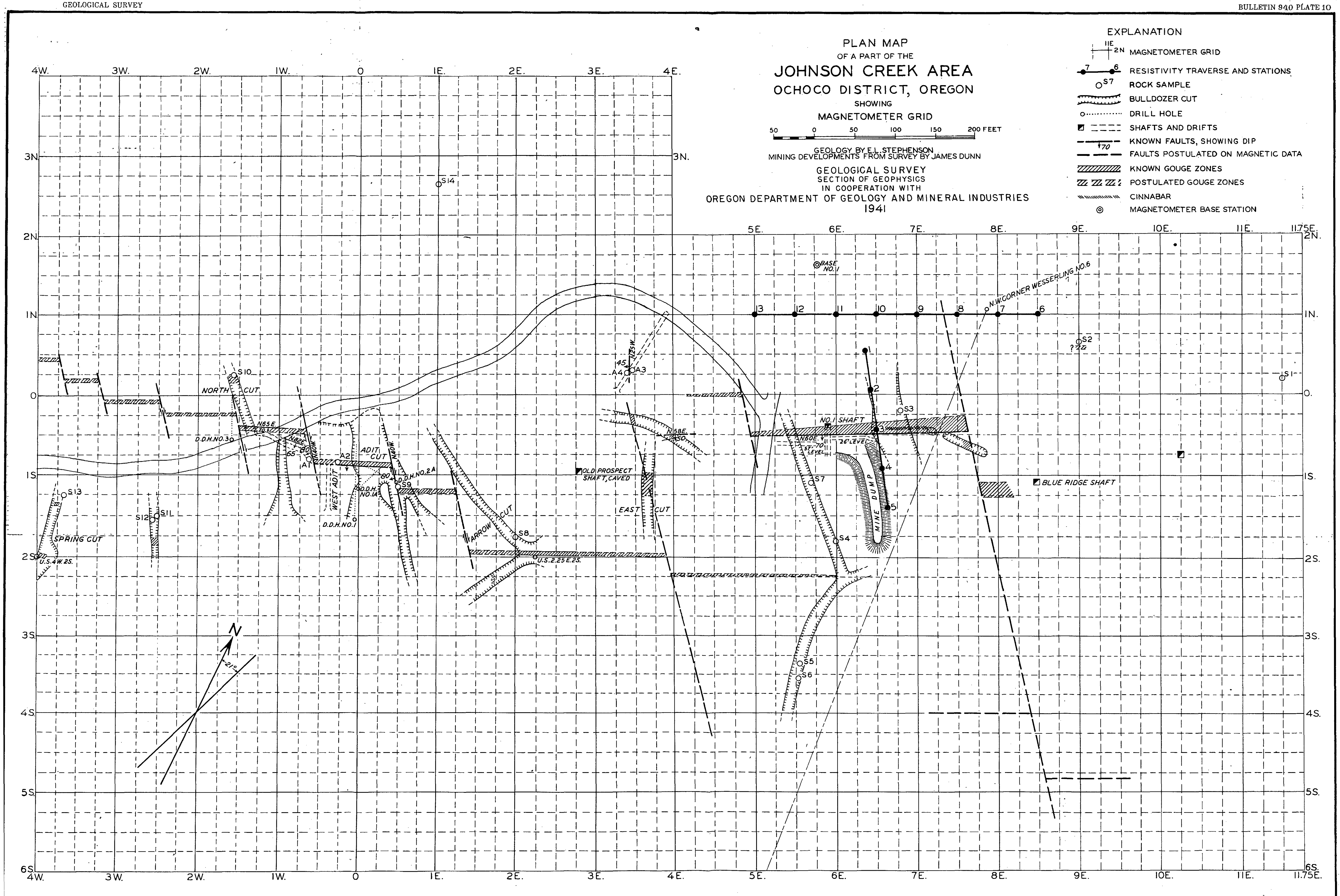
Geophysical surveys for quicksilver must be largely indirect. As the mineral cinnabar, the chief ore of quicksilver, is nonmagnetic and an electrical nonconductor, magnetic and electrical resistivity methods cannot be used for detecting it directly. Chemically, moreover, cinnabar is stable and relatively inert under normal conditions, and does not oxidize or react readily with ground solutions; bodies of cinnabar therefore do not produce measurable self-potentials in the ground, and the natural-potential method cannot be used to detect ore bodies. A distinctive physical characteristic of cinnabar is its high specific gravity of over 8.0, but as most cinnabar ore bodies are small their effect upon the gravity field at the ground surface would ordinarily be too small to measure, and gravity methods would not be effective. For these reasons geophysical surveys for quicksilver, in order to determine areas favorable for prospecting, must depend on the detection and delineation of geologic bodies or structures associated with the ore.

The geophysical work in the Ochoco district consisted of magnetometer surveys, resistivity measurements, and a few natural-potential measurements. The magnetometer surveys constituted the largest part of the work, and the electrical tests were made to supplement certain of the magnetic determinations. The magnetometer was chosen as the chief field instrument, because in areas of paramagnetic rocks magnetic methods probably lend themselves best to determinations of small, complicated details of geologic structures occurring near the surface. Although the cinnabar mineralization occurs within certain rather well established major zones, it is evident that the individual ore bodies occur erratically and that their localization is at least partly controlled by fault intersections. As preliminary tests showed that some of the faults are characterized by definite magnetic anomalies, certain critical areas were surveyed in detail by the magnetometer method.

Results of the Johnson Creek surveys

The geophysical surveys in the Johnson Creek zone were made in sec. 15, T. 14 S., R. 20 E., on the adjoining claims of the Johnson Creek, Number One, and Blue Ridge mines. The Number One and Blue Ridge properties are now being operated by Cinnabar Mines, Inc., of which Col. J. A. Maller is vice president and general manager and A. V. Quine is superintendent. The Johnson Creek mine, which is owned by W. J. Westerling, was being reopened in the fall of 1941 under a leasing arrangement.

The geophysical work comprised a detailed magnetometer survey, reconnaissance magnetometer traverses, vertical resistivity measurements, and a few natural-potential tests. A complete magnetometer grid 1,600 feet long and 800 to 1,000 feet wide, centering near the Number One shaft, was measured on 25-foot intervals, as shown on plate 10. The long axis of the grid bears N. 62° E., approximately parallel to the strike of the Johnson Creek shear zone, which extends along a small valley through the center of the grid. The grid extends 325 feet east of the Blue Ridge shaft and 1,000 feet west of the Number One shaft. West of this main grid, reconnaissance magnetometer traverses were run across the trend of the main zone at 200-foot intervals westward to the east edge of the old workings at the Johnson Creek mine, to tie this area to


PLAN MAP
OF A PART OF THE
JOHNSON CREEK AREA
OCHOCO DISTRICT, OREGON
SHOWING
MAGNETOMETER GRID
50 0 50 100 150 200 FEET
GEOLOGY BY E.L. STEPHENSON
MINING DEVELOPMENTS FROM SURVEY BY JAMES DUNN
GEOLOGICAL SURVEY
SECTION OF GEOPHYSICS
IN COOPERATION WITH
OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1941
EXPLANATION
MAGNETOMETER GRID
RESISTIVITY TRAVERSE AND STATIONS
ROCK SAMPLE
BULLDOZER CUT
DRILL HOLE
SHAFTS AND DRIFTS
KNOWN FAULTS, SHOWING DIP
FAULTS POSTULATED ON MAGNETIC DATA
KNOWN GOUGE ZONES
POSTULATED GOUGE ZONES
CINNABAR
MAGNETOMETER BASE STATION
BASE NO.1
N.W. CORNER WESSERLING NO.6
NORTH CUT
D.D.H.NO.3
ADIT CUT
WEST ADIT
D.D.H.NO.2A
D.D.H.NO.1A
D.D.H.NO.1
ARROW CUT
OLD PROSPECT SHAFT, CAVED
EAST CUT
NO.1 SHAFT
MINE DUMP
BLUE RIDGE SHAFT
SPRING CUT
U.S.4W.2S.
U.S.2.25E.2S.
N65E
N58E
N80E
26' LEVEL
57' LEVEL
N
21°

the main grid. In these surveys 2,610 magnetometer stations were occupied.

A resistivity traverse of five stations was run across the main gouge zone near the Number One shaft, and a second traverse of eight stations was run along the 1N line of the magnetometer grid from the 8.5E to the 5E grid lines. At all the stations vertical resistivity profiles were measured to a depth of 100 feet, at 10-foot depth intervals on the first traverse and at 20-foot depth intervals on the second traverse. As an additional test, a few natural-potential measurements were made on the main gouge zone near the Number One shaft.

Rocks.--Three chief types of rock have been observed in the area covered by the geophysical surveys, but their relations are obscure in detail because of inadequate exposures. Drab-gray, fine- to medium-grained andesite occupies much of the area. In most places where it is exposed it has been considerably softened and altered both by hydrothermal alteration and by weathering. Associated with this rock are other gray rocks that appear to be either altered and partially silicified fragmental rocks or highly altered phases of the lava. A hard, fine- to medium-grained, black basalt porphyry occurs in four small exposures in the southwest part of the magnetometer grid, where it evidently occupies a considerable area, and in one exposure in the north-central part of the grid. The andesite is a part of the Clarno formation; the basalt porphyry may be a part of the Clarno or it may be intrusive into the Clarno formation.

In the eastern end of the magnetometer grid the Clarno is overlain by the much younger Ochoco lava, here a fine-grained, dark gray basalt, in part vesicular, which is relatively fresh and essentially unaltered.

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Structure and ore deposits.--The exact nature and dimensions of the so-called Johnson Creek shear zone, along which the mines listed on page 61 are located, is not known. However, it can probably be thought of simply as a broad zone in which there has been extensive structural deformation. The trend of the zone is given by Wilkinson[8] as N. 60° E., which is the bearing of a line lying through the principal mine locations. The width of the zone is not known, but it may include all of the magnetometer grid. Correlation of rather scanty geologic evidence with the magnetic results suggests that the zone is not characterized by any single continuous major fault but consists of an en echelon series of faults and fractures of one or more trends, cut and more or less offset by a series of cross faults.

Definite fault systems or trends have been recognized within the zone. The main trend in the eastern end of the zone strikes about N. 62° E., and another definite trend strikes N. 40° W. Wilkinson[9] mentions faults trending N. 10° E. and N. 45° E., and he notes faults striking N. 12° E. in the workings of the Number One mine. No faults lying far outside of these trends have been observed.

In the west-central part of the magnetometer grid a major fault strikes N. 62°-65° E. and dips 65°-70° SE. In the Adit Cut and West Adit (pl. 10) the fault is marked by 4 or 5 feet of soft clay gouge containing some cinnabar. At the east side of the Adit Cut this main fault is broken by a cross fault, which displaces the west side 33 feet northward. A similar cross fault cuts the main fault in the West Adit, again offsetting the west side northward, though the exact amount of offset is uncertain. Both cross faults strike N. 40° W. and dip 80° SW. The movement along the cross fault in the adit was at least partly postmineral, as a band of cinnabar in the

8/ Wilkinson, W. D., op. cit.
9/ Idem.

main gouge zone is cut and cinnabar drag gouge occurs along the cross fault. There is strong evidence in the adit that the movement along the cross faults was largely horizontal, although either vertical or horizontal movement could produce the offsets in the main fault. An inclined drill hole of more than adequate depth from the south end of the Adit Cut toward the gouge zone did not encounter any soft material, but the significance of this fact is uncertain. Short segments of other faults and gouge zones were seen in the several bulldozer cuts, but no further direct evidence is available concerning the relationships of the different systems of faults.

Some of the faults served as channels along which cinnabar-bearing solutions moved, and in general it appears that ore bodies tended to localize at fault intersections. Because all of the main mine workings were inaccessible at the time of the surveys, little direct evidence is available concerning the exact relations of the several systems of faults to the mineralization, but these relations are known in part. As already noted, cinnabar occurs in the gouge of the main N. 62° E. fault at the Adit Cut and the West Adit (pl. 10), and has been displaced in the adit by the N. 40° W. fault. No cinnabar, other than gouge material, was found along the two N. 40° W. faults at this locality. It may be that the faults of the N. 40° W. trend are entirely postmineral, but it seems more probable that faults of this trend existed, at least in the incipient stage, prior to mineralization.

East of the Number One shaft the main gouge zone, 15 to 20 feet wide and striking about N. 60° E., is exposed for a distance of about 40 feet across a bulldozer cut. A band of cinnabar averaging about 4 inches in width occurs along the center of the gouge zone. The cinnabar increases in width and grade eastward toward the old workings between the Number One shaft and Blue Ridge shaft. No cross faults were observed in the cut, however. Slight indications of cinnabar also were noted 185 feet west of the Number One shaft in a bulldozer cut that exposes a soft 5-foot gouge zone striking N. 58° E. and dipping about 50° to the southeast.

Elsewhere in the area no cinnabar was seen in place, although considerable high-grade ore has been mined from both the Number One and Blue Ridge mines and cinnabar can be panned from the soil at many places, particularly in the bottom of the valley both east and west from the shafts. Wilkinson[10/] states that cinnabar occurs along the main fault in the Number One workings, particularly where the main fault is intersected by fractures trending N. 12° E.

The Blue Ridge workings were entirely inaccessible during the present surveys, and no adequate mining records were available; but certain high-grade ore specimens from a storage pile at the mine show evidence of postmineral movement, though they afford no evidence, of course, as to which fault trends were involved in the movement.

The incomplete evidence cited suggests that ore was deposited along the main N. 62° E. trend, particularly at intersections with the N. 12° E. trend. There is no reason to believe that ore bodies may not also occur along the latter trend. No geologic evidence is available concerning possible faults of the N. 45° E. trend, noted by Wilkinson elsewhere in the Johnson Creek zone. Postmineral movement may have occurred along the main trend, and postmineral movement and offsetting of faults having this trend has occurred along faults of the N. 40° W. trend. The possibility remains that ore may also occur along faults of the latter trend.

Magnetic properties of the rocks.--The area surveyed in the Johnson Creek zone is characterized by strong magnetic

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10/ Wilkinson, W. D., op. cit.

variability. The total range of variation in vertical magnetic intensity is of the order of 4,300 gammas[11/] and the range of variation of the stronger local anomalies exceeds 2,000 gammas, although many of the local variations are of smaller magnitude and lower gradient. These variations are largely the magnetic expression of relatively near surface variations and discontinuities in the underlying bedrock.

All of the rocks in the surveyed area appear to be paramagnetic, but no quantitative laboratory tests have been made. The gray andesite, though apparently variable in its magnetic properties, has a relatively low magnetic permeability, which appears to vary in part with the degree of alteration of the rock. The fault gouge, and rock that has undergone considerable hydrothermal alteration, appear to have lower magnetic permeability than the less-altered rock. The black basalt porphyry and the dark-gray basaltic Ochoco lava have fairly high magnetic permeability, although no quantitative data are available.

Magnetic determinations.--The results of the detailed magnetometer survey in the Johnson Creek zone are shown on the magnetic contour map, plate 11. The magnetic variability in the area is well illustrated by the many strong magnetic anomalies and sharp changes of trend shown on this map. The magnetic variations appear to be due largely to (1) differences in the composition of the rocks and (2) rock structures, particularly faults. In most of the area the bedrock is masked by soil, but in a few places, notably certain bulldozer cuts (pl. 10), direct geologic evidence is available for correlation with the magnetic readings. The geologic evidence thus obtained has been correlated with certain of the magnetic

11/ 1 gamma = 10^{-5} gauss. The value of the earth's magnetic field is approximately 0.6 gauss, or 60,000 gammas.

anomalies, affording a basis on which to extend the interpretations into covered areas.

On the magnetic map, plate 11, a strong magnetic anomaly enters the west end of the grid just north of the 0-line and runs diagonally southeastward to the 2E-2S point. This anomaly is largely the magnetic expression of the main fault exposed in the Adit Cut and the West Adit (pl. 10), but the general trend of the anomaly is not the strike of that fault, for the trend is determined in part by other faults. At the two cross faults exposed in the Adit Cut and West Adit, the magnetic contour lines change direction sharply and this sector of the major anomaly is seen to consist of three segments offset progressively southward on the east sides along the cross faults, as is the rock itself. The magnetic data indicate strongly that additional cross faults cut the main fault in about the locations shown on plate 10. The general trend of the main anomaly is thus the average trend of a zig-zag line representing the series of offset segments.

This main fault has been traced from the west edge of the grid eastward to about the 6E grid line, where it appears to die out as shown on plate 10. The magnetic results indicate that the cinnabar-bearing fault gouge exposed in the West Adit and Adit Cut is not the same that has been mined at the Number One shaft, as was thought during the earlier prospecting. Although the former gouge contains cinnabar in places, it does not contain ore bodies of economic grade where prospected in the West Adit and at the Adit and Arrow Cuts.

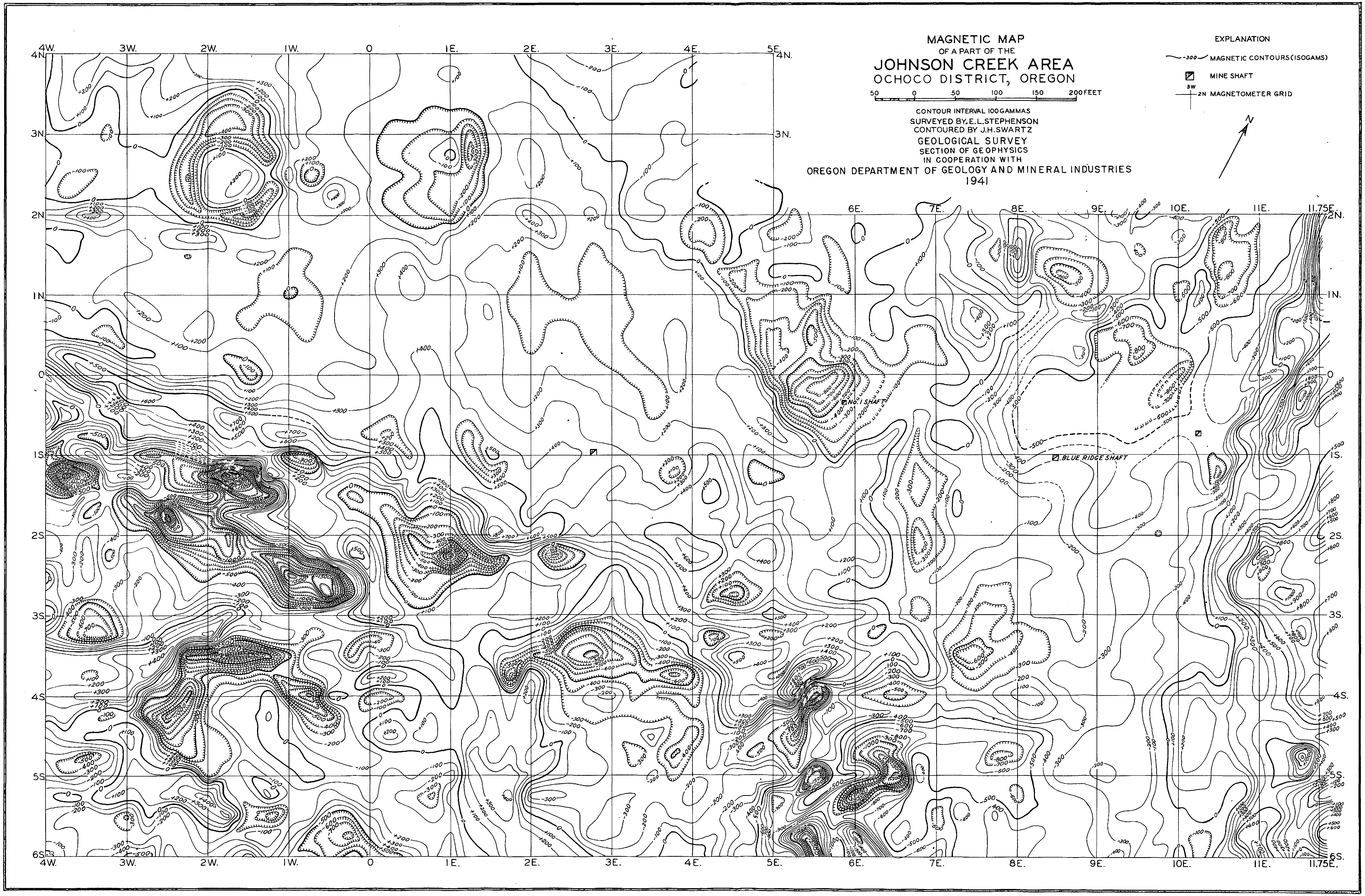
At the north end of the long bulldozer cut west of the Number One shaft (pl. 10) a strong magnetic anomaly occurs over the Number One gouge zone, but because of extraneous interference by the large amount of iron around the shaft, it was impossible to make a complete survey and an exact correlation between magnetic and geologic data in this place, where such a correlation would be of special value because the location and nature of the zone is well known. The magnetic anomaly, however, is intersected and cut off a short distance west of the shaft by a strong magnetic anomaly falling within the N. 40° W. trend (pl. 11), and a study of the readings suggests that the Number One gouge zone is here cut and offset northward by a strong cross fault. Whether the gouge zone extends far west of the cross fault is problematical, but a detailed correlation of the magnetic readings indicates that the zone probably dies out a short distance to the west, in a manner magnetically similar to the dying-out of the other main gouge zone south of the shaft.

The main fault anomaly at the north end of the bulldozer cut is part of a major negative anomaly that centers northwest of the Number One shaft. The southeast side of this major anomaly trends N. 12° E. and suggests the presence of a fault of this trend intersecting the main gouge zone. Such an intersection may account for the localization of ore at and near the shaft.

A large area around the Blue Ridge shaft, likewise, could not be surveyed magnetically because of the very large amount of machinery and scrap iron in the vicinity, and no correlation is available between the geology and the magnetic readings near the mine. There is some indication, however, that the Blue Ridge shaft occupies a magnetically negative area similar to that surrounding the Number One shaft. Whether such negative variations are characteristic of the mineralized zones in general, or at least of hydrothermally altered rock bodies in the Johnson Creek zone, is not known. In many places the rock is altered and bleached for some distance around the mineralized localities; it may be, therefore, that hydrothermal alteration has in places leached out some of the magnetic minerals, and that for this reason the rock in and near the mineralized zones generally has a low magnetic permeability.

Elsewhere in the grid area there is little or no available geologic evidence to correlate with the magnetic measurements. A very careful and detailed study of magnetic maps and other data would be necessary to determine structural details, and such a study is beyond the scope of this preliminary report. However, surface prospecting has shown some good indications of cinnabar in the magnetically negative area south of the Blue Ridge shaft, and, as this is an area of relatively low magnetic relief, a magnetic map of small contour interval is presented on plate 12.

The magnetic contours indicate that a fault or gouge zone similar to the other two main zones already noted enters this area from the west approximately on the 4S grid line. Its strike is about N. 62° E. This zone appears to be cut by a cross-break at about the 8.5E grid line, the west block being offset 75 feet or more northward. An assumed strike of N. 40° W. for this inferred cross-fault would carry it directly through the old workings between the Number One and Blue Ridge shafts and through a magnetic offset occurring on the 1N grid line between 7.25E and 7.5E. Additional evidence of a strong break is given by the resistivity traverse, where a strong resistivity anomaly occurs between stations 8 and 9. It is therefore highly probable that there is a major cross fault, having a strike of about N. 40° W., at or near the line shown on the map. This fault probably caused the apparent offset in the Number One gouge zone between the two shafts, although there is also magnetic evidence that a fault of the N. 12° E. trend intersects the main zone at this point. If this inferred N. 40° W. fault is premineral in origin, it might possibly account in part for the localization of cinnabar in the vicinity of the Number One and Blue Ridge shafts.


MAGNETIC MAP
OF A PART OF THE
JOHNSON CREEK AREA
OCHOCO DISTRICT, OREGON
50 0 50 100 150 200 FEET
CONTOUR INTERVAL 100 GAMMAS
SURVEYED BY E.L. STEPHENSON
CONTOURED BY J.H. SWARTZ
GEOLOGICAL SURVEY
SECTION OF GEOPHYSICS
IN COOPERATION WITH
OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1941
EXPLANATION
-300 MAGNETIC CONTOURS (ISOGAMS)
MINE SHAFT
3W 2N MAGNETOMETER GRID
N
No. 1 SHAFT
BLUE RIDGE SHAFT

A parallel cross fault may lie about 150 feet to the east, but, as its supposed locality is near the west edge of the strongly paramagnetic Ochoco lava the magnetic relationships are obscure. There is also some indication that a fault of either the N. 45° E. trend or the N. 12° E trend crosses the northern part of the area southeast of the Blue Ridge shaft.

About 325 feet south of the Number One shaft a strong magnetic trend occurs that suggests the presence of a fault striking northeastward, at or just south of the end of the long bulldozer cut. The magnetic trend is lost, however, in the negative area south of the Blue Ridge shaft. South of this trend in the central part of the grid there is a group of very sharp, strong negative anomalies, but their significance is not known.

In the west-central part of the grid strong negative anomalies occur which are believed to be associated at least in part with the black basalt porphyry, though they may be structural in part. They probably are associated in some way with the eastern and northern edges of the basalt body. In the northwestern part of the grid two roughly circular anomalies occur which by their shape and other characteristics suggest the presence of small plugs or similar intrusive bodies. These anomalies have no apparent economic significance.

The eastern end of the grid area is magnetically positive, and this positive area is bordered on the west by a sharp magnetic slope of irregular trend. The magnetic slope apparently marks the west edge of the basaltic Ochoco lava, which may be seen to overlie the Clarno formation in an old surface cut northeast of the Blue Ridge shaft. Boulders of Ochoco lava, also, are scattered through the positive area. As only the edge of the lava was surveyed, it is not established beyond doubt that high magnetic readings are characteristic of the lava, but they may be, inasmuch as the lava is rather strongly paramagnetic and essentially fresh and unaltered.

The magnetic data just discussed in conjunction with the reconnaissance traverses that join the grid to the area of the Johnson Creek mine, and the direct geologic evidence at the Adit Cut and West Adit, suggest that the Johnson Creek shear zone in part comprises a series of subparallel fractures lying en echelon at a low angle to the general trend of the zone and

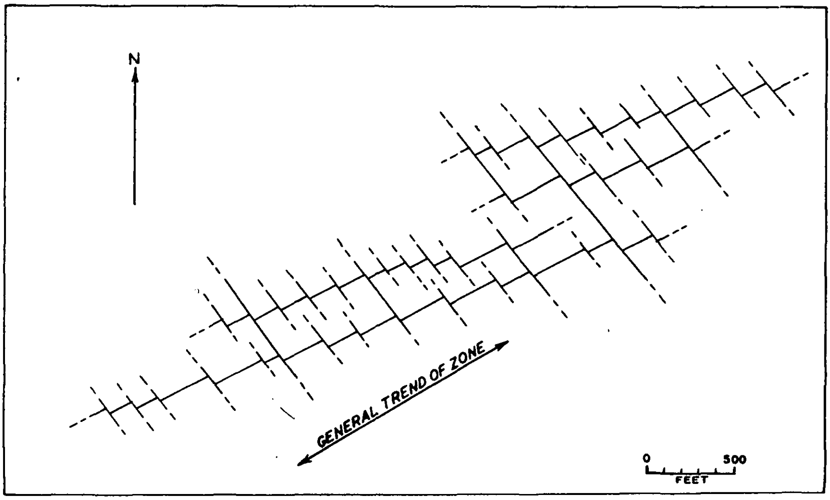


Figure 7--Diagrammatic sketch of an inferred fault system in a part of the Johnson Creek zone.

striking about N. 60° E. In part these fractures are cut and offset progressively northwestward by a series of cross faults striking about N. 40° W., the movement along which has been mainly postmineral but may have been at least in part premineral. The general plan of such a system is outlined diagrammatically in figure 7, although the pattern shown is not meant to suggest either the number or the location of the fractures. Faults of other strikes no doubt exist, and in particular the magnetic data suggest the presence of two magnetically less prominent trends striking about N. 12° E. and N. 45° E.

Electrical determinations.--The locations of the resistivity traverses are shown on plate 10, and the results of this brief survey are shown in figure 8 as horizontal resistivity profiles, in which the station locations are plotted as abscissae and the values of resistivity as ordinates. The

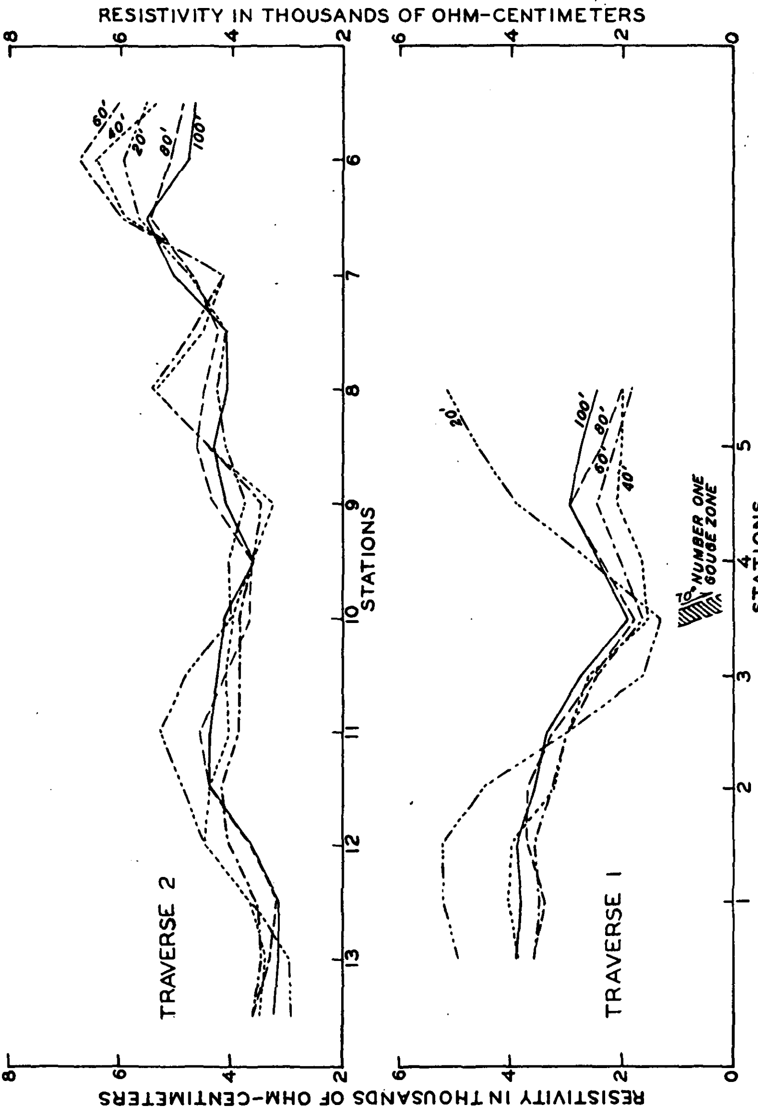


Figure 8.--Horizontal resistivity profiles near the Number One shaft.

first traverse was run across the Number One gouge zone along the wide bulldozer cut east of the shaft. As seen in the profile, a decrease in resistivity (increase in electrical conductivity) occurs directly over the gouge zone. While one test is not conclusive, it seems probable from experience elsewhere that similar electrical anomalies might be found over other gouge zones in the area.

The second traverse was run along the 1N magnetometer grid line to determine the electrical nature of the ground and to supplement the magnetic determinations concerning a cross fault thought to pass between the Number One and Blue Ridge shafts. All of the resistivity values are low, but the resistivity curves show definite anomalies. An anomalous condition near stations 6 and 7 possibly indicates a fault, and there is a sharp rock discontinuity between stations 8 and 9. In particular the vertical profiles indicate a fault between stations 8 and 9. The probable connection of this resistivity anomaly with the major discontinuity suggested by the magnetic readings has already been noted.

As an additional electrical test, a few natural-potential measurements were made on the main gouge zone in the bulldozer cut east of the shaft. At this locality, as already noted, the gouge zone is 15 to 20 feet wide, and near its center it contains a narrow vein of cinnabar. Although it is not to be expected that cinnabar bodies themselves will produce electrical self-potentials, the tests were made in order to determine whether any abnormal currents occur in this wide, ore-bearing gouge zone. No such currents were detected.

Suggestions for prospecting.--The geophysical results suggest several possibilities for further prospecting in the Johnson Creek zone. It should be emphasized that the magnetic information as well as the resistivity information is purely structural and largely qualitative and that the outlining of structural trends and rock discontinuities in no sense guarantees the finding of ore. Magnetic anomalies in particular can be caused by many different factors, and they should be used here only in the sense that they indicate points of change in the rock, some of which might be of economic importance.

Further, as already pointed out, the trend of a given major anomaly may not be the strike of the rock discontinuity that causes the anomaly, although at any given point the anomaly marks the approximate location of the discontinuity and indicates some kind of change in the rock. As the bed rock is largely covered, and as the mineralized zones are soft and at no place prominent, the magnetic results may provide helpful guides for prospecting.

The localization of ore bodies appears to have been largely controlled by fault intersections. Some of the intersections in the area no doubt are postmineral, and many of them probably are not mineralized, but in general they should guide the prospecting. Another point to consider is the evidence that hydrothermal alteration has locally affected the magnetic minerals in such a way as to make the rocks less magnetic. If this is true, some magnetically low areas that are unaccompanied by corresponding positive anomalies might bear investigation. In general it might be said that very sharp, localized negative anomalies probably are not due primarily to rock alteration, whereas relatively moderate, isolated negative anomalies may indicate alteration of the paramagnetic rocks.

The first underground exploration at either the Blue Ridge or the Number One shafts should of course follow the main Number One gouge zone, and particular attention should be given to any localities where this zone is intersected by other faults. From evidence so far available, any intersections of the main zone with faults of the N. 12° E. trend are especially promising localities.

At the Blue Ridge shaft it would seem advisable to give further attention to the inferred intersection, west of the shaft, of a fault striking about N. 40° W. with the main gouge zone. Although some mining has been done along this zone between the shaft and the intersection, accurate records regarding this work are not available; further work, therefore, along the main gouge zone and possibly along the trend of the inferred cross fault should be worth while. The area around the intersection is especially inviting if, as the magnetic data suggest, it is also crossed by a fault of the N. 12° E. trend.

In further underground development at the Number One shaft it may be advisable to investigate the northwestward magnetic trend west of the shaft. Little specific information is available regarding the present workings in this locality, including the main 57-foot level, but as the inferred cross fault is considerably stronger magnetically than most of the faults of the N. 40° W. trend, there is a possibility that it was in existence prior to mineralization and hence might be mineralized. If the 57-foot level of the workings has not already reached this break—a question that cannot be answered at present—a short crosscut or extension of the main drift would serve to check the possibility. Similarly, it seems that attention should be given to possible faults of the N. 12° E. trend, which may have played an important part in the localization of the ore.

In further surface prospecting it would seem advisable to investigate the inferred intersection on the 8.5E grid line between 4S and 5S and the magnetically low area immediately north and east, as well as the magnetically low area at about 9.25E-2.5S of the grid (pl. 12). Any showings of cinnabar here might well be traced along both the N. 62° E. trend and the N. 40° W. trend, and any indications of a northeastward trend should be investigated. If trenches are dug, they should be approximately perpendicular to each other and to the inferred strikes, and of considerable length. In this work it may be well also to investigate the strong negative anomalies occurring northwest and southwest of the inferred intersection. In part at least the negative anomalies probably are border phases of the positive anomalies—that is, effects of magnetic induction—but it seems difficult to explain their distribution and strength entirely on this basis.

The N. 62° E. trend appears to be intersected about 375 feet south of the Number One shaft by a strong northeastward trend. A sharp negative anomaly and a fairly sharp positive anomaly occur at this point. The locality was almost reached by the south end of the long bulldozer cut (pl. 10), and the rocks that were partially exposed gave some indication of a discontinuity, but little exact geologic information was obtained. Further search at this locality may well be warranted.

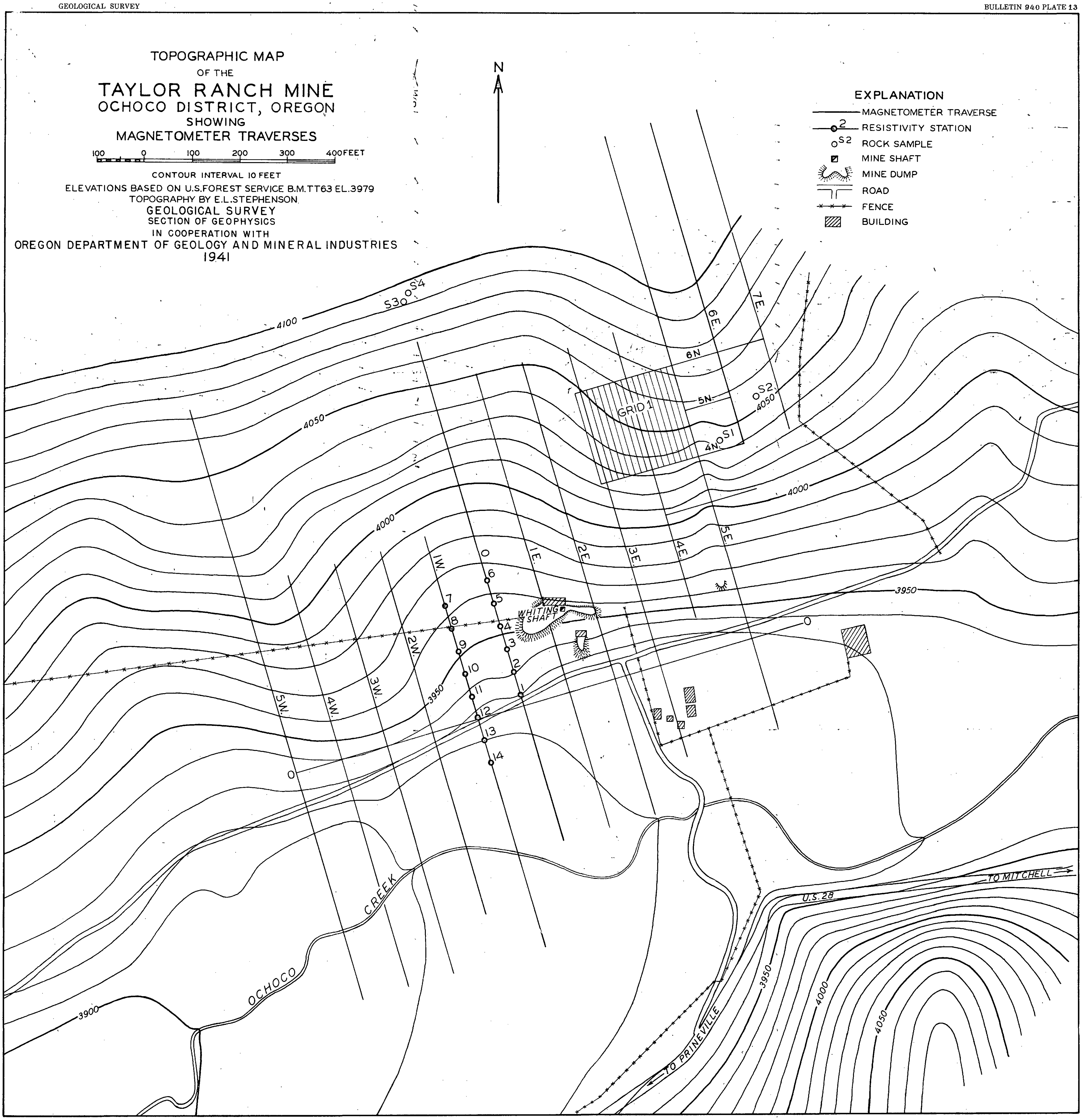
In general, from the available geologic information and the prospecting so far done, it appears that the area around the two shafts is the most favorable for the development of cinnabar ore bodies. Good showings of cinnabar can be panned, however, at some localities along the valley to the west, and further prospecting to the west seems justifiable. The main fault through the west-central part of the grid has been fairly well prospected by surface cuts, and although cinnabar occurs along it no commercial bodies of ore have been found. There are other magnetic anomalies and trends, however, that could be investigated. As development proceeds and additional direct geologic information is gained, the magnetic results probably can be implemented to form more specific guides. Further resistivity measurements may also prove desirable.

Results of the Taylor Ranch surveys

The Taylor Ranch mine is in section 34, T. 13 S., R. 19 E. and is owned and operated by Ray Whiting. The Whiting shaft is on the north side of the Ochoco Creek valley, just above the valley bottom. The geophysical surveys comprised magnetometer measurements and supplementary resistivity measurements. Thirteen magnetometer traverses at 100-foot intervals, averaging about 900 feet in length, were run from the valley bottom N. 15° W. up the north side of the valley (pl. 13). Along all of these traverses, magnetometer measurements were made at intervals of 12½ feet. In addition, a detailed magnetometer grid 200 feet square (grid 1, pl. 13), with a grid interval of 12½ feet, was measured at a magnetically anomalous locality about 400 feet northeast of the Whiting shaft. In the course of the survey 1,331 magnetometer stations were occupied.

To supplement the magnetometer surveys 14 resistivity stations were measured along the 0 and 1W magnetometer traverse lines, as shown on plate 13. Stations were spaced 50 feet apart along these lines, and resistivity measurements were made at depth intervals of 20 feet to a total depth of 100 feet.

Rocks.--Throughout a large area surrounding the Whiting shaft the bedrock is covered almost everywhere by a blanket of tough red clay, and almost nothing can be learned from the surface concerning the underlying rocks. Geologic information is available in the mine workings and in a few small, scattered outcrops. Two types of rock have been observed near the mine, an andesite porphyry which is the country rock in all of the mine workings and which crops out about 500 feet northeast of the shaft, and a dense black basalt which forms a small knob about 600 feet northeast of the shaft. In the mine the andesite porphyry is in part relatively unaltered and dark-brown to dark-gray, in part highly altered and bleached to a light gray color. The light-gray, altered porphyry apparently marks the courses of the several major faults encountered in


TOPOGRAPHIC MAP
OF THE
TAYLOR RANCH MINE
OCHOCO DISTRICT, OREGON
SHOWING
MAGNETOMETER TRAVERSES
100 0 100 200 300 400 FEET
CONTOUR INTERVAL 10 FEET
ELEVATIONS BASED ON U.S.FOREST SERVICE B.M.TT63 EL.3979
TOPOGRAPHY BY E.L.STEPHENSON
GEOLOGICAL SURVEY
SECTION OF GEOPHYSICS
IN COOPERATION WITH
OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1941
N
EXPLANATION
MAGNETOMETER TRAVERSE
RESISTIVITY STATION
ROCK SAMPLE
MINE SHAFT
MINE DUMP
ROAD
FENCE
BUILDING
4100
4050
4000
3950
3900
S3
S4
S2
S1
GRID 1
6N
5N
4N
6E.
7E.
5E.
4E.
3E.
2E.
1E.
0
1W.
2W.
3W.
4W.
5W.
WHITING SHAFT
OCHOCO CREEK
U.S. 28
TO MITCHELL
TO PRINEVILLE

the workings, and it contains most of the cinnabar that has been deposited along the faults. At certain fault intersections there are large masses of this altered porphyry.

Structure and ore deposits.--The chief structural features of the porphyry at the mine are faults, most of which fall according to strike into certain well-defined groups. The strikes of what appear to be the two chief groups are approximately N. 75° E. and N. 31° E., and the faults of both these groups dip steeply southeastward. Another group of faults strikes approximately N. 72° W., some of them dipping northeast and some southwest, and there are many minor faults and fractures of different strikes and dips. The porphyry for the most part is massive, and little can be ascertained underground concerning the amounts and directions of movement along the faults. At least some of the faults have served as channels along which ore-bearing solutions moved, and most of the ore occurs in or very close to the fault zones. The relation of the ore to the faults has not been ascertained in detail, but much of the ore is associated with fractures of the N. 31° E. trend. Postmineral movement has occurred along one or more major faults of the N. 75° E. group, and has offset faults and ore bodies of the N. 31° E. trend, although the former trend also existed at the time of mineralization. The relationships of other faults, particularly those of the N. 72° W. trend, to the ore bodies and main faults are obscure. In general, ore deposition was probably localized at intersections of the several fault groups, but the exact role played by each group is uncertain. The main stope of the mine is about 90 feet southwest of the shaft, and extends from the 80-foot level nearly to the surface. The ore mined here lay chiefly along the N. 31° E. trend, and apparently the ore body plunges steeply southwestward to the 130-foot level, the deepest level in the mine. The grade of ore appears to be lower below the 80-foot level. A narrow but persistent band of cinnabar and calcite striking N. 31° E. was followed along the western part of the 130-foot level to the present face. On the 130-foot level another smaller ore body, or extension of the main ore body, was found about 60 feet southwest of the shaft. It apparently lies along a strong fault striking N. 75° E. and dipping 70° S., indicating that the N. 75° E. group of faults existed prior to mineralization. The ore bodies may have been localized chiefly at intersections of the N. 75° E. and N. 31° E. groups of faults, and later movement along the N. 75° E. group then cut and offset ore bodies of the N. 31° E. trend.

Magnetic properties of the rocks.--At the Taylor Ranch mine the total range of variation in vertical magnetic intensity is about 2,900 gammas, and the area shows much less magnetic variability than the Johnson Creek zone. The andesite porphyry has relatively low magnetic permeability, which apparently varies in part with the degree of alteration. The dark-gray, unaltered rock is moderately magnetic; the brown, slightly altered rock is less magnetic; and much of the highly bleached and altered light-gray rock has very low magnetic permeability. The dense black basalt is rather strongly magnetic, and produces by far the strongest magnetic anomalies encountered in the area of the magnetometer traverses. The above conclusions are based on field tests, since no laboratory tests of the magnetic permeability of the rocks have yet been made.

Magnetic determinations.--The results of the magnetometer survey at the Taylor Ranch mine are shown on the magnetic contour map, plate 14. The chief magnetic feature is the moderately strong anomaly that extends northeastward entirely across the area. Its variation in vertical magnetic intensity ranges approximately from 300 to 1,100 gammas. The general trend of the anomaly is approximately N. 25° E., but in detail it consists of a series of segments offset progressively southeastward and each striking approximately N. 31° E. A short distance west of the Whiting shaft the main ore body, striking N. 31° E., lies within the anomaly, and the surface projection of the main N. 75° E. fault on the 130-foot level corresponds with a northwestward offset of the magnetic contour lines. The anomaly is therefore believed to be the magnetic expression of a major fault striking N. 31° E., which is cut and offset progressively southeastward by other faults, probably of the N. 75° E. trend. These other faults, then, are steep reverse faults—though not thrust faults—having a large horizontal component of movement.

It seems probable that the main ore body, already mined, was localized at the intersection of the two major faults, though other faults that are exposed in the mine workings may also have influenced ore deposition. Most of the ore at this locality occurs along the N. 31° E. fault, but smaller quantities of ore, some of which is said to be "drag ore," occur along the N. 75° E. fault. Although postmineral movement is thus indicated along the N. 75° E. fault, some of the indicated offset of the other fault may have occurred before the ore-bearing solutions came in.

The linear magnetic anomaly is interrupted 375 feet northeast of the shaft by a strong positive magnetic anomaly, covering a roughly circular area 200 feet in diameter, which is shown in detail on a large-scale magnetic map (pl. 15). This anomaly indicates the presence of a body of strongly magnetic rock, possibly of considerable thickness. No rock in place is exposed, but the clay soil contains numerous fragments of dense to fine-grained black basalt, and the only outcrop of the andesite prophyry occurs a short distance down the hill. Thus it is possible that the magnetic anomaly is caused by a thin tongue of basalt, a part of the eroded edge of a basalt flow, overlying the porphyry. The strength and the shape of the anomaly, however, suggest that a small plug of basalt may have invaded the porphyry at this locality.

Another strong linear positive anomaly enters the mapped area from the east on the 5N grid line and extends nearly to the other anomaly. Its strength and shape indicate a body of strongly magnetic rock that has a linear outcrop and large vertical extent. A small outcrop of dense black basalt occurs near the crest of the anomaly, which is therefore believed to mark the course of a large basalt dike striking northeastward or eastward. The two anomalies may represent parts of a single large body of basalt intruded into the porphyry. The trend of the eastern anomaly suggests that the basalt may have been intruded along a fault of the N. 75° E. group, at the intersection of this fault with the N. 31° E. fault. Wilkinson[12/] notes an apparently close relationship between basalt intrusions and cinnabar ore bodies at the Staley and Barney mine in the Ochoco Creek zone. There is a possibility that the magnetic anomalies indicate the general direction from which the mineralizing solutions came.

A strong negative anomaly of wide extent occurs south of the larger positive anomaly and along the N. 31° E. anomaly. In part at least the depression is doubtless a composite border phase of the two anomalies, but its wide extent and the fact that the altered gray porphyry in the mine is known to be very weakly magnetic suggests the possibility that in part the low may also indicate considerable alteration in the underlying rock. There seems to be little doubt, in the light of evidence accumulated during several magnetic surveys made by the writer, that the action of hydrothermal solutions on paramagnetic rocks in places breaks down the paramagnetic minerals to such an extent that measurable magnetic disturbances are produced. However, most magnetic anomalies are complex, and

12/ Wilkinson, W. D., op. cit.

little or no quantitative information on the factors composing them is available.

Resistivity determinations.--The locations of the resistivity stations are shown in plate 13. The resistivity results are shown in plate 16 as horizontal resistivity profiles, in which station locations are plotted as abscissae and values of resistivity as ordinates. All of the resistivity values are very low, and the rocks have little electrical contrast. The most prominent general characteristic of the profiles is a relatively strong increase in near-surface resistivity toward the valley bottom, which probably is due to sand and gravel in the valley fill. No prominent anomalies occur at the projected location of the main N. 75° E. fault (stations 4-5 and 8), although a change of slope in the curves occurs between stations 4 and 5 and stations 8 and 9. The tests are too restricted to warrant any conclusions other than that the very low and uniform resistivity of the rocks might make it difficult to locate gouge zones, and possibly faults in general, in this locality by resistivity methods.

Suggestions for prospecting.--The magnetic results suggest several possibilities for further mine development and surface prospecting in the Taylor Ranch area. In this connection it should be reiterated that both the magnetic information and the resistivity information are purely structural, and that their use does not guarantee the finding of ore. The anomalies simply indicate the approximate location of rock discontinuities and changes, some of which, in a mineralized area, may be of economic importance.

In the mine, "drag ore" is reported to have been encountered along the main fault of the N. 75° E. trend on the 80 level, and certain earlier geologic work led to the belief that the offset along the main fault was to the west on the south side. Thus it was thought that the ore lead in the northeast drift on the 80 level might be the northeastward extension of the ore mined in the main stope southwest of the shaft. The magnetic data, however, indicate that the main ore zone has been offset westward on the north side by the main fault of the N. 75° E. trend. Thus it appears that the ore recently encountered along the N. 31° E. trend in the northeast extension of the 80 level drift is not identical with the ore mined in the main stope southwest of the shaft. It may be in the same body as the small quantities of high-grade ore mined in earlier workings on the 80 level southeast of the shaft, or it may be in an ore lead lying beyond the southeast extension of the workings. The offset of about 45 feet suggested by the magnetic data indicates that the first assumption is probably correct.

In general the most promising indications of ore occur west of the shaft, in the locality of the main magnetic anomaly. A recent crosscut from the west drift on the 130-foot level into the main magnetic anomaly, driven because of the occurrence of that anomaly, has encountered some excellent ore, and it seems probable that ore may be found in both directions along the main N. 31° E. trend—that is, southwest along the present drift on the 130-foot level and above, and northeast in the virgin ground west and north of the shaft. The possibilities appear best in the latter locality, especially if the ore-bearing solutions came from the northeast. It would appear that ore possibilities might be most advantageously tested by a cross-cut on the 80-foot level north and west from a point near the northeast end of the present main stope; or the cross-cut on the 130-foot level might be extended.

A similar fault intersection is suggested about 135 feet feet northwest of the shaft, near the 3N point on the 1E traverse line. This point and the intersection of the N. 31° E.

anomaly with the basalt anomaly at the 5N point on the 3E traverse line might easily be explored by surface trenching. The entire central course of the N. 31° E. anomaly might be worth prospecting, and so might the general area of the magnetic depression northeast of the shaft. There is some indication of another fault intersection on the 3W traverse line about 150 feet south of the base line, but as this locality is in the valley of Ochoco Creek, prospecting would be difficult because of the relatively deep overburden and the large amount of water that would be encountered.

Results of the Maury Mountain survey

The Maury Mountain mine is in sec. 10, T. 17 S., R. 19 E. One claim, containing rather extensive workings, is owned and operated by Frank Towner, and the rest of the property is owned and operated by F. D. Eickemeyer and H. W. Eickemeyer. The underground workings have a total length of about 2,700 feet.

The geophysical survey comprised magnetometer traverses at 25-, 50-, or 100-foot intervals, running N. 30° E. from the main hill in which the Towner workings are located across a small valley and the low ridge in which the Eickemeyer workings are located. The plan of the magnetometer traverses is shown in plate 17. Along all of the traverses magnetometer measurements were made at intervals of 12½ feet, and a total of 1,094 magnetometer stations were occupied.

Rocks.--In the central valley area at the Maury Mountain mine, which includes most of the magnetometer grid, the bedrock is covered, but exposures of the rocks occur in the mine workings and prospect pits and in outcrops on the surrounding ridges. The rocks consist mainly of tuff and tuffaceous shale, in part silicified; fine to medium-grained gray andesite, part of which at least may be intrusive; and lesser amounts of dense to fine-grained, dark-gray to black basalt or andesite, which also may be partly or wholly intrusive. The bed-rock structure is complex and so largely covered that it cannot be fully worked out.

Structure and ore deposits.--The rocks at the Maury Mountain mine are badly shattered and intricately faulted. Faults and fractures of almost any strike and dip may be found in the various mine workings and prospect pits, and many details regarding the relations between the faults are difficult to ascertain. It appears, however, that certain major faults or fault trends exist, and that ore deposition has been controlled at least in part by these major trends. Analysis of a large number of determinations of strike indicates that there are three major fault systems trending approximately N. 74° E., N. 13° W., and N. 75° W., and two other strong ones, trending approximately N. 40° E. and N. 38° W. The N. 13° W. trend and N. 38° W. trend may be closely related in a general system, mentioned by Wilkinson[13] and Allen,[14] trending about N. 25° W. On the average, faults of the N. 74° E. and N. 75° W. trends dip steeply northward, faults of the N. 13° W. and N. 38° W. trends dip steeply eastward, and faults of the less well known N. 40° E. trend dip at more moderate angles southeastward.

It seems certain that in general mineralization has been localized at the intersections of faults, and that postmineral movement has occurred along some of the faults. Much of the ore occurs in small, very high grade bodies, which do not appear to have any regularity of occurrence, but there are also more continuous bands of ore, especially in the Towner workings, and areas of low-grade, disseminated ore occur along certain main faults. One extremely high grade body was found

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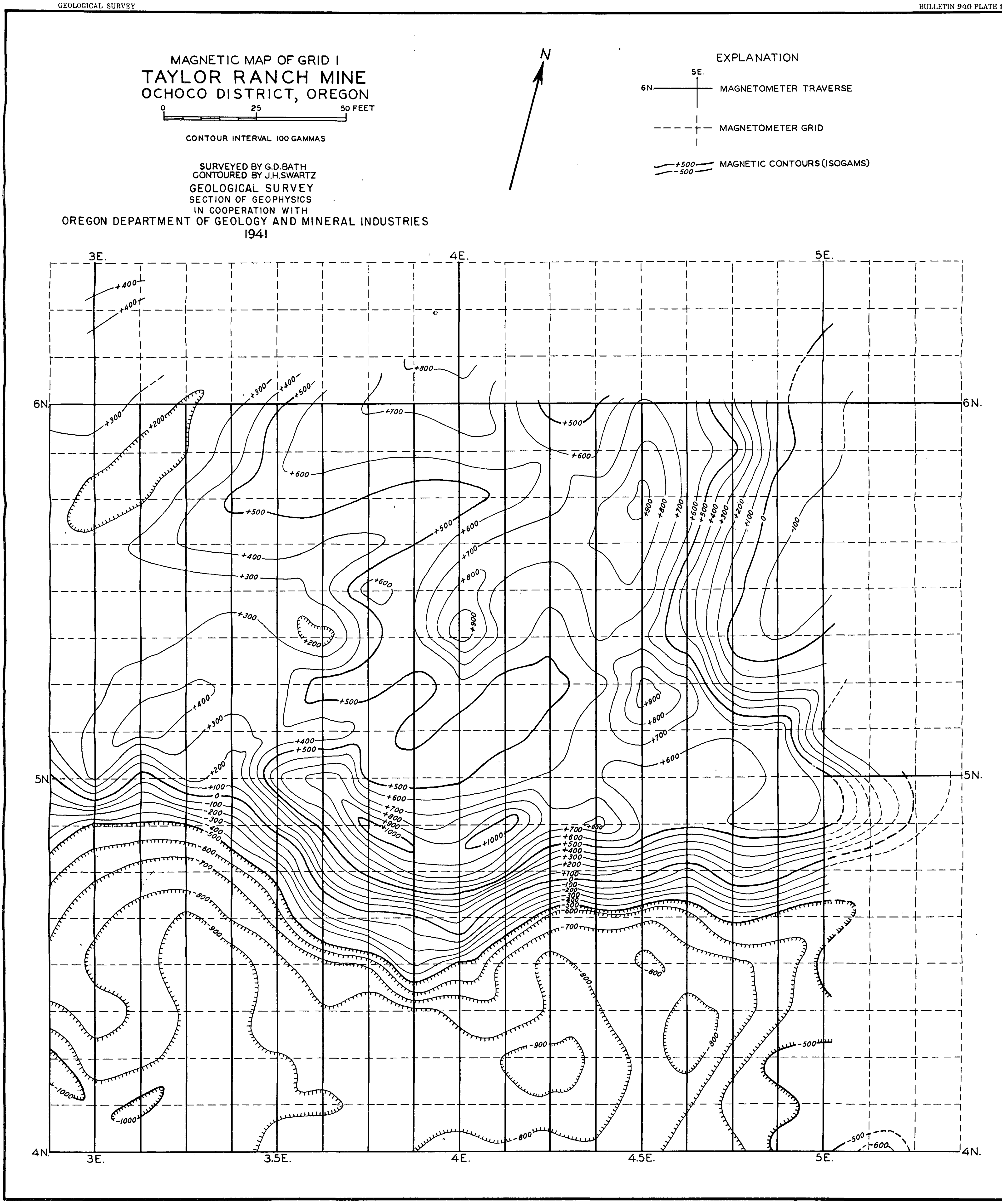
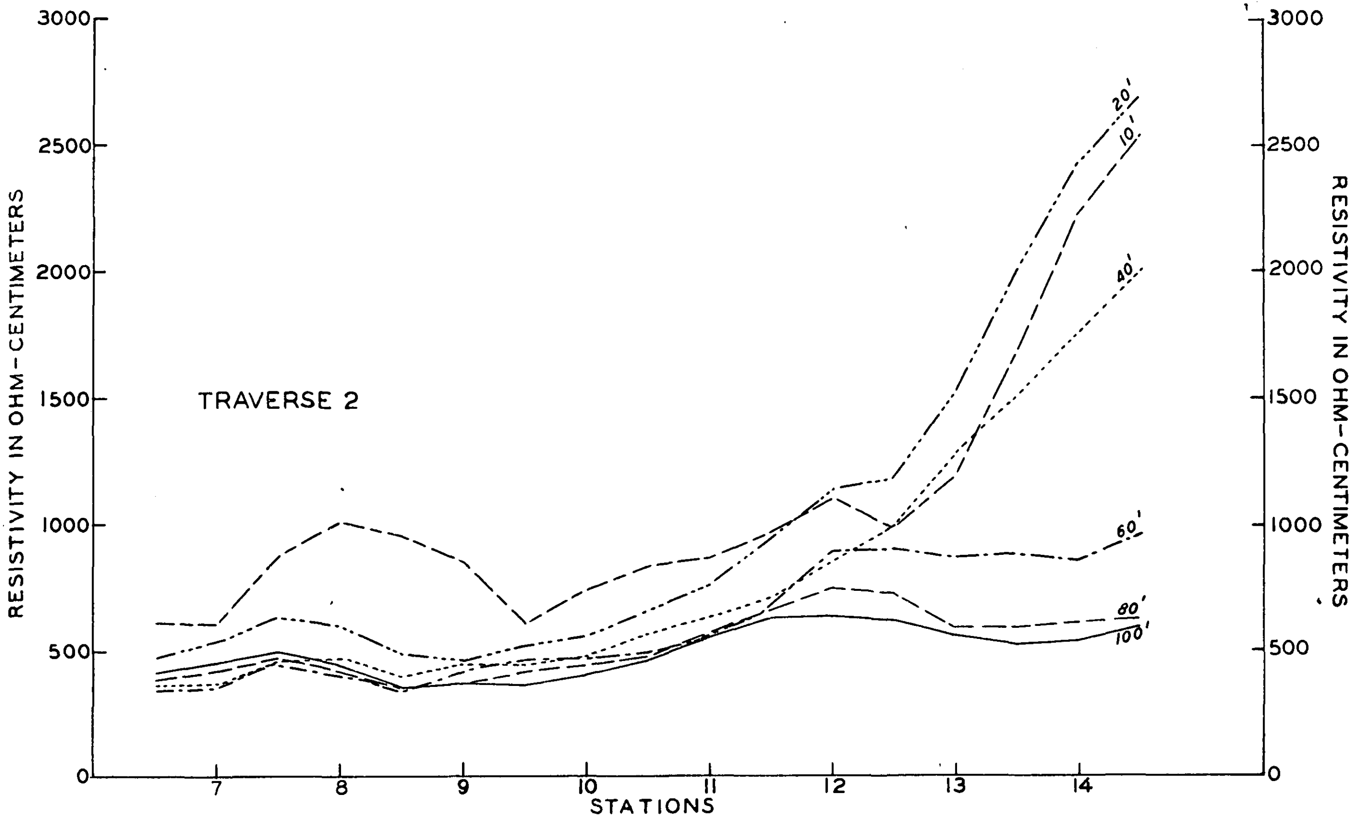
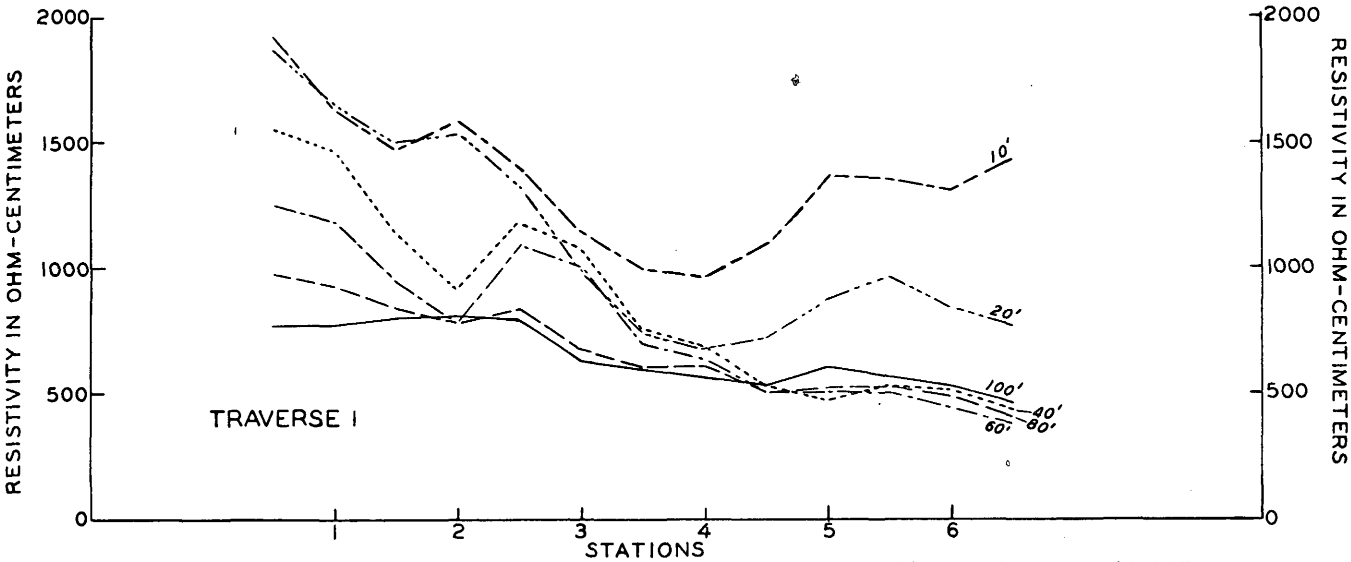
13/ Wilkinson, W. D., op. cit.
14/ Allen, J. E., Unpublished office report, Oregon Dept. Geol. and Min. Industries.


MAGNETIC MAP OF GRID I
TAYLOR RANCH MINE
OCHOCO DISTRICT, OREGON
0
25
50 FEET
CONTOUR INTERVAL 100 GAMMAS
SURVEYED BY G.D.BATH
CONTOURED BY J.H.SWARTZ
GEOLOGICAL SURVEY
SECTION OF GEOPHYSICS
IN COOPERATION WITH
OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1941
N
EXPLANATION
5E.
6N.
MAGNETOMETER TRAVERSE
MAGNETOMETER GRID
+500
-500
MAGNETIC CONTOURS (ISOGAMS)
3E.
3.5E.
4E.
4.5E.
5E.
6N.
5N.
4N.





HORIZONTAL RESISTIVITY PROFILES AT THE TAYLOR RANCH MINE

548759 O - 43 (Face p. 92))

OREGON QUICKSILVER FIG.4

in the upper Eickemeyer workings at the intersection of a main fault striking N. 80° W. and a cross fault striking N. 10° E., very close to the intersection of the main fault with another major fault striking N. 74° E. The cross fault displaces the main fault 3 feet to the south on the west side. In the lower Eickemeyer workings ore of lower grade occurs in two shoots along a fault striking N. 68°-80° W. and dipping about 72° northward. The main ore body in the Towner workings was found at the intersection of two faults striking N. 33° W. and N. 12° W., and at another place high-grade ore occurs along a fault striking N. 40° E.

Magnetic properties of the rocks.--The area surveyed at the Maury Mountain mine exhibits, in general, weaker magnetic variability than either the Johnson Creek area or the Taylor Ranch area. The total range of variation in vertical magnetic intensity is about 1,500 gammas. The magnetic permeability of the tuffaceous rocks is apparently low, and that of the andesitic and basaltic rocks higher and more variable. Laboratory tests would be necessary to reach more specific conclusions, but the very complex structure, which strongly influences the magnetic field measurements, would in any event render it difficult to apply specific determinations to the interpretation of the magnetometer readings.

Magnetic determinations.--The results of the magnetometer survey at the Maury Mountain mine are shown on the magnetic contour map, plate 18. As is to be expected from the structural complexity, the area is magnetically complicated; but definite magnetic trends can be recognized. The area is characterized chiefly by linear magnetic anomalies, many of which are relatively weak. Most of the anomalies are apparently due to bedrock structures, although certain broad, general magnetic changes are probably more closely related to differences in the rocks near the surface. Certain strong localized positive anomalies occur, which are probably caused by narrow bodies of more strongly paramagnetic rock.

Chiefly because of rugged topography and lack of time, the magnetometer measurements were not extended across the Towner workings or the other workings on the main hill, and for this area no correlation is available between magnetic measurements and geology. The measurements covered all of the Eickemeyer workings in the small ridge to the northwest, and the magnetic map (pl. 18) shows the relationship in this area between the magnetic data and the chief faults exposed in the workings. A magnetic trend follows the fault, one of the N. 74° E. group, along which the main tunnel was driven. Near the tunnel mouth this fault is intersected by fault A, of the N. 75° W. group, and at this point the magnetic contour lines bend sharply southward. It was here that a small, high-grade ore body was found in 1937. A strong negative anomaly occurs at the Eickemeyer shaft and extends along fault A, at the locality where two ore shoots are now being developed. Broad positive anomalies occur north and south of this magnetic depression, and the depression may be partly a border phase of the positive anomalies, so that it may be only by chance that a negative anomaly occurs over the ore-bearing locality.

A strong linear anomaly enters the southwest corner of the magnetometer grid. It appears to mark a rock discontinuity of the N. 74° E. trend, and similar anomalies occur in the southeast and northeast corners of the grid. Near the crest of the anomaly in the northeast corner is an outcrop of basalt porphyry, and the anomaly is believed to be at least partly caused by a basalt dike, which was probably intruded along a fault of the N. 74° E. trend. A similar body of rock is believed to occur in the southeast corner on the Towner claim. Basalt also may accompany the trend in the southwest corner.

The southwest anomaly lies along the bottom of the small valley between the main hill and the northwest ridge.

In the southern part of the surveyed area a strong magnetic trough crosses the northwest corner of the Towner claim and culminates in a strong negative anomaly lying on the 1E grid line. The trend of this magnetically low sector appears to correspond with the general N. 40° E. fault trend. West of this trough is a broad, roughly circular positive anomaly, which may indicate the presence of a body of basaltic or andesitic rock. A somewhat similar positive anomaly lies to the north across the magnetic depression occurring along the trend of fault A.

A strong negative anomaly and a strong positive anomaly, which might be considered parts of a single anomaly, occur in the northwest reentrant of the grid. It is not certain whether they are related—whether, that is, they are parts of a single distortion of the magnetic field. The positive anomaly may indicate additional basaltic rock lying along the same trend as the basalt in the northeast corner. However, the two positive anomalies should be regarded separately, for a broad magnetic trough, which falls definitely within the N. 13° W. trend, lies between them across the northeast part of the area. This magnetic trough is bordered on the northeast by a sharp magnetic slope of the same trend, which forms a prominent intersection with the basalt anomaly in the northeast corner of the grid.

Suggestions for prospecting.--The magnetic results, as already indicated, being largely qualitative, it is not certain that ore will be found in connection with any given magnetic anomaly. This is especially true in the Maury Mountain locality, where most of the known ore occurs in small, high-grade bodies of apparently erratic distribution, and where a number of fault intersections already examined in the mine workings have not produced commercial amounts of ore. However, as fault intersections have unquestionably had an important influence on ore localization, as major faults and structural trends are difficult to distinguish in rock outcrops or small surface pits, and as the bedrock is covered in much of the area, especially the valley sectors, the magnetic results may prove useful as a guide to prospecting.

The magnetic measurements are made on the surface, at varying distances above the bedrock and bedrock structures. Most of the magnetic anomalies simply represent distortions in the earth's magnetic field produced by discontinuities in the underlying rock, and the strength, form, and extent of the distortion varies according to the nature of the rock discontinuity and the plane in which the readings are made. Locations determined from the magnetic readings are therefore only approximate, and surface prospecting should be done, where possible, by cross-cutting trenches rather than by single small pits. As a first approach, magnetic anomalies suggesting the intersections of faults that are known to carry cinnabar should be considered.

Along the projection of fault A, on which ore bodies occur at the Eickemeyer shaft, there is a sharp magnetic break just west of the mine road, at 0.5N-1.5E of the magnetometer grid. The projection of fault B, along with the main ore body was found in the Towner workings, falls approximately at this point. West of this point the magnetic contour lines fan out along the B trend and into the magnetic depression at the shaft, and positive anomalies occur to the northeast and southeast in a pattern suggesting a possible low-angle intersection of faults. It would appear that this magnetic break should be examined by prospecting.

Another possible low-angle intersection is suggested about 120 feet southeast of the mine road along the 1N grid line. Just northeast of this point a linear magnetic low is partly outlined on the east edge of the grid, trending about N. 38° W. along the projection of the fault at the east prospect, which strikes N. 38° W. and carries cinnabar. A fault zone of the C group, of N. 13° W. trend, is indicated in outcrops in the northern part of the grid, and a projection intersects the other trend approximately at the point suggested. This intersection, like the intersection at which the main ore body was found in the Towner workings, would belong to the B-C group. It is difficult to determine an exact point from the magnetic anomaly, but if there is an intersection here it probably lies southwest or west of the negative anomaly.

An intersection of faults of the N. 13° W. trend and the N. 74° E. trend is strongly suggested by the magnetic contour lines about 220 feet due east of the building housing the Eickemeyer retort. A basalt dike is believed to extend along the easterly trend near the east edge of the grid, although there is no indication that the dike has any economic significance. Faults of the N. 13° W. trend are known to be mineralized in places, as in the Towner workings and upper workings on the main hill, but the relation of faults of the N. 74° E. trend to the mineralized zones is less certain. This locality may be less favorable than the other two intersections indicated.

Although no relationship between basaltic rocks and ore bodies in the Maury Mountain area has been proved to exist, it might be worth while to look for the supposed basaltic dike on the Towner claim near the southeast corner of the grid, and to explore the rock discontinuities indicated by the strong magnetic anomalies in the southwest corner of the grid and in the northwest reentrant west of the Eickemeyer retort. The best points for exploration are difficult to determine, although a study of the magnetic anomaly and of certain fault trends suggests one point about 180 feet west of the retort. Similarly the strong magnetic trough north of the Towner house might be explored for faults and indications of rock alteration. Other and more positive prospecting localities, many of them perhaps marked by only minor magnetic disturbances, can no doubt be determined as exploration proceeds, but a detailed discussion of them is beyond the scope of this preliminary report.