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METALLIFEROUS MINERAL DEPOSITS OF THE CASCADE RANGE IN OREGON

BY

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AND

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METALLIFEROUS MINERAL DEPOSITS OF THE CASCADE RANGE IN OREGON

By EUGENE CALLAGHAN and A. F. BUDDINGTON

ABSTRACT

This report deals with a group of mineralized areas containing Tertiary veins of base metal and gold, which occur at intervals throughout the Cascade Range in Oregon. Gold was discovered in this region in 1858, only a few years after its discovery in southwestern Oregon, and an output of nearly $1,000,000, almost entirely in gold, has been recorded. The gold was mined largely from the weathered parts of the veins; placer production has been negligible. Other metalliferous deposits include nodules of native copper between lava flows, nodules of manganese oxides, and deposits of quicksilver along the western margin of the Cascade Range.

The Cascade Range in Oregon, south of Mount Hood, is from 30 to 70 miles wide throughout the length of the State, is deeply dissected and heavily forested, and is composed almost wholly of volcanic rocks. It is divided longitudinally into two subprovinces—the High Cascades and the Western Cascades. The High Cascades consist of a narrow strip along the east side of the range that contains numerous volcanic cones and remnants of cones, is composed of younger rocks, and is less dissected than the Western Cascades. The crest rises generally to altitudes of 5,000 to 6,000 feet, with volcanic peaks as much as 5,000 feet higher. The Western Cascades consist of a maturely dissected region of narrow, steep-walled ridges and valleys, with a dendritic stream pattern and with summits ranging roughly between 2,000 and 6,000 feet. This region contains all the mineral deposits that have been worked.

The Western Cascades are made up of lava flows and fragmental rocks that are believed to range in age from Eocene to Miocene, though most of the flows were probably erupted in Miocene time. Beds of arkose, conglomerate, and tuff or volcanic breccia of Eocene and Oligocene(?) age in the valleys of the Rogue River and Bear Creek occupy a relatively small area but are closely related structurally to the lavas that overlie them. The volcanic rocks of the Western Cascades have been placed in two divisions on the basis of the dominance of certain types of flows. Black lavas that include andesites, basalts, rhyolites, and fragmental rocks occur in two areas along the western margin of the range, one in southern Oregon in the drainage basin of the Rogue River and the other in the Willamette Valley. The remainder of the Western Cascades is characterized by gray dominantly andesitic lavas that include andesites in which the chief constituent is labradorite, andesine, or oligoclase, rhyolite, basalt, and abundant fragmental rocks. The black lavas in southern Oregon are known from evidence of fossil plants to range in age from Eocene to middle Miocene. The gray andesitic lavas interfinger with the black lavas

in places and are believed to be largely of Miocene age, though definite evidence is lacking.

The High Cascades are composed largely of flows that range in composition from olivine basalt to obsidian and rhyolite, though in most of the large cones the principal rock appears to be hypersthene andesite. Olivine basalt, which makes up long flows extending down valleys in the Western Cascades, is the most common rock along the western margin of the High Cascades. The bulk of the rocks of the High Cascades are known to be earlier than the last extensive period of glaciation (Wisconsin?) of the region, and it is believed that at least some of these rocks may be of Pliocene age, but again definite evidence is lacking.

A belt of small dioritic intrusive bodies, ranging in composition from diorite to granite and mostly fine-grained and porphyritic, extends throughout the length of the Western Cascades and coincides in general with the mineralized areas. Zones of hornfels of greatly varying width surround the intrusive bodies.

The volcanic rocks of the Western Cascades have been gently folded and faulted, though the amount of displacement is not known. Flows along the western margin of the range dip gently to the east or northeast as far north as the Santiam River but dip mainly to the northwest from that point to the Columbia River. Linear elements of the range include (1) the north-northwestward to north-northeastward trend of the range as a whole, (2) the belt of volcanic cones along the eastern margin of the range, (3) the belt of dioritic intrusive bodies through the range, (4) the chain of mineralized areas that largely coincide with the belt of intrusive bodies, and (5) the belt of quicksilver deposits along the western margin of the range. The elongate intrusive bodies and most of the veins in the mineralized areas, other than the quicksilver deposits, trend to the west or northwest.

The mineral deposits occur in fissure veins of probable upper Miocene age and are believed to be genetically related to the dioritic intrusive bodies. They are of the low-temperature and shallow-depth, or epithermal type, except those in the Bohemia district, which bear evidence of an initial high-temperature stage. Typical vein matter consists of altered brecciated country rock cemented with quartz that contains sphalerite, galena, chalcopyrite, and pyrite. Very minor amounts of tetrahedrite occur in some of the veins, bournonite was seen in one vein, arsenopyrite in two veins, and stibnite in several veins. Gold and silver occur in most of the sulphide ore, commonly in small amounts, but visible gold in dendrites and "wires" is present in weathered vein matter. Quartz and altered rock are the principal materials accompanying the sulphides, but other minerals occur, including calcite, dolomite, mesitite, ankerite, adularia, johannsenite, epidote, sericite, chlorite, clay minerals, barite, and both specular and red hematite. The variation in the proportions of some of the minerals permits distinction of several types of veins. Complex sulphide veins in which sphalerite predominates are the most abundant. In a few veins chalcopyrite is the dominant sulphide. A few quartz veins contain free gold without appreciable sulphides. Another group is characterized by a gangue of carbonate, chiefly calcite. Veins with stibnite in cherty quartz occur in the southwestern part of the Bohemia district. Wall rocks of the veins are altered to an aggregate of quartz, carbonate, and chlorite, to quartz, carbonate, and sericite, or to quartz and clay minerals. Pyrite occurs in almost all the altered rock.

Veins exposed to weathering and readily permeated by water are characteristically leached and iron-stained, and secondary sulphides in them are negli-

gible. In some of the veins gold remains as minute flakes, "wires", and dendrites. No secondary zinc minerals remain, and galena is represented by only very minor amounts of anglesite and cerusite, except in one vein. Secondary copper minerals include covellite, which forms films on chalcopyrite, chalcocite, which remains as a powder in some veins, a very little azurite, malachite, and chrysocolla. Pyrite is leached or changed to limonite.

Some of the veins are nearly a mile long, and a few of these contain several ore shoots that consist of brecciated country rock cemented with quartz and sulphides or of sulphide streaks in quartz. No definite evidence of change in the primary mineral composition with depth was found, but evidence of areal zoning was seen in the North Santiam and Bohemia districts. In the North Santiam district a central zone of chalcopyrite veins is surrounded by a zone of complex sulphide veins, which in turn is surrounded by carbonate veins. In the Bohemia district a central zone of large veins with abundant sulphides is surrounded by a zone of veins containing minor amounts of sulphides, and this zone in turn is surrounded by one with stibnite veins.

Of the several mineralized areas the Bohemia district is the largest, the most extensively developed, and the most productive. It has accounted for about two-thirds of the total output of the Western Cascades. It also has greater possibilities of future production than any of the others, as indicated by a moderate tonnage of sulphide ore with a little gold and silver exposed in a few of the mines and some shoots of sulphide ore exposed in prospects. Possibly with the present high prices for the precious metals and with an increase in prices for the base metals, some of these deposits may be worked profitably. Such veins as were seen in the Cheeney Creek area are very small and will probably not be extensively mined. Small shoots of sulphide ore, particularly chalcopyrite, are exposed in the North Santiam district, but their precious-metal content is so low that their exploitation should await favorable prices for the base metals. Probably some small pockets of gold ore remain in the Quartzville district, but no minable sulphide vein was seen by the writers. Aside from some sporadic sulphide-vein matter exposed in the Lucky Boy mine, no appreciable quantity of ore is exposed in the Blue River district. Little ore is exposed in the Fall Creek area, where only a few very small veins have been found in altered rock. There has been no output from the cherty quartz stringers and altered rock in the Oakridge area. Only one small prospect with minor amounts of sulphides has been opened at the Zinc locality on the South Umpqua River. In the Buzzard area of altered rock only one vein has been developed, but its output is valued at nearly $24,000, chiefly in gold. The deposit of native copper at the Grand Cove prospect is not a fissure vein but occurs in a breccia between lava flows. Prospecting has not been sufficiently extensive to reveal an appreciable deposit. Deposits of manganese oxides nearby were productive on a small scale during the World War. No metalliferous deposits are known in the Climax area. The single vein in the Barron area has been slightly productive.

INTRODUCTION

FIELD WORK AND ACKNOWLEDGMENTS

This report is based on an investigation which was part of a cooperative project financed jointly by the State of Oregon and the United States Geological Survey. The field work was carried on from June 20 to October 1, 1930, and from May 22 to August 21,

1931. During the first season the authors examined the Bohemia and North Santiam districts, assisted after the middle of July by H. E. Wheeler. Work in the Bohemia district, which included the preparation of a topographic base map representing an area of 22 square miles, occupied late June and all of July and August. Owing to the necessity for a reconnaissance of the other districts, the geologic map of the region was not completed in as much detail as is warranted by the scale, and only the broader geologic features are shown. A reconnaissance of the North Santiam district was made during early September, and before the end of the season Callaghan spent 9 days in a reconnaissance of the Blue River district, assisted for 2 days by Wheeler and for the remainder of the time by George Cox. During the season of 1931 Callaghan, assisted by T. P. Thayer, examined the remaining mineralized areas and made a reconnaissance of the entire region. The part of the report concerned with the Bohemia and North Santiam districts is the joint work of Buddington and Callaghan; the rest of the bulletin is by Callaghan. The description of the Buzzard mine is taken largely from the notes of P. J. Shenon, of the United States Geological Survey, who examined this mine in 1930.

The authors are greatly indebted to the prospectors and mine operators for aid and information. The local Forest Service officials furnished helpful cooperation. Profs. W. D. Smith, E. T. Hodge, and E. L. Packard, then at the University of Oregon, gave valuable suggestions and made accessible unpublished theses on the region. Prof. P. F. Kerr supplied X-ray tests of kaolinite, and W. T. Schaller, M. N. Short, and Miss Jewell J. Glass did work on some of the minerals. J. T. Pardee supervised the work and with G. F. Loughlin, T. B. Nolan, and H. G. Ferguson, read the manuscript critically. Mr. Loughlin also made many valuable suggestions in the field during the second season.

PREVIOUS WORK

Published reports on metalliferous deposits in the Cascade Range in Oregon are limited largely to the work of Diller, Kimball, and MacDonald. Diller [1] made a reconnaissance of the Bohemia district in July 1898, when prospecting and mining activity was very nearly at its height, and he obtained some information on the Blue River district. In 1902 Kimball [2] described some of the geologic features and development. Mineral deposits are briefly mentioned in the

[1] Diller, J. S., The Bohemia mining region of western Oregon, with notes on the Blue River mining region and on the structure and age of the Cascade Range: U. S. Geol. Survey 20th Ann. Rept., pt. 3, pp. 1–36, 1900.

[2] Kimball, J. P., Bohemia mining district of western Oregon: Eng. and Min. Jour., vol. 73, pp. 889–890, 1902.

report on the Cascade Range Forest Reserve.[3] MacDonald[4] visited the Bohemia district in August 1908 and gave a summary account of the geology and mining activity of that time. Eaton[5] published a short description of the workings of the Vesuvius Mines Co., in the Bohemia district. Diller[6] reviewed previous work on the Blue River and Bohemia districts in 1914 but made no new field investigations. Smith[7] briefly mentioned some of the rocks of the Bohemia district. Winchell[8] described briefly some of the features of the Barron mine, Jackson County. Pardee[9] described the manganese deposits in Jackson County. Williams[10] briefly noted some of the features of the Bohemia, Quartzville, North Santiam, and Cheeney Creek areas. Wells and Waters[11] have described the quicksilver deposits near the western margin of the range. A few brief statements concerning the mineral deposits appear in the discussion of the Cascade Range by Waters.[12] Brief accounts of some of the districts and various mines and claims are included in compilations by Stafford[13] and by Parks and Swartley.[14]

A thesis by Eaton[15] is chiefly valuable for maps of the Vesuvius mine, in the Bohemia district. McDaniel and Marshall[16] describe some features of the Treasure mine, in the Blue River district. A thesis by Ralph Tuck[17] on the Blue River district contains consider-

[3] Langille, H. D., Plummer, F. G., Dodwell, Arthur, Rixon, T. F., and Leiberg, J. B., Forest conditions in the Cascade Range Forest Reserve, Oreg.: U. S. Geol. Survey Prof. Paper 9, 1903.

[4] MacDonald, D. F., Notes on the Bohemia mining district, Oreg.; U. S. Geol. Survey Bull. 380, pp. 80–84, 1909.

[5] Eaton, W. M., Description of the properties of the Vesuvius Mines Co., Bohemia district, Oreg.; Oregon Engineer, vol. 1, no. 1, pp. 32–37, 1909.

[6] Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, pp. 25–30, 1914.

[7] Smith, W. D., A summary of the salient features of the geology of the Oregon Cascades: Oregon Univ. Bull., new ser., vol. 14, no. 16, pp. 36–37, 1917.

[8] Winchell, A. N., Petrology and mineral resources of Jackson and Josephine Counties, Oreg.: Mineral Resources of Oregon, vol. 1, no. 5, pp. 51 and 123, Oregon Bur. Mines and Geology, 1914.

[9] Pardee, J. T., Deposits of manganese ore in Montana, Utah, Oregon, and Washington: U. S. Geol. Survey Bull. 725, pp. 214–223, 1922.

[10] Williams, I. A., Mineral resources of the lower Columbia and Snake Rivers, in Columbia River and minor tributaries, Oregon: 73d Cong., 1st sess., H. Doc. 103, vol. 2, pp. 171–174. 1934.

[11] Wells, F. G., and Waters, A. C., Quicksilver deposits of southwestern Oregon: U. S. Geol. Survey Bull. 850, 58 pp., 1934.

[12] Waters, A. C., Summary of the sedimentary, tectonic, igneous, and metalliferous history of Washington and Oregon: Ore deposits of the Western States (Lindgren volume), p. 265, Am. Inst. Min. Met. Eng., 1933.

[13] Stafford, O. F., Mineral resources and mineral industries of Oregon: Oregon Univ. Bull., new ser., vol. 1, no. 4, 1904.

[14] Parks, H. M., and Swartley, A. M., Handbook of the mining industry of Oregon: Mineral Resources of Oregon, vol. 2, no. 4, Oregon Bur. Mines and Geology, 1916.

[15] Eaton, W. M., Vein structure of Fairview Peak, Bohemia, Lane, and Douglas Counties, Oreg. (Oregon Univ. thesis), 1909.

[16] McDaniel, D. L., and Marshall, C. L., Report on Treasure mine (Oregon Univ. thesis), 1911.

[17] Tuck, Ralph, The geology and ore deposits of the Blue River mining district (Oregon Univ. thesis), 1927.

able pertinent information on that area. Barnes and Butler[18] mention prospects west and southwest of Mount Hood. These unpublished theses were available in the library of the University of Oregon.

Some unpublished reports by mining engineers were available. Those by W. J. Elmer on the Vesuvius mine, by W. L. Heidenreich on the Champion and Musick mines, by F. G. Bartels and Dale Wyatt on the Champion, Musick, Helena, and Sunset groups in the Bohemia district, and by W. J. Elmendorf on the Crown and Santiam groups in the North Santiam district were particularly valuable.

SURFACE FEATURES

The Cascade Range in Oregon extends from the Columbia River to the California boundary, a distance of 250 miles. The width ranges between 30 and 70 miles. That part south of Mount Hood has been divided longitudinally into two physiographic subprovinces, which have been designated[19] Western Cascades and High Cascades (pl. 1).

The Western Cascades include the western and larger part of the range. Several features of this part are shown on plate 2. It is essentially a deeply dissected mass of Tertiary volcanic rocks. Summits rise to altitudes of 2,000 to 6,000 feet, and the relief ranges from 1,000 to 4,000 feet in a distance of 2 to 4 miles. No original upland surfaces are preserved, divides are sharp, and valleys are narrow (pl. 2). The stream pattern is dendritic, and the drainage is toward the west. The highest ridges form divides between the major drainage systems, and the subsidiary ridges slope toward the valleys. Valley walls are commonly steep, and cliffs occur in many places. Glaciation has modified the higher summits, cirques have been developed, and in the Bohemia district the distribution of morainal material indicates the former presence of short valley glaciers.

The High Cascades consist of a narrow belt along the east side of the range that is characterized by great volcanic cones and remnants of cones such as Mount Jefferson, the Three Sisters, and Diamond Peak. It contains numerous original volcanic surfaces somewhat modified by glaciation and several small cones and lava flows that are later than the last period of extensive glaciation in this region. The eastern slope merges into the plateau of central

[18] Barnes, F. F., and Butler, J. W., Structure and stratigraphy of the Columbia River Gorge and Cascade Mountains in the vicinity of Mount Hood (Oregon Univ. thesis), 1930.

[19] Callaghan, Eugene, Some features of the volcanic sequence in the Cascade Range in Oregon: Am. Geophys. Union Trans., 14th Ann. Meeting, p. 243, 1933; Some aspects of the geology of the Cascade Range in Oregon (abstract): Washington Acad. Sci. Jour., vol. 24, no. 4, pp. 190–191, 1934.

Oregon. Along the western margin flows have poured down the valleys in the Western Cascades for long distances (pl. 1). Although these long valley flows have been trenched by glaciers and streams, it is apparent that they are much younger than the rocks of the Western Cascades and were poured out after the drainage in that region was established.

CLIMATE AND VEGETATION

The Cascade Range has a humid climate. According to a map compiled by Army Engineers,[20] the average annual rainfall in the mineralized areas is about 70 inches. In the higher areas much of the precipitation is in the form of snow. In areas above 5,000 feet, such as the Bohemia district, the snow is reported to accumulate sometimes to depths of 30 feet. July and August are generally dry, and commonly the last half of June and the first half of September have little rain. The remainder of the year is potentially rainy, but there are occasional dry periods.

The Cascade Range is covered with dense forest and brush except small areas that include the part above timber line, lava flows not yet covered with soil, talus slopes, cliffs, and cultivated land along some of the rivers.

ACCESSIBILITY

Four standard highways—the Mount Hood Loop, McKenzie River, Crater Lake, and Ashland-Klamath Falls (Green Springs)—and the Southern Pacific Railroad cross the Cascade Range between Mount Hood and the California State line. Secondary roads follow most of the major streams. Some of the mineralized areas, including the North Santiam, Quartzville, Oakridge, Bohemia, Zinc, Buzzard, and Barron, can be reached directly by automobile during the dry season. The Cheeney Creek area is a little more than 2 miles from a road, the principal prospects of the Fall Creek district are about 8 miles by trail from the end of the Fall Creek-Portland Creek road, and most of the prospects of the Blue River district are about 5 miles from the end of the road on Quartz Creek. Numerous trails in the region are maintained by the Forest Service.

GEOLOGY

GENERAL FEATURES

The Cascade Range in Oregon is composed mainly of volcanic rocks with a very minor proportion of small dioritic intrusive bodies. The proportion of flows to fragmental rocks varies from place to

[20] Willamette River, Oregon: 72d Cong., 1st sess., H. Doc. 263, p. 21, 1932.

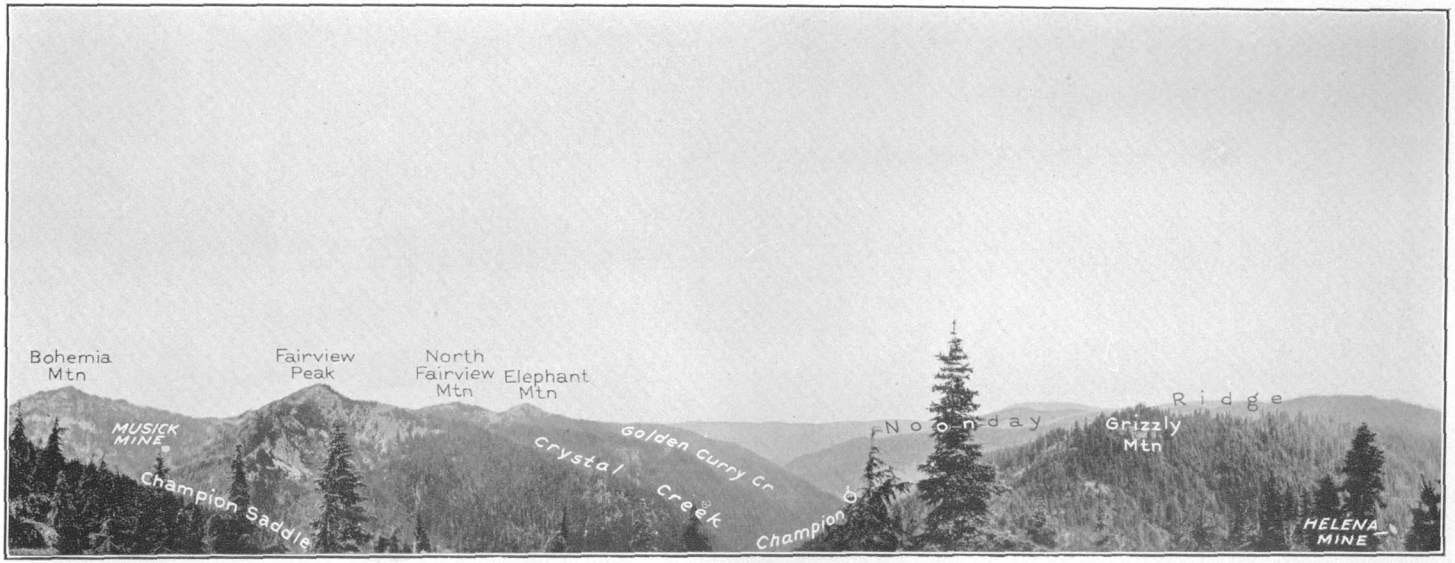
place. The area in the Rogue River and Bear Creek Valleys underlain by conglomerate, tuff, and volcanic breccia is included in the Cascade Range. Fluviatile and glacial deposits are of local significance only. These rocks range in age from Eocene to Recent(?), with probably every epoch of the Cenozoic represented. With the exception of references to the literature, this discussion concerns only the area from Cheeney Creek southward to the California State line.

Most if not all of the volcanic rocks of the High Cascades are believed to be younger than those of the Western Cascades, where flows that antedate the last period of extensive glaciation partly fill valleys. Constructional volcanic surfaces are preserved in the High Cascades but are mostly if not completely lacking in the Western Cascades. The High Cascades contain flows that were deeply trenched during the last (Wisconsin?) period of extensive glaciation and flows that are later than this glaciation. They are thus definitely both Recent and Pleistocene and are believed to extend back into the Pliocene, though there is no direct evidence.

Insufficient data were obtained by the writers to divide the volcanic rocks of the Western Cascades into definite formations, but for convenience the rocks have been divided into two groups on the basis of types of flows. Their approximate distribution is shown in plate 1. One group is characterized by extensive black stratified flows. The rocks appear to be mostly labradorite andesites, but associated with these are basalt, gray labradorite andesite, rhyolite, red breccias, and gray tuffs and breccias. The other group is characterized by gray andesite, a large part of which is of the labradorite or basaltic variety. Most of the flows are lenticular and do not have the regular-bedded appearance of the black lavas. They are associated with volcanic tuff and breccia and flows of basalt and rhyolite in large proportions. The proportion of flows to fragmental rocks and the relative proportions of the different kinds of flows vary from place to place. The age of these rocks is not definitely known. The black lavas and associated rocks in Jackson County are believed by Chaney [21] to range from Eocene to at least middle Miocene, for he has made collections of plants of Clarno (late Eocene and early Oligocene), later Oligocene, and Mascall (middle Miocene) age. Sedimentary rocks underlying the black lavas in the Rogue River and Bear Creek Valleys were correlated by Diller [22] with the Umpqua formation, of the Eocene. Black

[21] Chaney, R. W., Suggestions regarding the age of the southern Cascade Range [abstract]: Pan.-Am. Geologist, vol. 51, no. 5, pp. 366–367, 1929; personal communication.

[22] Diller, J. S., and others, Guidebook of the western United States, part D, The Shasta Route and Coast Line: U. S. Geol. Survey Bull. 614, p. 51, 1916. Diller, J. S., and Kay, G. F., U. S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), p. 4, 1924. Diller, J. S., The Rogue River Valley coal field, Oreg.: U. S. Geol. Survey Bull. 341, p. 405, 1909.



PANORAMIC VIEW TAKEN THROUGH ARC OF 165° IN A NORTHERLY DIRECTION FROM SUMMIT OF NORTH GROUSE MOUNTAIN, IN BOHEMIA DISTRICT.

Shows many of the characteristic surface features of the Western Cascades. A rough accordance of ridge tops may be noted. Noonday Ridge is typical of the long ridges sloping toward the valleys of the major streams. In the center short ridges slope gently, then break off abruptly into the very narrow valley of Champion Creek. The sharp peaks that rise above the general level stand out largely because they are composed of a series of flows without intervening tuff or volcanic breccia beds. Glacial cirques are visible in the area between Bohemia Mountain and Fairview Peak and on the east slope of Fairview Peak. Heavy forest cover is common to all the mineralized areas north of the Rogue River.

lavas east of the Willamette Valley rest upon marine sedimentary rocks of middle Oligocene age.[23] No identifiable fossils have been found within the area of the gray andesitic lavas except a few that were collected on Coal Creek southeast of the Bohemia district.[24] In the vicinity of the Rogue River the gray andesitic lavas appear to interfinger with the black lavas, but farther north they appear to be higher stratigraphically than the black lavas. Andesites in the vicinity of Blackbutte and Elkhead, according to Wells and Waters,[25] make up the upper part of the Calapooya formation, of Eocene (?) age, which lies unconformably upon the Eocene Umpqua formation. Andesite, basalt, and rhyolite belonging to the gray-andesite group are represented by Diller [26] as lying unconformably upon the Umpqua formation. These rocks have been deformed, intruded, altered, deeply eroded, and glaciated. It appears from this scant evidence that the gray andesitic rocks are probably in large part Miocene but possibly include rocks of several ages.

In the North Santiam River region Thayer [26a] has recently divided these major units into a number of formations. He has called the black lavas of the western margin of the Cascade Range the Stayton lavas, and he found that they overlie his marine Illahe formation of middle Oligocene age which grades eastward into his Mehama volcanics, chiefly pyroclastic rocks. Thayer's Stayton lavas are overlain by his Fern Ridge tuffs and conglomerates, and lens out to the east, but his Mehama volcanics and Fern Ridge formation grade by increase in proportion of andesite flows into his Sardine series of Miocene age. The latter "series" composes the bulk of the section between Mill City and Detroit, and represents much of the gray andesitic lavas of the Western Cascades in this region. An anticlinal fold brings up pyroclastic rocks termed "Breitenbush series", of Oligocene-Eocene ? age, which disappear under much younger formations of the High Cascades. Younger formations believed by Thayer to be Pliocene and Pleistocene include rocks which he designates Outerson basalts, undifferentiated young lavas, Minto basalts, Battle Ax basalts, Santiam basalts, and Olallie lavas.

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[23] Schenck, H. G., Stratigraphic relations of western Oregon Oligocene formations: California Univ., Dept. Geol. Sci., Bull., vol. 18, no. 1, p. 10, 1928.

[24] Diller, J. S., The Bohemia mining region of western Oregon, with notes on the Blue River mining region and on the structure and age of the Cascade Range: U. S. Geol. Survey 20th Ann. Rept., pt. 3, p. 34, 1900.

[25] Wells, F. G., and Waters, A. C., Quicksilver deposits of southwestern Oregon: U. S. Geol. Survey Bull. 850, pp. 11–17, 1934; Basaltic rocks in the Umpqua formation: Geol. Soc. America Bull., vol. 48, p. 963, 1935.

[26] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Roseburg folio (no. 49), structure-section sheet, 1898.

[26a] Thayer, T. P., Structure of the North Santiam River section of the Cascade Mountains in Oregon: Jour. Geology, vol. 44, pp. 701–716, 1936.

SEDIMENTARY ROCKS OF THE ROGUE RIVER AND BEAR CREEK VALLEYS

Arkose, conglomerate, tuff, and volcanic breccia underlie the greater part of the broad valley drained by Bear Creek and the Rogue River in Jackson County and lie between fossilferous Cretaceous arkoses and conglomerates and the black lavas. Their approximate distribution is outlined in plate 1. The lower part of the formation is arkosic and contains lenses of conglomerate with quartzite boulders and pebbles and some granodiorite pebbles. This material grades upward into beds made up almost wholly of tuffs and volcanic breccias. The upper part contains black lava flows and grades into the black-lava series. Some coal beds occur in the upper part.[27] No metalliferous deposits except quicksilver [28] occur in these rocks, though they are intruded by several dioritic bodies.

BLACK LAVAS OF THE WESTERN MARGIN OF THE CASCADE RANGE

The black lavas extend southward from the South Umpqua River to the California State line and make up the greater part of the Cascade Range south of the Rogue River that is not covered with olivine basalts and other rocks of the High Cascades. They also occur along the western margin of the range in the Willamette Valley from the vicinity of Cottage Grove northward to the vicinity of Silverton.

The outstanding feature of this group of rocks is the occurrence of thin flows that extend over large areas, imparting a stratified appearance to the rock masses in which they occur. Most of these thin flows are black because they contain glass, but most of the rocks studied were labradorite andesite rather than basalt. These flows are interbedded with tuffs and agglomerates and are associated with numerous flows of rhyolite, some basalt, and some gray andesite. Many of the black flows are separated by reddish breccias, as at the Grand Cove prospect, but greenish-gray tuffs and breccias occur in many places, as at the Barron mine. Thinly laminated beds, evidently water-laid, occur between flows in some places, as along the Ashland-Klamath Falls highway southeast of Ashland. Oil shale is associated with rhyolite northeast of Ashland.

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[27] Diller, J. S., The Rogue River Valley coal field, Oreg.: U. S. Geol. Survey Bull. 341, pp. 401–405, 1909; Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, pp. 140–141, 1914. Winchell, A. N., Petrology and mineral resources of Jackson and Josephine Counties, Oreg.: Mineral Resources of Oregon, vol. 1, no. 5, pp. 107–111, Oregon Bur. Mines and Geology, 1914.

[28] Wells, F. G., and Waters, A. C., Quicksilver deposits of southwestern Oregon: U. S. Geol. Survey Bull. 850, pp. 50–56, 1934.

In southern Oregon this group of rocks appears to be at least 7,000 feet thick and may be much thicker. It pinches out toward the north and appears to interfinger with the gray labradorite andesites, suggesting a contemporaneous age for at least part of the group. The maximum thickness of the group along the east side of the Willamette Valley is unknown.

In southern Oregon the Barron mine, the aragonite vein of Climax, the manganese deposits on Lake Creek, and the native copper at the Grand Cove prospect occur in the black lavas. No mineral deposits have been recognized in the area of black lavas along the east side of the Willamette Valley.

GRAY ANDESITIC LAVAS AND ASSOCIATED ROCKS OF THE WESTERN CASCADES

GENERAL FEATURES

The area occupied by the gray andesitic lavas extends from the Rogue River northward to the limits of the area under discussion. These lavas terminate on the east against the overlapping and abutting flows of the younger High Cascades almost as far north as Mount Hood. On the west they interfinger with or grade into the black lavas or extend to the western margin of the range, as in the area between the South Umpqua River and Cottage Grove and in the area northeast of Silverton. On the south they appear to interfinger with the black lavas, indicating an age contemporaneous with at least part of that series. Their relations to the Cascade andesite [29] of the Columbia River area were not established.

These rocks range from basalt to rhyolite but are characterized by andesite. A large part of the andesite is very calcic and is close to the borderline between basalt and andesite. It is designated labradorite andesite to indicate its calcic character but might also be called basaltic andesite. Augite is the principal ferromagnesian mineral in these rocks, and hypersthene is rare, though in many places it may be represented by chlorite aggregates. The next most common type is more normal augite andesite, which is characterized by andesine and oligoclase rather than by labradorite or bytownite. Hypersthene andesite, in which hypersthene is more abundant than augite, was found only in the North Santiam area. Some of the more sodic andesite contains hornblende, and some contains quartz phenocrysts and may be properly designated dacite. Rhyolite occurs in many places in the Western Cascades but makes up only

[29] Williams, I. A. The Columbia River Gorge, its geologic history interpreted from the Columbia River Highway: Mineral Resources of Oregon, vol. 2, no. 3, pp. 117, 121, 122, 124, Oregon Bur. Mines and Geology, 1916. Barnes, F. F., and Butler, J. W., op. cit. (Oregon Univ. thesis). Hodge, E. T., Columbia River fault: Geol. Soc. America Bull., vol. 42, pp. 965–967, 1931.

a small proportion of the total mass of igneous rocks. Some of the basalt is difficult to distinguish from the labradorite andesite, particularly where olivine is subordinate or lacking, but some small areas of olivine basalt were found, as at Galena Mountain, in the North Santiam district, and on the mountain northwest of Nimrod, on the McKenzie River. Fragmental rocks are associated with the flows in almost all areas and make up more than half the bulk of rock in many places. They are chiefly volcanic breccias that vary widely in size of fragments.[30]

The structure of the volcanic breccias is extremely irregular as compared with that of the black lavas. The flows vary greatly in thickness and can be traced for only short distances. They appear to have been derived from many local vents, with a consequent intermingling of flows from different vents, and have a wide variety of dips.

The area occupied by these rocks includes most of the mineral deposits, hence it is believed that a discussion of some of the details of petrography is warranted. More detailed description, analyses, and discussion appear elsewhere.[31]

BASALT

Those rocks in which the mafic or dark constituents and felsic or light constituents occur in about equal amounts [32] were found in many places in the Western Cascades. The basalt on Galena Mountain, in the southern part of the Quartzville district, is dark gray and vesicular. It contains labradorite phenocrysts as much as 10 millimeters in length and abundant olivine phenocrysts. The groundmass consists of minute grains of plagioclase, augite, and a little brown glass. The basalt northwest of Nimrod, on the McKenzie River, is nearly equigranular and consists of lath-shaped plagioclase, augite, and olivine. The basaltic rocks northeast of Gold Hill, in the Blue River district, consist of abundant augite, chlorite pseudomorphs after olivine, and fine plagioclase laths. Some of the flows making up the mountains on the east front of the Western Cascades near Fish Lake in Linn County are basalt. Undoubtedly many other true basalts will be found in this group of rocks.

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[30] Wentworth, C. K., and Williams, Howel, The classification and terminology of the pyroclastic rocks: Nat. Research Council Bull. 89, pp. 45–46, 1932.

[31] Callaghan, Eugene, Some features of the volcanic sequence in the Cascade Range in Oregon: Am. Geophys. Union Trans. 14th Ann. Meeting, pp. 243–249, 1933. Buddington, A. F., and Callaghan, Eugene, Dioritic intrusive rocks and contact metamorphism in the Cascade Range in Oregon: Am. Jour. Sci., 5th ser., vol. 31, p. 442, 1936. Thayer, T. P., Petrology of later Tertiary and Quaternary rocks of the north-central Cascade Mountains in Oregon, with notes on similar rocks in western Nevada: Geol. Soc. America Bull., vol. 48, pp. 1611–1651, 1937.

[32] Tyrrell, G. W., The principles of petrology, p. 126, London, Methuen & Co., Ltd., 1926.

LABRADORITE ANDESITE (BASALTIC ANDESITE)

The term labradorite andesite (basaltic andesite) is used to designate the rocks that are near the border line in mineral and chemical composition between basalt and andesite. They have approximately the five-eighths of felsic constituents regarded as necessary for classification as andesite [32] and are saturated with silica, yet are very calcic. They occur in flows a few feet to 100 feet in thickness. The labradorite andesites are dark rocks ranging from medium gray to nearly black. Nearly all are porphyritic, and many are amygdular and vesicular. Plagioclase, chiefly labradorite and bytownite, makes up the greater part of these rocks and occurs both as phenocrysts and in the groundmass. Augite, the principal ferromagnesian mineral, also accurs both as phenocrysts and in the groundmass. Hypersthene is rarely observed in these rocks, but in places it may be represented by chlorite pseudomorphs. Olivine was observed in only one flow assigned to this group, but it is represented by pseudomorphs in some flows. Magnetite and apatite are the principal accessory minerals. The primary minerals are commonly altered to a variable extent. Feldspars contain secondary feldspar, chlorite, sericite, quartz, epidote, carbonate, and kaolin minerals. Augite and hypersthene may be altered to uralite but chiefly to chlorite. Some of the amygdules contain chlorite, carbonate, and epidote.

NORMAL ANDESITE

The normal andesites include those rocks that are intermediate between labradorite andesite and rhyolite. Most of them are medium to light gray and porphyritic. Many have a platy structure on the weathered surface, and those that approach rhyolite in composition show flow banding in many places. The plagioclase is chiefly andesine, but oligoclase is abundant in some areas. Augite is the principal ferromagnesian mineral, but hornblende was found in a few flows. Quartz phenocrysts occur in some specimens, and these might properly be called dacite. Magnetite is the principal accessory mineral. The groundmass is extremely fine in most specimens. In all the mining districts these rocks are altered to a greater extent than the more calcic labradorite andesites. Feldspar phenocrysts are commonly mottled with a more sodic feldspar than the original phenocryst. Sericite, chlorite, and epidote are commonly abundant, and quartz and carbonate appear in many specimens.

Andesites containing appreciable quantities of hypersthene were noted in the North Santiam district in or near the highest points on the divide north of the Little North Santiam River. These rocks are dark gray or black and consist of phenocrysts of labradorite, hyper-

[32] Tyrrell, G. W., The principles of petrology, p. 126, London, Methuen & Co., Ltd., 1926.

sthene, augite, and magnetite in a very fine grained groundmass of the same minerals and brown glass. Hypersthene exceeds augite in abundance in the phenocrysts. Most of these rocks are unaltered.

RHYOLITE

The most siliceous gray andesitic lavas are designated rhyolite, though they contain a relatively small proportion of potash. Large masses occur in the Bohemia, Blue River, Quartzville, and North Santiam districts, along the South Santiam River east of Cascadia, along the Middle Fork of the Willamette River, and along Salt Creek southeast of Oakridge. Small flows occur in many other places throughout the area of andesitic rocks. Most of these rocks are characterized by light color and flow banding. Most are light gray, some are red because of red iron oxide, and some that contain glass are brownish. Spherulites occur in some flows. Scattered phenocrysts of plagioclase, chiefly oligoclase, some andesine, occur in an extremely fine grained groundmass. Original glass was devitrified in all samples examined. Original ferromagnesian minerals have been completely destroyed and are represented by chlorite pseudomorphs in nearly all flows. Hornblende occurs in glassy rhyolite in the North Santiam district. Magnetite occurs as phenocrysts and as small grains in the groundmass. The rhyolites are generally more altered than the associated calcic rocks and commonly contain abundant sericite, carbonate, and chlorite.

FRAGMENTAL ROCKS

The fragmental or pyroclastic rocks are consolidated masses of fragments of volcanic rocks largely ejected from volcanic vents. They make up one-tenth to nine-tenths of the section at various points throughout the andesitic series. They are present in all the mineralized areas, and many of the mines and prospects lie within them. They are generally designated tuff, though the fragments range in diameter from several feet to 4 millimeters and less. According to the classification of Wentworth and Williams [83] the upper limit of size of grain for tuff is 4 millimeters. Probably most of this material would be properly designated volcanic breccia or tuff-breccia. According to the classification noted above some true agglomerates may be recognized. The red breccias characteristically associated with the black flows or with the olivine basalts are absent. The tuffs or volcanic breccias in general are greenish gray but may contain fragments of various colors. The degree of sorting and

[83] Wentworth, C. K., and Williams, Howel, The classification and terminology of the pyroclastic rocks: Nat. Research Council Bull. 89, pp. 45–51, 1932.

stratification is extremely variable even within small areas. Much of this material lacks recognizable bedding, but some of it is finely laminated and contains plant remains. None of the fossils found by the writers, however, were identifiable. Crystal fragments of oligoclase and very fine grained rock fragments are cemented together with chlorite and carbonate. The greenish color of the rock is largely due to the chlorite.

LAVAS AND ASSOCIATED ROCKS OF THE HIGH CASCADES

As the High Cascades are not known to contain metalliferous mineral deposits, the rocks composing them were not studied except along the western margin. From incidental observations of the writers and from the studies of other workers [34] it appears that the large cones and perhaps many of the smaller ones are composed principally of hypersthene andesite with minor amounts of vitrophyre, obsidian, rhyolite, dacite, trachyte, andesite, and basalt. Postglacial flows of olivine basalt occur in the Three Sisters area. A postglacial eruption of Mount Mazama, on which lies Crater Lake, covered a large part of central Oregon with pumice, and the latest material erupted there was the andesite of Wizard Island.

The rock having the greatest significance for this discussion is olivine basalt, which extends southward along the western margin of the High Cascades from Clear Lake, in Wasco County, south of Mount Hood, at least as far as the highway between Ashland and Klamath Falls, near the California State line, and probably farther. It makes up the plateaulike surface of the range east of Ashland, in Jackson County, as well as the great lava tongues that extend from the High Cascades down the valleys into the Western Cascades.

[34] Hague, Arnold, and Iddings, J. P., Notes on the volcanoes of northern California, Oregon, and Washington Territory: Am. Jour. Sci., 3d ser., vol. 26, pp. 225–230, 1883. Diller, J. S., Fulgurite from Mount Thielsen: Am. Jour. Sci., 3d ser., vol. 28, pp. 252–258, 1884. Diller, J. S., and Patton, H. B., The geology and petrography of Crater Lake National Park: U. S. Geol. Survey Prof. Paper 3, pp. 1–167, 1902. Hodge, E. T., Geology of Mount Jefferson: Mazama, Ann. Ser., vol. 7, no. 2, pp. 25–58, 1925; Mount Multnomah ancient ancestor of the Three Sisters: Oregon Univ. Pub., vol. 3, no. 2, pp. 1–160, 1925. Williams, Howel, Mount Thielsen, a dissected Cascade volcano: California Univ., Dept. Geol. Sci., Bull., vol. 23, no. 6, pp. 195–213, 1933; Newberry volcano of central Oregon: Geol. Soc. America Bull., vol. 46, no. 2, pp. 253–304, 1935. Moore, B. N., Deposits of possible nuée ardente origin in the Crater Lake region, Oregon: Jour. Geology, vol. 42, no. 4, pp. 358–375, 1934. Russell, I. C., Preliminary report on the geology and water resources of central Oregon: U. S. Geol. Survey Bull. 252, pp. 94–97, 1905. Williams, I. A., Some little-known scenic pleasure places in the Cascade Range in Oregon: Mineral Resources of Oregon, vol. 2, no. 1, pp. 1–114, Oregon Bur. Mines and Geology, 1916. Hodge, E. T., Progress in Oregon geology since 1925: Northwest Sci., vol. 6, no. 2, pp. 44–53, 1932. Chaney, R. W., Central Oregon: 16th Internat. Geol. Cong. Guidebook 21, pp. 1–14, 1932. Thayer, T. P., Structure of the North Santiam River section of the Cascade Mountains in Oregon: Jour. Geology, vol. 44, pp. 701–716, 1936; Petrology of later Tertiary and Quaternary rocks of the north-central Cascade Mountains in Oregon, with notes on similar rocks in western Nevada: Geol. Soc. America Bull., vol. 48, pp. 1611–1651, 1937.

(See pl. 1.) These tongues or canyon flows are particularly well shown in the valleys of Butte Creek, the Rogue River,[35] the North Umpqua River,[36] Salt Creek and the North Fork of the Middle Fork of the Willamette River, and to a lesser extent in valleys of the McKenzie and North Santiam Rivers. Probably not all are of the same age. Most of them have been deeply trenched by glaciation and by streams. Where devoid of glass the olivine basalt is commonly medium or light gray, but glassy specimens are dark gray or black. Some of the basalt is porous and friable; some is nearly equigranular, but some is porphyritic. The rock consists of calcic labradorite or bytownite, augite, olivine, and magnetite, with brown glass in some places. In some specimens the augite is poikilitic and includes the feldspar aggregate. These rocks show almost no sign of alteration.

DIORITIC INTRUSIVE ROCKS AND CONTACT METAMORPHISM IN THE WESTERN CASCADES

Small intrusive bodies of dominantly dioritic rocks occur throughout the Western Cascades from Frazier Mountain, on the Columbia River, to Sampson Creek, near the California State line. Most of them appear to be restricted to a narrow belt that coincides with the belt of mineralized areas except south of the South Umpqua River. They are believed to have a genetic relationship to the mineral deposits, though not all the intrusives have associated mineralized areas. The detailed description of these rocks and the accompanying contact-metamorphic rocks has been recorded elsewhere.[37]

The intrusive bodies occur in clusters in the mining districts, and there may be considerable variation in appearance and composition in different bodies or within the same body. These bodies range in shape and size from dikes a few feet wide to the stock on the McKenzie River, which is roughly 2½ miles long and 1½ miles wide. Most of the elongate bodies trend to the west or northwest, or in approximately the same direction as the veins.

Structure and texture vary in different bodies and within the same body. All the intrusive rocks are porphyritic. The smaller and more isolated dikes commonly have scattered phenocrysts in a fine-grained lithoidal groundmass. In the larger bodies the proportion of pheno-

[35] Jones, B. E., Oakey, Warren, and Stearns, H. T., Water-power resources of the Rogue River drainage basin, Oreg.: U. S. Geol. Survey Water-Supply Paper 638, pp. 43, 76, 1932.

[36] Jones, B. E., and Stearns, H. T., Water-power resources of the Umpqua River and its tributaries, Oreg.: U. S. Geol. Survey Water-Supply Paper 636, pp. 233, 263–273, 1930.

[37] Buddington, A. F., and Callaghan, Eugene, Dioritic intrusive rocks and contact metamorphism in the Cascade Range in Oregon: Am. Jour. Sci., 5th ser., vol. 31, pp. 421–449, 1936.

crysts is so great as to give the rock a granitoid appearance. Also in some of the bodies the crystals in the groundmass are so large that the rock is fine granular and nearly even grained, with a few scattered phenocrysts, as in the granite body at Nimrod, on the McKenzie River.

The plagioclase in the intrusive rocks is generally andesine, but in one of the bodies in Jackson County it is labradorite, and in the large granite body at Nimrod it is oligoclase in combination with orthoclase. Augite is the principal ferromagnesian mineral in most of the intrusive bodies. Hypersthene occurs sparingly in a large number and exceeds augite in abundance in the most calcic body. Hornblende occurs sparingly in some of the intrusives and appears to have formed from pyroxene in most places. Biotite is the only ferromagnesian mineral in the center of the large body on the McKenzie River. Magnetite occurs both as large and small grains. Quartz occurs in greatly varying amounts in nearly all masses. In most bodies it is interstitial to the feldspars, but in some places it occurs as equant grains. Orthoclase is interstitial to the plagioclase or occurs as veinlets and irregular replacement bodies in the plagioclase. Nearly all the dioritic rocks are partly altered. Uralite, chlorite, and sericite are the common alteration products.

Six specimens from the Bohemia district that were analyzed chemically range from 52.67 to 65.7 percent SiO_2, 14.29 to 17.36 percent Al_2O_3, 2.08 to 3.57 percent Fe_2O_3, 2.85 to 5.14 percent FeO, 2.15 to 5.06 percent MgO, 4.13 to 8.80 percent CaO, 0.73 to 2.42 percent K_2O, and 3.06 to 3.65 percent Na_2O. Fine-grained varieties are called dacite porphyry; granitoid calcic varieties are called porphyritic diorite; and more silicic varieties are called granodiorite, granodiorite porphyry, or granite.

Aureoles or zones of contact-metamorphic rocks occur around all the intrusive bodies and range in width from a few inches to 2,000 feet or more. Contact metamorphism is not necessarily confined to the immediate contact of the intrusive rocks with the country rock but also occurs along fractures, indicating the effect of hot solutions escaping from the intrusive magma. In general, the effect decreases with distance from the intrusive. In some places the intrusive body is not exposed in the contact-metamorphic area but probably lies a short distance below it.

Contact metamorphism has affected all types of country rock, producing almost imperceptible changes in some and completely obliterating the original structure and minerals in others. The chief effect is silicification, which was accompanied by the formation of one or several of the minerals tourmaline, sericite, sodic and potassic feldspar, epidote, chlorite, specular hematite, magnetite, and pyrite.

Most of the more thoroughly metamorphosed rock is dark gray or black, but some is light gray. Much of the metamorphic rock is a tough flinty hornfels.

The structure and texture vary from place to place and with degree of metamorphism. Quartz and sericite are generally very fine grained, though conspicuous terminated quartz crystals have been found lining cavities in tourmaline hornfels. Tourmaline lines fractures or occurs as rosettes or spherulitic masses as much as 30 millimeters in diameter. Magnetite veinlets occur in hornfels in the Bohemia district. Nodules of contact minerals occur in some places and may consist of specular hematite surrounded by epidote, by epidote and chlorite, by epidote, chlorite, and pyrite, or by pyrite and chlorite. The different varieties of hornfels are designated by the dominant contact mineral.

STRUCTURE

The structure of the Cascade Range in Oregon is only vaguely known, partly because of the lack of extensive detailed geologic work, partly because of the difficulty of recognizing structure due to deformation in the flows, particularly in the gray andesitic series, and partly because of the dense forest and detrital cover. However, such information as is available is summarized below. The volcanic rocks of the Western Cascades were deformed, probably in late Miocene time, by tilting, very broad folding, and minor normal faulting. No overthrusts, reverse faults, recumbent folds, or any other indications of a high compression have been found. The younger High Cascades, on the other hand, do not appear to have been deformed to any appreciable extent, though one of the writers, in an airplane flight across the area of youthful volcanic cones south of Crater Lake, saw traces of three faults.

The most readily recognized structural feature is the gentle eastward or northeastward dip of the flows along the western margin of the range from Bear Creek Valley, in Jackson County, northward to the Santiam River, where the dip changes to the northwest and continues in this direction to the Columbia River. This feature has been recognized by almost all investigators.[38] So far as the

[38] Diller, J. S., The Rogue River Valley coal field, Oreg.: U. S. Geol. Survey Bull. 341, p. 402, 1909; Guidebook of the western United States, pt. D, The Shasta Route and Coast Line: U. S. Geol. Survey Bull. 614, p. 51, 1915. Washburne, C. W., Reconnaissance of the geology and oil prospects of northwestern Oregon: U. S. Geol. Survey Bull. 590, pp. 79–80, 90–91, 99, 1914. William, I. A., The Columbia River Gorge, its geologic history interpreted from the Columbia River Highway: Mineral Resources of Oregon, vol. 2, no. 3, p. 36, Oregon Bur. Mines and Geology, 1916. Smith, W. D., A summary of the salient features of the geology of the Oregon Cascades: Oregon Univ. Bull., new ser., vol. 14, no. 16, pp. 26, 45, 1917. Harrison & Eaton [firm]. Report on investigation of oil and gas possibilities of western Oregon: Mineral Resources of Oregon, vol. 3, no. 1, p. 15, Oregon Bur. Mines and

writers could determine this eastward or northeastward dip is maintained throughout the area of black lavas in the southern part of the range. It is also maintained as far east as the Zinc prospect, the South Umpqua River, and the Bohemia district. In the central and eastern part of the Western Cascades between the Middle Fork of the Willamette River and the North Santiam district no definite structural trends were ascertained. Hodge [39] states that there is an anticline in the valley of the South Santiam River. Steeply tilted beds of tuff in the vicinity of Detroit, on the North Santiam and Breitenbush Rivers, have been noted by Hodge [39] and Piper [40] and were mapped by Thayer.[41] Thayer[41a] found broad folds that have a northeasterly trend along the North Santiam River in the Western Cascades. From west to east these folds are the Willamette syncline, Mehama anticline, Sardine syncline, and Breitenbush anticline. Thayer also postulates an eastward-dipping fault between the High Cascades and the Western Cascades. The more distinct and steeper folds in the Columbia River lava on the Columbia River have been noted by other investigators.[42] Hodge [43] showed several folds and faults that have a roughly eastward trend in the area between Bend and the Columbia River and disappear under the lavas of the High Cascades. Diller [44] suggested that the major drainage divides, particularly the Calapooya Mountains, which separate the Umpqua and Willamette drainage systems, are anticlinal warps athwart the trend of the range, but no supporting evidence was obtained by the writers. Though many faults were seen in the Western Cascades, lack of marker beds prevented determination of the amount of displacement. So far as is known none of the faults are large. Though there has been some postmineral movement along the frac-

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Geology, 1920. Hodge, E. T., Framework of Cascade Mountains in Oregon: Pan-Am. Geologist, vol. 49, no. 5, pp. 346, 354–355, 1928; Progress in Oregon geology since 1925: Northwest Sci., vol. 6, p. 47, 1932. Barnes, F. D., and Butler, J. W., Structure and stratigraphy of the Columbia River gorge and Cascade Mountains in the vicinity of Mount Hood (Oregon Univ. thesis), 1930.

[39] Hodge, E. T., Framework of Cascade Mountains in Oregon: Pan-Am. Geologist, vol. 49, no. 5, p. 346, 1928.

[40] Piper, A. M., Water resources of Willamette Valley and other unpublished reports on dam sites in files of U. S. Geological Survey.

[41] Thayer, T. P., The general geology of the North Santiam River section of the Oregon Cascades (California Inst. Technology thesis), 1934.

[41a] Thayer, T. P., Structure of the North Santiam River section of the Cascade Mountains in Oregon: Jour. Geology, vol. 44, pp. 701–716, 1936.

[42] Williams, I. A., The Columbia River gorge, its geologic history interpreted from the Columbia River Highway: Mineral Resources of Oregon, vol. 2, no. 3, pp. 117–122, Oregon Bur. Mines and Geology, 1916. Hodge, E. T., Columbia River fault: Geol. Soc. America, Bull., vol. 42, pp. 923–984, 1931; Geological map of north-central Oregon: Oregon Univ. Pub., vol. 1, no. 5, p. 7, 1932. Piper, A. M., Geology and ground-water resources of The Dalles region, Oreg.: U. S. Geol. Survey Water-Supply Paper 659, pp. 134–140, 1932.

[43] Hodge, E. T., op. cit. (geological map), p. 7.

[44] Diller, J. S., The Bohemia mining region of western Oregon, with notes on the Blue River mining region and on the structure and age of the Cascade Range: U. S. Geol. Survey 20th Ann. Rept., pt. 3, pp. 10–11, 1900.

tures occupied by the veins, no definite offsetting of veins along faults has been recognized.

Of more interest are the linear elements of the range, which serve to distinguish it from contiguous areas of similar rocks or of rocks of about the same age. The linear elements include (1) the trend of the range as a whole, (2) the trend of the volcanic cones and remnants forming the High Cascades, (3) the trend of the belt of dioritic intrusive bodies, (4) the trend of the areas mineralized with base metals and gold, and (5) the trend of the quicksilver deposits.

The southern part of the Cascade Range, in line with the Sierra Nevada, trends north-northwest from California into southern Oregon. The westernmost part of the range is in the vicinity of Blackbutte, west of the Bohemia district. North of the Bohemia district the range trends north-northeast through Oregon and on through Washington.

The belt of young volcanoes trends north-northwest from Mount Lassen, in California, to Mount McLoughlin, in southern Oregon, then north-northeast toward Mount Hood. Mount Shasta lies on the west side of the range, Mount McLoughlin lies near the center, but the High Cascades in the central part of the range in Oregon lie beyond the eastern scarp of the Western Cascades. In Washington the younger cones appear to be scattered.

The belt of dioritic intrusive bodies and the chain of mineralized areas that extend throughout the length of the Western Cascades coincide north of the South Umpqua River but possibly diverge north of the North Santiam district. They diverge south of the South Umpqua River but reunite at the Barron mine, near the California State boundary. In general, both belts follow the trend of the range—that is, north-northwest south of the Bohemia district, and north-northeast north of the Bohemia district. The fact that the Bohemia district is the largest in the Cascade Range in Oregon may bear some relation to its position at the point of change in trend of these major linear elements. Individual elongate dioritic intrusive bodies and veins trend mainly to the west or northwest throughout the Western Cascades. Both the dioritic intrusive bodies and the mineralized areas continue through the Cascade Range to Washington. The intrusive bodies appear to be larger in Washington[45]

[45] Zapffe, Carl, The geology of the St. Helens mining district of Washington: Econ. Geology, vol. 7, pp. 340–350, 1912. Smith, G. O., The rocks of Mount Rainier: U. S. Geol. Survey 18th Ann. Rept., pt. 2, p. 422, 1898. Smith, G. O., and Calkins, F. C., U. S. Geol. Survey Geol. Atlas, Snoqualmie folio (no. 139), pp. 9–10, 1906. Patty, E. N., The metal mines of Washington: Washington Geol. Survey Bull. 23, pp. 300–305, 1921. Spurr, J. E., The ore deposits of Monte Cristo, Wash.: U. S. Geol. Survey 22d Ann. Rept., pt. 2, pp. 779–865, 1901. Smith, G. O., and Mendenhall, W. C., Tertiary granite in the northern Cascades: Geol. Soc. America Bull., vol. 11, pp. 217–230, 1900. Coombs, H. A., The geology of Mount Rainier National Park: Univ. Washington Pub. Geology, vol. 3, no. 2, pp. 167–170, 1936.

and the associated mineral deposits show local variations but are similar to those in Oregon. The trends of the veins and of many of the diorite dikes indicate in their broad structural relationships a belt of fractures approaching an en echelon arrangement at an angle to the general trend.

A belt of quicksilver deposits [46] follows the western margin of the range southeastward from Blackbutte, west of the Bohemia district, to a point near the Rogue River.

SUMMARY OF GEOLOGIC EVENTS

So far as the writers could gather from reconnaissance study of the Cascade Range in Oregon, from information obtained by other investigators, and from inferences from studies of nearby areas, which have been summarized by Hodge,[47] Piper,[48] Chaney,[49] and Gilluly, Reed, and Park,[50] the principal events in the history of the range are as follows:

1. Accumulation of the lavas of the Western Cascades at various places and at various times from Eocene to Miocene. There were undoubtedly many erosional unconformities within the series although only a few were seen. There was undoubtedly some deformation at various times, for the gray andesite lavas overlie unconformably Eocene marine sediments in the Roseburg area, whereas the two formations appear to be conformable on the east slope of Bear Creek Valley.

2. Deformation, dioritic intrusion and contact metamorphism, further deformation, and deposition of minerals, probably near the end of the Miocene.

3. Extensive erosion, possibly accompanying regional uplift, and possibly further slight deformation.

4. Accumulation of the lavas of the High Cascades and the valley flows that extend down into the Western Cascades. The valley flows are known to have been modified by the latest extensive glaciation (Wisconsin?), but it is not definitely known whether most of the flows of the High Cascades antedate all the glacial periods. It is inferred that some may be as old as the Pliocene, but no definite

[46] Wells, F. G., and Waters, A. C., Quicksilver deposits of southwestern Oregon: U. S. Geol. Survey Bull. 850, pp. 1–58, 1934. Waters, A. C., Summary of the sedimentary, tectonic, igneous, and metalliferous history of Washington and Oregon: Ore deposits of the Western States (Lindgren volume), p. 265, Am. Inst. Min. Met. Eng., 1933.

[47] Hodge, E. T., Progress in Oregon geology since 1925: Northwest Sci., vol. 6, pp. 44–53, 1932.

[48] Piper, A. M., Geology and ground-water resources of The Dalles region, Oreg.: U. S. Geol. Survey Water-Supply Paper 659, pp. 139–142, 1932.

[49] Chaney, R. W., Central Oregon: 16th Internat. Geol. Cong. Guidebook 21, pp. 2–10, 1932.

[50] Gilluly, James, Reed, J. C., and Park, C. F., Jr., Some mining districts of eastern Oregon: U. S. Geol. Survey Bull. 846, pp. 15–17, 1933.

proof has been evolved. Some flows in the High Cascades are definitely later than the latest extensive glaciation. During the Pleistocene the Western Cascades continued to be eroded and were somewhat modified by glaciation.

MINERAL DEPOSITS

GENERAL FEATURES

The Cascade Range in Oregon contains the only extensive Tertiary base-metal and gold deposits in the State. The metalliferous deposits in the other two principal mining regions—northeastern Oregon [51] and southwestern Oregon [52]—are almost wholly within pre-Tertiary rocks and are believed to be almost entirely of pre-Tertiary age. Mineralized areas occur in a belt through the Western Cascades from the Cheeney Creek area, near the Columbia River, to the Barron mine, near the California State boundary, as shown in plate 1, and are continuous with a similar belt through the Cascade Range in Washington. Intensively mineralized areas along this belt are separated by areas whose only evidence of mineralization is altered country rock commonly impregnated with pyrite. Almost all the mineralized areas contain groups of dioritic intrusive bodies, which are believed to be genetically related to the mineral deposits. Nearly all the veins in each of the mineralized areas trend to the northwest or west and dip steeply. Typical veins consist of a breccia of altered country rock cemented with vuggy quartz that contains sulphides, chiefly sphalerite with lesser amounts of galena, chalcopyrite, and pyrite. Several other minerals occur in the veins, and there is a wide variation in the proportion of the different minerals to one another and in the amount of coarse-grained quartz. A rough areal zoning of mineral deposits is shown in the North Santiam and Bohemia districts and to a slight extent in the Blue River district. Though the

[51] Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: U. S. Geol. Survey 22d Ann. Rept., pt. 2, pp. 551–776, 1901. Pardee, J. T., and Hewett, D. F., Geology and mineral resources of the Sumpter quadrangle, Oreg.: Mineral Resources of Oregon, vol. 1, no. 6, pp. 1–128, Oregon Bur. Mines and Geology, 1914. Gilluly, James, The copper deposits near Keating, Oreg.: U. S. Geol. Survey Bull. 830, pp. 1–32, 1932. Gilluly, James, Reed, J. C., and Park, C. F., Jr., Some mining districts of eastern Oregon: U. S. Geol. Survey Bull. 846, pp. 1–40, 1933. Gilluly, James, Geology and mineral resources of the Baker quadrangle, Oregon: U. S. Geol. Survey Bull. 879, pp. 1–119, 1937.

[52] Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, pp. 1–147, 1914. Winchell, A. N., Petrology and mineral resources of Jackson and Josephine Counties, Oreg.: Mineral Resources of Oregon, vol. 1, no. 5, pp. 1–265, Oregon Bur. Mines and Geology, 1914. Shenon, P. J., Geology of the Robertson, Humdinger, and Robert E. gold mines, southwestern Oregon, with notes on the Chieftain and Continental mines, Douglas County, Oreg., by F. G. Wells: U. S. Geol. Survey Bull. 830, pp. 33–64, 1933. Shenon, P. J., Copper deposits in the Squaw Creek and Silver Peak districts and at the Almeda mine, southwestern Oregon, with notes on the Pennell & Farmer and Banfield prospects: U. S. Geol. Survey Circ. 2, pp. 1–35, 1933; Geology and ore deposits of the Takilma-Waldo district, Oreg., including the Blue Creek district: U. S. Geol. Survey Bull. 846, pp. 141–194, 1933.

veins are characteristically of the epithermal or shallow, low-temperature class, they are associated in some places with tourmaline, epidote, and specularite in such a way as to indicate high temperature during one stage of vein filling, a condition that has led Buddington [53] to classify them in part as xenothermal. Most of the recorded production of approximately $1,000,000, almost entirely of gold, has been obtained from the oxidized parts of the veins. The unweathered vein matter contains variable but generally small amounts of gold and silver. The Bohemia district contains the largest and most persistent veins, some of which are more than half a mile long and more than 20 feet wide, including masses of country rock. It also contains the largest group of intrusive bodies, has been the most productive, and has better prospects for future production than any of the other areas in the Cascades. The age of the mineralization is not definitely known, but it is probably late Miocene. The deposits of native copper and oxides of manganese in Jackson County occur in nodules and irregular masses without any obvious connection with veins. The quicksilver deposits [54] along the western margin of the range, part of which are outside the limits of the range, are not included in this discussion.

HISTORY AND PRODUCTION

The history of prospecting and mining in the Cascade Range goes back to the discovery of gold in the Bohemia district in 1858 and in the Quartzville district in 1863, scarcely a decade after the discovery of gold in southwestern Oregon. Interest in this region apparently languished after the first flurry of discovery until the 1890's, when the greater part of the mining in the Quartzville district and much of that in the Bohemia district was done. The Bohemia district was again productive between 1905 and 1916 and has produced a little gold almost every year since that time. The Blue River district was most extensively developed and had its greatest production between 1900 and 1912. The Buzzard mine was productive between 1909 and 1918, and the Barron mine in 1917–18 and 1923. The North Santiam district attracted attention in the 1890's, but most of the production was intermittent between 1915 and 1930.

A condensed table of the recorded production of the various districts is given below. The figures were obtained from reports of the United States Mint for the years prior to 1900 and from unpublished data of V. C. Heikes for the years after that date. The total

[53] Buddington, A. F., High-temperature mineral associations at shallow to moderate depths: Econ. Geology, vol. 30, pp. 219, 221, 1935.

[54] Wells, F. G., and Waters, A. C., Quicksilver deposits of southwestern Oregon: U. S. Geol. Survey Bull. 850, pp. 1–58, 1934.

production of the different counties from 1902 to 1930 has been published in the annual volumes of Mineral Resources.[55]

Summary of production of mining districts of Cascade Range, 1880–1930

[From reports of U. S. Mint and data of V. C. Heikes]

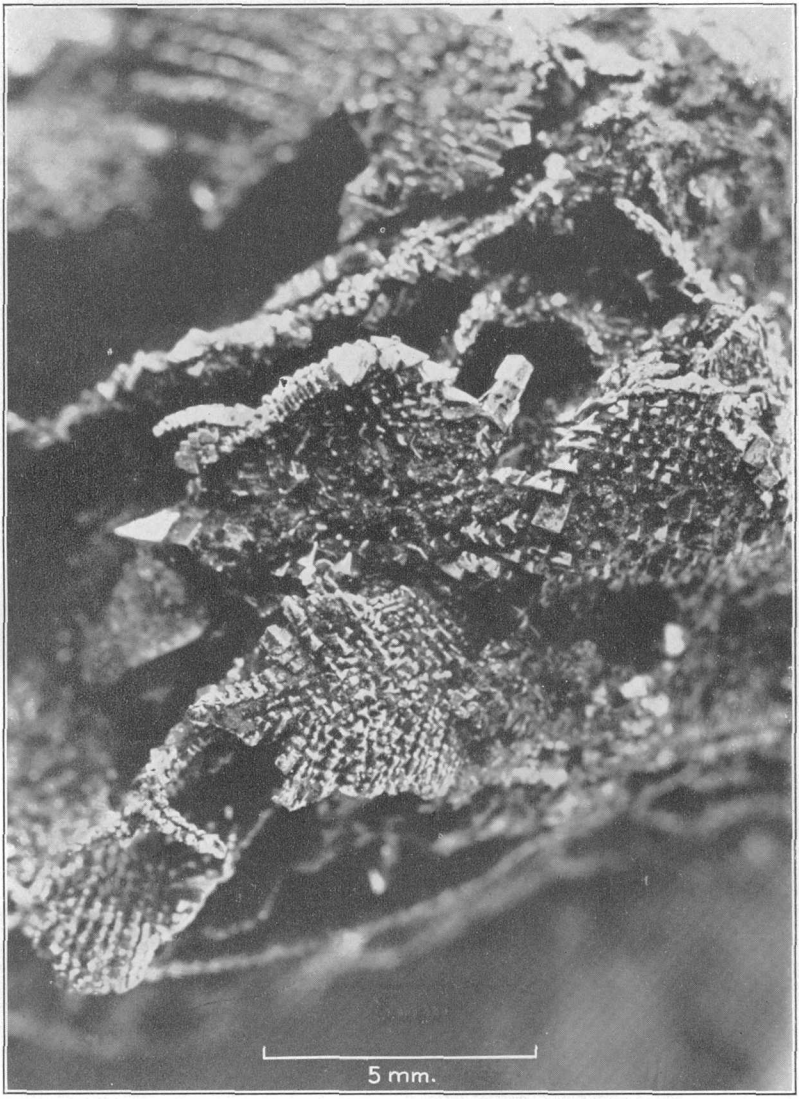
District	Gold (ounces)	Silver (approximate value)	Copper (pounds)	Lead (pounds)	Zinc (pounds)	Approximate total value
Salmon Creek, Clackamas County	48.38					$1,000
North Santiam	277.63	$1,146	14,206	3,336	12,528	10,554
Quartzville	8,402.29	2,894				176,585
Blue River	7,727.89	8,601	257			168,390
Bohemia	28,285.55	6,473	14,831	120,816		599,442
Buzzard	1,080.51					24,000
Barron	63.79					1,500
Total						981,471

MINERALOGY

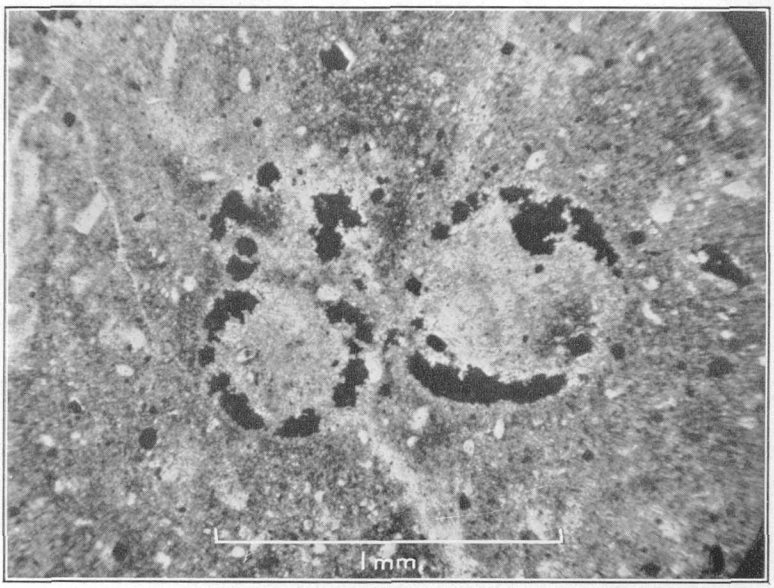
In the weathered and leached parts of some of the veins gold occurs as small flakes and wires or dendritic growths of cubes and octahedrons. Large flakes were seen in one of the veins in the Bohemia district, and an unusual specimen from the Buzzard mine, containing rows of cubes, octahedrons, and cubes twinned on octahedral axes, is shown in plate 3. No gold was seen in the sulphide ores, although its presence is shown by assays. No native silver was seen, nor was any silver mineral recognized, though in quantity silver appears to exceed gold in the average proportion of about 7:1. Probably part of the silver is alloyed with the gold. An unknown white mineral containing copper, silver, bismuth, and sulphur was seen under the microscope in chalcopyrite from the Santiam or Minnie E. mine.

Sphalerite is the only zinc mineral observed by the writers and is the most abundant sulphide in most of the veins. It ranges from light green, in the Silver King mine, through light yellow to black, and both light and dark varieties were found in the same vein. It rarely exhibits crystals except in vugs, as at the Blende Oro prospect. Many of the larger crystals are fractured and the openings are filled with quartz. (See pl. 4, *B*.) This structure suggests movement along the vein and subsequent deposition of quartz. The quartz remains as a honeycombed structure when the sphalerite is leached. Zonal banding was seen in some specimens under the microscope, and microscopic blebs and veinlets of chalcopyrite and galena, especially near the borders, as shown in plates 5, *A*, *B*, 6, *A*, are common. Peculiar spherules (rings in cross section) of sphalerite in cherty quartz occur in the Barron vein (pl. 4, *A*).

[55] Heikes, V. C., chapters on Oregon in Mineral Resources of the United States.

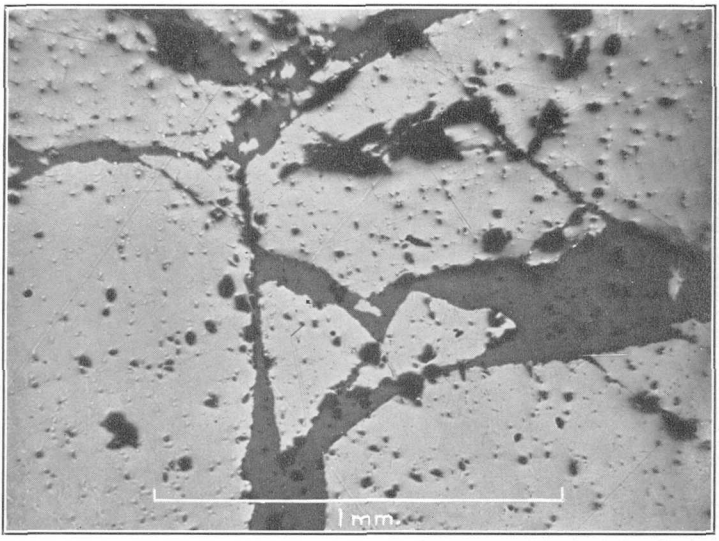


DENDRITIC GOLD FROM LEACHED PART OF VEIN AT BUZZARD MINE, JACKSON COUNTY.



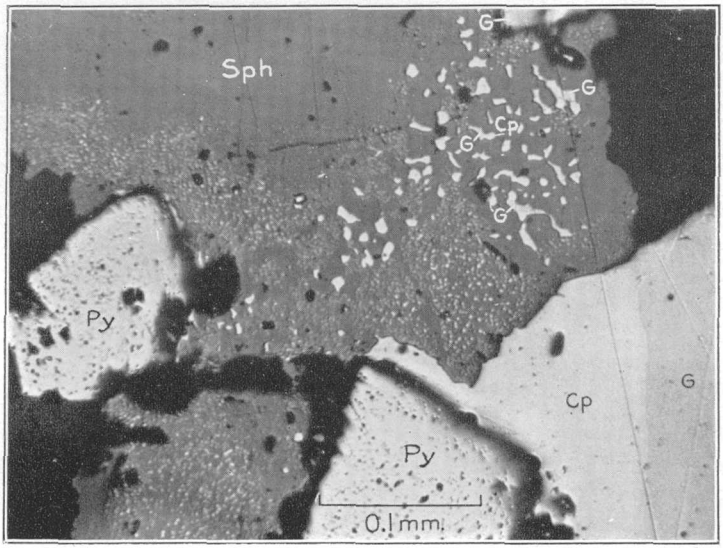
A. THIN SECTION SHOWING RINGS OF SPHALERITE IN CHERTY QUARTZ FROM BARRON MINE, JACKSON COUNTY.

These rings (sections of spherules) suggest a colloidal deposition of the sulphide.



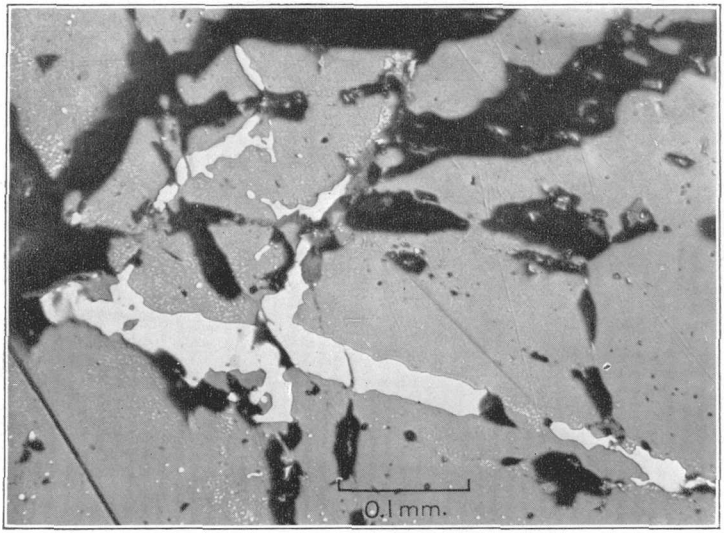
B. POLISHED SURFACE OF SPHALERITE FROM MINERAL HARBOR PROSPECT, NORTH SANTIAM DISTRICT.

Shows brecciation and veining by quartz (dark).



A

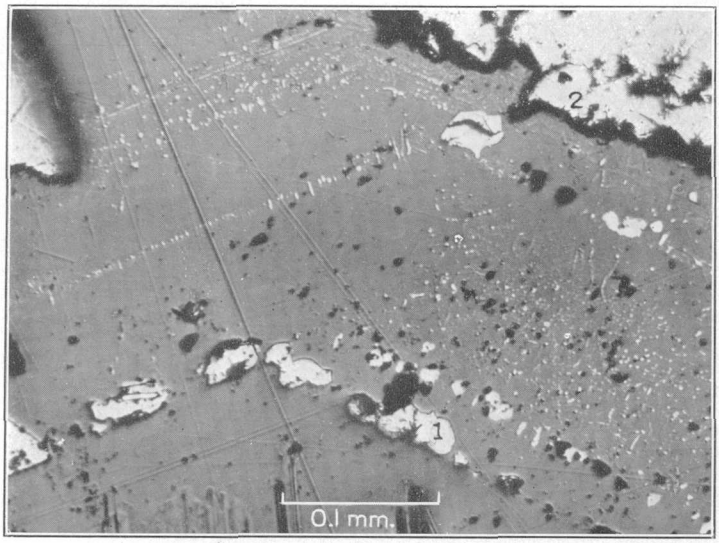
Shows innumerable blebs of galena (G) and chalcopyrite (Cp) at the margin of sphalerite (Sph), as well as larger areas of pyrite (Py), chalcopyrite, and galena. *This appears to be a replacement structure.*



B

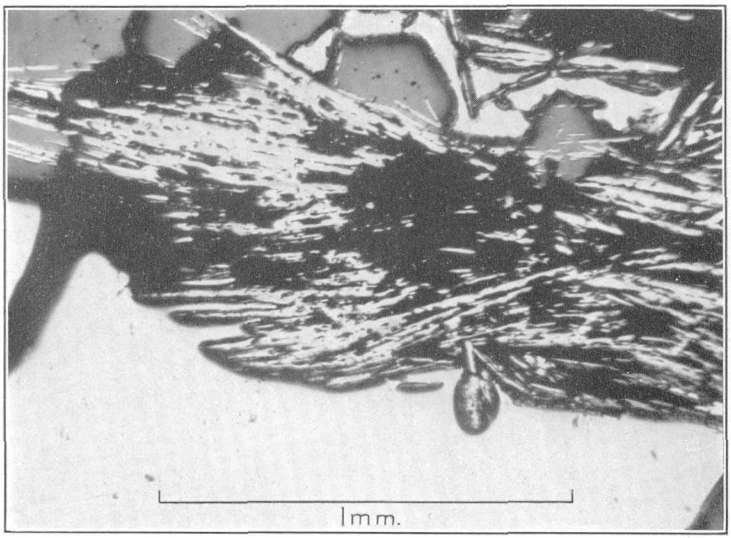
Veinlets of chalcopyrite (white) surrounded by innumerable blebs of the same mineral in sphalerite. Association of the minute blebs and veinlets suggests that the blebs are of replacement origin.

POLISHED SURFACE OF SULPHIDES FROM CAPITAL CLAIM, NORTH SANTIAM DISTRICT.



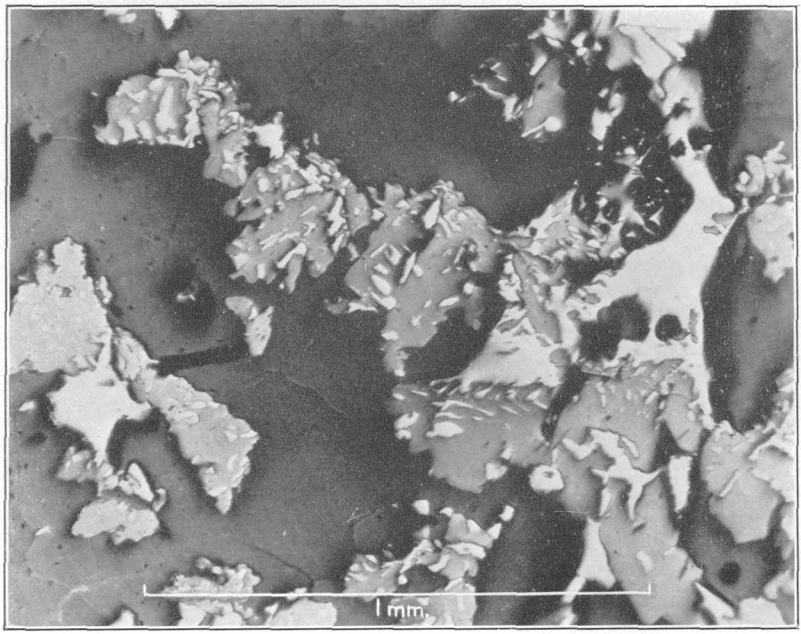
A. POLISHED SURFACE OF SULPHIDES FROM BUZZARD MINE.

Rows of minute blebs and veinlets of chalcopyrite between rows of blebs of galena (1) and the edge of the enclosing sphalerite grain marked by the pyrite (2). An unusual structure indicating control of deposition of the small blebs by the crystallographic directions of the sphalerite.



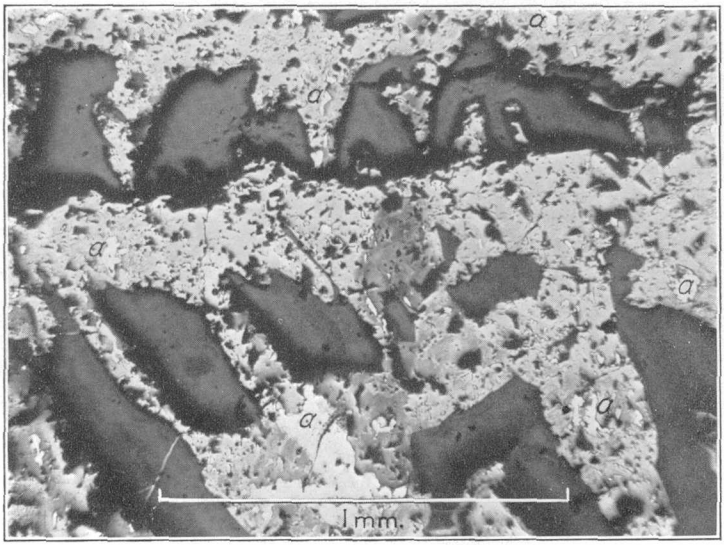
B. POLISHED SURFACE OF VEIN MATTER FROM MINERAL HARBOR PROSPECT, NORTH SANTIAM DISTRICT.

Bladed light-gray specularite is surrounded and partly replaced by chalcopyrite (white).



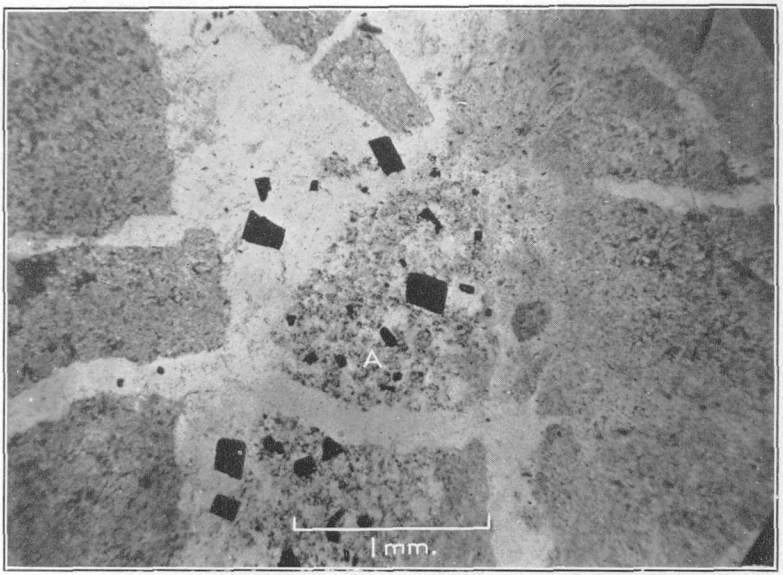
A. POLISHED SURFACE OF ORE FROM HELENA MINE, BOHEMIA DISTRICT.

Sulphides in arborescent form in cherty quartz, and galena (white) in graphic intergrowth with sphalerite (gray).



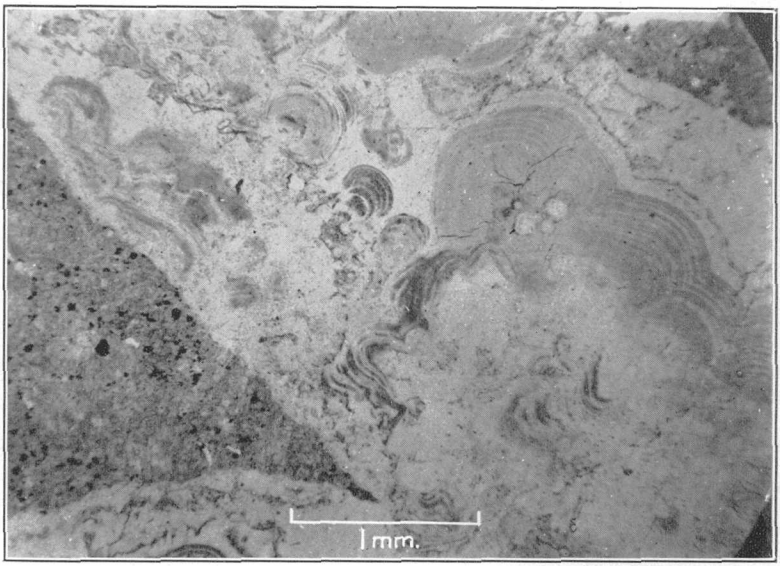
B. POLISHED SURFACE OF ORE FROM GRAND COVE PROSPECT, JACKSON COUNTY.

Native copper (white, *a*) has been largely replaced by cuprite (light gray), which retains the original dendritic structure of the copper.



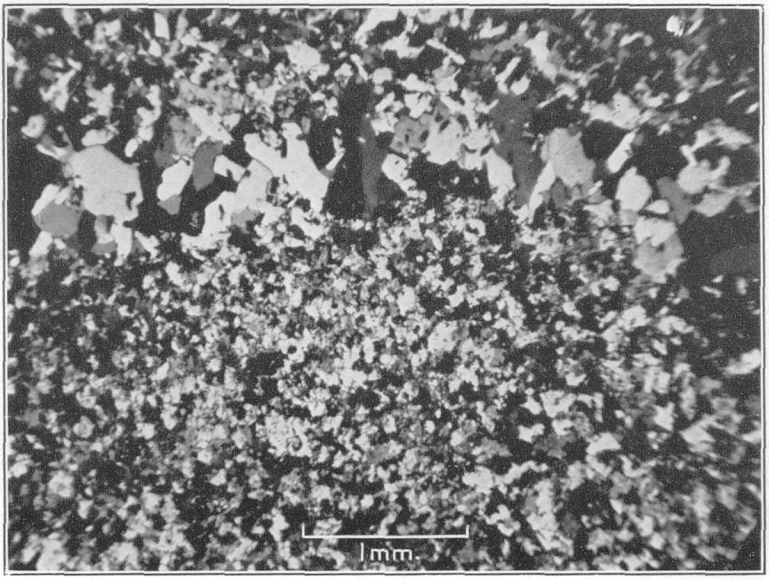
A. THIN SECTION OF VEIN MATTER FROM TUNNEL ON SOUTH SIDE OF CREEK AT GOLD CREEK M. & M. PROSPECT, NORTH SANTIAM DISTRICT.

Silicified country rock (dark) and quartz vein (A) cut by later quartz (clear). Pyrite in black grains. Silicified rock is charged with other alteration products, whereas quartz veins tend to be clearer, and the last quartz to form in veinlets and vugs is commonly very clear.



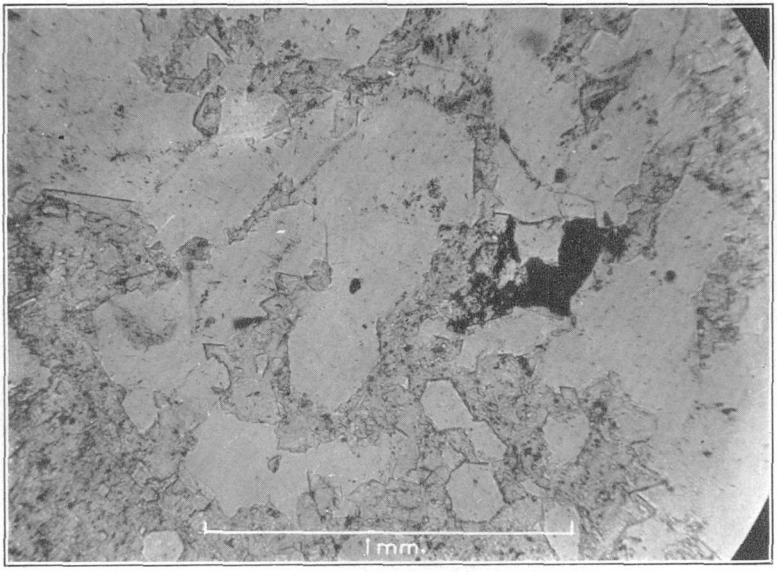
B. THIN SECTION OF VEIN MATTER FROM DURANGO PROSPECT, BLUE RIVER DISTRICT.

Colloform structure in cherty quartz, cementing a breccia of andesite (dark), indicates colloidal deposition of quartz that is now cryptocrystalline.



A. THIN SECTION OF VEIN MATTER FROM COSMOS MINE, BOHEMIA DISTRICT.

Quartz in silicified rock is fine grained and charged with other alteration products, whereas that in veinlet is coarser grained, elongate, and nearly euhedral. Crossed nicols.



B. THIN SECTION OF ADULARIA AND QUARTZ (CLEAR) IN VEIN MATTER FROM LEROY TUNNELS, BOHEMIA DISTRICT.

The tendency of adularia to show crystal outlines is conspicuous. Black is galena.

TYPICAL VEIN BRECCIA OF PARTLY ALTERED LABRADORITE ANDESITE IN SHARPLY ANGULAR FRAGMENTS CEMENTED BY VUGGY COMB QUARTZ CONTAINING SCATTERED SULPHIDES.

Some of the quartz is stained by iron oxide. Specimen obtained by Mr. F. S. Day from a vein at the southwest corner of sec. 12, T. 23 S., R. 1 E., Bohemia district.

Galena is the dominant lead mineral and occurs in practically all veins in which sphalerite and chalcopyrite are present, though generally it is subordinate to the sphalerite. It is intimately mixed with the other sulphide minerals and in most veins, except a few in the Bohemia district, appears to be later than sphalerite and pyrite and perhaps slightly earlier than chalcopyrite, though the relations are rarely clear. It occurs as coarsely granular lumps in sphalerite ore from the Blue vein in the Amalgamated mine, and commonly occurs as minute blebs and veinlets near the borders of sphalerite grains. (See pl. 6, *A*.) More rarely it forms graphic intergrowths with sphalerite, as shown in plate 7, *A*. Bournonite, a sulphide of lead, antimony, and copper, was observed only in vein matter from the Bob and Betty prospect, where it occurs as euhedral crystals on galena. Weathering of the veins in most places leaches away the galena, but small amounts of anglesite were found in the Lucky Boy vein, and a few other places, and considerable cerusite is stated by Wyatt [56] to have been taken from the upper workings of the Musick mine.

Chalcopyrite is the principal copper mineral of the veins and in most places occurs in irregular-shaped masses, though sphenoidal crystals were observed in vugs in the Blende Oro and Crown prospects. It also occurs as veinlets in wall rock, as microscopic veinlets and globules in sphalerite (pls. 5, *A*, *B*, 6, *A*), and as veinlets through pyrite. It appears to be mostly later than sphalerite and pyrite, but its relation to galena is not clear, and its relation to tetrahedrite and bournonite is not known. Tetrahedrite, a sulphide of copper and antimony, occurs in small grains with the other sulphides in the Lucky Boy vein, the Bob and Betty prospect, and several veins of the Bohemia district. Chalcocite was noted in weathered vein matter as a fine black powder. Covellite in microscopic amounts is present in some of the partly oxidized ores and as thin films on chalcopyrite. Lumps of chrysocolla and very small amounts of azurite and malachite occur in the weathered part of the Black Eagle vein. At the Grand Cove copper deposit there is no recognizable vein, but native copper occurs as dendritic masses surrounded by its weathering products and by chalcedony and opal. It is partly replaced by cuprite, as shown in plate 7, *B*. These masses or nodules occur in volcanic breccia between flows of black vesicular lava of basaltic composition. The breccia appears to correspond to the "breccia tops" [57] in the Lake Superior region. The breccia is partly altered to beidellite and undetermined claylike minerals, but the black lava

[56] Wyatt, Dale, oral communication.

[57] Butler, B. S., and Burbank, W. S., The copper deposits of Michigan: U. S. Geol. Survey Prof. Paper 144, pp. 29–33, 1929.

is fresh except for pseudomorphs of iddingsite after olivine. Probably the native copper was formed by ascending or hypogene solutions that followed some unexposed channel and spread out in the porous breccia bed.[58] Cuprite was probably formed from the copper by supergene or surface solutions.

Pyrite is the most abundant iron mineral and is present not only in the veins but in altered rock and in contact-metamorphic zones. It occurs mostly as anhedral grains (pl. 5, *A*), though at the Santiam mine there are striated cubes in vugs and octahedrons disseminated through the country rock. Most of the vein pyrite appears to be contemporaneous with sphalerite or perhaps slightly later. Crusts and veinlets of pyrite occur in cherty quartz veins in the Bohemia district. Marcasite was found intergrown with pyrite in late-stage crusts on cherty quartz in the Bohemia district. Marcasite was also found in vugs in vein matter at the Zinc prospect. Arsenopyrite occurs in groups of minute interlocking euhedral or subhedral crystals in vein matter from level 4 of the Buzzard mine and as crusts on fractures in the Barron mine.

Specular hematite is a prominent vein mineral in the central part of the Bohemia district. It is intimately associated with the sulphides and is also interbanded with or disseminated in the quartz. Much of the vein hematite is red, though it has a micaceous structure and tends to remain after the leaching of the sulphides. Specular hematite also occurs in sheafs, nodules, and veinlets in contact-metamorphic rock. In vein matter from the Mineral Harbor prospect (pl. 6, *B*) specular hematite is earlier than the sulphides and is partly replaced by chalcopyrite. Magnetite occurs in veinlets, is disseminated through much of the contact-metamorphic rock, and remains in rock fragments in veins that traverse such rocks. Limonite, including all the hydrous oxides of iron, whether yellow, brown, or black, soft or hard, that have formed as a result of weathering, occurs mostly as a stain in leached vein matter, and no large masses have been observed. Under the microscope limonite in some specimens was seen to have replaced both pyrite and chalcopyrite.

Manganese minerals are limited mostly to thin films and powders in weathered parts of the veins. The only prominent primary manganese mineral in veins is the johannsenite described elsewhere in this section. Those veins that contain considerable calcite, as in the Great Northern mine, yield more manganese oxide in the weathered and leached parts than the siliceous veins. Manganese deposits

[58] Idem, pp. 141–142. Broderick, T. M., and Hohl, C. D., Differentiation in traps and ore deposition: Econ. Geology, vol. 30, pp. 301–312, 1935.

on Lake Creek in Jackson County have been described by Pardee [59] as consisting of manganite, psilomelane, and small amounts of wad, which fill cracks, vesicles, and other cavities in tuff that generally contains not more than 1 or 2 percent of manganese, though bodies at some places contain 10 to 20 percent or more. A little gold was reported to have been obtained from the concentrates. The deposits appear to be close to the surface and to have been formed by descending solutions. Clay minerals, gypsum, barite, and zeolites occur locally with the manganese deposits.

Stibnite occurs as bladed crystals with pyrite and cherty quartz in some of the veins, particularly in the Tall Timber claims. Stibiconite, a hydrous oxide of antimony, occurs in the weathered parts of the stibnite veins.

Quartz is the most prominent of the gangue minerals and occurs as moderately large terminated crystals lining vugs, as veinlets with comb structure, as cherty masses, some of which show traces of colloform structure (pl. 8, *B*), and as masses of silicified rock with a cherty aspect (pl. 9, *A*). Quartz appears to have been formed at several stages in the process of vein filling, and masses of silicified rock or cherty quartz are in many places cemented by coarser-grained quartz. (See pl. 8, *A*.) Some quartz was apparently contemporaneous with the sulphides, some occurs on surfaces of sulphide grains or on other quartz grains, and crystals of chalcopyrite were found on the tips of quartz crystals at the Blende Oro prospect. Quartz also occurs as thin veinlets in sphalerite (pl. 4, *B*) and along cleavage and other surfaces in calcite. Pyrite fills fractures in some of the cherty quartz. Opal, some of it stained green, is associated with the native copper at the Grand Cove prospect.

Calcite is the most abundant carbonate and is a major gangue mineral in several of the veins, particularly at the margins of the mineralized areas. Most of it is coarse-grained and white, though black calcite occurs at the Zinc prospect, charged with extremely fine grained pyrite, and brown calcite, containing oxides of iron and manganese, was found at the Black Eagle prospect. Carbonate veins, such as those in the Great Northern mine, leave a residue of oxides of manganese and iron. At the Bob and Betty property and the Amalgamated mine calcite is closely associated with the sulphides. Ankerite is a common mineral in many of the veins and occurs as crusts of brownish crystals with curved surfaces in vugs. Dolomite occurs in a similar form, particularly in the Bohemia district. Mesitite, a carbonate of magnesium and iron with very little lime, was noted in altered rock near the veins, and perhaps

[59] Pardee, J. T., Deposits of manganese ore in Montana, Utah, Oregon, and Washington: U. S. Geol. Survey Bull. 725, pp. 213–223, 1932.

several other carbonates occur in altered rock. Siderite was not found in any of the veins but occurs in cavities in volcanic rock at Climax, Jackson County. Aragonite occurs as aggregates of radiating crystals making up the greater part of a vein a foot or more in width at Climax. It is associated with a little calcite and chalcedony but contains no sulphides.

Barite is prominent in the Helena No. 1 vein and occurs in the Barron mine, in the Oakridge area, and in several of the veins in the southern part of the Quartzville district. It generally appears as well-formed crystals on the surface of vugs, mostly on the surface of carbonate crystals. Gypsum is present in pyritic altered rock just below the weathered surface but was not observed in the veins.

Silicates in the veins include adularia, johannsenite, epidote, sericite, chlorite, and clay minerals. Adularia is prominent in many veins of the Blue River district and has been noted in a few veins in the Bohemia district and in the Ogle Mountain carbonate vein in the North Santiam district. It commonly exhibits crystal outlines and occurs in aggregates that partly replace altered country rock and that also form the margin of veins in which quartz fills the center (9, *B*). Johannsenite, a new mineral first recognized in material from the Bohemia district, appears in fibrous aggregates in the California vein, in the Musick group of claims. It has been described by Schaller[60] as the manganese analog of diopside and hedenbergite and has a composition of $MnO.CaO.2SiO_2$. It is partly altered to a buff material and on weathered surfaces has changed pseudomorphously to a brownish-black oxide of manganese, probably manganite. It was probably formed during an early high-temperature stage of the vein. Epidote occurs as a loose aggregate of needles in ore from the Blue vein of the Amalgamated mine but is otherwise limited to altered rock, where it is disseminated or occurs in small veins, and to contact-metamorphic areas. Sericite is a very common vein mineral and has almost completely replaced the country rock in some of the veins, particularly the Bimetallic vein, where it occurs as soft claylike masses. It occurs as white spots in some veins and is difficult to distinguish superficially from kaolinite, which has essentially the same appearance in other veins. It also occurs in gouge clays, in areas of altered rock, and as a late-stage mineral in the intrusive rocks. It is associated more with dense, cherty quartz than with coarse crystalline comb quartz. Chlorite makes up a large part of the greenish altered rocks and is associated with the sulphides in some veins. Probably several minerals are included under the collective name "chlorite." Recognized clay

[60] Schaller, W. T., Johannsenite, a new manganese pyroxene [abstract]: Am. Mineralogist, vol. 18, no. 3, pp. 113–114, 1933.

minerals were kaolinite, checked by X-ray tests by Prof. P. F. Kerr, and beidellite. The kaolinite is the more abundant and occurs as white nodules in partly oxidized sulphide ore at the Musick mine, and in typical vermicular aggregates in material from the Jumbo prospect. It occurs in the altered rock also. Beidellite occurs with kaolinite in altered volcanic rocks in many places. Other clay minerals may be present but were not recognized.

CLASSIFICATION OF VEINS

Although all the veins belong to the epithermal class, they are separated on the basis of mineral composition into the subclasses briefly described below.

Typical complex sulphide veins are characterized by sphalerite with lesser amounts of pyrite, galena, chalcopyrite, and in some places tetrahedrite and bournonite. The gold content ranges from a trace to about 5 ounces to the ton and the silver content from 1 to 6 ounces, though the precious-metal content is low in most unweathered veins. The gangue is mostly quartz and altered rock, though in the small mineralized areas, such as the Buzzard, there is almost no coarse-grained quartz. Several of these veins in the Bohemia district contain hematite.

A few veins are characterized by chalcopyrite as the dominant sulphide, particularly in the Oregon-Colorado, Crown, Silver Star, and Santiam claims, the Black Eagle mine and the Rowena vein. The gold and silver content of these veins is low according to the few assays available. So far as is known ore has been shipped only from the Santiam mine.

The Western vein and a few others contain flake gold without appreciable sulphides. A massive quartz vein known as the Mammoth reef, has not yielded either gold or sulphides.

Several veins, most of them on the outer margins of the mineralized areas, are characterized by a gangue of carbonate, chiefly calcite. They include the Ogle Mountain, Elkhorn Creek, and Great Northern veins. The weathered parts of the Ogle Mountain and Great Northern veins yielded several thousand dollars in gold.

Veins containing bladed crystals of stibnite in cherty quartz associated with pyrite and some comb quartz occur at the outer margin of the southwestern part of the Bohemia district.

Metalliferous deposits previously referred to and not occurring as fissure veins include areas of disseminated pyrite, areas of disseminated magnetite and specularite, all of no value, the deposit of native copper at the Grand Cove prospect, and the deposits of manganese in Jackson County.

ROCK ALTERATION

The igneous rocks are altered to a variable extent, not only along the veins but also throughout large areas in which no veins have been recognized. The areas under discussion differ from many other mineralized Tertiary areas in their lack of large silicified masses, though silicification was a significant part of the alteration process in the Cascade Range. Though most of the altered rocks consist largely of very fine grained quartz, other secondary minerals are rather evenly distributed, so that the altered rocks are no more resistant to erosion than the unaltered rocks and are commonly less resistant.

A large number of the minerals listed above that do not belong to the primary magmatic group may have been formed by several processes, as follows: (1) Autometamorphism, or alteration during the final stages of formation of magmatic minerals, due to igneous solutions originating in the same magma, producing quartz, secondary feldspar (chiefly orthoclase), uralite, magnetite, hematite, chlorite, epidote, sericite, and carbonate minerals; (2) contact metamorphism, producing quartz, secondary feldspar, uralite, tourmaline, magnetite, hematite, epidote, chlorite, sericite, and pyrite; (3) alteration by hypogene solutions, prior to the formation of the veins or contemporaneous with them, producing quartz, adularia, chlorite, hematite, epidote, sericite, pyrite, various carbonate minerals, clay minerals, and leucoxene; (4) alteration by supergene solutions, producing quartz, clay minerals, jarosite, gypsum, limonite, calcite, pyrite, and possibly marcasite. There was obviously considerable overlapping of the different processes, and it is not everywhere possible to demonstrate by which process or processes a certain mineral was formed.

The widespread alteration of country rock involved the formation of chlorite, epidote, quartz, carbonate, and sericite as the principal new minerals. The rock is commonly greenish. This type of rock is most prominent in the mineralized areas but occurs to a moderate extent throughout the Western Cascades. It may be related in a broad way to a general rise in the thermal gradient throughout the Western Cascades during the intrusion of the dioritic bodies and the emplacement of the veins. Alteration of propylitic character in the wall rock of the veins appears to be definitely related to at least one stage in the succession of solutions in the vein.

The other principal kind of altered rock is light-colored and is commonly bleached and iron-stained in the outcrop. It is characterized by quartz with sericite, carbonates, and clay minerals, though in a particular specimen any one of the three auxiliary components may be missing. Altered rock at the Bimetallic mine consists almost entirely of sericite with a minor amount of quartz. Fresh altered

rock at the nearby Blende Oro vein contains much carbonate in addition to the sericite and quartz. Sericite is prominent in the gouge clay of many of the veins. At other places, particularly in the Bohemia district, clay minerals occur in the light-colored altered rocks. Pyrite occurs in almost all altered rocks of this type below the zone of leaching. Some of these altered areas are irregular-shaped and may be as much as a mile in diameter.

The table below gives analyses of light-colored altered rocks, including altered granodiorite porphyry, altered labradorite andesite, and altered rhyolite, and comparisons of their chemical and mineral composition with that of their unaltered equivalents. Though these samples were collected in mines, there was ample opportunity for circulation of surface waters through them. Perhaps the most obvious feature of the altered rocks brought out by the analyses is the change of rocks of divergent composition to rocks having nearly the same composition. In general there is stability or increase in SiO_2 Al_2O_3, FeS_2, TiO_2, H_2O, SO_3, and K_2O and notable decrease in the other constituents, particularly in iron oxide, magnesia, soda, and lime. The only recognized potash mineral in the deposits is sericite, which does not appear to be sufficiently abundant in the altered labradorite andesite to account for all the potash indicated in the analysis. However, actual increase in potash in the altered rock, particularly in the labradorite andesite, is probably due largely if not wholly to sericitization. Increase in the potash content of rocks through hydrothermal alteration, with the formation of sericite or adularia, is not uncommon and has been noted in many other districts. Such alteration with the formation of adularia has been shown by Fenner [61] to be taking place in the geyser basins of Yellowstone Park.

The clay minerals distinguished in the light-colored altered rocks are kaolinite and beidellite, the former checked by X-ray as well as by optical examination. Both of these clay minerals are regarded by Ross and Kerr [62] as of supergene origin, though Burbank [63] regards some of the clay minerals of the Bonanza district, in Colorado, as hypogene. No definite age relation of the sericite and clay minerals in the specimens examined could be established. In other words, it was not possible to demonstrate that a feldspar crystal which was only partly altered to sericite by hypogene solutions may not have had the unaltered portion changed to clay minerals by supergene

[61] Fenner, C. N., Hydrothermal metamorphism in geyser basins of Yellowstone Park, as shown by deep drilling: Am. Geophys. Union Trans. 15th Ann. Meeting, pp. 240–243, 1934.

[62] Ross, C. S., and Kerr, P. F., The kaolin minerals: U. S. Geol. Survey Prof. Paper 165, p. 172, 1931; The clay minerals and their identity: Jour. Sedimentary Petrology, vol. 1, pp. 61–62, 1931.

[63] Burbank, W. S., Geology and ore deposits of the Bonanza mining district, Colo.: U. S. Geol. Survey Prof. Paper 169, p. 81, 1932.

solutions. The mine workings were not sufficiently deep to eliminate the possibility of supergene solutions, though the rock contains abundant pyrite. No conclusive evidence was obtained as to just what proportion, if any, of the clay minerals was of hypogene origin.

Comparison of analyses of altered and equivalent unaltered rocks

[T. Kameda, analyst of sample 1; George Steiger, analyst of other samples]

Chemical analyses

	1	2	3	4	5	6
SiO_2	65.16	64.41	53.27	63.00	69.58	74.02
Al_2O_3	15.24	16.76	17.08	16.98	13.68	14.73
Fe_2O_3	2.08	.49	2.93	.72	1.39	.42
FeO	3.04	.66	6.06	1.06	1.88	.40
MgO	2.22	.38	5.12	.48	.63	.30
CaO	4.69	.27	9.60	.66	2.68	.31
Na_2O	3.62	.20	2.28	.17	3.66	.62
K_2O	2.08	1.80	.72	2.10	3.22	2.64
H_2O+	.77	4.28	1.52	4.73	1.46	3.89
H_2O-	.13	1.06	.15	2.07	.45	.45
CO_2	.17	None	.08	None	1.38	None
TiO_2	.74	1.18	1.04	1.20	.44	.52
P_2O_5	.29	None	.20	.03	.09	.10
MnO	.09	None	.15	None	.07	None
SO_3	----------	.68	----------	1.21	----------	.20
FeS_2	----------	8.04	----------	5.68	----------	2.08
	100.32	100.21	100.20	100.09	100.61	100.68

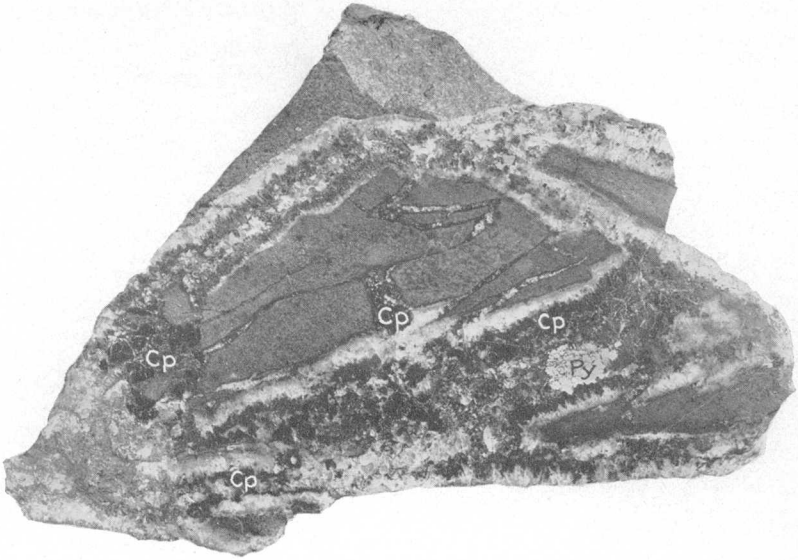
Mineral composition

1	2	3	4	5	6
Andesine	Quartz	Labradorite	Quartz	Oligoclase	Quartz.
Augite	White clay (kaolinite).	Augite	White clay (kaolinite).	Orthoclase?	White clay (kaolinite).
Hypersthene	Brown clay (beidellite).	Magnetite	Brown clay (beidellite, much).	Quartz	Brown clay (beidellite, very little).
Apatite	Opaque powder (leucoxene).	Chlorite	Sericite Opaque powder (leucoxene).	Chlorite	Opaque powder (leucoxene).
Magnetite	Sericite (very little).	----------	Pyrite	Apatite	Sericite (very little).
Zircon	Pyrite	----------	A sulphate	Magnetite	Pyrite.
	A sulphate	----------	----------	----------	A sulphate.

1. Augite-hypersthene granodiorite porphyry, from core of dike on road to Champion Saddle, above Champion boarding house, sec. 13, T. 23 S., R. 1 E., Bohemia district.
2. Altered equivalent of no. 1, from level 9, Champion mine, at Excelsior vein, sec. 13, T. 23 S., R. 1 E., Bohemia district.
3. Labradorite andesite, from Rocky Point, on trail to Grizzly Saddle, southeast corner of sec. 12, T. 23 S., R. 1 E., Bohemia district.
4. Altered equivalent of no. 3, from tunnel on Evening Star raise on Champion vein, northeast center of sec. 13, T. 23 S., R. 1 E., Bohemia district.
5. Rhyolite, from dump at Wild Hog adit, Vesuvius mine, southwest corner of sec. 11, T. 23 S., R. 1 E., Bohemia district.
6. Altered equivalent of no. 5, from level 7, Champion mine, north center of sec. 13, T. 23 S., R. 1 E., Bohemia district.

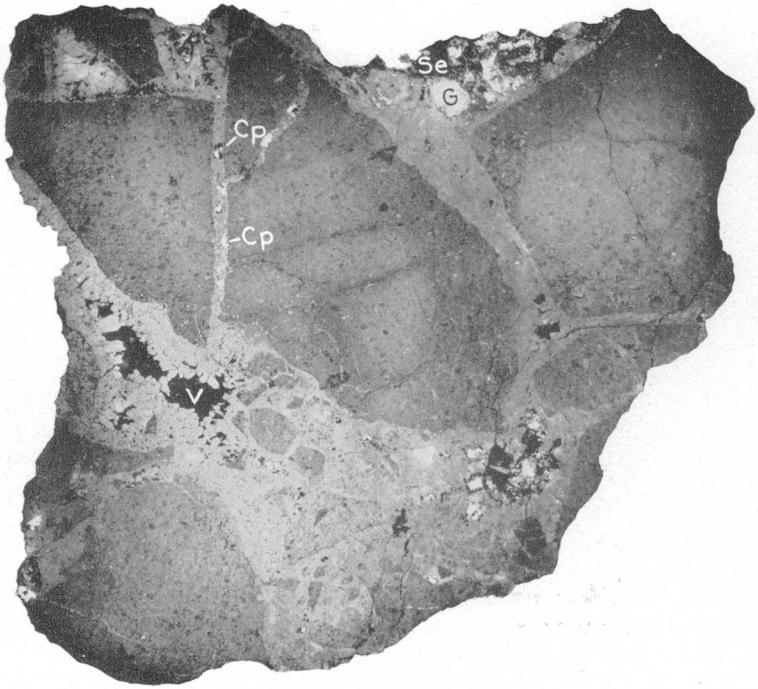
WEATHERING OF VEINS

The principal effect of known weathering has been the leaching and removal of the sulphides, with consequent relative enrichment in gold in the veins where the gold content was appreciable. There has been no recognized sulphide enrichment except thin films of covellite on chalcopyrite and a residual powder of chalcocite. Ga-



A. VEIN MATTER FROM OREGON-COLORADO PROSPECT, BOHEMIA DISTRICT.

A characteristic breccia of elongate fragments of greenish chloritic andesite with cockade structure of vein minerals, including comb quartz (light), chlorite (dark), chalcopyrite (Cp), and pyrite (Py).

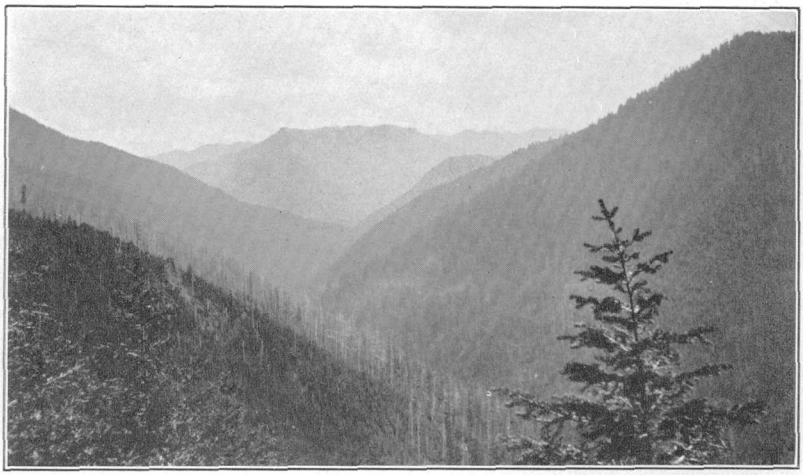


B. VEIN BRECCIA OF NEARLY EQUANT FRAGMENTS OF GREENISH CHLORITIC ANDESITE CEMENTED WITH COMB QUARTZ (LIGHT).

Contains galena (G), chalcopyrite (Cp), specularite (Se), and vugs (V). Bohemia district.

A. VEIN MATTER FROM BLENDE ORO PROSPECT, NORTH SANTIAM DISTRICT.

Pyrite (Py), galena (G), chalcopyrite (Cp), and sphalerite (Sph) disseminated irregularly through altered tuff, which consists of quartz, sericite, and calcite. Some angular masses of sericite (Sc) stand out prominently.



B. VIEW LOOKING EAST UP NARROW VALLEY OF LITTLE NORTH SANTIAM RIVER, NORTH SANTIAM DISTRICT.

The rugged surface, steep timbered slopes, and sharp V-shaped valley are characteristic of those parts of the Western Cascades made up of lava flows without appreciable fragmental rocks.

lena changed to anglesite and cerusite, though very little of these minerals has remained in the veins except the "lead shoot" in the Musick vein. A little malachite, very little azurite, and some chrysocolla occur in certain veins in which chalcopyrite was originally prominent. No secondary zinc minerals were observed, and pyrite is either leached out or replaced by limonite.

The leached parts of the veins have furnished the bulk of the gold produced, and the gold can be seen in some rich streaks as small flakes and wires or dendrites adhering to the walls of cavities. There is a strong suggestion, which, of course, cannot be proved, that there has been transportation and concentration of gold in the weathered parts of the veins, for veins with rich shoots of free gold ore near the surface contained very little gold in the sulphide ore. A specimen of leached ore with a core of fresh sulphides from the Silver Signal prospect was assayed and found to contain 0.32 ounce of gold and 4.9 ounces of silver to the ton in the sulphides and 0.92 ounce of gold and 5.2 ounces of silver to the ton in the leached ore. With the difference in density taken into account, this suggests a slight increase in the gold content and a relative decrease in the silver content in the weathered vein matter. The paucity of manganese minerals in most of the veins does not favor large-scale transportation of gold. Many more data would be necessary to prove this point, however.

Leached sulphide ore commonly has a cellular structure, and an outcrop of quartz with cavities and thin quartz filaments indicates the former presence of sulphides. However, quartz that contained carbonate or angular lumps of clay minerals or sericite has a similar appearance on weathered surfaces. Veins that cross ridge tops are weathered completely to depths of about 100 feet, particularly in the Bohemia, Quartzville, and Blue River districts, and weathered streaks may extend to much greater depth. Outcrops of veins near the bottoms of the valleys or in glacial cirques commonly have sulphides within a foot of the surface. The high relief and consequent ready circulation of water in the veins probably account for the leaching and lack of appreciable secondary sulphides. Though the deepest weathering occurs on ridge tops, it cannot be demonstrated to be related to old erosion surfaces, for too little is known of the erosional history of the Cascade Range.

VEIN STRUCTURE AND ORE SHOOTS

Typical veins consist of a fracture zone and the enclosing rock in various stages of alteration, country rock replaced in various degrees by vein minerals, and cavities filled with vein minerals. In places there are several parallel fractures faced with gouge, which

produces a sheeted structure. In other places a single fracture splits and reunites, enclosing a lens of sheared and brecciated rock. In some veins the fractures are very complex, passing into and across each other and into the wall rock. Some of the larger veins exhibit all these types of structure and characteristically pinch to a single fracture and swell again as a complex group of fractures over a width of 10 or 12 feet. A wide zone of sheeted or brecciated rock occurs at many of the intersections of fracture zones.

The vein matter commonly consists of a breccia of partly or completely altered country rock cemented with comb quartz. (See pl. 10.) In some of the veins the fragments are long and thin, as shown in plate 11, *A*, but in others they are nearly equant, as shown in plate 11, *B*. In some places the vein minerals are limited to the spaces between the fragments, as shown in these two figures, but in others they have largely or wholly replaced the fragments. In some of the veins, particularly those in tuff, the sulphides are disseminated irregularly through the altered material, as shown in plate 12, *A*. In some veins, particularly the Bob and Betty, the sulphides and later vein minerals form the matrix for fragments of earlier vein matter. Quartz and sulphides form the matrix for small bodies of nearly pure kaolinite in material from the Musick mine. Most of the veins are vuggy or drusy, and the openings are lined with comb quartz, and in places with sulphides. Some of the vein matter is banded, either parallel to a fracture or surrounding a rock fragment, producing a cockade structure. In places cherty quartz is traversed by veinlets of coarser quartz, as shown in plate 9, *A*. Colloform structure in the cherty or very fine grained quartz, together with cracks faced with pyrite, indicates that much of the quartz was originally deposited as a gel. Postmineral brecciation is indicated in many veins in which fragments of vein matter are cemented with gouge. In some veins, notably the Buzzard, sulphides without comb quartz and with very little cherty quartz occur in streaks in direct contact with altered rock.

Sulphide ore shoots generally occur in the lenticular brecciated parts of the veins and are themselves generally lenticular. Workings in most of the mines are not sufficiently extensive to distinguish any regular direction of pitch of the ore shoots. The ore shoot in the Lucky Boy mine, which occurs at the intersection of two veins, appears to pitch to the southeast. Some of the large shoots in the Bohemia district do not appear to depend upon vein intersections, but others appear to have been so controlled, and such intersections may be regarded as favorable areas for prospecting. Some of the shoots are as much as 500 feet long, but most of them are about 100 feet. The width of the heavy sulphide bands is generally less than 1 foot,

but a 7-foot band of sulphides occurs in one place in the Musick mine. In the weathered parts of the veins the shoots are extremely irregular, and rich streaks of gold ore are commonly only a few feet long.

ZONING OF MINERAL DEPOSITS

No vertical zoning of sulphide ores was observed in the mine workings, most of which do not reach a depth greater than 400 feet, nor was any appreciable change noted in the several veins in the Bohemia district, which crop out through a vertical range of 2,800 feet. So far as can be ascertained at the present time, the same general sulphide minerals may be expected through depths of several hundred feet in the larger veins.

Evidence of areal zoning of mineral deposits is found in the North Santiam and Bohemia districts and to a slight extent in the Blue River district. In the North Santiam district there is a central zone of chalcopyrite veins, surrounded by a zone of complex sulphide veins and an outer zone of carbonate veins. A group of pyrite veins on Gold Creek is transitional between the chalcopyrite veins and the complex sulphide veins. The chalcopyrite veins are mostly at the lowest altitude in the areas of the largest intrusive bodies and of contact metamorphism. The central part of the Bohemia district, near the largest intrusive bodies, contains the largest and most persistent veins and the veins containing the most sulphides. Farther out, particularly toward the southwest, the veins contain smaller amounts of sulphides, and a marginal group of veins contains stibnite and cherty quartz. Most of the veins in the Blue River district contain variable amounts of sulphides, chiefly sphalerite, though one vein is characterized by chalcopyrite. A group of carbonate veins at the north side of the Blue River district probably represents the outer margin of the mineralized area.

There is a suggestion in the areal zoning that the complex sulphide veins may change in depth through increase in chalcopyrite and possibly pyrite at the expense of sphalerite and galena with consequent diminution of the precious-metal content. Proof to substantiate such a suggestion must await deep developments. The dominance of chalcopyrite in the central zone, particularly in the North Santiam district, does not appear to be consistent with its place in the order of succession of ore minerals in the veins, as it appears to be later than pyrite and sphalerite and probably as late as galena. No proved explanation is offered. Perhaps in the early stages of mineralization only small amounts of the sulphides were deposited in the central zone as compared with the outer zones, and as the mineralization progressed and the solutions cooled chalcopyrite was deposited in the central area, where the other sulphides were scarce, as well as to

a moderate extent in the veins in which the earlier sulphides were emplaced. The chalcopyrite veins in the Bohemia and Blue River districts are eccentric to the most extensively mineralized areas and the areas of largest intrusives, so that probably other factors are effective, such as recurrent fracturing similar to that at Gold Hill, Utah, as pointed out by Nolan,[64] or successive waves of mineralization.

GENESIS

The features of the veins in the Western Cascades pointed out in this discussion lead to the conclusion that the vein solutions rose from a cooling magma at a considerable depth below the present outcrop, for the veins traverse both the intrusive bodies and the volcanic rocks. The period of maximum or renewed fissuring must have followed closely the emplacement and cooling of the intrusive bodies. Undoubtedly a wide range of conditions prevailed during the deposition of the ores, and there is evidence, particularly in the Bohemia district, of an initial high-temperature stage. Some of the material of the mineral deposits is colloform. Some of the earliest silica was probably deposited as a gel, for the quartz, though now very fine grained and cherty, in part contains fractures faced with pyrite, which suggests shrinkage through desiccation, locally is black because of disseminated pyrite dust, and in places shows microconcretionary structure. The sulphides locally also show evidences of colloform structure, such as hollow spherules of sphalerite, arborescent or dendritic intergrowths of galena and chalcopyrite with sphalerite, and microconcretionary pyrite. The later quartz, which contains a large part of the sulphides, is coarser-grained almost everywhere. In the less extensively mineralized areas sulphides were deposited with very little if any accompanying quartz. Carbonates, chiefly calcite, dolomite, and ankerite, were later than the quartz in many of the veins, and in some veins barite is contemporaneous with the carbonates or later.

PLACERS

Little placer mining has been done in the Cascade Range. There has been a very small production from Steamboat Creek, south of the Bohemia district, and a small production from Quartzville Creek, where gold has been obtained from crevices. Prospectors maintain that most of the gold is too fine to be recovered. A large mass of rubble in Dry Gulch, in the Quartzville district, has been located

[64] Nolan, T. B., The Gold Hill mining district, Utah: U. S. Geol. Survey Prof. Paper 177, pp. 107–108, 1935.

as placer ground, but the amount of gold is reported to be very small, and readily available water is insufficient for large-scale operation.

ECONOMIC CONSIDERATIONS

Mining in the Cascade Range in the past has been confined almost wholly to gold, which has been obtained largely from the weathered parts of sulphide veins. The output has been small compared with that of the larger mining districts. Undoubtedly some of the small operations on relatively rich free-milling oxidized ore were profitable, but so far as could be learned the larger operations yielded little or no profit. No very successful method of treatment of the sulphide ores had been developed before the larger mining operations ceased. No data on mining and milling costs within the Cascade Range are available, and no operations carried on in 1930–31 were sufficiently large to yield any pertinent data on costs. Transportation facilities have been improved since the earlier operations, so this item of expense should be greatly reduced. New milling methods should increase the proportion of metals recovered, particularly the zinc, which would now be paid for, whereas formerly it was penalized by the smelter. However, this advantage over the old operations is partly offset by the relatively higher gold content of the oxidized ores, which "sweetened" such sulphide ores as were formerly treated. Though most of the ore shoots are rather small, they were sufficiently large to yield as much as 8,000 tons in a year of operation in the Bohemia district. The metals recovered from the largest operations in the Bohemia district when more than 1,000 tons was milled ranged in value from slightly less than $5 a ton to slightly more than $9 a ton, with gold selling for $20.67 an ounce. According to old records, the gold and silver recovered from large runs at the mill of the Lucky Boy mine ranged between $5 and $6 a ton. Because of the relatively small size of most of the ore shoots and because of difficulties involved in transportation in such rugged country, the cost of obtaining metal may be regarded as relatively high.

Probably enough free-milling oxidized gold ore remains in some of the mines to be minable in a small way, and possibly other shoots of such ore await discovery, though the larger mineralized areas have been extensively prospected. Some sulphide bodies with a low precious-metal content remain in some of the mines in the Bohemia district, and some of the prospects expose promising sulphide shoots. Although insufficient ore was blocked out in 1930–31 to justify a mill at any one of the mines, it appeared that further exploration and development, in the Bohemia district in particular, would possibly re-

veal sufficient ore to justify a custom mill or, better still, a mill handling ore from several veins in the productive area as a unit operation. Probably some sulphide ore, particularly in the Bohemia district, is of high enough grade to bear shipment to a smelter, but no assays revealing such ore as blocked out were available to the writers. Sampling and further exploration may reveal ore shoots which, with the prices of precious metals prevailing in 1935 and with augmented prices for the base metals, may be attractive for profitable exploitation.

Small sulphide ore shoots are exposed in the North Santiam district, but so far as is known their precious-metal content is very low and their profitable exploitation will probably be obliged to await higher prices for base metals. No ore shoots containing appreciable sulphides were seen in the Quartzville district, though some small pockets of free gold ore near the surface undoubtedly remain. The proportion of sulphides in most of the veins in the Blue River district is very low, though streaks of sulphides are exposed over a length of several hundred feet in the lowest level of the Lucky Boy mine. The smaller mineralized areas probably cannot be depended on for any appreciable production, though one or more veins comparable to those already found may be discovered. In general, the Bohemia district has by far the best possibilities for future production of all the mineralized areas in the Cascade Range.

It is suggested for future prospecting and development that bodies of sulphide vein matter already revealed be carefully sampled and that, if the results warrant, further work be done to block out the ore. Additional prospecting might be done on veins known to have contained minable shoots of sulphide ores and on veins of demonstrated continuity in the productive area. Vein intersections are not necessarily highly mineralized but are nevertheless regarded as favorable areas for prospecting. Prospecting around the margins of the productive areas of the larger districts, particularly the Bohemia district, or in the smaller mineralized areas would be expected to reveal only minor amounts of sulphides, but it might result in finding small shoots or pockets of gold ore that may yield a profit if worked in a very small way with a minimum of overhead and investment.

MINERALIZED AREAS AND MINING DISTRICTS

BOHEMIA DISTRICT

The Bohemia district is described first because it is the most extensively developed, has had the largest production, furnishes the best examples and greatest variety of factors influencing mineraliza-

tion, and was studied in greater detail than the other districts. The remaining districts and mineralized areas are described in the order of their occurrence from north to south.

LOCATION AND ACCESSIBILITY

The Bohemia mining district is in Lane County, 35 miles southeast of Cottage Grove, largely within Tps. 22 and 23 S., Rs. 1 and 2 E. The productive part of the district is in one of the highest parts of the divide between the Willamette and Umpqua drainage systems. The district is larger than the area represented by the geologic map (pl. 13), as it includes a roughly circular area of about 60 square miles.

A good macadamized road follows the valley of the Row River from Cottage Grove to the mouth of Frank Brice Creek. Two mountain roads branch from this road, one following Frank Brice and Champion Creeks and the other following Sharps Creek; they join at the Bohemia district. According to F. S. Day the Champion road has been largely rebuilt and improved since 1931. A railroad connecting with the Southern Pacific line at Cottage Grove and extending to Rujada, near the mouth of Frank Brice Creek, is used for hauling logs and lumber, but it has never been extended to the Bohemia district. There are numerous trails through most of the district.

SURFACE FEATURES

The Bohemia district lies in a rugged, maturely dissected area in the Western Cascades. The most conspicuous feature is a group of sharp peaks rising 1,000 feet or so above the general summit of the range. (See pl. 2.) This group includes Bohemia Mountain, with an altitude of 5,987 feet; Fairview, 5,933 feet; Grouse, 5,570 feet; Grizzly, 5,450 feet; North Fairview, 5,550 feet; and Elephant, 5,522 feet. These mountains are the highest in the central part of the Western Cascades. The first four—Bohemia, Fairview, Grouse, and Grizzly—all lie on the ridge known as Calapooya Mountain, which divides the drainage basins of the Umpqua and Willamette Rivers. Narrow ridges and valleys radiate in all directions from the central part of the area, and steep forested slopes are characteristic. Glaciation has modified the upper parts of the valleys, particularly on northern and eastern slopes, and glacial debris extends down the valley of Champion Creek possibly as far as the mouth of Golden Curry Creek, or to an altitude of 3,100 feet. Glacial cirques, some of them with lakes and muskegs, are best represented by Crystal, Golden Curry, Champion, Horseheaven,

and Musick Basins. Some of the veins, particularly the Musick, have been eroded by glaciers. Possibly others have been covered by glacial debris, as in the vicinity of the old Champion mill.

GEOLOGY

GENERAL FEATURES

More than nine-tenths of the mapped area of the Bohemia district is underlain by a series of bedded volcanic rocks of Miocene (?) age, having a maximum thickness of 6,500 feet. These rocks comprise tuffs, volcanic breccias, and andesite lavas in about equal amounts, with minor lenses of coarse volcanic breccia and agglomerate and flows of rhyolite intercalated in the tuffs. The andesites range between very calcic and very sodic extremes, but the calcic type (labradorite or basaltic andesite) is the most characteristic of the district. There are many irregularities in the stratigraphic relations of the volcanic rocks, and all their characters are consistent with an origin through subaerial accumulation from volcanoes of the centric type. These rocks commonly dip at low angles to the northeast and east, although locally the dips vary, and some east-southeast dips were observed. Several dikes of andesite varying widely in strike traverse the bedded volcanic rocks and are presumed to be closely related to them. A considerable number of small plugs, dikes, and a stock of dioritic intrusive rocks occur in a belt extending northward through the central part of the area. They are included in an area of hornfels 3½ miles long and half to three-quarters of a mile wide.

VOLCANIC ROCKS

Andesites, chiefly of the calcic or labradorite variety, make up the greater part of the ridge that includes Grouse Mountain and Noonday Ridge, as shown on plate 13. The high points in the western part of the area, including Bohemia, Fairview, Elephant, and Cat Mountains, are also characterized by labradorite andesite. Monte Rica Ridge, in the southwestern part of the area, contains about 700 feet of andesite.

A large lenticular mass of rhyolite occurs in the Sharps Creek Basin, on the west side of the area, and smaller masses occur in Champion Saddle; on the spur south of Crystal Creek; on the Johnson Meadows trail in sec. 8, T. 23 S., R. 2 E.; 500 feet south of the Golden Slipper tunnel on Horseheaven Creek, in sec. 20, T. 23 S., R. 2 E.; and on the Oregon-Colorado road in sec. 19, T. 23 S., R. 2 E.

The remainder of the area is made up chiefly of fragmental rocks—greenish tuffs, volcanic breccias, and agglomerate. Many flows of andesite, particularly of the light-gray andesine-bearing variety, are

included. The andesite rocks are particularly prominent on the west slope of South Grouse Mountain and on Jackass Butte. Coarse volcanic breccia occurs at several places, including the band above the Oregon-Colorado mine, at the Mayflower mill on Horseheaven Creek, in the bed of Champion Creek a short distance above the mouth of Cat Creek, and in crosscut 9 of the Champion mine, where the material has a rude cross-bedding. A somewhat different breccia or agglomerate constitutes the whole ridge top between Fairview Peak and North Fairview Mountain. The smaller fragments are about 1½ inches and the larger fragments several inches in diameter. Some of the andesite of the fragments is massive, and some is highly amygdular. There is very little difference between fragment and groundmass, and the aggregate weathers uniformly and breaks smoothly. It forms a lens between flows and may be a flow breccia.

As the whole series of volcanic rocks dips mainly to the east or northeast, the series is believed to be essentially conformable, possibly except the flows of Bohemia Mountain, with the oldest rocks at the southwest side of the area and the youngest at the east. The stratigraphic relations of the rock groups that crop out along the lines represented by A–A′ and B–B′, plate 13, are shown in the sections on the same plate.

Local unconformities occur at various places, but they probably have no great significance. The seven upper flows of the series forming Bohemia Mountain are in conformable sequence without intercalated tuff, but the two lower flows interfinger with tuff and do not appear on the south side of the mountain, suggesting a possible unconformity. An erosional unconformity appears on the southwest side of Grouse Mountain, where beds of tuff and a small fault are cut off on the erosion surface beneath a succession of flows.

DIORITIC INTRUSIVE ROCKS

Numerous small bodies of dioritic intrusive rocks occur in the Bohemia district, and 26 different bodies ranging from thin dikes to cylindrical plugs and a small stock are shown on the geologic map (pl. 13). Doubtless some bodies, obscured by the forest litter, have been overlooked. These rocks are most prominent in a belt extending in a northeasterly to northerly direction from the south end of Bohemia Mountain through Champion Saddle and down the valley of Champion Creek. Several appear on Noonday Ridge. Elongate bodies trend chiefly to the west or northwest except for the stock in the valley of Champion Creek, which is elongate in a northerly direction. Most of the plugs are less than 250 feet wide, most of the large dikes are less than 600 feet wide, and the stock on

Champion Creek is about 1¼ miles long and about 2,000 feet wide. Most of the dikes are less than a mile long.

The intrusive rocks are medium to light gray, porphyritic, and variable in texture and composition, though characterized chiefly by augite. The stock and the large dikes consist chiefly of granodiorite or granodiorite porphyry, some of the small plugs are diorite or diorite porphyry, but most of the small plugs and dikes are dacite porphyry. A large part of the workings of the Champion, Helena, and Leroy mines are in the intrusive rocks. The body at the south side of the area mapped is a porphyritic rhyolite and is not definitely related to the group of dioritic intrusives.

CONTACT-METAMORPHIC ROCKS

The volcanic rocks near all the dioritic intrusive bodies have been modified to some extent by the heat and solutions given off by the intrusive mass. In addition to the narrow zones or aureoles of contact-metamorphic rock around the small isolated intrusive bodies, there is a large continuous zone of contact-metamorphic rock extending from City Creek southwest of Champion Saddle northward to the Cape Horn vein, a distance of 3½ miles.

The contact-metamorphic rocks, called hornfels, range from those which are only slightly modified to those in which the original minerals and structure are obliterated. Tourmaline hornfels, which represents the most intense degree of metamorphism, occurs in the vicinity of the Champion mine and particularly on the north side of the dike west of the United States mineral monument. Rugged outcrops of hornfels occur along the valley of Champion Creek, particularly along the west side of the stock and on to the northwest for half a mile downstream beyond the stock. The group of veins in the vicinity of the Champion mine and the old Champion mill and the Cape Horn vein are the only prominent veins lying partly or wholly within the large zone of contact-metamorphic rock.

STRUCTURE

A gentle regional deformation has affected the volcanic rocks, which dip prevailingly to the northeast. (See pl. 13.) The most notable variations are along Champion Creek, where the dip is north to north-northeast, and in the area south of Grouse Mountain and east of Champion and City Creeks, where the dip is mainly east-northeast, changing to east for 2 miles north of Champion Saddle and resuming the northeasterly direction farther north. There are southeasterly dips in some places. The steepest dips for any considerable area were observed in the vicinity of Fairview Mountain, where the contact between the lavas and tuffs underlying the northeast spur of the mountain dips about 30° NE. North of Crystal

Basin the angle of dip is smaller than that of the surface. Diller [65] has suggested that the Bohemia district is on the limb of an anticline, but the prevailing easterly or northeasterly dip continues as far south as the writers' investigation extended, and the axis of such an anticline must therefore be well outside the district. The flows forming the caps of Bohemia, Elephant, and Cat Mountains dip at low angles to the east or northeast. The average dip of the lavas in Noonday Ridge and Grouse Mountain was not ascertained, but dips of 20° or less are inferred in the sections. The tuffs east of Horseheaven Creek also dip to the east at low angles.

Faults are not abundant, so far as could be ascertained. The most prominent fault is that along the Crystal vein, which strikes N. 70° W. and dips 56° S. In the saddle between North Fairview and Elephant Mountains the vertical component of the displacement amounts to about 200 feet, but the presence of horizontal striations leaves the actual direction and amount of displacement in doubt. Faulting is indicated along the fracture of the Yucon vein, which strikes about N. 80° W. through the narrow gap in the north spur of Bohemia Mountain. It is followed for about 350 feet by the Musick vein, and there may be that much displacement of the original Musick fracture. A slight displacement was also noted along the Yellow Jacket vein. The walls of many of the veins show slickensides and striations, but because of the lack of marker beds no measurement of the displacement could be made. The striations on the walls of the veins are usually more nearly horizontal than vertical.

The major structural axis of the area is the curving line through the center of the district, trending north-northwest in the north and southwest in the south. It largely marks the change of strike of the volcanic rocks from the northeast to east, and also coincides with the belt of intrusive and contact-metamorphic rocks. The trend of the large stock is parallel to this axis, but the smaller elongate bodies trend west or northwest.

By far the greater part of the joints in the western part of the area strike N. 60°–90° W. and dip 70°–90° S., but lower and northerly dips occur in some places. There are two minor joint systems, one with a strike of N. 20°–40° W. and the other with a strike of N. 20°–40° E. Some joints striking in other directions were found. On the east spur of North Grouse Mountain, and farther northeast there are two sets of joints, one striking N. 45°–70° E. and dipping 60°–80° NW. and the other striking N. 75°–90° W. and dipping 50°–90° N., with a minor set striking N. 20°–40° W. A set of joints

[65] Diller, J. S., The Bohemia mining region of western Oregon, with notes on the Blue River mining region and on the structure and age of the Cascade Range: U. S. Geol. Survey 20th Ann. Rept., pt. 3, p. 10, 1900.

north of the Mayflower claims strikes N. 50°–65° W. and dips 70°–90° NE. In general there is a set of joints within 20° of the direction of dip of the beds.

The veins likewise have a dominant trend to the northwest and west. About half of them strike N. 50°–70° W., about a quarter N. 70°–90° W., and the remainder N. 30°–50° W. Dips are mainly 60°–80° S. Most of the veins with a northwesterly strike are in the southern half of the area, and those with a westerly strike are in the northern part.

MINERAL DEPOSITS

GENERAL FEATURES

Though the Bohemia district covers a roughly circular area of about 60 square miles, the main mineralized belt occupies an area 5½ miles long and 1½ miles wide trending N. 60° W. It includes the Mayflower, Riverside, and Oregon-Colorado mines at the southeast and the Utopia, Sweepstakes, and Musick at the northwest. Gold has been the principal ore mined and has been obtained largely from the oxidized parts of sulphide veins. The veins are younger than any of the other rocks in the district, including the intrusive bodies. The vein matter in most places consists of brecciated, altered, and partly replaced country rock cemented by or containing fissure fillings of drusy or comb quartz that locally contains sulphides. In some veins there are bodies of cherty quartz with pyrite crusts along intersecting short fractures. The dominant sulphide, sphalerite, is associated with galena, chalcopyrite, and pyrite in varying amounts, and in some places with a little tetrahedrite. Galena is the dominant sulphide in the Musick vein, chalcopyrite in the Oregon-Colorado, and stibnite in the Tall Timber. Primary specularite is associated with quartz in several of the veins. The gold content of the unweathered sulphide ores is low in most places, though a few high-grade pockets have been found. There is a rough areal zonal distribution of mineral deposits in relation to intrusive rocks. Base-metal quartz shoots with variable amounts of gold and in places with specularite and dolomite are grouped in the area of most intensive igneous intrusion; and veins with generally less sulphide, more carbonate (commonly calcite), and in places stibnite occur in an area to the south, where there are fewer intrusive bodies.

HISTORY AND PRODUCTION

Diller [66] gives the following account of the early history of the region:

[66] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), p. 7.

The Bohemia mining region was discovered, according to Dr. W. W. Oglesby, of Junction City, Oreg., by himself and Frank Brass [Brice?] in August 1858. The region was named for James Johnson, also called Bohemia Johnson, who, with George Ramsey, reached it in 1863 from Roseburg by way of the North Fork of Umpqua River and Steamboat and City Creeks. Free gold was found in a small vein near the headwaters of City Creek but gave out at a depth of 6 feet. Bird Farrier discovered what, by purchase, became later the Knott claim, where a 5-stamp mill was put up in 1875. It shut down in 1877, and the Bohemia region was almost forgotten until interest in it was revived by Dr. W. W. Oglesby, O. P. Adams, and others in 1891. The first ledge of importance located the same year, was the Musick, which has been running a 5-stamp mill almost continuously ever since. In 1892 the Annie (since called the Noonday) was opened. The Champion put in a 10-stamp mill in 1895 and the Noonday a 20-stamp mill in 1896. Over a hundred claims have been located in the district.

In 1902 operation of the Champion, Helena, and Musick mines was consolidated under the West Coast Mines Co., and a 30-stamp mill was erected at the Champion mine. Kimball [67] reports that in 1902 there were—

> not less than 2,000 mining claims of record, some of which, as may be assumed, are fractional and some relocations. * * * The district numbers about 60 head of stamps.

The Noonday mine was productive between 1896 and 1908, when it was closed down. MacDonald [68] states that in 1908 no ore was being milled in the district, nor had any milling been done since the preceding summer. In 1912 the combined Champion, Helena, and Musick mines were shut down. W. W. Elmer [69] states that from 1912 to 1918 the Champion was held under lease and bond by two operators who did a little development work and mining but ceased operations in 1917. Development and some mining was carried on by the Vesuvius Mines Co. for several years prior to 1921. The Evening Star mine, on the eastern part of the Champion vein, has been worked in a small way in recent years on oxidized ores. In the summer of 1930 there was no mining and only sufficient prospecting to satisfy the requirements of assessment work.

Within the area shown on the map (pl. 13) there are 78 patented claims and 59 claims surveyed for patent. To the west of this area, in the vicinity of Glenwood and Mineral and farther south, there are 30 claims surveyed for patent. About 200 adits and 75 veins are shown on the map (pl. 13).

The recorded production of the district is given in the table below. Undoubtedly metal was produced that was not recorded, especially in

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[67] Kimball, J. P., Bohemia mining district of western Oregon: Eng. and Min. Jour., vol. 73, p. 889, 1902.

[68] MacDonald, D. F., Notes on the Bohemia mining district, Oreg.: U. S. Geol. Survey Bull. 380, p. 83, 1909.

[69] Elmer, W. W., private report.

the earlier years and some of the mines that are known to have produced are not mentioned in the records. Consequently the total production very probably exceeds the figure given, but not by any very large amount.

Output of gold and silver in Lane County, 1880–1900 [1]

[From records of United States Mint]

Year	Gold (ounces)	Silver	Year	Gold (ounces)	Silver
1880	131.87		1892	1,523.81	$247.50
1881	181.41		1893	2,757.37	
1882 [3]			1894	1,572.19	
1883 [2]			1895	1,647.80	29.51
1884 [2]			1896	2,709.00	
1885 [2]			1897	117.99	10.47
1886	145.13		1898 [3]		
1887	241.88		1899	2,015.01	1,131.31
1888	241.88		1900 [3]		
1889	169.31				
1890	145.13		Total	14,590.96	1,418.79
1891	991.18				

[1] Probably almost entirely from Bohemia district.
[2] No record.
[3] Small production.

Output of metals in the Bohemia district, 1901–30

[From data supplied by V. C. Heikes]

Year	Crude ore (tons)	Concentrates (tons)	Gold (ounces)	Silver (ounces)	Copper (pounds)	Lead (pounds)
1901 [1]						
1902	420		167.10			
1903	1,000		290.25			
1904 [1]						
1905	6,100		2,231.92	1,024		
1906	6,000		2,633.73	1,049		
1907	7,647	134	1,816.92	727		
1908	26		42.38	143	629	2,138
1909	2,312		648.85	349		
1910	1,337		213.10	73		
1911	4,650	8	1,465.48	451		
1912	8,104	120	2,465.19	1,681	5,098	35,785
1913	1,375	118	290.11	1,604	7,308	59,204
1914	631		188.08	29		
1915	2,142	73	470.11	57	406	5,979
1916	49		159.98	128	1,390	16,348
1917	24		95.93	328		
1918	15		46.01	88		1,362
1919 [1]						
1920 [1]						
1921	20		42.96	229		
1922	Sluice		25.44	6		
1923	200		94.88	44		
1924	100		97.06	46		
1925	78		63.48	29		
1926	178		61.93	27		
1927						
1928	100		63.75	29		
1929	15		7.94	3		
1930	25		11.96	4		
Total	42,548	453	13,604.59	8,148	14,831	120,816

[1] No record.

NOTE.—Approximate values, 1880–1930: Gold (at $20.67 per fine ounce), $584,662; silver, $6,473; copper $2,480; lead, $5,775; total, $599,390.

The value per ton in terms of recovered metals for outputs of 100 tons or more for the various mines since 1902 has ranged from $1.20 to $16 (with gold figured at $20.67 an ounce), as deduced from data of V. C. Heikes, of the United States Bureau of Mines. The value per ton for small shipments of sorted ore has been as much as $100 or more. The average value per ton for the largest operation, that of the combined Musick and Champion mines, was $6.90 for 14 years. Annual averages for years in which more than 1,000 tons was milled range from slightly less than $5 to slightly more than $9 a ton ($20.67 an ounce for gold). Zinc was a liability rather than an asset in these complex ores during the years when concentrates were produced, and the price of lead was high only in 1916–18, when there was base-metal production. No data on costs during the productive years are available, but the obvious difficulties of transportation and the cost of mining relatively small ore shoots must have made the cost per ton relatively high. From the scanty data available it seems unlikely that the original cost of the elaborate plant and equipment of the largest company was amortized.

CLASSIFICATION

Base-metal veins with variable amounts of gold.—Most of the production has come from the base-metal veins, of which the Champion, Helena, Musick, Noonday, Vesuvius, Crystal, Grizzly, Shotgun, Utopian, Vindicator, and War Eagle are examples. The features of this type of vein have been described in the general descriptive part of this report (pp. 24–29). The metal content of the sulphide ore shoots is highly variable. Such assays of minable shoots as are available indicate that most of the gold ranges from a trace to slightly more than 1 ounce to the ton, with an average of about 0.4 ounce. Most of the silver ranges from a trace to 4 ounces to the ton, with an average of about 2 ounces. Copper ranges between a trace and 1.5 percent and averages 0.75 percent. Lead ranges from a trace to 6 percent, with an average of about 3 percent; and zinc ranges from 1 to 14 percent, with an average of about 5 percent. Variations occur in the proportions of the various minerals in the base-metal veins, and some, such as the Cross vein, of the War Eagle group, a vein of the Orofino group, the Alpharetta vein, and shoots on the Sultana and Cape Horn veins, contain abundant specularite. The California vein contains johannsenite.

Veins of quartz and clay minerals.—The veins containing quartz and clay minerals consist of kaolinized and silicified country rock with sparse to abundant seams and lenses of quartz that in some places contain a little sulphide. Examples of such veins include some near the west border of the granodiorite stock along Champion

Creek and the North Fairview and Syndicate veins. They have not been productive.

Pyrite and cherty quartz veins.—Parts of the Sultana, Cape Horn, and Orofino veins, the northern vein east of Helena No. 2 camp, and the Golden Slipper vein are made up of cherty quartz with many small fractures faced with pyrite containing some intergrown marcasite.

Chalcopyrite-quartz veins.—The only example of the chalcopyrite-quartz veins is the Oregon-Colorado vein, which is described on pages 72–73.

Gold-quartz and gold-calcite-quartz veins.—Low-grade gold-quartz veins occur in the western part of the district, outside the mapped area. At the Star mine the ore consists of white massive and vuggy quartz with calcite and pyrite. Sphalerite, chalcopyrite, and galena are present in some veins in minor amounts. A shoot on the Western vein of the Cripple Creek group consists of massive quartz with very sparse sulphide and some coarse gold. Calcite is the major gangue mineral in the El Capitan vein on St. Peters Creek, where it is associated with sulphides, principally galena, and comb quartz.

Stibnite-pyrite-quartz veins.—Stibnite veins are represented by one of the veins of the Tall Timber group described on page 78.

Specularite and magnetite veinlets and disseminated specularite.—Fractures in hornfels adjacent to many of the intrusive bodies contain specularite and magnetite. Specularite and pyrite are disseminated in bleached zones of andesite or tuff near intrusive masses.

Disseminated pyrite.—Pyrite is disseminated in the contact zones around the smaller intrusive bodies and in the outer part of the large areas of contact-metamorphic rock.

ZONAL ARRANGEMENT

No evidence of vertical zoning and only poorly defined evidence of areal zoning of sulphide minerals has been found. Veins with sulphides have a vertical range of 2,800 feet, though the maximum depth within any single mine is only about 400 feet, but sulphides persist through this range without any apparent change.

A rough areal zoning is indicated in the principal mineralized belt, which extends west-northwestward from the Mayflower to the Utopia. This belt is characterized by shoots in which the gold content is variable and the chief sulphides are sphalerite, galena, and pyrite, with subordinate amounts of chalcopyrite, in a gangue of quartz, sericite, clay minerals, and a little dolomite in vugs. In the center of this belt, in the vicinity of the Champion mine and the area of large intrusive bodies and extensive contact metamorphism,

primary specularite is associated with quartz in several veins, and metamorphic rock nearby contains tourmaline. Vein matter in the Grizzly, Cape Horn, and Sultana veins, farther north, is similar.

Farther south and southwest there are fewer intrusive bodies, fewer veins, and fewer shoots that contain noteworthy proportions of sulphides. Sphalerite and galena are less abundant. Stibnite occurs at the south end of the Western vein and in the El Capitan and Tall Timber veins and is reported to occur in veins in the vicinity of Twin Rocks, farther southwest. Carbonates are common in some of the veins in this area. Dolomite forms considerable bodies in the Western vein, and calcite is abundant in the El Capitan vein. Sulphides are sparse in the Glenwood and Combination veins and at the Star mine. All these characters are consistent with mineralization at lower temperatures than those in the area to the north and northeast.

HYDROTHERMAL AND SUPERGENE ALTERATION OF WALL ROCK

The wall rocks of all the veins have been altered and new minerals have been formed. Several veins, such as the Oregon-Colorado, are accompanied by altered rock characterized by chlorite. In these the rock is greenish and superficially appears fresh, though the microscope shows that original minerals are partly or completely destroyed. Large areas of altered rock that is bleached and iron-stained at the surface occur in Champion Saddle, in Bohemia Saddle, in the saddle between Fairview and North Fairview Mountains, in the saddle between North Fairview and Elephant Mountains, in Grizzly or Helena Saddle, in the saddle in the eastern part of sec. 7, T. 23 S., R. 2 E., in the western part of sec. 8, T. 23 S., R. 2 E., on Monte Rica Ridge, in sec. 23, T. 23 S., R. 1 E., and on the south and west slopes of Jackass Butte. Similar altered rock occurs in the vicinity of the Knott shafts, in the saddle between North Grouse and South Grouse Mountains, and in the western part of the district, outside the area represented by the geologic map. Smaller areas accompany many of the veins throughout the district. The bleached altered rock is characterized in outcrop by its light color (white or various tints of yellow), craggy or pitted weathered surface, and low resistance to weathering and erosion, hence its occurrence in saddles and other relatively low places. Samples collected from the Champion workings and discussed on pages 31–32 are made up largely of very fine grained quartz, abundant pyrite, a little sericite, and abundant clay minerals. Some of the clayey material tends to slough in underground workings. Thoroughly weathered material contains no pyrite but is iron-stained.

FUTURE OF THE DISTRICT

By its recorded production of nearly $600,000, the Bohemia district has proved itself worthy of consideration, though this output is small as compared with that of many other mining camps or with that of the placer operations in northeastern and southwestern Oregon. The output has come chiefly from the weathered parts of the veins, and probably all but a small part of the free-milling ore has been removed. Though the district has been extensively prospected, it is possible that other veins with oxidized free-milling ore shoots will be found in an area so densely covered with forests and forest litter. Shoots or parts of shoots of sulphide ore remain in the principal mines, and bodies of sulphide vein matter have been partly explored in some of the prospects. Many of the veins as a whole, as distinguished from ore shoots, have been shown to be persistent over lengths of more than half a mile, and some contain several ore shoots. The fact that the difference in altitude between the lowest and highest veins within the productive part of the district is 2,800 feet is encouraging for deeper exploration on the larger veins. It may be expected that sulphide ores will persist to depths of several hundred feet at least in the large veins, though there are no data on which to base predictions of possible metal content of the ore. The veins outside of the main productive area previously outlined may be expected to include shoots containing some gold but very little sulphide ore, and they should be worked in only a very small way with a minimum of overhead.

The gold and silver content of the sulphide ore is low in most places, but the sulphides are doubtless amenable to flotation, a process that has not been tried in this district. No sufficiently large shoots of ore were blocked out in 1930 to justify installation of a modern flotation mill at any one of the mines. Further exploration and development of several of the veins should, however, reveal sufficient ore to justify a custom mill. Unit operation of several of the mines in the central part of the district might be a profitable enterprise, but the margin of profit in any large operation will undoubtedly be small, because of the low gold and silver content of the sulphide ores and the high costs of transportation. However, improved transportation facilities now available and modern equipment designed to yield a large proportion of the metals in the ore should tend to offset the advantage of higher grade of ore enjoyed by the earlier producers. Favorable prices for the base metals together with the prices of precious metals prevailing in 1935 should make some of the veins attractive for exploitation. Operations should proceed with a minimum of overhead until the amount and grade of the ore are established.

MINES AND PROSPECTS

The mines that have made noteworthy production—Champion and Evening Star, Helena, Musick, Noonday, and Vesuvius—are described first, and the other veins and properties are described in alphabetical order.

Champion and Evening Star.—The Champion group comprises 10 claims lying in and near the head of the Champion Creek Basin. The mine is on the narrow ridge between the Champion Creek and City Creek Basins at Champion Saddle. Operations were carried on from the Champion Creek side, so that all buildings and tunnel portals are on that side. The Evening Star mine is on what is regarded as the southeasterly extension of the Champion vein, and the crosscut tunnel portal and mill are on the City Creek side. The property has been known as the Hartford mine of the Calapooia Mining & Tunnel Co. and was formerly one of the properties of the West Coast Mines Co.

The recorded production up to 1930 was about $291,500, including the value of small amounts of lead and copper. An unknown part of this production should be credited to the Musick mine, as ore from both mines was milled together for several years. The period of maximum production appears to have been 1900 to 1913.

A boarding house, bunkhouse, office, and tunnel house at level 12 are located in the Champion Creek Basin. There is a cabin and mill at the Evening Star.

The Champion and Evening Star veins have been developed by drifts on five levels for a distance of about 1,600 feet along the strike. The total length of workings, crosscuts, drifts, and raises is about 10,000 feet (fig. 1), of which a part is now inaccessible. The lowest level, no. 9, is reached from the north by a large haulage tunnel 950 feet long and was connected to all other levels by raises. Level 6 is reached from the south by a crosscut 210 feet long at the Evening Star (fig. 1). Crosscut 12 was started at the foot of the slope at the head of the Champion Creek Basin and advanced 420 feet S. 10° E. It is estimated that the Champion vein will be intersected about 460 feet farther in and about 320 feet below level 9.

The Champion vein traverses rhyolite, labradorite andesite, tuff, hornfels, and granodiorite porphyry. The average strike of the vein in the Champion workings is N. 65° W., though it ranges from N. 45° W. to N. 80° W. In the Evening Star workings the strike is N. 60° W. The average dip is 65°–70° S., though the dip is as low as 60° on level 5 and as high as 80° on level 9. The vein matter consists of sphalerite, pyrite, chalcopyrite, galena, and a little hematite in quartz and altered rock. Oxidation is nearly complete near the surface, and there is some oxidation throughout the workings.

Two principal ore shoots appear on level 6, one at the west end and the other at the east. The west ore shoot has a maximum horizontal length of about 500 feet and extends down to level 9, but it is barren in places. It has been largely stoped to the surface from level 9 (pl. 14). According to engineers' reports a few samples from pillars between levels 8 and 9, east of the west ladder between

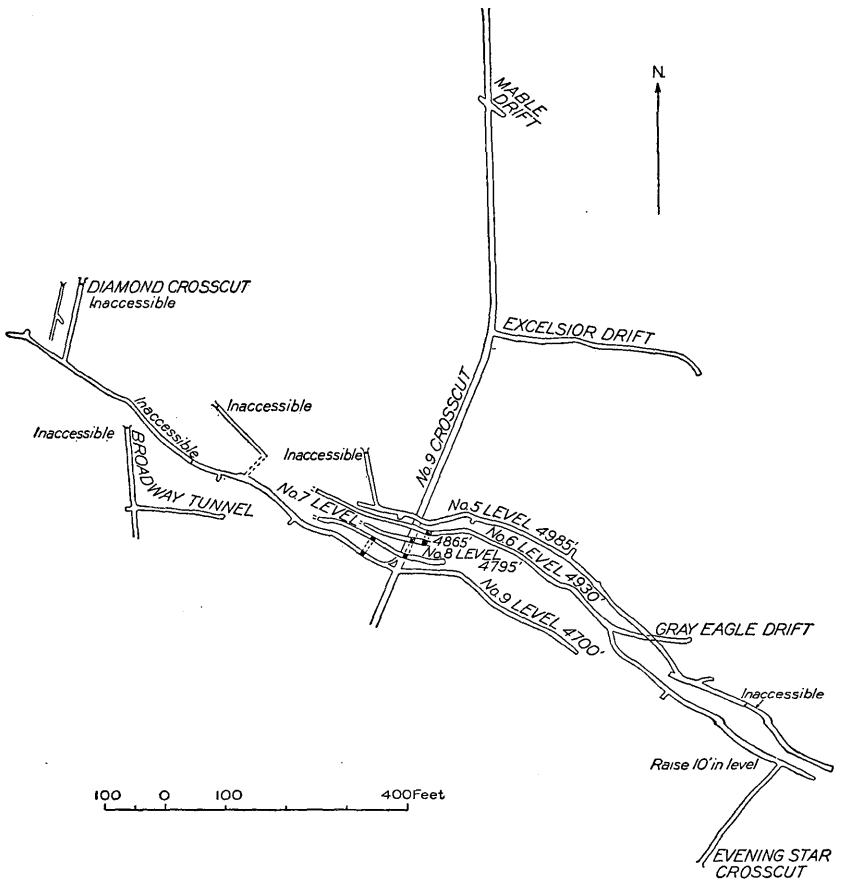


FIGURE 1.—Sketch of underground workings of Champion mine, Bohemia district. Level 5 and all of level 9 except east drift from old mine map; remainder from compass and pace traverse. Altitudes approximate.

these levels, assayed 0.44 to 0.82 ounce of gold and 1 to 2 ounces of silver to the ton, a trace of lead, 0.25 to 1 percent of copper, and 3 to 8 percent of zinc, with an average of about 5 percent of zinc, for an average width of 2.7 feet. One assay showing 4.64 ounces of gold to the ton and 12 percent of zinc over a width of 0.9 foot was reported. The west ore shoot is about 120 feet long on level 9, and to the west for about 150 feet the samples assayed about 0.10 ounce

of gold and a little over 1 ounce of silver to the ton, 3 percent of lead, 1 percent of copper, and 5 percent of zinc for an average width of a little over 3 feet. Samples from the intermediate level between levels 8 and 9 east of the ladder and from pillars just west of the ladder at level 8 for an average width of a little over 3 feet assayed about 0.3 ounce of gold and 3 ounces of silver to the ton, 2 percent of lead, 8.5 percent of zinc, and 0.5 percent of copper. A shoot of base-metal ore between levels 8 and 9 along the ladder west of crosscut 9 assayed about 0.10 to 0.20 ounce of gold and 1 to 4 ounces of silver to the ton, 0.3 percent of lead, 0.2 percent of copper, and 3 to 14 percent of zinc, with an average of 6 percent of zinc, for an average width of 3.5 feet. Samples from the back of the stope east of crosscut 9 assayed about 0.16 ounce of gold and 1 ounce of silver to the ton, 1 percent each of lead and zinc, and an insignificant amount of copper. The vein east of this stope contains very little gold or sulphide.

The east ore shoot at the Evening Star appears to have a horizontal length of 120 feet or more. It has not been stoped to the surface, and a block of good ore remains. Samples of pillars assayed a little over 0.63 ounce of gold and 2 ounces of silver to the ton and a few tenths of 1 percent each of lead, zinc, and copper for an average width of 4 feet. The vein at the east end of levels 5 and 6 assayed 0.20 to 0.24 ounce of gold to the ton. The vein matter is largely oxidized.

A small ore shoot on level 7 about 100 feet from the east end has a maximum width of 2½ feet and a horizontal length of about 65 feet.

The Excelsior vein lies 420 feet north of the Champion vein and strikes east. It is penetrated in crosscut 9 and has been prospected by a short drift. The vein is essentially an altered zone in granodiorite porphyry and does not appear to be a promising source of ore.

A vein on the Mable claim has been prospected by three adits and a short drift from crosscut 9, about 360 feet north of the Excelsior vein. The portals of the two upper adits, at altitudes of 5,300 and 5,200 feet, are caved. The adit, at an altitude of about 5,160 feet, is 50 feet long and trends S. 65° E. The vein has an average strike of about N. 70° W. and dips 85° S. It trends toward the mineralized area around the old Knott shafts. In crosscut 9 the vein consists of quartz stringers with pyrite and a little sphalerite in a zone of altered tuff.

The Vindicator vein is on the spur west-northwest of the Champion vein, on the Vindicator or Frank Brice or Dot claim. It is prospected by two cuts and a shaft 30 feet deep near the top of the ridge and two adits on the west side. The upper adit runs 100 feet S. 60° E., and the lower one 150 feet S. 66° E. The vein strikes N. 50°–66° W. and dips 60°–65° S. in the cuts and 65°–75° N. in the adits. The vein matter consists of quartz seams 6 to 16 inches wide in greenish andes-

ite. The quartz in the lower adit is drusy and contains seams of sulphide, chiefly sphalerite but some galena and chalcopyrite.

The Columbia (?) vein is prospected by a short adit southeast of the Champion mill, where it consists of an altered zone in granodiorite porphyry. It also appears in the bed of Champion Creek about 50 feet below the old tramway crossing, where it is a zone of brecciated granodiorite porphyry cemented by quartz. It is not sufficiently exposed to reveal possible ore shoots.

Two openings have been made on a vein on the Bluebird claim just south of the intersection of the Champion road and the trail to Grizzly Saddle. The vein strikes N. 80°–85° W. and dips from 80° S. to vertical. The vein consists of a narrow quartz seam with scattered sulphides in altered rock.

The workings on what was originally the Knott claim are between 100 and 500 feet northeast of the United States mineral monument on the west side of North Grouse Mountain. According to Diller,[70] the Knott claim was the first mined on any considerable scale, and it was equipped in 1875 with a 5-stamp mill that operated for about 4 years. Several inaccessible shafts and cuts are located in a large area of altered iron-stained rock, and the vein matter is almost completely oxidized. Specimens with visible fine gold were found near the old shafts. A few years ago a short crosscut was made below the brow of the hill about 150 feet northeast of the mineral monument, and a drift was run 75 feet S. 80° E. on a vein to a junction with one of the shafts. Ore from this vein was milled at the Evening Star mill. About 150 feet east-northeast of the portal of this tunnel a crosscut has been driven 135 feet S. 30° E., and 12 feet of drift was run N. 80° E. along a band of altered rock.

West of the mineral monument, within a switchback on the Bohemia trail, on a vein known as the Gray Eagle, is an inaccessible shaft. The owners report that it is 60 feet deep and that a drift 110 feet long extends from the bottom toward the east. The vein strikes about east and dips south. It may be the same as the vein called the Gray Eagle by the owners, which appears on level 6 of the Champion mine. Southeast of the mineral monument there is also a Gray Eagle vein, which trends toward the altered area at the Knott shafts.

The Birdie vein, which lies on the west slope of Grouse Mountain south of the Evening Star, strikes N. 70°–80° E. through the saddle between North Grouse and South Grouse Peaks to the Ingham group of claims. It has been prospected by two adits and several cuts, which are all caved.

Helena.—The Helena group comprises 11 claims, of which 3 are patented and 7 are surveyed for patent. They extend across Grizzly

[70] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), p. 27.

Mountain from the east side of Champion Creek to the Noonday mill on Horseheaven Creek. The principal workings constituting the Helena mine lie on the east slope of the mountain and are reached by the Noonday road. The property remained idle since its sale in 1902 to the West Coast Mines Co. until the writer's visit in 1931.

No records of production are available. Probably a part of the production credited to the Noonday came from the Helena. P. J. Jennings, superintendent of the mine at the time of operation, in an oral communication to the writers, estimated the production at $150,000.

The mine was developed by five tunnels. The lowest, no. 7, is just above the site of the mill, at an altitude of about 4,700 feet. All were inaccessible at the time of examination except no. 4, at an altitude of about 4,950 feet, and no. 3, at an altitude of about 5,050 feet. Tunnel 4 is 75 feet long. A small lens of ore 30 feet long near the portal was stoped, and no ore appears in the face of the tunnel. Tunnel 3 follows the vein for 70 feet and has a crosscut 60 feet long running S. 63° W. at the face, but no ore appears in these workings. In 1898, according to Diller,[71] the lower level, probably no. 7, followed the vein for 225 feet and the upper tunnel, about 110 feet higher, followed the vein for 125 feet. Probably additional work has been done since that time.

The vein has been proved for a distance of almost 3,000 feet by tunnels, cuts, and a shaft at the top of Grizzly Mountain. It strikes N. 47°–57° W. and dips 65°–75° N. The principal ore shoot appears to have had a horizontal length of about 200 feet, as indicated by caved stopes at the surface, and probably reached to level 7, a vertical distance of about 200 feet from the surface. The greater part of the ore shoot is in the large granodiorite porphyry dike, but the remainder of the vein is largely in andesite, chiefly the labradorite variety. The vein appears to have been 8 or 10 feet wide in places but was in general less than 5 feet. According to Diller[71] the oxidized ore contained some fine specimens of free gold, and assays showed a high gold content. One assay taken by Diller yielded 0.9 ounce of gold and 1.15 ounces of silver to the ton. The sulphide ore consists chiefly of sphalerite with some pyrite, chalcopyrite, galena, and a little tetrahedrite with quartz, included rock fragments, kaolin, and barite. Several stages of vein filling are shown. The first deposit consists of greenish quartz, of which the fine-grained varieties show microconcretionary structure, and sulphides. The early vein matter has been brecciated, and the fragments are surrounded by crusts of comb quartz. Much of the ore shows vein fill-

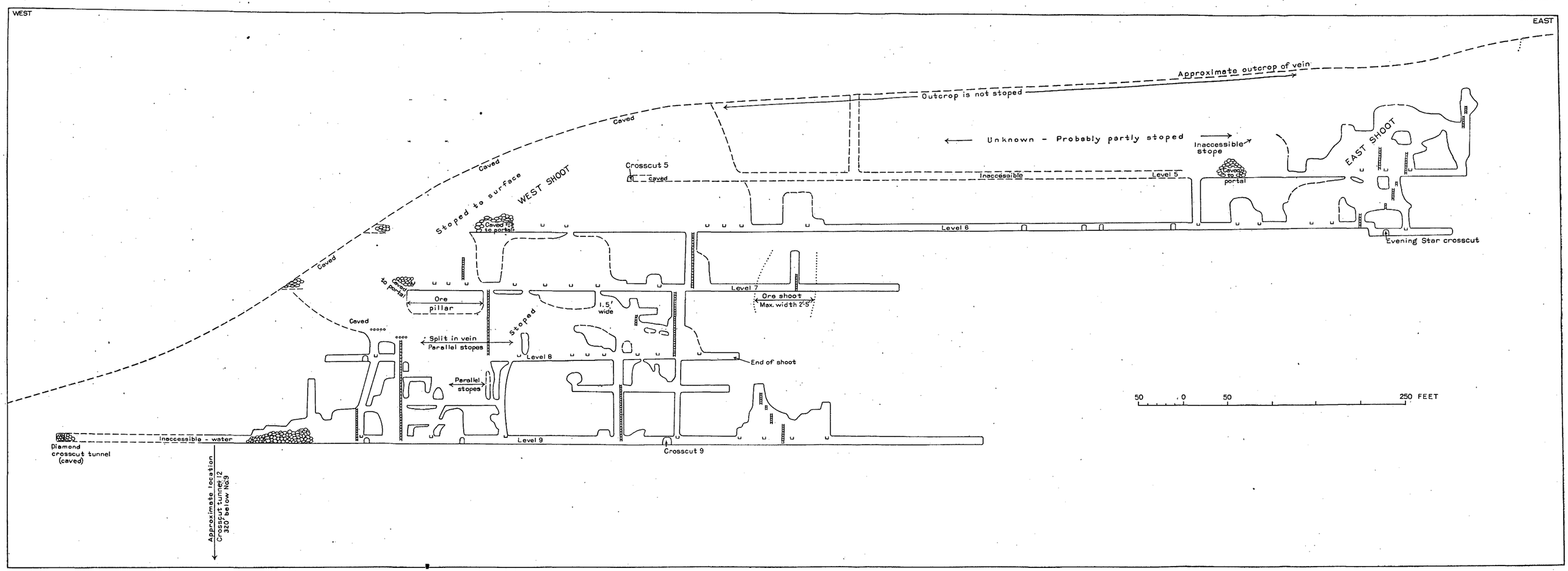
[71] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), p. 30.

ing of a third stage; this consists of two or more alternating crusts of sphalerite, comb quartz, and cherty quartz, which is followed by pyrite and barite. Barite occurs in tabular crystals in vugs and on the pyrite. Secondary hematite appears as red borders around the early fragments.

Several veins have been prospected by short tunnels and cuts on the west slope of Grizzly Mountain. They all dip to the south and do not appear to be a part of the Helena No. 1 vein. A vein north of the Helena No. 1 vein on the White Bear claim has been prospected by three short adits between altitudes of 4,700 and 5,100 feet; they are now inaccessible. The vein is in andesite and strikes N. 75° W. with a steep dip to the south. It contains quartz and the usual sulphides. Two inaccessible tunnels about 1,000 feet to the west at altitudes of 4,100 and 4,000 feet have about the same strike and appear to have been driven in search of the extension of the Helena No. 2 vein. The Helena No. 2 vein is prospected by a tunnel about 600 feet south of Jennings' cabin, near Champion Creek, on the Fallen Leaf claim. The tunnel is 300 feet long and trends S. 75° E. except near the face, where it turns to the east. The vein, scarcely more than a foot wide, dips 70°–80° S., and the small ore shoot contains sphalerite, pyrite, galena, and chalcopyrite. Fresh sulphides are exposed almost at the surface. Another tunnel 100 feet lower has been driven 48 feet S. 70° E. to cut the same vein. The rock here consists of a breccia of porphyry cemented by green dacite. Fractures in this breccia are faced with coarse pyrite, and it contains some quartz veinlets with a little sulphide.

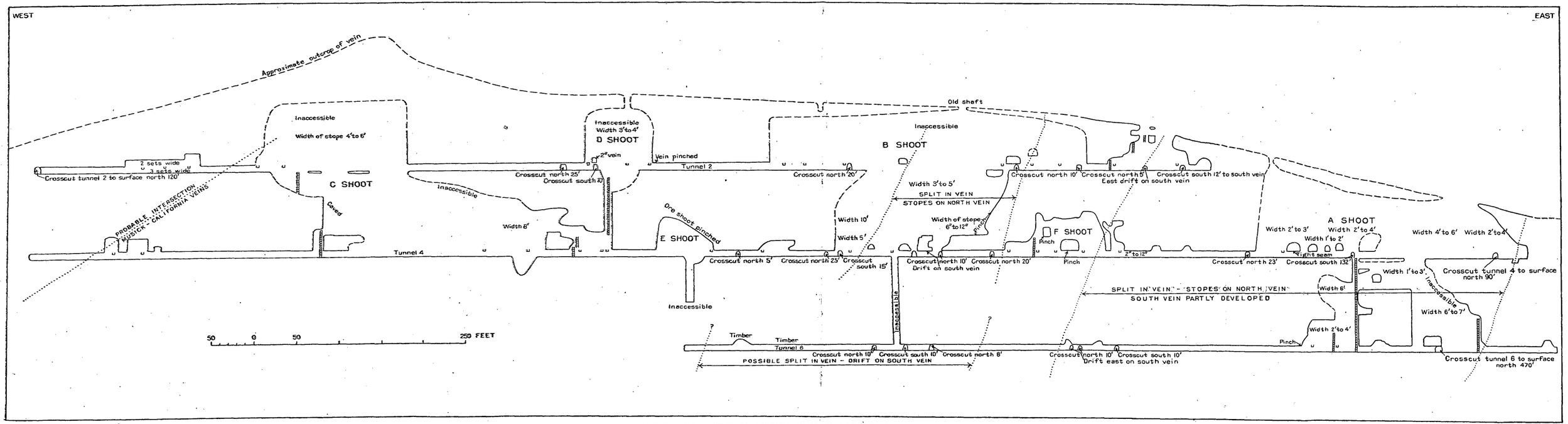
A vein trending N. 30° W., or at an angle to the others, is exposed in a tunnel about 100 feet northeast of the gulch that passes north of Jennings' cabin, at an altitude of about 4,170 feet. A crosscut extends 40 feet N. 55° E. to a drift running 90 feet S. 30° E. on vein matter that consists of brecciated greenish andesite with a network of quartz veinlets containing a little sulphide. A few fragments of quartz 1 foot in diameter on the dump contain moderate amounts of sphalerite, a little chalcopyrite, and a trace of galena.

A vein in andesite north of the Helena No. 2 vein is prospected by three short tunnels at altitudes of about 4,670, 4,500 and 4,400 feet. The vein strikes nearly east and dips 60°–70° S. The vein consists of white altered rock and quartz, which is 10 feet wide in a bend in the middle tunnel. Quartz is exposed for the full width of the face of the tunnel. The quartz contains numerous fractures and cavities lined with thin crusts of pyrite, and vein matter on the dump contains a little sphalerite, pyrite, and chalcopyrite. A tunnel east of Jennings' cabin at an altitude of about 3,840 feet is in line with this vein, but the vein does not appear to have been found in it.



LONGITUDINAL SECTION OF CHAMPION MINE, BOHEMIA DISTRICT.

From sketch supplied by owners.



LONGITUDINAL SECTION OF MUSICK MINE, BOHEMIA DISTRICT.

From sketch supplied by owners.

A tunnel 100 feet long, following a vein S. 51° E., is about 400 feet southeast of the vein described above, at an altitude of about 4,700 feet. A quartz stringer dipping 70° S. and containing seams of sphalerite and pyrite is exposed in the tunnel, which is in tuff.

On the road to the Helena mine some 500 feet north of the mine are two short drifts on zones of altered rock. The one nearer the mine trends N. 60° W.

Musick.—The Musick group comprises 16 claims, of which 13 are surveyed for patent. The claims lie mostly in the valley of City Creek but extend across the divide into the basin of Sharps Creek. The Musick mine is the principal working and is at the head of City Creek in the Bohemia Saddle, on the north slope of Bohemia Mountain. The mine is accessible by automobile from either the Sharps Creek or Champion Creek road. A boarding house, bunkhouse, cabins, and mill house are located on the property.

According to Diller [72] the Musick vein was discovered in 1891 and was worked almost continuously till 1898 and possibly later. In 1902 the Musick property was consolidated with the Champion and Helena under the West Coast Mines Co., and the ore was hauled by electric locomotive to the Champion mine and milled at the Champion mill. However, most of the work appears to have been done prior to 1903.

The recorded production is nearly $100,000, but an additional unknown part of that credited to the Champion area came from the Musick.

The mine is developed by some 4,900 feet of drifts and crosscuts, which were accessible at the time of the examination, and numerous stopes, raises, and winzes. Three main levels about 100 feet apart explore the vein for nearly 1,800 feet. The upper level, no. 2, goes all the way through the mountain and is accessible by a short crosscut at the west or Sharps Creek end. Level 4 (fig. 2) and level 6 are reached by crosscuts from the east or City Creek slope. Level 6, though not so long as the other two, is the haulage level, and the crosscut leads directly to the mill house and the tramway that formerly extended to the Champion mine.

The Musick vein differs from most other veins in the district by having sharp bends in its course. (See fig. 2.) At the east end of level 4 the strike is N. 55° W. for a short distance, then nearly west for 300 feet, then N. 42° W. for 600 feet, then west for 500 feet. The dip ranges between 65° S. and vertical, but in most places it is 70°–80° S. The country rock is light-colored rhyolite except a few exposures of andesite and tuff in the eastern part of levels 2 and 4.

[72] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), p. 7.

The vein matter consists chiefly of the usual sulphide assemblage and quartz but differs from that in other veins in having a distinctly higher proportion of galena. The upper 100 feet of the vein, especially at the west end, is almost completely weathered, and some weathered material extends to level 6. Several splits in the vein enclose lenses of country rock.

The ore shoots are arranged as shown in the longitudinal section (pl. 15). Shoot A has been stoped for a horizontal distance of 300 feet and for widths of 2 to 6 feet above level 4. It extends down to level 6 as two roots enclosing a lens of very low grade vein matter. The two parts extending down to level 6 are 2 to 7 feet wide and are stoped for horizontal distances of 50 to 75 feet. According to engi-

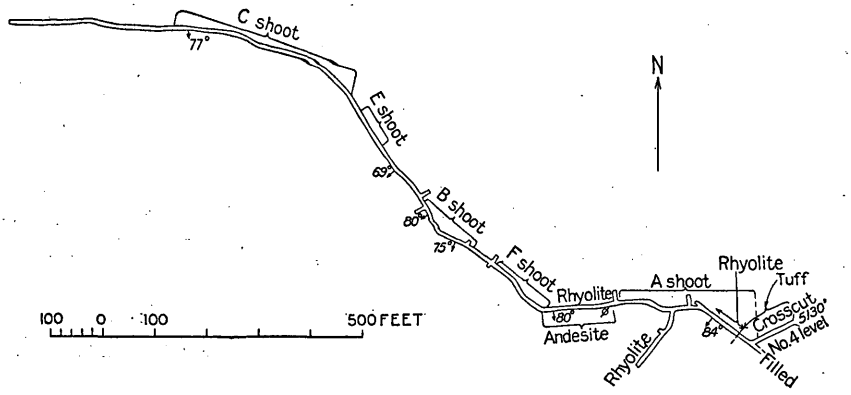


FIGURE 2.—Sketch map of level 4 of Musick mine, Bohemia district. From pace and compass traverse.

neers' reports, two samples from the floor of level 6 in the westernmost stope assayed about 0.24 ounce in gold and 2 ounces of silver to the ton, 8 percent of lead, 1 percent of copper, and 4 percent of zinc, for an average width of 3.2 feet. A sample of weathered ore in a pillar above level 4 assayed 1.40 ounce of gold and 2 ounces of silver to the ton and 2.3 percent of lead. Samples from 80 feet of drift east of the easternmost stope on level 6 averaged about 0.07 ounce of gold and 1 ounce of silver to the ton, 2 percent of lead, 2 percent of zinc, and 0.2 percent of copper for an average width of 5 feet.

Shoot B is stoped for a horizontal length of 375 feet above level 2 and for 160 feet between levels 2 and 4. Most of the stopes are 3 to 5 feet wide. Two samples of partly weathered ore from pillars above level 4 assayed 1.98 ounces and 0.9 ounce of gold and 2 and 2.4 ounces of silver to the ton, 1 and 3.7 percent of lead, a trace of copper, and 5.7 and 8.9 percent of zinc for widths of 1 foot and 3.7 feet, respectively. Samples taken along level 4 for 125 feet west of

shoot B assayed 0.1 to 0.2 ounce of gold and 1½ to 2 ounces of silver to the ton, 5 percent of lead, 0.5 percent of copper, and 5 to 6 percent of zinc for widths between 2 and 5 feet. A tongue of ore about 40 feet in horizontal length extends below level 4 west of the raise below shoot B. A little sulphide occurs in this tongue, which is 3 feet wide below shoot B.

Shoot F is separated from shoot B by a pinch of the vein. It is partly stoped above levels 2 and 4 and has a horizontal length of about 150 feet on level 4. According to engineers' reports, samples from the back of the stope above level 4 assayed 0.24 to 0.96 ounce of gold and 1 to 3 ounces of silver to the ton, 2 to 6 percent of lead, a trace to 1 percent of copper, and about 7 percent of zinc for an average width of 1.4 feet. This vein matter consists of seams of solid sulphide 6 to 10 inches wide and altered rock. Shoot F has a length of a little over 200 feet on level 6. Samples from the west half assayed about 0.34 ounce of gold and 3 ounces of silver to the ton, 6 percent of lead, 1½ percent of copper, and 7 percent of zinc for an average width of 2.6 feet. Samples from the east half assayed 0.20 to 0.48 ounce of gold and 2 ounces of silver to the ton, 3 percent of lead, 1 percent of copper, and 4½ percent of zinc for an average width of 2.8 feet.

Shoots D and E may be parts of a single ore shoot, though barren vein matter lies between the two stopes. The stope on shoot D is 3 to 4 feet wide. The vein between shoots D and C assayed only a trace of gold. Shoot E on level 4 is about 75 feet in horizontal length. Samples at the east end assayed about 0.63 to 0.68 ounce of gold and 2 ounces of silver to the ton, 6 percent of lead, 0.5 percent of copper, and 5 percent of zinc for an average width of 3.4 feet.

Shoot C has been stoped from level 4 to a point near the surface. It has a horizontal length of 175 feet on level 2 and about 250 feet on level 4. The width is mostly 4 to 6 feet. A stope 30 feet wide and 10 to 15 feet high lies 100 feet west of shoot C on level 2. The vein matter here is completely oxidized and contains much oxide of manganese. This is regarded as the combined Musick and California veins. Samples near the west end of level 2 assayed about 0.15 ounce of gold and 1 ounce of silver to the ton, 0.1 to 0.3 percent of copper, and a trace of lead and zinc for an average width of 5.5 feet.

The California vein lies north of the Musick vein but intersects it on the west side of the ridge at an angle of about 15°. It has been proved for a length of more than 1,500 feet at the surface by several prospect pits, a shaft at an altitude of 5,250 feet, and two drifts at altitudes of 5,120 and 4,970 feet. The probable intersection with the Musick vein is exposed on levels 2 and 4 of the Musick mine. The

drift at an altitude of 5,120 feet is 300 feet long. The country rock is light-colored rhyolite except at the east end of the vein, where it is tuff. The vein is 5 to 12 feet wide and consists of brecciated rhyolite and quartz. The quartz contains some sulphides and some seams of johannsenite, which weathers to brownish-black oxides of manganese.

The Mystery vein is on the Mystery claim, in the east-central part of sec. 14, T. 23 S., R. 1 E. It has been prospected by a shallow shaft, shallow pits or trenches, and a short cross-cut tunnel running S. 35° E. for 30 feet. The country rock is hornfels; some of it is tourmaline-bearing, which indicates that it is part of the contact-metamorphic aureole of the intrusive plug that lies north of the vein. The vein strikes N. 75°–80° W. and dips 80° S. It consists of a band of quartz 1½ feet wide that contains knots of clay minerals, some disseminated specularite, and a little chalcopyrite, sphalerite, galena, and pyrite. According to Diller[73] one sample containing much micaceous red hematite and a trace of galena assayed 1.95 ounces of gold and 7.25 ounces of silver to the ton, 0.16 percent of lead, and a trace of copper. Another assay yielded 0.05 ounce of gold and 1.30 ounces of silver to the ton, 5.57 percent of zinc, and 2.27 percent of lead.

The Alpharetta vein is on the Alpharetta claim, near the east side of sec. 14, T. 23 S., R. 1 E. It has been prospected by two drifts on Alpharetta Creek at altitudes of 4,310 and 4,410 feet. The lower drift follows the vein, which dips 50°–70° SW., for about 175 feet N. 52°–61° W. The country rock is andesite. A 3-foot band of quartz occurs in one part of the drift, but this band is only about 8 inches wide in the footwall part of the vein at the face. The vein matter contains only a little specularite, sphalerite, chalcopyrite, pyrite, and galena with a little dolomite, though there are a few seams of abundant sulphides. The upper drift follows the vein, which dips 70° SW., for 100 feet N. 65°–80° W. A seam of quartz is exposed at the face of the drift.

An adit 60 feet long, generally known as the Cline, has been driven on a vein on the north side of Alpharetta Creek about 600 feet east of the Alpharetta. The vein strikes N. 40° W. and dips 80° SW. It consists in part of a well-defined quartz vein with altered rock and in part of a fracture zone in tuff with a few reticulating quartz veinlets. The quartz contains a little sphalerite, chalcopyrite, pyrite, and galena and is associated with considerable ankerite.

Noonday.—Five patented claims and one unpatented claim constitute the Noonday group, which is in sec. 18, T. 23 S., R. 2 E., on

[73] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), p. 24.

the east slope of Grouse Mountain and the south rim of Horseheaven Basin. Three veins—the Henry, Maggie, and Annie—are included in the property; the Annie vein is the one on which the Noonday mine is located.

According to Diller [74] the Noonday mine was first opened in 1892, though it is credited with production for 1891. It appears to have been operated until 1908, when it changed hands. A new mill was built in Horseheaven Basin, and an aerial tram constructed, but the ore remaining was not free-milling, so the mine was closed. Some small shipments were made in 1917 and 1918. The recorded production for 1891–96 and 1918 is almost $96,000. Possibly this may also include production from the Helena.

The mine was largely inaccessible at the time of the writers' visit. It has been developed on three levels. Level 1 is on the Noonday road at an altitude of about 5,350 feet, level 2 is 100 feet below level 1, and level 3 is 180 feet below level 2. In 1898 Diller [75] estimated a total of 2,000 feet of workings. Level 1 is near the surface, and the outcrop of the vein is marked by caved stopes. Level 2 is accessible by a crosscut running S. 44° W. to drifts running N. 55°–60° W. Level 3 is reached by a crosscut running 400 feet S. 50° W. to a drift that runs N. 70° W. for about 370 feet. A crosscut extends south from the drift at a point 270 feet from the main crosscut. It is 225 feet long and was driven to intersect the Maggie vein, which it lacks some 50 or 75 feet of reaching. Two short drifts, one caved, explore the vein southeast of the mine, and a crosscut 100 feet long, which did not penetrate the vein, lies to the extreme southeast.

The vein is prospected for about 1,300 feet and trends N. 45°–70° W. The dip ranges from 75° N. to 85° S., according to Diller.[75] The country rock is labradorite andesite, but a small plug of dacite porphyry lies a short distance north of the west end of the vein, as shown by the map (pl. 13). The vein matter from level 1 to the surface, which was completely weathered, was stoped, and according to the owners it was largely leached down to level 2. The high-grade ore shoot was 90 feet long and was stoped for about 140 feet for a width of 5 feet, of which 1½ to 2 feet was rich ore. In 1917 and 1918 test shipments of sorted ore containing abundant sulphides and some leached material from an intermediate level between levels 2 and 3 yielded the smelter returns shown below.

[74] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), p. 7.
[75] Idem, p. 28.

Smelter returns from sorted ore from Noonday mine

Date	Gross weight (pounds)	Gold (ounces)	Silver (ounces)	Value
Sept. 6, 1917	9,180	6.70	8.38	$134.13
Nov. 1, 1917	1,765	4.76	12.83	100.29
Dec. 1, 1917	13,380	5.00	6.75	101.29
May 2, 1918	1,856	4.46	6.41	90.12

The vein was partly stoped on level 3 for a length of 200 feet. Several small quartz lenses with sulphides are irregularly spaced over a width of 20 to 25 feet on this level. Banding of vein matter is more characteristic of this vein than of some of the others, but the usual sulphides and some red hematite, believed to be secondary, prevail.

A vein, supposed to be the Henry, is cut by crosscut 3 at 50 feet from the portal. The strike is N. 48° W.

The Maggie vein, south of the Annie, has been prospected by a shaft and near the Noonday cabin by a cut. Some free-milling gold ore is reported to have been obtained from the shaft. The strike is N. 57° W.

Vesuvius.—The Vesuvius group comprises 11 patented claims, located mostly in the southern part of sec. 11 and the northern part of sec. 14, T. 23 S., R. 1 E., on the south and southwest slopes of Fairview Mountain. Four veins—the Jasper, Stocks-Harlow, and Vesuvius, largely on the southwest slope of Fairview Mountain, and the Storey, on the southeast spur—have been prospected by pits, shallow shafts, and drifts, and some mining has been done.

At the time of Diller's visit[76] in 1898, ore from the Vesuvius and from other prospects, probably the Stocks and Harlow, was being milled at a 5-stamp mill (formerly the Knott mill) on the Sharps Creek slope. Operations were carried on intermittently until 1921. The recorded production, probably incomplete, is slightly over $5,000. A mill and large bunkhouse on Sharps Creek at an altitude of about 4,650 feet are now in ruins.

The mine workings were almost wholly inaccessible in 1930, so that the descriptions of the workings are largely taken from a report made in 1927 by W. W. Elmer. The total length of the mine workings is about 6,000 feet. The main adit of the Vesuvius is just above the Sharps Creek road at an altitude of about 5,400 feet. It explores the Vesuvius vein for 800 feet to an intersection with the Jasper vein, where the ore shoot was located. A raise extends about 300 feet to the surface. There were three levels above the main level.

[76] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), pp. 24–25.

Two small stopes were started at 460 and 550 feet from the portal of the main adit.

The portal of the Wild Hog adit is about 665 feet below the main Vesuvius adit, near the main buildings, on Sharps Creek. The total length of drift and crosscuts on this level is 2,470 feet, of which 1,200 feet is drift on what is regarded as the Vesuvius vein. The workings on the Jasper vein, northwest of the Vesuvius, consist of a cut 60 feet long and a level 60 feet lower with 150 feet of crosscuts and 265 feet of drift. The Stocks-Harlow vein has been developed by 300 feet of drift on two levels and 100 feet of crosscuts.

The country rock of the veins at the main Vesuvius workings is labradorite andesite with intercalated tuff and volcanic breccias. The Vesuvius vein curves to the east on approaching the Jasper vein, but the average strike is N. 85° E. and the dip is 60° S. The Jasper vein here strikes N. 67° W. and dips 50° S. The ore shoot at the intersection of the veins was largely on the Jasper vein. It was 120 feet long on the main level and 70 feet long on the level above. The stope width is 3 to 5 feet. The Wild Hog adit follows the vein for 1,200 feet where it strikes S. 77° E. and dips 70° S. The country rock of the Wild Hog adit is largely if not wholly rhyolite. Specimens on the dump consist of fragments of rhyolite cemented by comb quartz containing a little sulphide and dolomite.

Some mining was done on the Stocks-Harlow vein, which strikes N. 80° E. and dips south. Some ore was removed from the workings on the western part of the Jasper vein, where the strike is N. 77° W. and the dip is 50°–60° S. A vein believed to be the Jasper was penetrated in crosscut 1 of the Wild Hog adit. Apparently the probable intersection of the Stocks-Harlow and Jasper veins has not been prospected. Another vein at the face of the crosscut consists of 2.6 feet of altered rock and pyrite that assayed 0.13 ounce of gold to the ton. The innermost 500 feet of the Wild Hog adit crosses some fractures, then follows fractures and vein matter to the face, where 3 feet of vein matter without value is exposed.

The Storey vein, on the southeast spur of Fairview Mountain, strikes N. 56° W. and dips 70°–75° S. It has been prospected by two short drifts, two shafts, and several cuts. The wall rock is largely andesite. The vein matter is leached and consists of altered rock and quartz.

Combination.—The Combination prospect is outside the mapped area, at an altitude of about 1,800 feet, 3 miles from the Sharps Creek road, near the junction of Puddin, China, and Martin Creeks, at the west side of sec. 19, T. 23 S., R. 1 E. The main dump is on the west side of Martin Creek. The workings were inaccessible in

1930. According to Diller[77] the vein strikes N. 86° E. and dips 65° S. It has been explored by short drifts from crosscuts at two levels. Vein matter and altered rock in the upper level is nearly 10 feet wide. A sample of ore yielded 0.55 ounce of gold and 47.75 ounces of silver to the ton. Small amounts of pyrite, galena, sphalerite, and chalcopyrite are associated with a small amount of quartz and much soft altered rock. Pyritiferous quartz from the lower level yielded no gold and 0.2 ounce of silver to the ton.

Cosmos.—The Cosmos group of 12 claims, formerly known as the Green Rock mine, is the farthest north in the district (pl. 13) and is in the southern part of sec. 25, T. 22 S., R. 1 E. It is reached by a branch of the Noonday road. A house and mill are located on the property. Most of the work appears to have been done in recent years, and the production has been small.

The principal vein is the Sultana, which is developed by two drifts 650 and 850 feet long from crosscuts, by a 20-foot shaft, and by shallow cuts. These workings prove the vein for more than 2,500 feet. It strikes N. 66°–80° W., averaging N. 70° W., and dips 80° S. The country rock is andesite, but float of intrusive porphyry and of hornfels with epidote and pyrite knots occurs near the eastern tunnel.

The east tunnel includes a crosscut running 225 feet S. 50° W. to the vein and drifts running 300 feet to the east and 360 feet to the west. The vein is mostly 3 to 4 feet wide and consists of altered rock with small shoots of quartz and sulphides. A shoot about 100 feet long in the east drift ranges from several inches to 5 feet in width at a depth of 200 feet beneath the surface. Three other smaller lenses occur in this drift. A shoot of quartz and sulphides about 150 feet long occurs in the western drift. The east end of this shoot is 40 feet beneath the surface and the vein matter is partly weathered. It becomes more leached toward the west as it approaches the surface. A short crosscut to the west drift starts about 360 feet southeast of the cabin. Leached vein matter near this crosscut is reported to contain appreciable gold. A new crosscut has been started with the object of reaching the ore shoot in the west drift about 200 feet below the surface.

The west crosscut lies west of the cabin at an altitude of about 3,820 feet. It extends 275 feet S. 34° W. to the vein, where drifts have been run 200 feet to the east and 650 feet to the west, according to the owners. This tunnel was partly inaccessible in 1930. The owners state that a moderately mineralized, partly leached ore shoot 100 feet long occurs on this level. Material from this shoot contains much brecciated cherty quartz cemented by crusty pyrite containing

[77] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), p. 20.

some marcasite and some quartz with sphalerite, galena, pyrite, chalcopyrite, and a little tetrahedrite. The face of the west drift is reported to be beneath the small shaft, or about 200 feet below the surface. Weathered vein matter 15 feet wide occurs on top of the ridge near the shallow shaft.

Other veins on the property are developed slightly or not at all. The east crosscut, about 75 feet from the intersection with the Sultana vein, cuts a breccia 16 feet wide that consists of andesite with carbonate cement and a little sulphide.

Cripple Creek.—The Cripple Creek group comprises 11 claims in secs. 13 and 24, T. 23 S., R. 1 E., on the east slope of Jackass Ridge, in the valley of City Creek. Most of the prospecting has been concentrated on three veins—the Western, Cripple Creek, and Lost. The property is reached by a trail 4,300 feet from the Oregon-Colorado road. The cabin is at an altitude of 4,300 feet. There is no recorded production. The country rock of all the veins is tuff and volcanic breccia.

The Western vein has been prospected by six adits and several shallow cuts for a length of 3,000 feet. The strike is N. 30°–50° W. The dip at the ends is 60° N. to vertical, but in the central part it is 60°–80° SW. The middle part of the vein for 750 feet consists of vuggy quartz with sparse sulphides and a thick band of clay with included blocks of country rock. In two places the quartz vein is 2 feet wide. Coarse leaf gold and wire gold occur in vugs in a few places. The northern and southern parts of the vein are unusual in that they consist of fine-grained smoky quartz brecciated and cemented by dolomite that contains smoky scalenohedron calcite crystals in vugs. A little sphalerite, galena, chalcopyrite, and pyrite occur in the fine-grained quartz. In the southern part a crosscut exposes about 20 feet of vein matter consisting of quartz, dolomite, and bands of altered rock. Small amounts of amethystine quartz and stibnite were found in this part of the vein. There is considerable vein matter along the Western vein, but it is of low grade except in shoots whose extent has not been determined.

The Cripple Creek vein is about 1,000 feet southwest of the north end of the Western vein and has been developed by an adit 275 feet long and two short crosscuts. It strikes N. 32° W. and dips 70°–80° NE. The main drift is at an altitude of about 4,500 feet in the gulch southwest of the cabin. The vein ranges from 4 to 15 inches in width and consists of quartz with knots of kaolin and a little disseminated sphalerite, pyrite, and chalcopyrite. Part of the quartz is greenish, and cherty quartz is interbanded with coarse vuggy quartz. A little late calcite and pyrite occur in the vein. The two short crosscuts southeast of the drift expose narrow quartz stringers.

The Lost vein is on the slope about 250 feet east of Pilot Rock. It strikes N. 30°–60° E. and dips 55°–70° NW. It is prospected by two drifts and several pits. A drift 20 feet long, trending N. 60° E., exposes an 8-inch seam of clayey altered rock with pyrite seams and drusy quartz stringers. The quartz contains fragments of altered country rock and a little disseminated sphalerite, pyrite, and chalcopyrite. A drift 200 feet long curves from N. 60° E. at the entrance to N. 30° E. at the face and exposes vein matter mostly less than 2 feet wide that contains a little disseminated chalcopyrite.

A tunnel near the cabin and west of the Western vein follows a vein in a porphyry dike for 80 feet N. 76° W. About 2½ feet of weathered vein matter with much drusy quartz is exposed in the face of the drift.

About 2,000 feet north-northwest of the cabin a short crosscut has been driven S. 26° W. to explore a band of reticulating quartz veinlets containing a little chalcopyrite and calcite.

Crystal.—The Crystal vein is in the northern part of sec. 11, T. 23 S., R. 1 E. It extends from Crystal Basin northwestward across Elephant Lake Basin and across the ridge south of Elephant Mountain. It is proved throughout this distance of 3,300 feet by tunnels and pits. It is of more than usual interest in that it occurs on a fault that appears to have a throw of about 200 feet in the ridge south of Elephant Mountain. The principal workings and some buildings are located in Crystal Basin and are reached by a branch of the Champion road. As the Lizzie Bullock, the mine is credited with production as early as 1890, but the total production has probably been small.

The average strike of the vein is about N. 65° W., and the dip is to the south. The country rock consists of both labradorite andesite flows and tuffs or volcanic breccias. The main drift is in Crystal Basin at an altitude of about 4,580 feet. It follows the vein 300 feet to a place where the roof is caved, but it is reported to be 100 feet longer. It is timbered through much of the exposed length, so that little of the vein was seen. The vein matter appears to be considerably weathered and contains some small shoots of quartz with sulphides. The upper tunnel, 107 feet higher, consists of a crosscut running 45 feet northwest to the vein and a drift, only 60 feet of which was accessible. The vein here consists of a breccia cemented by quartz. It is largely leached but appears to have originally contained a moderate amount of sulphide. On the slope west of Elephant Lake is an inaccessible drift on the vein that strikes N. 60° W. and dips 57° S. Vein matter on the dump consists of fragments of country rock cemented with quartz containing a little sulphide. Another drift extending 100 feet to a cave is located on the Fairview Creek slope at an altitude of 5,100 feet.

The vein matter consists of a breccia of country rock cemented with quartz containing slight to moderate amounts of sphalerite, pyrite, and chalcopyrite and a little galena.

El Capitan, President, or Churchill.—The President group of claims is in the valley of St. Peters Creek, in sec. 23, T. 23 S., R. 1 E. Prospecting was active in 1930, and a 2-stamp mill and cabin had been erected on the property. The El Capitan vein crops out on the slope northeast of the creek and has been prospected by two short adits and numerous cuts. It has a sinuous course, but the average strike is N. 60° W. and the dip 80° S. In an adit at an altitude of about 3,800 feet the vein is 2 feet wide and contains a streak of quartz, calcite, and sulphides 9 inches or less in width. Galena is more abundant than sphalerite and chalcopyrite, with which it is associated. Stibnite is reported to have been found in one cut. The country rocks are andesite, tuff, and porphyritic rhyolite.

Glenwood.—The Glenwood workings are in sec. 22, T. 23 S., R. 1 E. The vein strikes N. 60° W. and is nearly vertical. It is prospected by a drift 30 feet long on the main trail and by two drifts, now inaccessible, near the cabin. The upper adit reveals some vuggy quartz without appreciable sulphide. In general there appears to be a wide zone of altered tuff, andesite, and rhyolite, with lenticular veins of quartz containing very little sulphide.

Four Monte.—The most extensively prospected vein on the Four Monte group is in sec. 10, T. 23 S., R. 1 E., in the drainage basin of Fairview Creek. It strikes N. 50°–55° W. and has been prospected by a short drift and two short crosscuts. A narrow band of altered rock with drusy quartz veinlets and sparse sulphides is revealed in the drift. There are veinlets and crustified fillings of dolomite and one small lens of cherty quartz.

Gem, Rico, and Slide.—The Gem, Rico, and Slide are patented claims on the west slope of Fairview Mountain, in sec. 11, T. 23 S., R. 1 E. An adit 100 feet long, trending S. 62° E., on the Gem claim near the trail to Adams Mountain follows a narrow quartz stringer in tuff that contains disseminated pyrite near the vein. Several prospect pits on altered rock and quartz stringers occur on the other claims.

Gold Cross.—The Gold Cross vein extends across two patented claims, the Gold Cross and Bohemia Girl, lying for the most part in sec. 19, T. 23 S., R. 2 E., on Grouse Mountain. The vein strikes N. 60° W. and is prospected by an adit and numerous cuts extending across a low ridge. All are caved, so that little can be seen.

Golden Slipper.—The Golden Slipper vein is in sec. 20, T. 23 S., R. 2 E., near Horseheaven Creek on the trail to the Riverside tunnel. At the level of the trail a drift has been driven over 400 feet on the

vein, which strikes from S. 80° W. to N. 80° W. and dips 80° S. A 2-foot band of quartz cementing brecciated andesite is exposed at the face of the tunnel. The quartz is mostly cherty and contains pyrite seams and disseminated pyrite with some marcasite crusts facing fractures.

Gray Eagle and Alice.—The Gray Eagle and Alice patented claims lie in the southwest corner of sec. 18, T. 23 S., R. 2 E., on Grouse Mountain. Most of the work has been done on a vein that strikes N. 50° W. across both claims, toward the Knott shafts. On the Gray Eagle claim the vein, which dips 65° SW., has been prospected by a 50-foot drift at an altitude of 5,140 feet and several cuts. To the southeast, near the trail down Annie Gulch, are two adits driven on what may be the southeasterly extension of the vein on the Gray Eagle. The adit to the west of the trial, at an altitude of 4,810 feet, follows an altered zone in andesite for 75 feet. Apparently there is very little quartz. The adit east of the trail is 125 feet long and follows a zone of altered andesite with some quartz containing a little sulphide.

Grizzly.—The Grizzly group of three claims lies mostly in the NE¼ sec. 12, T. 23 S., R. 2 E., on the west slope of Noonday Ridge. The property is reached by a trail from the Champion road. The vein is developed by three tunnels and by several cuts with a maximum difference of altitude of 600 feet and a horizontal length of 2,000 feet. The vein strikes N. 54°–71° W., predominantly about N. 60° W., and dips 55°–65° S.

The first tunnel, about 150 feet in altitude above the cabin, comprises a cross-cut 200 feet long running N. 20° E. to the vein and a drift trending N. 56° W. The country rock is andesite except a dike at the face of the drift, which is porphyry. The vein is a small stringer of quartz with sulphides. About 150 feet above this tunnel, on the south side of a small gulch, a tunnel more than 400 feet long trending N. 40°–70° W. follows the vein, which here dips 55°–65° SW. The vein ranges from 1 to 4 feet or more in width, and quartz occupies the full face of the drift. The quartz includes fragments of silicified andesite and is associated with some claylike altered rock. Small shoots contain sulphides, some of which are veined by later quartz. A cut 100 feet above the tunnel exposes 6 feet of quartz containing slight to moderate amounts of sphalerite, pyrite, chalcopyrite, and galena. Another cut 150 feet higher, in the bed of a small tributary gulch, exposes 6 feet of quartz containing moderate amounts of sulphides. The hanging wall was not exposed. The footwall is slightly altered porphyry, and andesite is exposed a short way from the hanging wall. Sphalerite and chalcopyrite are the most abundant sulphides, but they are associated with some pyrite and a

little galena. Some of the quartz is brown because of disseminated sphalerite, but most of it is fine-grained and greenish and contains blebs of kaolin. A tunnel about 100 feet above this cut follows the vein for 90 feet S. 70° E. A little quartz on the dump contains sulphides.

A vein on the west side of Champion Creek is prospected by a tunnel over 100 feet long, trending westward. The vein matter contains sulphides.

Ingham.—The Ingham group of 10 patented claims is in secs. 18 and 19, T. 23 S., R. 2 E., and sec. 13, T. 23 S., R. 1 E., on the southeast slope of Grouse Mountain. Most of the development work is on the McCrum, Key, Gold Dollar, and Lucky Grouse claims.

A drift 60 feet long on the Great Falls claim follows a vein that strikes N. 60° W. and dips 70° S. The face of the drift reveals 1½ feet of altered andesite with a narrow quartz stringer.

The Sunset vein, on the Lucky Grouse, Key, and Elsie claims, is prospected by two adits and several cuts in andesite. It strikes about N. 60° W. and dips steeply south. On the Key claim, at an altitude of about 4,750 feet, a short crosscut extends to a drift 30 feet long on the vein. About 200 feet higher on the Lucky Grouse claim is another adit that is partly caved at the portal and full of water. A cut has been made on the vein at the crest of the ridge. These openings afford little information concerning the vein. Apparently it consists of altered rock stained with iron oxide and containing a little quartz. In some places the rock is altered for a width of 10 feet on each side of the vein, but in others fresh rock is close to the vein.

The Gold Dollar vein is prospected by a shaft at an altitude of about 4,720 feet and several cuts. The vein is in tuff and strikes N. 80°–90° W. On the Key claim a crosscut 225 feet long at an altitude of 4,600 feet was driven N. 50° W. in tuff to intersect the vein below the shaft, but the writers found no evidence that this object had been attained.

On the McCrum claim a vein striking N. 70°–80° E. and dipping 80° N. has been prospected by two adits just south of the Bohemia trail on the east slope of the saddle between North and South Grouse Mountains. The lower adit, at an altitude of about 5,470 feet, consists of a crosscut 110 feet long running S. 50° W. to the vein and a drift on the vein, which is a thick claylike band of altered andesite.

Leroy.—The Leroy group of seven patented claims is northwest of the old Champion mill, in secs. 11 and 12, T. 23 S., R. 1 E. The vein is developed by three short tunnels and a long one, which have a total length of 1,000 feet, and by numerous cuts. The vein is in a dike of granodiorite porphyry that strikes northwest up the hill west

of Champion Creek. The vein strikes N. 60°–70° W. and dips 55°–70° S., probably for the most part at the lower angle. The dike also appears to have a southwesterly dip.

The main tunnel, at an altitude of about 3,920 feet, extends 300 feet N. 70° W. to a fork. One branch of the fork continues 100 feet in the same direction, and a short crosscut near the face exposes the andesite hanging wall of the dike. The other branch consists of a crosscut 90 feet to the north and a drift 270 feet long trending N. 66° W. The vein matter consists of a breccia of porphyry cemented by reticulating veinlets of quartz 1 inch to several inches thick, which form about one-fourth of the mass. Vugs in quartz are lined with sulphides or dolomite and a small amount of late calcite. The veinlets contain small to moderate amounts of sphalerite, chalcopyrite, and a little galena. Some of the porphyry on the dump contains abundant knots of black tourmaline.

Three cuts between altitudes of 4,000 and 4,075 feet reveal vein matter in the porphyry similar to that in the main tunnel. Three short tunnels at an altitude of 4,170 feet beside the road to the Crystal mine follow vein matter in the dike. The northeastern tunnel is about 175 feet long and extends N. 75° W. A short tunnel 25 feet above follows weathered vein matter that dips 55°–70° S. and for 45 feet runs N. 80° W. Quartz is exposed across the whole face of the lower tunnel except 18 inches in the footwall, which is clay. Much of the quartz contains abundant inclusions of the altered dike rock but only slight amounts of sulphides, although some contains moderate amounts. Another tunnel 50 feet long, 65 feet to the southwest, strikes N. 70° W.

The southeasterly extension of both the Leroy porphyry dike and the vein is completely obscured for some distance by glacial drift, and the northwesterly extension of the vein is not exposed. It is of interest to note that the northwesterly extension of the vein system of the Helena would intersect the Leroy dike in the region of the development work.

A large volume of material with an average low percentage of base metals is developed by these workings.

Mayflower.—The Mayflower group of five patented claims is in the valley of Horseheaven Creek near the junction of secs. 16, 17, 20, and 21, T. 23 S., R. 2 E. It is reached by the Mayflower trail down Horseheaven Creek from the Noonday road. On the property, at an altitude of about 3,075 feet are a mill, an assay office, and a cabin. Although there appears to have been considerable ore mined, no production records are available.

The Mayflower vein has been developed by four adits, two on each side of Horseheaven Creek, and several cuts. A tram extends from

the mill on the west side of the creek to an adit on the Buckhorn claim, on the east side at an altitude of about 3,375 feet. A crosscut extends 30 feet to the vein, which has been stoped 25 feet to the surface for a length of about 60 feet. The stopes are now caved. The vein matter is oxidized and consists of altered tuff with reticulating veinlets of drusy quartz. Diller [78] stated that an assay showed that 0.05 ounce of gold and 0.10 ounce of silver to the ton was obtained and that rock rich in pyrite north of the vein yielded 0.05 ounce of gold and 0.15 ounce of silver to the ton. The lower adit, at an altitude of about 3,120 feet, is partly caved and full of water. Below this adit an open cut 30 feet wide exposed tuff containing quartz seams and fractures faced with pyrite.

On the Yreka claim, on the west side of the creek at an altitude of about 3,240 feet, a drift follows the vein N. 68° W., but it is partly full of water. The vein has been stoped about 40 feet to the surface, and the stopes dip 75° N. Diller [78] stated that:

> Four feet of the material is quartzose with much pyrite, which yields upon assay a trace of gold and 0.10 ounce of silver per ton. Upon the upper side of the vein, for about 8 to 12 inches in thickness, the ore is rich in sulphides of zinc, lead, and copper. An assay yielded no gold and only 0.05 ounce of silver per ton but contained 17.71 percent of zinc, 11.88 percent of lead, and 1.38 percent of copper.

The other drift, trending west at an altitude of about 3,370 feet, was inaccessible because of water. There is considerable pyrite in the vein matter on the dumps of both tunnels. Most of the vein matter consists of a rubble of altered country rock in a network of drusy comb-quartz veinlets. Sulphides are sparse except in small shoots.

North Fairview.—The North Fairview group of 12 unpatented claims is located largely in sec. 11, T. 23 S., R. 1 E. Most of the development work has been concentrated on a vein crossing the ridge between Fairview Peak and North Fairview Mountain.

The vein is in coarse andesite agglomerate and strikes from N. 75° E. to N. 70° W. but averages due west and dips 60°–75° S. It has been developed by one tunnel 850 feet long extending completely through the top of the ridge and two short tunnels. The vein is as much as 12 feet thick and consists of clayey altered rock with quartz stringers, which is almost wholly weathered, though it is 200 feet below the crest of the ridge. Very little sulphide appears on the dumps.

A tunnel just below the old cabin in North Fairview Basin, at an altitude of 4,960 feet, penetrates a thick veneer of glacial drift to a

[78] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), p. 31.

vein and follows it a short way S. 70° W. The vein, which dips 45° S., consists of quartz and clayey altered rock.

A tunnel 50 feet long below and west of the west end of the main tunnel is driven S. 84° E. on a vein that dips 60° S. The vein matter consists of quartz and clay minerals with fractures faced with pyrite.

A vein south of the North Fairview vein in North Fairview Basin has been prospected by a few cuts and short adits. It strikes a little north of west and dips 75°–85° S. It contains quartz lenses as much as 2 feet wide that in some places contain a little sulphide associated with brecciated country rock, some of which is altered to clay.

Ophir.—The Ophir vein is near the center of sec. 14, T. 23 S., R. 1 E., on the east slope of Bohemia Mountain, at an altitude of a little more than 5,000 feet. It has been prospected for more than 1,500 feet by three adits and several cuts. The strike is N. 10°–30° W., and the dip is 70° W. The northern part of the vein is in andesite, the southern part in tuff.

In the northernmost cut the vein is weathered and consists of altered rock with disseminated pyrite, fractures faced with pyrite, and a few quartz stringers. At the cut next south a wide vein consists of pyritized andesite with 2 feet of altered rock in the hanging wall and 5 feet of quartz and silicified rock in the footwall. A drift 90 feet long follows a band of breccia cemented with quartz N. 15° W. The adit next south consists of a crosscut 25 feet to the vein and a drift running 165 feet south-southeast on the vein. The vein narrows to less than 1 foot at the face of the drift. Pyrite is the principal sulphide, but there are a few seams with galena, sphalerite, and a little chalcopyrite. The third adit, 600 feet to the south, follows a band of altered rock, which is probably continuous with the vein to the north, for a distance of 125 feet N. 40° W. Cuts show the extension of the vein to the southeast.

Oregon-Colorado.—The Oregon-Colorado group of seven patented claims, the property of the Vesuvius Mines Co., includes the southernmost developed vein in the district and is in secs. 19, 29, and 30, T. 23 S., R. 2 E. It is reached by the Oregon-Colorado road, which was impassable in 1931. The Oregon-Colorado vein is notable for its relatively high proportion of copper.

The vein strikes northwest and dips 60°–65° S. The country rock consists of tuff, volcanic breccia, and coarse agglomerate; and a dike of very fine grained andesite is exposed at the portal of the lower tunnel. The vein is developed by two drifts and numerous cuts. The portal of the lower adit is in a gulch on the east side of Annie Creek, at an altitude of about 3,300 feet, on the Dora claim, and

the other adit is about 300 feet higher, on the Confidence claim. The lower adit is caved at the portal, and the upper adit is caved a little over 100 feet from the portal. The vein matter consists of a breccia of country rock cemented by comb quartz and chlorite containing sulphides, chiefly chalcopyrite and pyrite, and dolomite filling vugs, as shown in plate 11, *A*. According to Diller [79] a sample from the upper or Confidence drift 60 feet from the portal contained considerable pyrite and chalcopyrite and assayed 1 ounce of gold and 3.4 ounces of silver to the ton.

According to a report by W. W. Elmer, the lower drift is 1,800 feet long and the upper drift is 450 feet long. Four ore shoots, 50, 137, 50, and 140 feet in length, were revealed within the first 1,100 feet of drift. No data on the width of the vein are given. A report on samples of the ore submitted to a flotation company in 1918 and 1920 indicated that copper recovery would be about 98 percent. The samples averaged 3.69 percent of copper and 4.22 ounces of silver to the ton.

Orofino.—The Orofino claims are in the northern part of sec. 36, T. 22 S., R. 1 E., south of the Sunset group, and are reached by a short trail from the Noonday road. The country rock is thin-bedded metamorphosed tuff or hornfels. An adit 50 feet long east of Owen's cabin at an altitude of 3,620 feet, in the bed of a gulch, follows a vein S. 30° E. The vein matter on the dump is chiefly cherty quartz with crusts of pyrite along fractures. There are a few seams of quartz with sphalerite, chalcopyrite, and pyrite. To the southeast, at an altitude of 3,430 feet, some prospecting has been done on veinlets of specularite associated with the intrusive porphyry masses. A cut on the Golden Rod claim, at an altitude of 3,900 feet, reveals a small vein striking N. 50° W. and consisting of comb quartz with specularite and a little chalcopyrite.

Peekaboo.—The Peekaboo group of claims is located on Jackass Butte, in the southeastern part of sec. 14 and the northeastern part of sec. 23, T. 23 S., R. 1 E. There is a mill and a cabin on the property. Four veins have been prospected—the southern extension of the Ophir, the Tipperary, an unnamed vein, and the Peekaboo. They are reached by a trail from the road at the Musick mine.

The Peekaboo is a cross vein in tuff for most of its length that has been prospected for 1,200 feet by cuts and an adit. The strike ranges from N. 20° E. at the south end to N. 45° E. at the north end, and the dip is 60°–70° NW. The adit is on the west slope of the ridge, at an altitude of 5,100 feet, and follows the vein about 175 feet N. 45°–50° E. The vein is 2 feet wide at the portal but pinches down to a few inches at the face. The vein matter consists of vuggy

[79] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), p. 28.

quartz with some late dolomite and a little sulphide consisting of chalcopyrite and very small amounts of pyrite, sphalerite, and galena. In the southern cut the vein contains a little quartz with sparse sulphides, and the adjacent andesite is altered and impregnated with pyrite.

Southwest of the new cabin a vein that strikes N. 50°–55° W. and dips 80° S. has been prospected by a short drift and two cuts. The drift, at an altitude of 4,840 feet, follows a narrow quartz vein for 75 feet.

The Tipperary vein, on the east slope of Jackass Butte, strikes N. 48° E., dips 70° SE., and intersects the Ophir. It has been prospected by several shallow cuts. The lower cut, at an altitude of 4,810 feet, exposes 14 to 18 inches of quartz containing moderate amounts of chalcopyrite and sphalerite, and a little galena associated with clay-mineral aggregates.

Rattlesnake.—The workings on the Rattlesnake vein are at an altitude of about 4,825 feet on the west slope of Calapooya Ridge, south of Bohemia Mountain, in the northeast corner of sec. 22, T. 23 S., R. 1 E. The vein is developed by a drift 100 feet long trending N. 70° E., from which short crosscuts have been driven, and by two parallel drifts each 50 feet long. The vein matter is about 20 feet wide and consists of stringers of pyritic quartz and massive veins including fragments of country rock. A little chalcopyrite and sphalerite occur in a few places.

Reed and Fletcher.—The Reed and Fletcher group of six patented claims is in sec. 12, T. 23 S., R 1 E., and sec. 18, T. 23 S., R. 2 E., and extends from Helena or Grizzly Saddle westward toward Champion Creek. Several small veins have been prospected.

Two adits prospect a vein on the west slope of Grizzly Saddle within the switch-back on the Grizzly trail. The upper drift, at an altitude of about 5,000 feet, is more than 200 feet long and strikes S. 40°–68° E. The inner part of the drift is inaccessible. There is some quartz on the dump. The lower adit, at an altitude of 4,890 feet, is just above the trail and trends S. 60° E. at the portal but is also inaccessible. About 200 feet farther south is a zone of altered rock that dips 75° S. and is prospected by a drift that runs S. 45° E. On the spur to the northwest, at an altitude of 4,350 feet, another inaccessible drift trends S. 65° E. at the entrance. Quartz on the dump is vuggy, surrounds fragments of altered country rock, and contains moderate amounts of sphalerite and a little chalcopyrite. There are other prospect pits and small adits on the property.

Riverside.—The Riverside group of three patented claims is another property of the Vesuvius Mines Co. It is in the center of sec. 20, T. 23 S., R. 2 E., west of Horseheaven Creek, and is reached by a

trail from the Noonday road. The vein is developed by numerous shallow cuts, short tunnels, and a main drift, which is now caved. The drift is on the McKinley claim at an altitude of 2,900 feet. The vein is in tuff and strikes northwest. Ore on the dump consists of quartz and brecciated silicified tuff containing veinlets and blebs of chalcopyrite and sparse seams of sphalerite and galena. Some sulphides occur in vugs, and there is some crustified pyrite of late origin.

Eaton [80] stated that the width of the vein is greater than that of the tunnel.

In an engineer's report W. W. Elmer states that old mine survey notes show that the main adit is 1,780 feet long, that it follows the vein for several hundred feet, and that after the drift left the vein numerous crosscuts were driven that cut the vein and showed continuity of vein matter from the portal to the face. Two assays reported by Elmer averaged 0.1 ounce of gold and 2.9 ounces of silver to the ton, 1.86 percent of copper, 0.7 percent of lead, and 6.8 percent of zinc. Another assay yielded 0.54 ounce of gold and 4.33 ounces of silver to the ton.

Shotgun.—The Shotgun vein is on the ridge between Crystal Basin and East Fairview Creek, largely in the eastern part of sec. 11, T. 23 S., R. 1 E. It is developed by four short drifts and several pits on the south slope and by several cuts on the north slope. The vein is proved for a length of 1,000 feet. It strikes N. 40°–60° W. and dips generally from 80° N. to vertical, though in places the dip is as low as 65° N. The country rock is labradorite andesite except for a narrow dike of dacite porphyry. The vein matter consists of brecciated country rock cemented with an equal amount of vuggy quartz. All the tunnels reveal ore shoots containing moderate to large proportions of sphalerite, galena, and chalcopyrite and a little pyrite. The vein matter in the upper tunnels is weathered somewhat, but the lower tunnels reveal fresh sulphides.

The lowest tunnel, at an altitude of 4,750 feet, is partly full of water and inaccessible. The second tunnel, about 75 feet higher, is 30 feet long and shows nearly 4 feet of quartz at the face. The third tunnel, about 50 feet above the second, is over 100 feet long. The fourth tunnel, about 75 feet higher, is nearly 200 feet long, and quartz is exposed for the full width of the face. The fifth tunnel, 100 feet above the fourth, is about 80 feet long and reveals partly oxidized sulphide vein matter throughout its length.

Star.—The Star group of claims lies on the east slope of Fairview Mountain, in the southeastern part of sec. 11, T. 23 S., R. 1 E.

[80] Eaton, W. M., Description of properties of the Vesuvius Mines Co., Bohemia, Oreg.: Oregon Engineer, vol. 1, no. 1, pp. 32–37, 1909.

Two veins north of Sears' cabin have been prospected. A drift 120 feet long at an altitude of about 4,700 feet has been driven on the southern vein, which strikes N. 40°–65° W. A 3-foot band of partly leached vein matter with some pyrite and a little sphalerite and chalcopyrite is exposed at the face. A porphyry dike lies just south of the vein. The upper drift follows a narrow vein with sparse sulphides dipping 60° S. for 175 feet S. 73°–80° W. Vein matter occurs in other places on the claims.

Stonewall.—The Stonewall group of claims is in secs. 8 and 9, T. 23 S., R. 2 E., north of the divide between the basins of Frank Brice and Horseheaven Creeks, and is reached by a branch of the Johnson Meadows trail. Three veins have been prospected, the easternmost at an altitude of about 4,100 feet, in the bed of a gulch, where a cut exposes at least 6 feet of vein matter containing a little chalcopyrite, sphalerite, and galena. The next adit to the west follows a vein 75 feet S. 50° E. The vein is wide and contains a shoot with seams of sphalerite, pyrite, and chalcopyrite as much as 3 inches thick. A cut on the northwest side of the gulch reveals no ore. Another drift 150 feet up the gulch follows a vein dipping northeast for 75 feet N. 40° W. The vein is 2 feet wide and contains a moderate amount of sulphides at the entrance but pinches down to two narrow seams at the face. Some stringers of solid sulphide, mostly sphalerite and some chalcopyrite, as much as 2 inches thick, occur in the vein. Another drift 100 feet farther up the gulch follows a seam containing galena for 50 feet N. 50° W.; the dip is to the northeast.

Sunset.—The Sunset group of 20 claims is in the northern part of the district, mostly along the north side of sec. 36, T. 22 S., R. 1 E., and extends from the west side of Champion Creek eastward to a point a short distance beyond the summit of Noonday Ridge. The property is reached by the Noonday road. Most of the prospecting has been confined to the Cape Horn vein, which is proved for a length of nearly 4,000 feet and may extend an additional 1,500 feet to Champion Creek. Numerous cuts and several drifts to the east have been made on the vein through a range in altitude of 1,000 feet. The strike is nearly east, and the dip is 75°–80° S. The country rock is labradorite andesite at the top of Noonday Ridge, but it is mostly metamorphosed tuff or hornfels throughout the area of outcrop of the vein.

Typical vein matter consists largely of alternating bands of drusy comb quartz and thin bands of cherty quartz, lumps of kaolin, and sulphides disseminated and in veinlets. Disseminated flakes, sheaves, seams, and small rosettes of specularite give bands of quartz a pink to red color. Sphalerite is the most abundant sulphide and is asso-

ciated with chalcopyrite, pyrite, galena, a very little terahedrite, and a very little secondary chalcocite. There are also bodies of cherty quartz containing closely spaced fractures faced with crustified pyrite. The veins have been insufficiently developed to yield satisfactory data on the size and metal content of the ore shoots. Shoots of base metal, mostly zinc, are known to exist, but their gold content is unknown to the writers.

The upper tunnel is 175 feet long and lies east of the Noonday road above the switchbacks at an altitude of 4,300 feet. The vein matter consists of brecciated country rock cemented with quartz. Some pyrite occurs in fractures, but sulphides, if present, have largely been removed by weathering.

A second drift 300 feet long is about 1,100 feet farther west and more than 400 feet lower. The 100 feet of drift nearest the face reveals a shoot of quartz with sulphides, the first half consisting of fractured cherty quartz with crusts of pyrite and the remainder consisting of a band of quartz 9 inches to 2¼ feet wide containing moderate amounts of sphalerite, galena, and chalcopyrite and a little tetrahedrite. The sulphides are only slightly oxidized, even at the face. A sample across the vein at the face is reported to have yielded a trace of gold and silver and 10 percent of zinc.

A third drift 700 feet long lies about 150 feet lower. It starts on the vein, leaves it, but reaches it again about 300 feet from the face. A shoot, presumed to be the same as that in the drift above, appears in the face of this drift. Seven feet of rather low grade vein matter in the face consists of quartz with sulphides and altered rock. A sample 4.5 feet wide at the face is reported to have yielded a trace of gold and silver, 7 percent of zinc, and insignificant amounts of lead and copper.

Syndicate.—The Syndicate group of 12 claims lies on the west slope of the valley of Horseheaven Creek, in secs. 17 and 18, T. 23 S. R. 2 E., and includes several veins. The Paymaster vein strikes about east, crosses the Mayflower trail, and has been prospected by three adits. An adit 85 feet long at the level of the trail has been driven N. 85° W. on a narrow band of altered rock with some seams of solid sulphide. Another adit 100 feet below is inaccessible. Three adits and several cuts along a trail west of the Syndicate cabin prospect a vein striking N. 85°–90° W. and dipping 75°–80° N.

The vein consists of a wide band of white altered claylike or silicified rock cutting across both tuffs and andesite and containing lenses and seams of quartz. The quartz is characteristically gray, is moderately drusy, and includes fragments of pyritized country rock. Pyrite is the principal sulphide, but a little sphalerite was found. The easternmost adit is a crosscut 70 feet long that inter-

sects the vein at an altitude of about 4,480 feet. Another crosscut is 45 feet higher. The third tunnel, more than 1,000 feet farther west, on the north bank of a small gulch, at an altitude of about 4,800 feet, is a drift 100 feet long running N. 82° W. A narrow seam of altered rock with a little quartz lies north of the vein described above, in sec. 17, and is followed by an adit 150 feet long trending N. 77° W. The contact of a porphyry dike with andesite is exposed in the face. Other adits prospect veins southeast of the Syndicate cabin.

Sweepstakes.—The Sweepstakes claims lie in sec. 3, T. 23 S., R. 1 E. Most of the workings are near the trail from the Sharps Creek road to Adams Mountain. Three veins appear to have been prospected. The northernmost crops out near the top of a group of tuff or volcanic breccia beds below cliffs of andesite that form a conspicuous butte (Kitten Rock). This vein strikes N. 55°–65° W. It is prospected by pits now caved and a crosscut tunnel, now inaccessible, that penetrates the vein about 130 feet below the surface. The iron-stained quartz on the dump is drusy and contains vugs lined with dolomite crystals. Another adit 50 feet lower consists of a crosscut 20 feet long and a drift 50 feet long on a vein striking N. 70° W. An adit at the road follows a stringer of quartz that strikes N. 60° W. and dips 70° N. for 75 feet. This vein is also prospected by an adit, now inaccessible, 100 feet lower. A raise connects the two adits. The property is credited with a small production in 1909 and 1910.

Tall Timber.—The Tall Timber claims lie in the northeast corner of sec. 22, T. 23 S., R. 1 E., on the west slope of Calapooya Ridge, near the trail from Shane Saddle north to Glenwood. A drift 25 feet long running S. 70° E. on the trail at an altitude of about 4,620 feet follows a quartz vein containing pyrite and large crystals of stibnite. Pits below the trail, at an altitude of about 4,500 feet, reveal vuggy cherty quartz with radiating fans of large stibnite crystals and many small fragments of altered andesite with disseminated pyrite. At the surface the stibnite is altered to stibiconite. An adit on the trail, at an altitude of about 4,570 feet, on the north side of a small gulch, follows a vein that consists of brecciated andesite with veinlets of quartz containing moderate amounts of sphalerite, chalcopyrite, galena, and pyrite.

Utopian.—The Utopian group of two claims is near the north boundary of sec. 3, T. 23 S., R. 1 E. It was at one time the property of the Vesuvius Mines Co., and it is reported that some ore was packed from these claims by horses to the Vesuvius mill. A cabin on the property is reached by a trail that branches from the Adams Mountain trail just beyond Cat Mountain. Most of the prospecting

work has been concentrated on the Plato vein, which is in a dacite porphyry dike. It strikes N. 40°–45° W. and dips steeply southwest. A crosscut has been driven 20 feet to the vein and a drift 165 feet along the vein at an altitude of about 4,350 feet. A crosscut 20 feet long has been driven from the tunnel to a parallel vein in the hanging wall and follows it for 25 feet. The vein matter on the dump consists of coarse granular vuggy quartz with a pale-greenish hue, considerable disseminated sphalerite, and a little galena, chalcopyrite, and pyrite. Similar quartz and sulphides appear at the face of the main drift. Another adit 75 feet below has been driven on the vein for 200 feet. The vein matter here consists of stringers of quartz and seams of iron-stained altered rock.

War Eagle.—The War Eagle group of six claims and a fraction lies for the most part below the Oregon-Colorado road and the Bohemia trail, in the northern part of secs. 13 and 14, T. 23 S., R. 1 E., in the ground between the Musick, Champion, and Vesuvius groups. Four veins have been prospected—the War Eagle Nos. 1 and 2, Morning Glory, and a cross vein. A crosscut tunnel at an altitude of about 4,470 feet, or 75 feet above the bed of City Creek, is on the claim formerly known as Wall Street, and Diller [81] referred to it as being 120 feet long in 1898. It is now 600 feet long and runs N. 10° E. The wall rock is andesite. About 300 feet from the portal an ore shoot at the intersection of the War Eagle Nos. 1 and 2 veins was penetrated.

The War Eagle No. 1 vein strikes N. 60°–85° W. but averages about N. 60° W. and dips 80° S. From the crosscut a drift follows the vein 120 feet to the west and 150 feet to the east. In the east face of the drift 3 feet of quartz is exposed and at the west face 4 feet of vein matter. The vein at the west face consists of brecciated andesite cemented with vuggy quartz that contains seams and disseminated small aggregates or grains of sphalerite, pyrite, galena, and chalcopyrite. Some of the vugs in the quartz are lined with dolomite or calcite. The andesite is altered only in a narrow band adjacent to the quartz and is relatively fresh though slightly altered at the cores of the included fragments. The sulphides in the vein are sparse except in a shoot 50 feet long at the intersection, which contains moderate amounts. Diller [81] stated that iron-stained quartz at the surface above the tunnel assayed 0.15 ounce of gold and 2.20 ounces of silver to the ton. He also described a small spur vein containing principally galena, sphalerite, and red hematite, which assayed 2.75 ounces of gold and 16.65 ounces of silver to the ton, 3.95 percent of zinc, and 53.80 percent of lead. In addition to the main tunnel, pits and short tunnels prospect the War Eagle for a

[81] Diller, J. S., op. cit. (20th Ann. Rept., pt. 3), p. 24.

length of half a mile. A short crosscut 600 feet east-southeast of the main tunnel reaches the vein, and a drift follows it for 60 feet to the west. The sulphides are considerably oxidized 15 feet below the surface. A short drift follows the vein west of the main adit at the Musick tram. A cut on the vein just west of the intersection of the Sharps Creek and Musick roads reveals considerable iron-stained quartz.

The War Eagle No. 2 vein is thought by the owner to be the eastern extension of the California vein. It is approximately along the same line of strike, but the continuity has not been proved. It has been prospected by shallow cuts and short adits for somewhat more than 2,000 feet to the east of the main tunnel. The average strike is N. 75° W., and the dip is nearly vertical. A drift follows the vein for 30 feet about 650 feet northeast of the portal of the main tunnel. A cut 300 feet east exposes 8 feet of vein matter consisting of iron-stained quartz stringers in tuff and quartz with included country rock. A large shallow pit about 100 feet farther east on the west side of a gulch has been excavated at the intersection with the Johnson cross vein. A crosscut 40 feet long about 500 feet to the east reveals 2½ feet of quartz containing a little sulphide, which is largely oxidized. East of the Oregon-Colorado road a pit exposes 5 feet of iron-stained vein matter striking N. 75° W. and dipping 85° S. It consists of brecciated tuff cemented by reticulating quartz veinlets.

The Morning Glory vein has been prospected north of the road north of the tramline. A pit and a caved trench in andesite on the vein indicate a strike of about N. 85° W.

The cross vein strikes about N. 15° E. On the Oregon-Colorado road the vein occurs in a porphyry dike and consists of a breccia of porphyry cemented by a network of quartz veinlets. Cockade structure in the vein is made up first of a thin crust of comb quartz followed by a thin layer of specularite, which in turn is succeeded by layers of comb quartz with sulphides in druses in some places. The cross vein intersects another vein striking northwest and dipping south on the slope below. About 300 feet below the road the vein is exposed in a shallow pit and consists of 3 feet of breccia or tuff with reticulating veinlets of quartz and films of specularite. The adjacent tuff contains a little disseminated pyrite. This vein intersects War Eagle No. 2 vein and appears as a series of small quartz stringers in andesite just west of the easternmost tunnel on War Eagle No. 1 vein.

Yellow Jacket.—The Yellow Jacket or Sunset vein lies near the center of sec. 13, T. 23 S., R. 1 E., in the valley of City Creek. It has been prospected for 1,500 feet by two tunnels and several pits.

R.3 E. 122° 20′ R.4 E. R.5 E. 122° 10′

T. 8 S.

T. 9 S.

44° 50′

Nasty Rock 4650

Burnt Mtn.

Henline Mtn. 4653

Whetstone Mtn. 4974

CLACKAMAS CO / MARION CO

OGLE MOUNTAIN

BLENDE ORO

BIMETALLIC & GOLDBUG

GOLD CREEK M. & M.

SANTIAM NO. 11 (FIVE SPOT)

SANTIAM NO. 11 (LOWER GRANGER)

SANTIAM NO. 10 (SHILO)

(JOSEPHINE)

SANTIAM NO. 8

BLACK EAGLE

SILVER STAR

S. NO. 5 RIVERSIDE

SANTIAM NO. 1 (MINNIE E)

WOLZ

SILVER KING

CAPITAL

CROWN

MINERAL HARBOR

AMALGAMATED

CALCITE VEIN

Elkhorn

Little North Santiam River

Ogle Cr.

Copper Cr.

Henry Cr.

Gold Cr.

Whetstone Cr.

Evans Cr.

Henline Cr.

Slaughter Cr.

Horn Cr.

Thread Cr.

Dry Cr.

Cedar Cr.

Battle Ax Cr.

Stony Cr.

Elkhorn Cr.

EXPLANATION

- Dioritic intrusive rocks
- Veins
- Strike and dip of beds
- Prospect
- Mine tunnel

SKETCH MAP OF NORTH SANTIAM DISTRICT, MARION AND CLACKAMAS COUNTIES, OREGON

Showing location of mines and prospects, veins, and dioritic intrusive bodies

Base from U. S. Geological Survey map of Mill City quadrangle, Oregon.

1 0 1 2 3 MILES

It is narrow for most of its length, strikes N. 60°–80° W., and dips 60°–70° S. The country rock is chiefly tuff or volcanic breccia with a small amount of intercalated andesite. About a quarter of a mile east of the road an adit follows the vein for 120 feet at an altitude of 4,770 feet. A 2-foot band of quartz is exposed in the face, but the average width is 14 inches. A little sulphide, chiefly galena, with sparse sphalerite and pyrite, occurs in a few places.

Other prospects.—In the northeast corner of sec. 13, T. 23 S., R. 1 E., a vein striking east has been prospected by a short adit and several pits between an altitude of 4,900 feet and the crest of the saddle connecting Champion and Horseheaven Basins.

A vein in sec. 14, T. 23 S., R. 1 E., about 800 feet east-southeast of the Forest Service cabin south of the Musick mine, has been prospected to a small extent. There is a crosscut 50 feet long running S. 30° W. to the vein and a 70-foot drift along the vein, which strikes N. 55°–85° W. The country rock at the portal is tuff. To the northwest a shaft has been sunk 15 feet on quartz veinlets in andesite impregnated with pyrite near its contact with a small plug of dacite porphyry.

About 600 feet east-northeast of the Forest Service cabin an adit has been driven 100 feet N. 76° W. on a vein that dips 50°–68° S. The vein consists of iron-stained quartz and altered rock 2 to 2½ feet wide. The quartz is drusy and contains a little sulphide, chiefly chalcopyrite and pyrite. The country rock is andesite.

CHEENEY CREEK AREA

The Cheeney Creek area is 14.5 miles west-southwest of Mount Hood, in sec. 20, T. 3 S., R. 7 E. It is reached from the end of the road at Tawneys by a trail following Cheeney Creek and a series of switchbacks up the steep slope of the ridge, a distance of nearly 3 miles. The only prospect found by the writers is in a ravine on the steep slope west of Cheeney Creek at an altitude of 2,500 feet. According to Stafford,[82] in 1903 about 100 claims had been located, and 20 were being developed. The Northern Light Mining & Milling Co. at that time reported having a shaft 87 feet deep and 400 feet of tunnel. No production is recorded other than $1,000 or 48.38 ounces of gold ascribed to "Salmon Creek Chinese" in the records of the United States Mint for 1893.

The only tunnel seen by the writers was a crosscut that extends 85 feet west to a drift trending N. 2° E., but the drift was caved 20 feet from the crosscut. Only narrow gouge seams appear in the drift, and no definite vein was recognized. The rocks exposed at

[82] Stafford, O. F., Mineral resources and mineral industries of Oregon: Oregon Univ. Bull., new ser., vol. 1, no. 4, p. 57, 1904.

and below the prospect are light-gray andesites, dark labradorite andesites, tuffs, and volcanic breccias, with an apparent dominance of flow rocks. No dioritic intrusive bodies were found. The country rock at the prospect is a light-gray andesite, only slightly altered. The open cut above the tunnel reveals two thin seams of vein matter on intersecting fractures that are neither large nor persistent. The more persistent fracture strikes N. 20° W. and dips 59° SW., and the other strikes N. 22° E. The vein matter consists of fragments of country rock altered to an aggregate of quartz and clay minerals on which are crusts of galena and sphalerite with quartz and dolomite. The remaining spaces are filled with dolomite and a little calcite. Galena equals or exceeds sphalerite, and both are more abundant than pyrite. No chalcopyrite was observed.

NORTH SANTIAM DISTRICT

LOCATION AND ACCESSIBILITY

Most of the mines and prospects included in the North Santiam district (pl. 16) are in T. 8 S., Rs. 4 and 5 E., mainly within the drainage basin of the Little North Santiam River, in Marion County. The central part of the area is known locally as the Lester mining district, and the eastern part has been called the Mineral Harbor district.[83] Several outlying mineralized areas or claims include the calcite vein on Elkhorn Creek in sec. 1, T. 9 S., R. 3 E.; the Ogle Mountain mine, designated the Molalla district by Stafford,[83] on Ogle Creek, a tributary of the Molalla River; a group of three patented claims in sec. 12, T. 7 S., R. 4 E., on the Table Rock Fork of the Molalla River; and a prospect on Humbug Creek near Dunlap Lake, in the northwestern part of T. 9 S., R. 6 E.[83] The areas on the Table Rock Fork and Humbug Creek were not visited by the writers. All those properties in the drainage basin of the Little North Santiam River are served by a mountain road that extends from the Amalgamated mine, on Battle Ax Creek, to Lyons, on the Detroit branch of the Southern Pacific Railroad. The distance is about 22 miles from the center of the district. The Ogle Mountain mine was reached by a road that followed the ridge tops to Scotts Mills, on the margin of the Willamette Valley.

SURFACE FEATURES

The North Santiam district is the most rugged of all the mineralized areas of the Cascade Range in Oregon (pl. 12, B), partly on account of the relief, but largely on account of the large proportion

[83] Stafford, O. F., Mineral resources and mineral industries of Oregon: Oregon Univ. Bull., new ser., vol. 1, no. 4, p. 58, 1904.

of lava flows to fragmental rocks. The altitude of the bed of the river within the district ranges from 1,100 to 2,500 feet, whereas the surrounding mountains within 2 miles of the river attain altitudes of 4,000 feet, and Battle Ax Mountain, east of the district, reaches an altitude of 5,547 feet. Steep slopes are common, and high cliffs occur in Henline Mountain. Most of the mines and prospects are less than 500 feet above the river or its larger tributaries.

GEOLOGY

VOLCANIC ROCKS

The most significant features of the volcanic rocks in those parts of the North Santiam district that were studied are the dominance of flow rocks over fragmental rocks and the dominance of light-colored oligoclase andesites and rhyolites over the more calcic andesites. Most of the flows within 1,000 feet vertically of the Little North Santiam River are oligoclase andesites—light-colored rocks in which oligoclase is the dominant feldspar and in which chlorite represents the original ferromagnesian minerals—though labradorite andesite occurs at the Riverside prospect. Epidote is an unusually abundant alteration product in the oligoclase andesites. Rhyolite, a light-gray or brownish rock with flow bands and fragments, makes up the bulk of Henline Mountain above an altitude of about 2,800 feet. White altered rhyolite also occurs at the Crown and Santiam or Minnie E. mines, and dikes of white rhyolite with quartz phenocrysts are exposed in workings at the Amalgamated. Hypersthene andesites occur on or near the tops of the ridges, such as near the summit of the trail between the Silver King and Ogle Mountain mines, in a sharp peak whose altitude is 4,633 feet, in the NW¼ sec. 13, T. 8 S., R. 4 W., and in the peaks in the vicinity of Silver King Mountain, east of Whetstone Mountain. A lens of coarse volcanic breccia 300 feet thick is exposed between the upper and lower workings of the Silver King mine on Henline Creek. Laminated fine-grained greenish-gray tuffs occur in several places in the district. Oligoclase andesite on the north bank of the river at the Santiam mine has a fragmental appearance and may be a flow breccia. A dike of hornblende-biotite andesite occurs in the Crown workings.

DIORITIC INTRUSIVE ROCKS

Small intrusive bodies are widely scattered through an area from the Crown mine on the west to the Amalgamated properties on the east. They are mostly dikes of dacite porphyry trending to the northwest, such as the bodies at the Silver King property and those on Gold Creek. A dacite porphyry plug 200 feet wide occurs in the

upper reaches of Horn Creek and is nearly surrounded by a resistant contact zone that weathers out as a circular wall 40 feet high in places. The body at the Bimetallic prospect, on Gold Creek, is probably a plug. A larger body of quartz diorite of undetermined shape occurs at the Crown mine. The large area of contact-metamorphic hornfels on the river near Stony Creek indicates the presence of intrusive rock nearby, but the intrusive rock was not found.

CONTACT-METAMORPHIC ROCKS

Tourmaline-quartz-sericite hornfels occurs near the quartz diorite at the Crown mine and along the river near Stony Creek. Near Stony Creek the tourmaline rosettes are as much as an inch in diameter, and the rock contains cavities lined with quartz crystals. A hornfels with dark spots made up of quartz, sericite, chlorite, and a halo of magnetite around the margin occurs at the Mineral Harbor prospect. A hornfels derived from volcanic breccia at the crosscut at the Silver King mine contains dark spots 2 to 10 millimeters in diameter which, under the microscope, are revealed as sheaflike aggregates of magnetite in brown chlorite. Narrow zones of hornfels surround the smaller bodies.

STRUCTURE

There appears to have been little deformation in this area, as most of the structural features observed can be explained as originating during volcanic accumulation. Local warps occur, and their directions are shown on plate 16. In general, dips on the north side of the valley of the Little North Santiam River have a dominant northerly component, whereas those on the south side have a dominant southerly component, suggesting that the valley is on the crest of an anticline. No faults of measurable displacement were observed. The amount of movement along the veins was not sufficient to bring recognizably different rocks into juxtaposition.

Most of the elongate intrusive bodies trend N. 20°–40° W. Dips are vertical so far as could be determined. From a few observations on joints it was ascertained that a more persistent system strikes N. 20°–50° W. and dips steeply (70°–90°), mainly southwest, whereas the other system strikes N. 40°–60° E. and dips steeply either southeast or northwest. The trend of the veins ranges from N. 80° W. in the No. 1 and No. 2 veins at the Crown to N. 10° E. in the Blende Oro vein. The calcite vein on Elkhorn Creek, at the west side of the district, strikes N. 65° E. The average strike is about N. 40° W. Two-thirds of the veins dip steeply northeast, and one-third dip steeply southwest.

MINERAL DEPOSITS

HISTORY AND PRODUCTION

The early history of discovery of metalliferous minerals in the North Santiam district is largely lost. R. E. Peery,[84] who is interested in the Crown mine, stated that so far as he could learn ore was discovered by Indian Hirn in 1896 at what is now the main tunnel of the Amalgamated mine. Fred Buesche located claims nearby in 1897. Most of the properties now known are reported by Stafford[85] for 1903. J. B. Fairclough[86] stated that the Ogle Mountain mine was worked from 1903 to 1914 and again in 1918–19. Ore was shipped from what is now the Santiam mine in 1915–17 and again in 1924. Operators of the Amalgamated mine were active in 1930, and a shipment of ore was made. The recorded production is given in the table below. The production for 1926 may be erroneously ascribed to this district.

Production of North Santiam district

[From data supplied by V. C. Heikes]

Year	Crude ore (tons)	Gold (ounces)	Silver (ounces)	Copper (pounds)	Lead (pounds)	Zinc (pounds)
1915	47	68.55	48			
1916	40	80.93	9	6,504		
1917	5			1,000		
1918	75	67.00	14			
1919	118	50.98	129			
1924	71		105	6,219		
1926	35	10.17	1,352	112	276	
1930	43		102	371	3,060	12,528
Total	434	277.63	1,759	14,206	3,336	12,528

NOTE.—Approximate values: Gold (at $20.67 an ounce), $5,739; silver, $1,146; copper, $2,914; lead, $191; zinc, $564; total, $10,554.

MINERALOGY AND TYPES OF VEINS

The veins are broadly similar to those in the Bohemia district, yet certain differences are apparent. Chalcopyrite, sphalerite, pyrite, galena, and gold are the principal metallic minerals. Gold was the principal mineral sought in the Ogle Mountain mine. The gold content of the sulphide ores is very low, however. Veins characterized by chalcopyrite are more numerous in this district than in the Bohemia district. Relatively little quartz occurs with the chalcopyrite. An unidentified white mineral containing copper, bismuth, silver, and sulphur was observed under the microscope in chalcopyrite from the Santiam mine. Sphalerite at the Silver King mine is unusual in that

[84] Personal communication.
[85] Stafford, O. F., op. cit., pp. 57–58.
[86] Personal communication.

it is light green. One of the ore shoots of the Amalgamated mine is unusual in having a gangue of minute epidote needles and calcite. Specularite occurs only in the Mineral Harbor and Silver Star veins in contact rock and is not nearly so abundant as in the Bohemia district. Ankerite and adularia occur at the Ogle Mountain mine. As the veins are mostly down in the valleys, erosion has nearly kept pace with weathering and oxidation. No weathered zones comparable with those in the Bohemia district were seen. Oxidation was probably deepest at the Ogle Mountain mine, but its exact depth is not known to the writers.

Though at least three of the usual sulphides are common to almost all the veins, the variations in their proportions are sufficient to suggest a classification of the veins. Complex sulphide veins characterized by sphalerite as the dominant sulphide, with variable proportions of galena, chalcopyrite, and pyrite, include the Amalgamated, Blende Oro, Capital, Mineral Harbor, Silver King, Wolz, and the vein on the mountain side northeast of the mouth of Gold Creek. Veins characterized by pyrite as the principal sulphide include those at the Gold Creek M. & M. tunnels and the Santiam group of tunnels on Gold Creek. The Bimetallic vein is transitional between the pyritic type of the Gold Creek M. & M. and the complex sulphide type of the Blende Oro. Chalcopyrite is the dominant sulphide in the Minnie E. vein of the Santiam group and the Crown veins, as well as in the Black Eagle and Silver Star. In the Silver Star vein early epidote and specularite are traversed by quartz containing both sphalerite and chalcopyrite, but the chalcopyrite has also invaded the epidote. Oxidation and leaching of chalcopyrite veins in the Black Eagle and Crown has produced a little chrysocolla, malachite, and azurite. Carbonate veins include the calcite vein on Elkhorn Creek and the Ogle Mountain vein, which also contains sparse sulphides.

In general, the veins in the North Santiam district are less persistent, are narrower, and contain narrower ore shoots and less gold than those in the Bohemia district. The veins and the dioritic intrusive bodies are also more scattered than those of the Bohemia district.

However, the areal zoning of the veins of different types is more evident here than in the Bohemia district. The chalcopyrite veins from the Crown mine to the Santiam form a central zone. This is succeeded in the section up Gold Creek by the pyrite veins, and that in turn by the complex sulphide vein of the Blende Oro. The outer limits of mineralization are represented by the calcite vein on Elkhorn Creek and the Ogle Mountain mine. Probably the zones are not continuous and the pyrite zone appears to be largely absent except on

Gold Creek. No prospects have been opened south of the chalcopyrite veins.

The wall rock of the veins is altered, generally to an aggregate of chlorite, epidote, sericite, quartz, clay minerals, and carbonate. The carbonate is probably mostly calcite, but ankerite occurs in some places, and mesitite occurs in the wall rock of the Capital vein. Sericite is the principal alteration product at the Blende Oro and Bimetallic. Though there are narrow zones of soft altered rock along the veins, none of the large areas of bleached and partly silicified altered rock, such as occur in the Bohemia district, were observed.

Future development in the district should depend largely on high prices for the base metals. Small shoots of complex sulphide and chalcopyrite ores have been explored, but they contain almost no gold and very little silver, according to available assays. Possibly more shoots of base-metal ores will be found, as the district covers a large area, is heavily forested, and has not been thoroughly prospected. Further prospecting might reveal gold-ore shoots like that of the Ogle Mountain mine, in the outlying parts of the district. Only small ore shoots may be expected, and plant and development work should be planned accordingly.

MINES AND PROSPECTS

Amalgamated.—Three contiguous groups of claims—the Amalgamated, Columbia, and Blue Jay—constitute the Amalgamated properties, which lie mainly on the south side of the Battle Ax Fork of the Little North Santiam River in unsurveyed T. 8 S., R. 5 E., about 26 miles by road from Lyons. The main workings were formerly the property of the Lewis & Clark Mining & Milling Co.[87] The present owners were active in 1930. A road 4 miles long was built to the mine, buildings and ore bins were constructed, and foundations were started for a mill, though almost no new development work was done. An ore shoot previously developed was mined, and 43 tons of crude ore was shipped to the smelter.

The underground workings consist of about 1,350 feet of drifts, of which about 1,020 feet is in the workings on the main drift. There are also several short adits and open cuts. The main tunnel enters the south side of the valley several hundred feet above Battle Ax Creek and trends S. 55° E. but curves to the east near the face. The country rock is mainly oligoclase andesite, but a dike of porphyritic rhyolite about 5 feet wide crosses the tunnel near the portal and

[87] Stafford, O. F., Mineral resources and mineral industries of Oregon: Oregon Univ. Bull., new ser., vol. 1, no. 4, p. 58, 1904. Parks, H. M., and Swartley, A. M., Handbook of the mining industry of Oregon: Mineral Resources of Oregon, vol. 2, no. 4, p. 140, Oregon Bur. Mines and Geology, 1916.

parallels it throughout on the northeast side. The principal vein, the Blue vein, is intersected by the tunnel about 350 feet from the portal. The principal ore shoot lies south of the tunnel and has been opened by a drift 30 feet long from a short crosscut and by a raise and small stope. The trend of the vein ranges from N. 70° W. to west, and the dip is 65° NE. The ore shoot is 30 feet long, about 3 feet wide in the middle, and pinches out to thin seams in the soft gouge.

The vein matter in the ore shoot is composed of sphalerite, galena, chalcopyrite, and very little pyrite, with sphalerite predominating. Sulphides are disseminated irregularly through the vein matter, and large lumps of almost solid sulphides occur in places. The gangue is mainly a soft greenish mass of chlorite with some sericite, but locally calcite cements the other constituents and lines vugs. Quartz is very subordinate. Some of the ore contains yellowish-green needles of epidote. Gouge clays are chiefly chlorite with some clay minerals, sericite, and comminuted rock and vein matter. Assays supplied by the owners are given below.

Assays of samples from Amalgamated properties

	1	2	3	4	5	6	7
Gold.....ounces to the ton..	0.66	.....	.....	Trace	Trace	0.12	0.06
Silver.....do....	4.00	.....	.....	3.2	2.00	5.20	5.80
Copper.....percent..	4.4	4.85	.....	2.32	1.20	1.16	1.26
Lead.....do....	15.08	2.1	28.4	10.10	10.20	7.25	13.5
Zinc.....do....	3.5	10.1	26.0	26.2	19.00	17.85	28.75

NOTE: Assays (4) and (5) are reported as from the Blue vein; locations of others are not given.

Analysis of ore

Gold.....	Trace	Iron.....percent..	4.3
Silver.....ounces to the ton..	4.1	Zinc.....do....	35.5
Lead.....percent..	19.4	Sulphur.....do....	23.0
Copper (wet).....do....	1.8	Arsenic.....do....	.2
Copper (insoluble).....do....	3.8	Antimony.....do....	.1

A small stope on the Brown vein, a group of nearly horizontal fractures with calcite veinlets in soft pyritic altered rock, is located at the crosscut 250 feet from the portal of the main adit. Some sulphides occur in this material. A short drift in the innermost part of the tunnel follows a vein trending nearly east and dipping 60° N. It contains 42 inches of quartz and sparse sulphides with 1 foot of gouge on the footwall.

On the south side of a ravine about 200 feet vertically above and to the west of the face of the main tunnel are two tunnels. The eastern one is a drift 80 feet long on a vein trending S. 30° E. in greenish pyritic andesite. The vein is 12 to 20 inches wide and con-

sists of vuggy quartz with sulphides, almost entirely pyrite and sphalerite in about equal proportions. The other tunnel is a crosscut running 90 feet S. 40° E. to a vein 12 feet wide that consists of brecciated altered rock with streaks of quartz, pyrite, and sphalerite, and a little galena and chalcopyrite. The hanging wall strikes N. 45° W. and dips 65° N.

On the steep slope a short distance above Battle Ax Creek and below the main tunnel are two short tunnels. One is a drift 45 feet long on a seam of brecciated country rock trending S. 30° E. and dipping 61° S. The hanging wall is a somewhat pyritized rhyolite. The other tunnel is about 300 feet upstream and follows a seam of brecciated country rock trending S. 55° E. and dipping 80° SW. The breccia is 4 feet wide at the portal but pinches to 1 inch at the face and is associated with a thin dike of porphyritic rhyolite. Thin seams of pyrite, sphalerite, galena, and chalcopyrite occur in the altered rock. Several other cuts have been made on veins and fractures along Battle Ax Creek.

Bimetallic and Goldbug.—The Bimetallic vein (Wall Street?) and Goldbug claim are on the north branch of the east fork of Gold Creek in unsurveyed T. 8 S., R. 5 E. They are reached by a trail from the road at the mouth of Gold Creek, a distance of about 2 miles. The Bimetallic tunnel, on the west side of the creek, follows the vein for 290 feet N. 30° W. The vein consists of brecciated country rock (diorite) and vuggy quartz and dips 80° SW. The ground is heavy, and the soft white material is largely sericite. The vein matter contains the usual sulphides, including considerable chalcopyrite but with pyrite predominating.

The Goldbug tunnel, on the east side of the creek, is presumably on the same vein. Most of it is timbered, and it follows the nearly vertical vein for 170 feet S. 40° E. The vein matter consists of brecciated andesite, in places 2½ feet wide, with lenticular streaks of quartz 1 to 10 inches thick containing some sulphides, principally sphalerite and pyrite.

Black Eagle.—The Black Eagle mine is on the road on the west side of Horn Creek in sec. 24, T. 8 S., R. 4 E. A compressor house with a few pieces of machinery stands at the portal of the main tunnel, and there is a cabin farther south on the terrace. No production is recorded, and the development work appears to have been done prior to 1916.[88]

Nearly 1,000 feet of workings, of which about 400 feet is a drift on the main vein, constitute the main level, which is near the break

[88] Parks, H. M., and Swartley, A. M., Handbook of the mining industry of Oregon: Mineral Resources of Oregon, vol. 2, no. 4, pp. 33–34, Oregon Bur. Mines and Geology, 1916.

between the steep mountain side and a sloping terrace that is nearly 300 feet above the river. The portal is in partly consolidated gravel. The tunnel runs nearly due west for 250 feet, then turns N. 10° W. for 50 feet on a thin seam with quartz streaks mainly less than 2 inches wide, dipping from vertical to 80° W. The tunnel then turns N. 15° E. and follows a fracture dipping 54° E. to an intersection with another fracture having an average trend of N. 45° W. and a steep dip, mainly to the northeast. This drift is 400 feet long and exposes an ore shoot 85 feet long in the westernmost 100 feet. A stope nearly 20 feet square and 20 feet high reveals several parallel veins and streaks. The principal one of these veins contains 2½ feet of vein matter with an additional 7 feet of stained material apparently of low grade, which strikes N. 20° W. and dips 68° N. The primary vein matter consists of a breccia of silicified greenish andesite that has been cemented by quartz containing chalcopyrite with very little galena and almost no pyrite. Weathering has formed limonite, malachite, and a little azurite in fractures and on vug surfaces. Chrysocolla has been formed in openings 3 or 4 inches in diameter. The drift continues beyond the stope on one of the lesser fractures and reveals a cavity about 3 feet wide lined with coarse dark-brown manganese-bearing calcite. Beyond this the vein pinches down to a narrow zone of soft altered rock and very thin seams of quartz. A crosscut driven 150 feet northeast from a point in the main drift 130 feet east of the stope reveals near the face a fracture containing a lens of brecciated country rock parallel to the main vein.

Blende Oro.—The Blende Oro claims are on the north branch of the east fork of Gold Creek in unsurveyed T. 8 S., R. 5 E., about 2 miles by trail from the road at the mouth of Gold Creek, and the main tunnel and cabin are about 300 feet north of the Bimetallic. The main tunnel, about 215 feet in length, follows the vein N. 10° E. beyond an entry running N. 30° W. The country rock, probably originally a tuff, has been altered to a mass of sericite and cherty quartz with disseminated pyrite. The vertical vein consists of this altered country rock with sulphides either irregularly disseminated (pl. 12, *A*), in bunches, or in bands. The material with considerable sulphides ranges from 12 to 65 inches in width and forms an ore shoot over 100 feet long. Sphalerite, pyrite, galena, and chalcopyrite are present, with sphalerite—a light resinous variety—predominating. All the sulphides occur as well-defined crystals lining vugs; some of the sphalerite crystals are over an inch in diameter. In places there are lumps of nearly solid sphalerite over 6 inches thick. Galena is scattered through the more massive parts of the vein. Chalcopyrite is disseminated in the massive parts of the vein or occurs in bunches or in well-formed sphenoids on the surfaces of quartz and

sphalerite crystals. A very little calcite and pyrite occur on the surfaces of the other crystals.

Capital.—The main tunnel on the Capital claim is 400 feet upstream from the road near the mouth of Henline Creek, in sec. 28, T. 8 S., R. 4 E. Township plats of 1893 show this claim patented as the Capital Consolidated. A shipment of ore is reported to have been made from this claim to Swansea, Wales. The tunnel is reported to be 400 feet long, but access beyond 100 feet was prevented by a cave-in. A small stope 50 feet from the portal reveals two veins separated by 5 feet of altered country rock. One of the veins is 30 inches wide and the other 15 to 24 inches. They converge farther in the tunnel and have an average strike of N. 50° W. and a dip of 75°–80° SW. The vein matter consists of a breccia of silicified andesite charged with sericite and mesitite, an iron-magnesium carbonate, and cemented with stringers and reticulating veinlets of quartz with sulphides, chiefly sphalerite. One streak of almost solid sphalerite 3 inches wide was observed (pl. 5). There is a little galena and chalcopyrite.

Crown.—The 10 claims of the Crown Mining & Milling Co. are mainly in the southeast corner of sec. 33, T. 8 S., R. 4 E., on the steep northern slope of the ridge between the Little North Santiam River and Elkhorn Creek. A trail to the workings extends from a branch of the main road at the river. Assessment work has been done on the ground for 23 years, but most of the development work was done in the 4 years prior to 1927, according to the owners. The developments consist of about 1,000 feet of crosscut and drift on the main level and some short tunnels and cuts on the surface. The equipment includes a compressor and drilling materials. There is a good cabin about 400 feet below the main tunnel.

The crosscut (fig. 3) cuts several veins and fractures of altered andesite, tuff, volcanic breccia, and rhyolite near the contact of an intrusive mass of quartz diorite lying to the southwest. There are also dikes of porphyritic diorite and hornblende-biotite andesite.

The veins consist largely of lenticular masses of brecciated altered country rock with chalcopyrite lining vugs and in veinlets. The first (No. 1) vein, 35 feet from the portal of the crosscut, strikes N. 80° W. and dips 70° NE. About 100 feet of drift reveals a 2-inch seam with almost no sulphides that toward the east splits into two seams, one of which widens to 1 foot. The second (Blind) vein, 85 feet from the portal of the crosscut, is explored by a short drift, now caved. It consists of an altered zone 6 inches to more than 1 foot in width. The Salem vein is explored by a drift 130 feet long trending mainly N. 55° W. and consists of a seamy brecciated zone with a little chalcopyrite and pyrite. Another altered zone (Thirteen-foot

vein) is explored by short drifts. It consists of gouge seams in altered rock through a width of 10 feet and strikes N. 60° W. Some of the seams contain chalcopyrite and pyrite. The Blackwall vein is a seam of brecciated altered rock, which has been explored by a drift for 65 feet S. 62° E. The main drift follows a broad altered and sheared zone (Winze vein) near the contact with the quartz diorite body, which is exposed in the ends of three short crosscuts

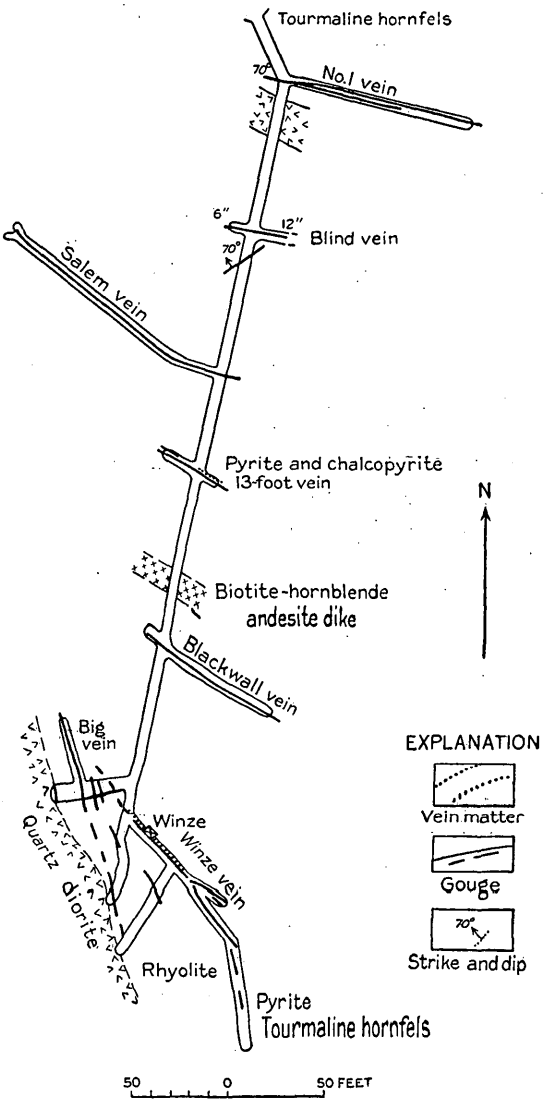


FIGURE 3.—Sketch map of main level of Crown mine, North Santiam district. From compass and pace traverse.

and drifts. The vein near the main crosscut contains a short lens of silicified country rock with seams of vuggy quartz and of chalcopyrite and a little sphalerite. Supergene solutions have formed

malachite, chrysocolla, iron oxide, and stains of covellite or chalcocite on chalcopyrite. Flakes of native copper are reported to be obtained by panning. A broad shear zone in rhyolite, known as the big vein, parallels the quartz diorite contact but reveals no ore minerals.

The following assays are taken from a report by W. J. Elmendorf:

Assays of samples from the Crown mine

	1	2	3	4	5	6
Width.....inches..	Stringers	Selected	18	6	.....	12
Gold.....ounces to the ton..	0.10	0.06	0.03	0.22	0.08	0.08
Silver.....do....	2.76	.90	.68	1.80	.90	1.60
Copper.....do....	1.11	1.93	1.93	4.24	2.31	6.26

NOTE.—Samples 1 and 2 are from Blind vein, 3 from Blackwall vein, 4 from Thirteen-foot vein, and 5 and 6 from Winze vein.

Elkhorn Creek.—A calcite vein occurs on Elkhorn Creek in the southeast corner of sec. 1, T. 9 S., R. 3 E., and is reached by trail from Elkhorn School over a series of terraces on the south side of the Little North Santiam River. A partly caved drift on the south bank of the creek follows the vein S. 65° W. The vein consists of fragments of altered andesite cemented with calcite, in places over 1 foot wide. Short lenticular veinlets of cherty quartz occur in the calcite. No metallic minerals were observed, though tetrahedrite is reported to have been found here.

Gold Creek M. & M.—The Gold Creek M. & M. is on the east fork of Gold Creek, about half a mile northeast of the forks and nearly 1½ miles by trail from the road at the mouth of Gold Creek. No production has been recorded, and apparently most of the development work was done prior to 1916.[89] Stafford[90] reports 400 feet of development work in 1904. A crosscut driven in a northerly direction from the north bank of the creek attains a point about 1,300 feet nearly due north of the portal. The wall rock throughout is andesite considerably altered and containing disseminated pyrite.

The first vein is reached by the tunnel 150 feet from the portal. It trends N. 30° W., dips 60° SW., and consists of 6 inches to 1 foot of quartz with 1 foot of soft altered rock. The next vein is reached 250 feet from the portal and is followed for 300 feet by the drift to a cave-in. The strike of this vein averages N. 35° W., and the dip is 60°–85° NE. The vein consists of brecciated andesite with seams of quartz containing pyrite and a little chalcopyrite. A crosscut 410 feet to the northeast reaches another vein striking nearly north and dipping 60° W. The tunnel follows this vein for 70

[89] Parks, H. M., and Swartley, A. M., op. cit. (Mineral Resources of Oregon, vol. 2, no. 4), p. 104.

[90] Stafford, O. F., op. cit. (Oregon Univ. Bull., new ser., vol. 1, no. 4), p. 57.

feet and exposes about 13 inches of vein matter containing pyrite and chalcopyrite. Still another vein near the end of the tunnel is explored for 110 feet by a drift running N. 45° W. The dip of this vein is 70° NE. It contains as much as 18 inches of quartz with pyrite and some chalcopyrite.

Another tunnel, 280 feet in length to a cave-in, enters the south bank of the creek about 250 feet upstream and approximately in line with the second vein exposed in the main tunnel. However, it differs in orientation, having an average strike of S. 15° E. and a dip of 55° SW. The vein is nearly three-fourths calcite, which is banded and associated with quartz, pyrite, and minor amounts of chalcopyrite. The calcite is nearly free of sulphides, but it contains later quartz along cleavage planes. A dump at the caved portal of another tunnel about 500 feet upstream contains pyrite with chalcopyrite and a little sphalerite in a gangue of quartz with some calcite.

Mineral Harbor.—The Mineral Harbor group of 30 claims lies in the vicinity of Stony or Boulder Creek in the southwest-central part of unsurveyed T. 8 S., R. 5 E. The trail to the cabin leaves the road along the Little North Santiam River 1½ miles east of the mouth of Gold Creek. The only tunnel seen is on a branch of Stony Creek at an altitude of about 2,500 feet; it runs S. 50° E. for 20 feet to a cave-in. The country rock is spotted hornfels or andesite modified by contact metamorphism, though the intrusive rock was not seen. The tunnel exposes a band of cherty quartz and sericite 10 feet wide. Quartz veinlets with specularite and chalcopyrite (pl. 4, *B*) or with sphalerite and minor amounts of chalcopyrite and a little galena occur in the altered rock.

Ogle Mountain.—Eight claims surveyed for patent constitute the Ogle Mountain property,[91] which is in the S½ sec. 9, T. 8 S., R. 4 E., near the Clackamas County line, in the drainage basin of the Molalla River. The mine is reached by a trail up the steep valley of Henline Creek from the road on the Little North Santiam River, by trail up the Molalla River and Ogle Creek, or by a trail that was formerly a road following the ridge from Scotts Mills, at the margin of the Willamette Valley. According to the owner, work was started on the property in 1903, and machinery was brought to the mine in 1905. Operations were carried on until 1914, and the property was operated under lease in 1918–19. The owner reports the total production as about $10,000. The surface establishment, which is in a fair state of preservation, includes one large cabin and several small ones, an assay office, a sawmill, a 10-stamp mill, a tube mill, and cyanide tanks. Ore was carried to the mill by aerial tram from

[91] Parks, H. M., and Swartley, A. M., op. cit. (Mineral Resources of Oregon, vol. 2, no. 4), p. 166.

the main working level about 300 feet above the mill on the east side of the valley.

All the workings were closed at the time of this investigation. The vein, as judged from some caved stopes, strikes about N. 25° W. and dips steeply to the northeast. A crosscut reported to be 1,460 feet long penetrates the ridge at the level of the mill, near the creek. The main working level is about 300 feet higher and runs N. 60° E. for the first 100 feet. Raises and stopes extend from this level to the surface, where the stopes are about 6 feet wide. The country rock consists of porphyritic oligoclase andesite and volcanic breccia, though a little labradorite andesite occurs in the lower crosscut. Vein matter from the lower level consists of cherty quartz veins cut by carbonate veins, which are in turn cut by vuggy calcite veins. One specimen contains a vein of coarse calcite with abundant galena, a little sphalerite, pyrite, and chalcopyrite, and quartz and adularia along the walls. Some of the vein matter consists of gray ankerite with sphalerite and a little pyrite, in silicified wall rock. Parks and Swartley [92] state that the average recovery of gold was $5, or 0.24 ounce to the ton. The owner states that gold specimens were exhibited at the Lewis and Clark Exposition in 1905.

On the east side of the valley, south of the main workings, are some short drifts on other veins or fractures containing calcite and clay minerals. These strike N. 10°–20° W. Some cuts on altered rock near the swamps in section 16 may be on a continuation of the main vein. Some placers are reported to have been worked on the creek east of Ogle Creek.

Riverside.—The Riverside claim is in T. 8 S., R. 4 E., on the Little North Santiam River near the township line, probably in section 24. The workings consist of a tunnel 240 feet long on the south bank and a drift 30 feet long on the north bank. The drift follows a breccia zone 28 inches wide, striking N. 23° W. and dipping 62° NE., which contains a few thin veins of silicified material with a little copper stain and some pyrite. The tunnel on the south bank follows a vertical breccia seam, mainly less than 2 inches wide, S. 26° E. for 75 feet. The tunnel turns and for the remainder of its length follows two unmineralized fractures.

Santiam.—The Santiam group of claims, known at various times as the Freeland Consolidated, Electric Mining & Smelting Co., Consolidated Copper & Power Co., Northwest Copper Co., and Lotz & Larsen, extends from the mountain side southeast of the mouth of Gold Creek in a northwesterly direction to a point on the west fork of Gold Creek, all on the west side of unsurveyed T. 8 S., R. 5 E. A road leads directly to the main tunnel on the Little North Santiam

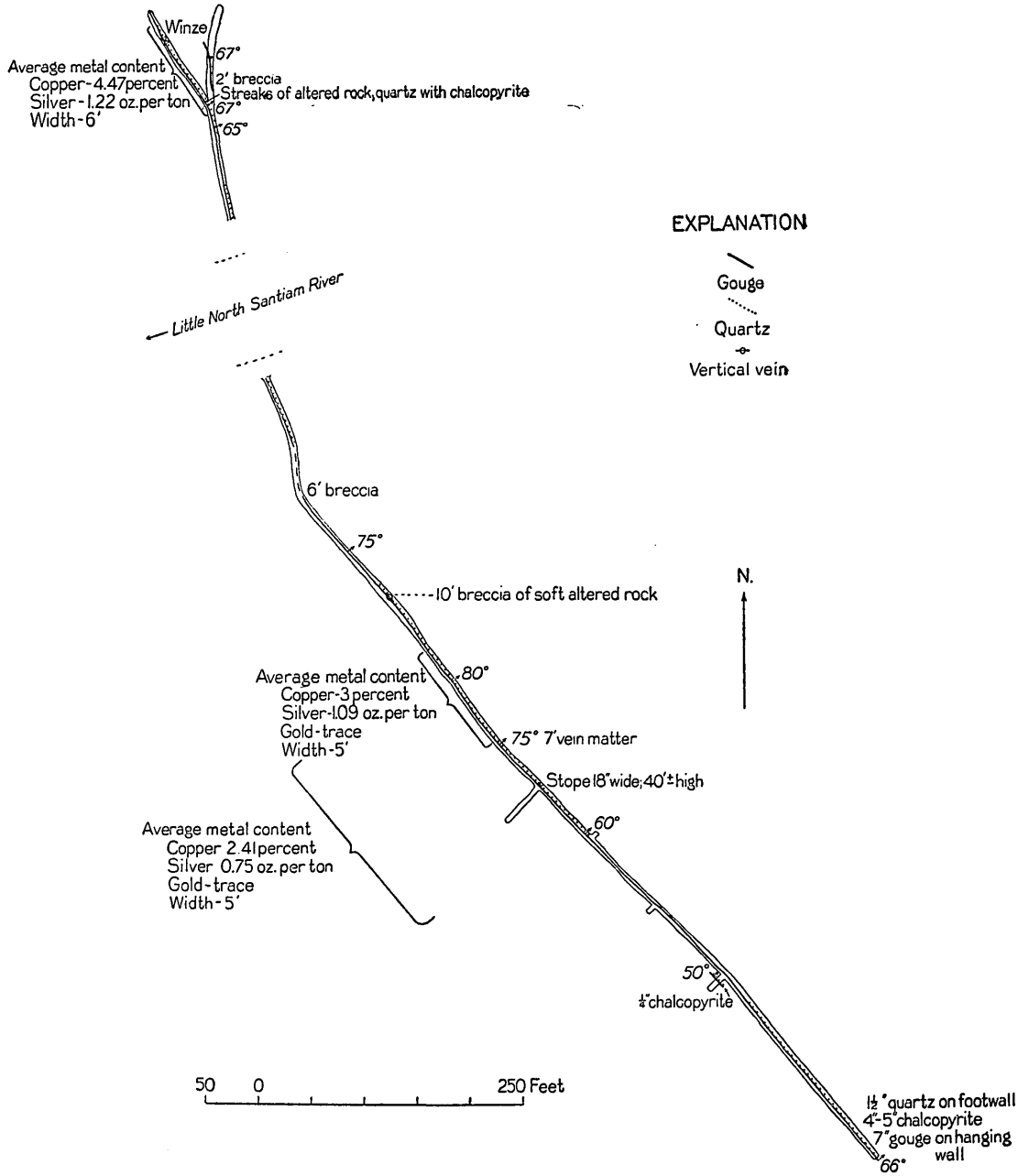
[92] Idem, p. 166.

River about a quarter of a mile above the mouth of Gold Creek. The other prospect tunnels on Gold Creek are reached by trail. There are several cabins in a fair state of preservation and a small mill at the mouth of Gold Creek. Stafford [93] reports 300 feet of tunnel on these properties in 1903. Apparently most of the mining and development work was done in 1915–17, though two carloads of ore were shipped in 1924.

The principal vein is the Minnie E., on the Santiam No. 2 claim, which crosses the river and is explored by drifts on both sides. (See pl. 17.) There is about 925 feet of drift on the south side of the river and 300 feet on the north side. The vein in the south drift, all but 110 feet near the portal, strikes N. 43° W. and dips 50°–80° NE. For the distance of 360 feet from the bend in the south drift to the forks in the north drift the average strike is N. 15° W. and the dip 65° NE. One branch of the vein at this point strikes N. 35° W. The other branch exposes nearly barren shear zones that average N. 15° W. The country rock on the north side of the river is agglomeratic oligoclase andesite, and that on the south side is mainly porphyritic oligoclase andesite. Chalcopyrite is the principal ore mineral, but there are also subordinate pyrite, sphalerite, and an unknown white metallic mineral, visible only under the microscope, that contains copper, silver, bismuth, and sulphur.

Though ore minerals are sporadically distributed throughout the vein, there are four fairly distinct narrow ore shoots, as shown in plate 17. That in the north drift is 100 feet long and in some places 18 inches wide. A winze, now full of water, is reported to have exposed 14 inches of chalcopyrite 96 feet below the tunnel. In places the shoot contains three seams of almost solid chalcopyrite, each 3 inches wide, associated with quartz stringers and altered rock. The vein pinches down to 1 inch at the end of the drift. An assay map by W. J. Elmendorf shows an average metal content for this shoot of 4.47 percent of copper, 1.22 ounces of silver to the ton, and no gold for a width of 6 feet. A shoot at the portal of the drift on the south side contains only a small amount of chalcopyrite. The first 180 feet of drift has an average metal content of 1.25 percent of copper, 0.1 ounce of silver to the ton, and no gold, according to the assay map. A shoot nearly 200 feet long extending southeastward from a point 280 feet from the portal has been partly stoped. This shoot averages, for a width of 5 feet, 2.41 percent of copper, 0.75 ounce of silver to the ton, and a trace of gold. Another shoot about 80 feet long, extending southeastward from a point about 760 feet from the portal, has been partly stoped. The vein at the face of the tunnel consists of 4 to 5 inches of nearly solid chalcopyrite,

[93] Stafford, O. F., op. cit. (Oregon Univ. Bull., new ser., vol. 1, no. 4), p. 57.



SKETCH MAP OF MAIN TUNNELS OF SANTIAM OR MINNIE E. MINE, NORTH SANTIAM DISTRICT.

From pace and compass traverse. Assays from map submitted by owners.

1½ inches of quartz with a little calcite, and 7 inches of gouge.

An open cut about 500 feet east of the main tunnel reveals a seam of chalcopyrite half an inch wide. Some open cuts and a short drift west of the mouth of Gold Creek show gouge seams and some pyrite but no appreciable chalcopyrite.

Several of the tunnels along Gold Creek are believed locally to be on the same vein. The Mayday or Santiam No. 8 tunnel, on the west side of Gold Creek about 1,700 feet north of the camp, follows a soft pyritic altered zone 6 inches wide N. 40° W. for 100 feet. The Josephine crosscut, about 100 feet south of the footbridge near the forks of Gold Creek, extends 65 feet to a vein that strikes N. 10° W. and dips 70° E. The vein consists of gouge seams in andesite with no appreciable sulphides. The Shilo or Santiam No. 10 drift, 300 feet up the west fork of Gold Creek from the forks, follows a seam of pyritic altered rock with quartz and calcite stringers for 215 feet, mainly N. 15° W. The Lower Granger or Santiam No. 11 is a short distance north of the Shilo. A crosscut extends 155 feet S. 65° W. to the vein, which is followed by drifts of 110 feet N. 10° W. to a cave-in and S. 5° E. to a face that reveals silicified rock with a few quartz stringers. Vein matter on the dump contains scattered pyrite, a few streaks of chalcopyrite, and a very little sphalerite. The Five Spot tunnel or Santiam No. 11, about 1,200 feet upstream from the Lower Granger, consists of a crosscut 275 feet long running S. 80° W. and a drift on the vein for 50 feet N. 3° E. The vein dips 60°–70° W. and consists of a breccia of country rock with vuggy quartz veinlets and disseminated pyrite.

Silver King.—The 12 claims constituting the Silver King property are on Henline Creek, mainly in sec. 28, T. 8 S., R. 4 E. There are several good buildings and a water-power plant and compressor at the portal of the main crosscut. A branch road leads directly to the crosscut from the main road.

The principal vein is the Queen of the West, which is prospected by drifts on each bank of Henline Creek several hundred feet above the crosscut. The crosscut is reported to be 1,600 feet long but was inaccessible at the time of the writers' visit. The eastern tunnel on the El Capitan claim follows the vein, which dips 40°–45° SW., for 50 feet S. 45° E. A dike of dacite porphyry forms the hanging wall, but the footwall is altered andesite. The vein matter averages 18 to 24 inches in width and consists of fragments of altered andesite cemented by vuggy quartz in veins that contain sulphides, chiefly sphalerite, ranging from nearly black to light green, but also some galena, a little chalcopyrite, and pyrite. Some veinlets containing quartz and sphalerite are offset along other quartz veinlets. A little ankerite occurs on the surfaces of other minerals in vugs. The drift on the west side of the creek reveals as much as 6 feet of vein matter,

but the strike is N. 85° W. and the dip 40°–50° S. Dacite porphyry forms both walls of the vein in this drift.

Another vein near the south boundary of the property, on a rock terrace southeast of the portal of the crosscut, has been prospected by a shaft reported to be 80 feet deep but now filled with water and debris to a point within a few feet of the surface. The vein matter is very similar to that of the Queen of the West.

The assays given below are taken from a prospectus supplied by the owners. Samples 1 and 2 were taken from the shaft. Samples 3, 4, and 5 were taken progressively inward along the drift on the Queen of the West vein on the east side of the creek, sample 5 being at the face. The remainder were taken progressively inward along the drift on the west side of the creek, sample 12 being near the face. Zinc was not determined in those samples where its quantity is not given.

Assays of samples from Silver King property

	1	2	3	4	5	6	7	8	9	10	11	12
Width.....inches..	------	------	20	10	18	------	75	-------	-------	18	60	------
Gold ounces to the ton..	0.05	0.06	0.045	0.02	0.04	0.07	Trace	Trace	0.06	0.02	Trace	0.02
Silver ounces to the ton..	1.6	2.1	3.1	9.8	4.4	5.2	7.4	14.6	39.1	40.8	4.2	5.2
Lead.....percent..	.53	.1	2.1	3.2	2.92	3.8	3.2	3.7	2.93	1.73	3.9	4.7
Zinc.....do....	3.74	4.2	------	1.44	------	------	-------	-------	-------	3.38	3.7	------

Silver Star.—The Silver Star and Helvetia claims are on the road west of Tincup Creek, in the SE ¼ sec. 23, T. 8 S., R. 4 E. The owner was actively prospecting in 1931. The main tunnel is at the side of the road and runs 30 feet N. 25° W., then 35 feet N. 37° E. The vein, which is approximately vertical, appears mainly in the inner part of the tunnel. The country rock is greenish-gray altered oligoclase andesite containing much epidote.

The vein ranges from a few inches to 18 inches in width and consists chiefly of epidote and quartz, though some quartz veins without epidote cut epidote veins. Dark sphalerite and chalcopyrite are associated in the later vuggy quartz veins, and chalcopyrite is disseminated or occurs in veinlets in the epidote. A little chalcopyrite occurs with knots and vugs of coarse specularite. Near the vein is a dioritic intrusive body that strikes N. 10° E. Near the end of the drift the ore minerals appear to occur in jointlike fractures rather than in a well-defined vein.

Wolz.—The Wolz property is between the road and the Little North Santiam River near the mouth of Cold Creek and between Tincup and Stack Creeks at the north side of sec. 26, T. 8 S., R. 4 E. It is reached by a trail that joins the road near Cold Creek. The vein strikes N. 35° W. and dips 75° NE. It has been explored by

an open cut in the bank of the river, a drift 20 feet long above this, and a drift 80 feet long about 50 feet above the short drift. The country rock is greenish porphyritic andesite. The open cut reveals 18 inches of vein matter that consists of fragments of altered rock cemented by quartz. Sphalerite and chalcopyrite are disseminated through this material in nearly equal proportions, and there is a little pyrite. Some thin seams of comb quartz with these three sulphides occur in the hanging wall. The short drift reveals two thin seams of gouge without perceptible sulphides. The upper drift is lagged throughout, but at the face it shows 8 to 15 inches of brecciated andesite with moderate amounts of sulphides, which are partly leached. Greenish porphyritic andesite 2½ feet thick with thin seams of vuggy quartz occurs in the hanging wall. The vein also appears on the south bank of the river.

Other prospects.—A prospect tunnel 30 feet long in andesite is located on the southwest slope of Whetstone Mountain, about 500 feet above the road and 0.9 mile east of the mouth of Gold Creek. An open cut lies about 240 feet to the northwest along the strike. The vein strikes N. 25° W. and dips 65° SW. It consists of 1½ to 2 feet of partly leached vein matter and fragments of altered rock with some sphalerite and chalcopyrite and a little pyrite.

QUARTZVILLE DISTRICT

LOCATION AND ACCESSIBILITY

The Quartzville district is second to the Bohemia district in production and takes its name from the camp and post office, long ago destroyed by fire, which served the Lawler mine. (See pl. 18.) It is in eastern Linn County, 40 miles nearly due east of Albany, on the headwaters of Quartzville Creek, a tributary of the Middle Santiam River. Most of the actively prospected part of the district lies in the southeastern part of T. 11 S., R. 4 E., but the district extends into the northeast corner of T. 12 S., R. 4 E. Almost all the production has come from the ridge south of Dry Gulch in secs. 22 and 23, T. 11 S., R. 4 E. Though formerly served by a road from Gates on the North Santiam River, the district was accessible only by trail in 1931. The distance from Quartzville to Detroit, on the North Santiam River, is 22 miles; to Gates, 21 miles; and to Foster, near the junction of the Middle Santiam and South Santiam Rivers, 34 miles. A road up Quartzville Creek, under construction by the United States Forest Service in 1931, has since been completed.

SURFACE FEATURES

The district is a part of the rugged and deeply dissected Western Cascades. The altitude ranges from 1,800 feet at the mouth of

Canal Creek to 5,000 feet on Galena Mountain, but most of the prospects are within 1,000 or 1,500 feet in vertical distance above the major streams. Both the mountain sides and the gradients of all but the major streams are steep. The entire district is drained by Quartzville Creek and its tributaries. A series of terraces and alluvial fills extending from the mouth of Canal Creek to the eastern boundary of the Lawler placer claims on Dry Gulch (pl. 18) constitutes a noteworthy feature. Bedrock is not exposed in the lower 2 miles of Dry Gulch, and the stream flows on the surface only during periods of excessive run-off.

GEOLOGY

VOLCANIC ROCKS

Flows of labradorite andesite, normal andesite with andesine or oligoclase, and rhyolite are interbedded with one another or with tuff or volcanic breccia. The volume of flows appears to equal or possibly to exceed that of the fragmental rocks. The normal andesites make up the bulk of the flows in the area between Quartzville and Detroit and along Quartzville Creek. Labradorite andesites are common south of Quartzville Creek and along the trail from Quartzville to Gates. Rhyolite is prominent in the lower part of White Bull Mountain. It forms the wall rock of the Crosscut tunnel of the Albany and most of the Lawler mine and occurs on the south side of the ridge at the Silver City prospects, on Silver Creek. A thick flow or series of flows of vesicular gray olivine basalt occurs on Galena Mountain and on the top of the ridge both to the east and to the west. Tuff or volcanic breccia makes up the greater part of White Bull Mountain above the rhyolite, but it contains intercalated flows of andesite. It also occurs in the ridge north of Dry Gulch and forms the wall rock of the Savage mine, in the southern part of the district. Andesite dikes are common, though not readily distinguished from flows in small isolated outcrops.

DIORITIC INTRUSIVE ROCKS AND CONTACT METAMORPHISM

Dikes and possibly some plugs, chiefly of dacite porphyry, are scattered through the district. The width of these bodies was nowhere found to exceed 200 feet, and most of those observed range from 14 to 40 feet. The intrusive rock on the trail west of McQuade Creek is porphyritic diorite, and float from the area of tourmaline-quartz-sericite hornfels near the head of Galena Creek is similar. The dacite porphyry varies somewhat in the several other dikes that occur at the United States location monument, on Quartzville Creek near the mouth of Canal Creek, at the mouth of McQuade Creek,

in the central part of the district, and in the northeastern part of the district north of Gold Butte. An isolated group of dikes occurs on the Quartzville-Detroit trail in the southwestern part of T. 10 S., R. 5 E.

Narrow aureoles of hornfels are associated with the intrusive bodies, and tourmaline-quartz-sericite hornfels occupies a considerable area near the head of Galena Creek.

STRUCTURE

Outcrops are not sufficiently continuous to yield definite information concerning folding and faulting. No angles of dip were observed that exceed possible initial dips of flows. In several places along Quartzville Creek flows between beds of tuff dip 5°–10° upstream, to the east or northeast, suggesting a regional dip in this direction. No good indication of major faulting was observed. Both walls of all the veins observed except part of the Bonanza tunnel of the Albany mine contain rock of the same kind. Striae on the walls of veins are more nearly horizontal than vertical.

Five diorite dikes trend N. 30°–60° W. One trends due north. The striae of most of the veins is N. 20°–60° W. and averages N. 40° W. The dip ranges from 63° to vertical and averages 80°. Equal numbers of veins dip to the northeast and to the southwest, and nearly as many are vertical. Some gouge seams in the veins curve from a northeast dip to a southwest dip.

MINERAL DEPOSITS

HISTORY AND PRODUCTION

According to R. E. Peery,[94] the first location in the district was made by Jeremiah Driggs on September 5, 1863. The White Bull was located in June 1864 by C. S. Woodworth, A. L. Buckingham, S. L. Clarke, H. C. Sterling, and I. J. Dennis; and the Red Bull by David Wood, William Chrisman, Robert Carey, and J. A. Crabtree. A mining district was organized July 29, 1864. Apparently interest in the district waned, for the White Bull and Red Bull claims were again located July 11, 1887. The Lawler and Albany mines were developed, and mills were installed in the early 1890's. Apparently most mining operations had ceased by 1900. A Chilean mill was installed at the Albany, and a small amount of ore was treated in 1925. Prospectors have been in the district almost every summer since the period of mining operations and have recovered some gold from pockets and from placers.

The recorded production, largely from records of the United

[94] Personal communication.

States Mint, is given in the table below. Though the district is in Linn County, much of the production is reported from Marion County, as the traffic was almost entirely through Marion County.

Production of Marion and Linn Counties [1]

[From U. S. Mint reports]

Year	Marion County		Linn County	
	Gold (ounces)	Silver	Gold (ounces)	Silver
1884	50.65	$119		
1887	725.63			
1888	[2] 483.75			
1890			314.44	
1891			232.20	
1892			661.77	$750
1893			202.93	
1894	47.69		241.88	
1895	406.83	2,000	302.83	
1896	749.81		3,938.92	
1924 [3]			42.96	25
Total	2,464.36	2,119	5,937.93	775

[1] Probably almost entirely from Quartzville district.
[2] Recorded as Madison County.
[3] From data of V. C. Heikes, U. S. Bureau of Mines.

NOTE.—Value of gold (at $20.67 an ounce), $173,690.74; silver, $2,894; total, $176,584.74.

MINERALOGY AND TYPES OF VEINS

The veins of the Quartzville district are much less extensive and contain much less sulphide than those of the Bohemia district. They differ from those of the North Santiam district in having less sulphide but more gold and silver. Most of the prospects and mines have developed only the upper weathered parts of the veins. Some large stopes were made on the Lawler vein and a smaller one on the Albany, but the production from the others has been largely from pockets—rich streaks within a few feet of the surface—which have been found at various times since the discovery of the metalliferous area. Some of these pockets are reported to have yielded as much as $5,000 in gold and a little silver, but generally a few hundred dollars is the limit. No large shoots of sulphide ore were open to view in 1931.

Few of the veins have been prospected below the zone of oxidation and leaching, but it appears that most are complex sulphide veins in which sphalerite predominates. Some of the veins, such as the Mammoth Reef, Snowstorm, or Edson, and to a certain extent the Bob and Betty, consist of broad zones of brecciated country rock cemented by massive or vuggy quartz veinlets without appreciable sulphides. Some, such as the Golden Fleece and Munro, consist of altered rock, cherty quartz veinlets, and no sulphide except pyrite. Those with appreciable sulphides occuring in streaks and lenses in-

clude parts of the Bob and Betty, Silver Signal, and Winter. Material on the dump indicates that the Galena and Paymaster, in the southern part of the district, contain sulphides in appreciable quantity. Small grains of bournonite and tetrahedrite were recognized in sulphide vein matter of the Bob and Betty. Barite occurs on the surface of vugs in vein matter from the Galena and Winter veins and in one of the veins at the mouth of McQuade Creek. Ankerite occurs in the Winter vein, and clear calcite is intimately associated with the sulphides in the Bob and Betty. In the Bob and Betty a breccia of cherty quartz or silicified pyritized country rock is cemented by the sulphides and calcite. Gold occurs as little plates and wires in the pockets. The Riverside vein reveals postmineral brecciation. There is no definite evidence of zonal arrangement of sulphide minerals.

Large areas of bleached and iron-stained altered rock occur on White Bull Mountain. Zones of altered rock are commonly present along the veins.

Though prospecting has been rather extensive it seems probable that small pockets yielding gold will continue to be found in unexplored parts of known veins or in veins that have heretofore escaped attention because of soil and forest litter. If worked in a small way with a minimum of cost in plant and development work, these small ore shoots might possibly be made to yield a profit. There is nothing to indicate the probable development of large shoots of sulphide ores.

MINES AND PROSPECTS

Albany.—The Albany property consists of three patented and four unpatented claims, not all contiguous, located largely in Dry Gulch, in sec. 23, T. 11 S., R. 4 E. It is now reached by a short branch of the Quartzville-Detroit trail and is at the end of the road that formerly connected the district with Gates. According to local reports, most of the development was undertaken between 1888 and 1893, when the Crosscut and Bonanza tunnels were driven and ore was removed from the Bonanza and milled in a small mill. Later a 10-stamp mill, operated by steam power, was installed. Stafford[95] reported 1,100 feet of tunnel and a 10-stamp mill in 1903. According to Parks and Swartley,[96] development work was done during the "past summer", presumably in 1916, by the Lincoln Mines Co. In 1925 a Chilean mill was installed, and ore was brought by cable tram from the open cut to the southeast. The mine is credited with

[95] Stafford, O. F., op. cit. (Oregon Univ. Bull. new ser., vol. 1, no. 4), p. 58.

[96] Parks, H. M., and Swartley, A. M., op. cit. (Mineral Resources of Oregon, vol. 2, no. 4), p. 141.

a production of $13,500 (653 ounces) in gold for the years 1890, 1892, and 1893 in the records of the United States Mint. The equipment includes a Chilean mill, a cable tram in disrepair, a dilapidated 10-stamp mill, two cabins, and outbuildings. A total of 1,090 feet of tunnel was accessible in 1931. The distribution of all workings except the Lincoln and Goodman is shown in figure 4, and details of all the workings are shown in plate 19.

The Crosscut tunnel penetrates the south bank of Dry Gulch a few feet above the stream bed at the cabins. It follows a zone of shearing, alteration, and some quartz veining for 444 feet in an average direction of S. 52° E. to a fork, then turns in 40 feet to a course due east for 237 feet. The last part is definitely a crosscut but intersects no veins. The other fork continues for 50 feet but leaves the shear zone on which it started. A large part of the tunnel

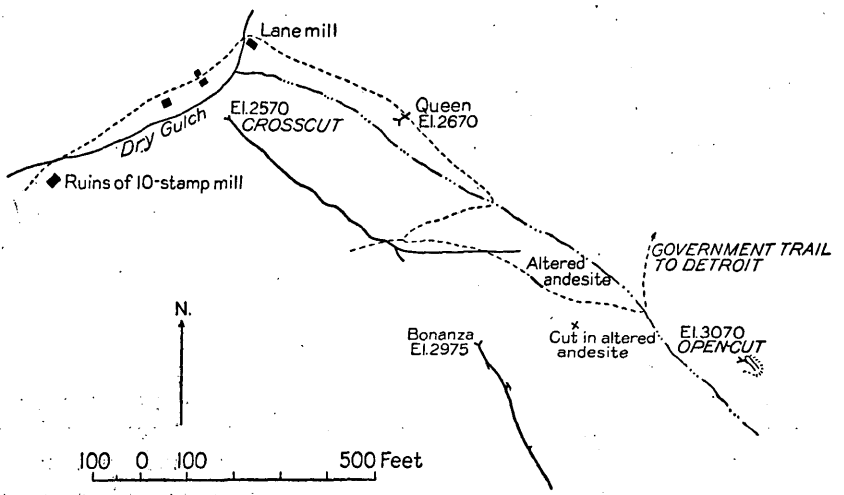
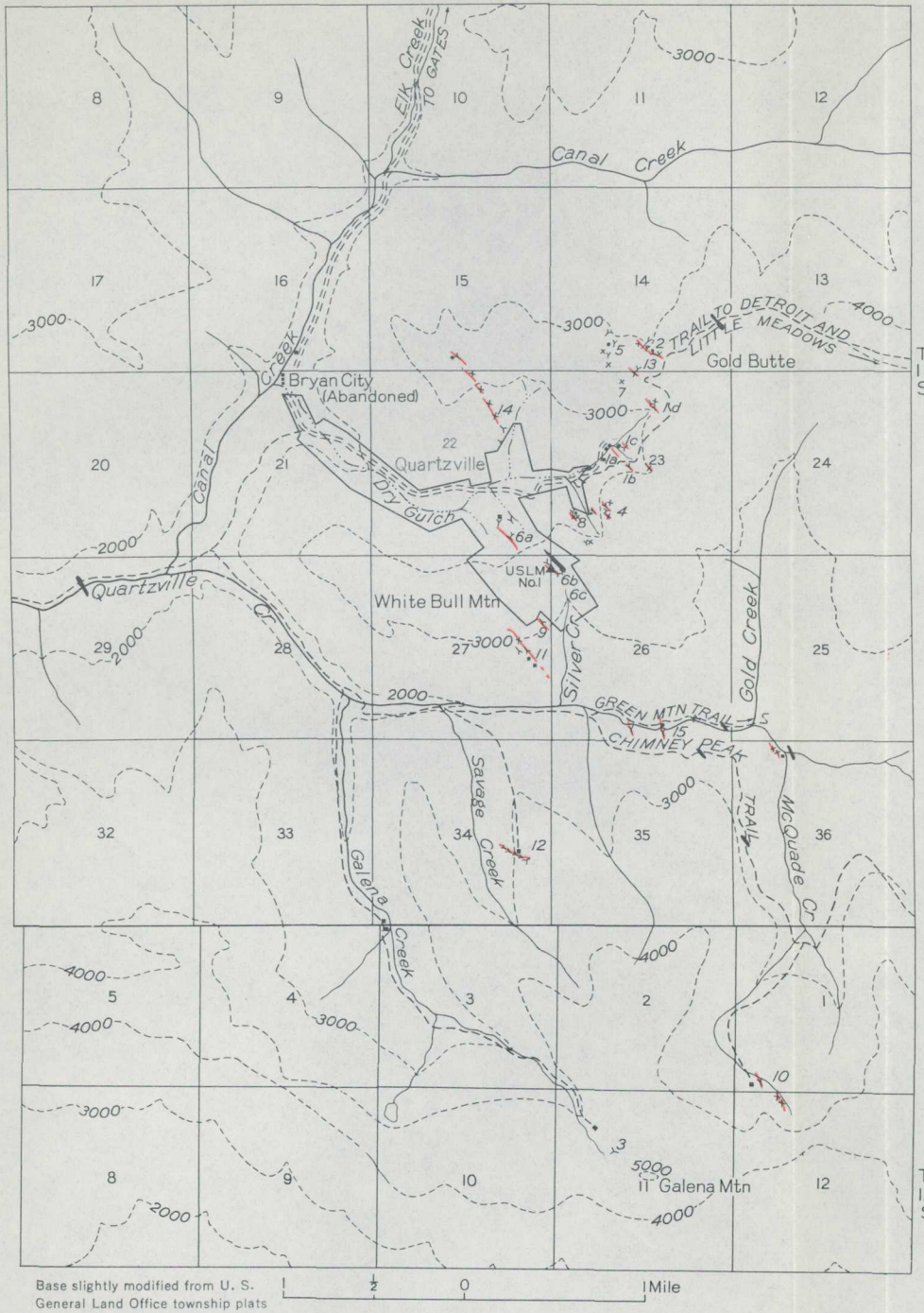


FIGURE 4.—Sketch showing distribution of workings on Albany claims, Quartzville district. From tape and compass traverse.

is lagged, so only a few quartz stringers and no sulphides but pyrite were seen. The country rock is rhyolite.

The Bonanza tunnel is 400 feet higher on the mountain side southeast of the Crosscut tunnel and above the Quartzville-Detroit trail. It follows a vein for 350 feet in an average direction S. 26° E. The two drifts are in line and are probably on the same vein, though the strike is different. The Bonanza drift reveals more quartz than the Crosscut, and a stope 95 feet long has been opened on the vein. Pyrite was the only sulphide seen. Most of the vein matter is weathered and leached. The country rock is largely volcanic breccia on the east side of the drift and altered andesite or rhyolite on the west side.



EXPLANATION

Veins

Dikes

Prospect

Mine tunnel

LIST OF PROSPECTS

1. Albany (mine)
   - 1a Crosscut
   - 1b Bonanza
   - 1c Queen
   - 1d Lincoln
2. Bob and Betty or Smith and McLeary
3. Galena
4. Golden Fleece
5. Hastings
6. Lawler (mine)
   - 6a Lawler
   - 6b White Bull
   - 6c Silver City
7. Mammoth Reef
8. Munro
9. Mule
10. Paymaster
11. Riverside
12. Savage or Vandalia
13. Silver Signal
14. Snowstorm or Edson
15. Winter

Enclosed area Lawler patented claims

Base slightly modified from U. S. General Land Office township plats

1 0 1 Mile

SKETCH MAP SHOWING APPROXIMATE LOCATION OF PROSPECTS, VEINS, AND DIORITIC INTRUSIVE BODIES. QUARTZVILLE DISTRICT, LINN COUNTY, OREGON

EXPLANATION

Quartz or vein matter

Gouge seams

70° Strike and dip

Strike of vertical seam

0 50 100 Feet

OPEN CUT
Some sphalerite
Altered tuff

Some sulphides
Breccia
6" gougy zone
4" postmineral breccia
65°
72°
Lagged
75°
Brecciated country rock cemented with quartz
All in altered tuff or volcanic breccia
LINCOLN TUNNEL EL. 3035'

Caved

Outcrop of seam with sphalerite, galena, and a little chalcopyrite
Altered tuff
Caved

N

GOODMAN TUNNEL EL. 3050'
Silicified pyritic tuff
Brecciated silicified rock; gouge
75°
74°

82°
Cherty, vuggy quartz, pyrite; no other sulphides visible.
Volcanic breccia
62°
Stoped
At least 30' high
Volcanic breccia
Altered andesite
Stope 12'; drusy quartz veinlets
75°
78°
Volcanic breccia
80°-90°
Filled
Cherty vein quartz 2"-6" gouge
Bleached altered andesite
BONANZA TUNNEL EL. 2975'

S

60° 70° 70°
Gray pyritic rhyolite
White pyritic rhyolite
1' gouge
80°
65°
2' gouge
2"
Joints
85°
2' shear zone
Quartz veinlets ¼"-½" wide
80°-90°
Narrow breccia zone cemented with cherty quartz
Lagged
70°
Some cherty quartz seams
73°
CROSSCUT TUNNEL EL. 2570'
80°

N

Quartz and a little sphalerite
Stope 30' to surface on seam 1' wide
75°
Andesite
Altered andesite
QUEEN EL. 2670'
Caved
Breccia

SKETCHES OF PRINCIPAL UNDERGROUND WORKINGS ON ALBANY CLAIMS, QUARTZVILLE DISTRICT.

From tape and compass traverse.

The Queen tunnel is on the east side of the ravine that joins Dry Gulch from the southeast at the cabins. It consists of 52 feet of crosscut and 40 feet of drift on the vein, which strikes N. 37° W. and dips 75° SW. to vertical. A stope on a seam 1 foot wide extends 30 feet to the surface. Quartz and a little sphalerite occur in the vein. A large open cut and some short tunnels are on the east side of the same ravine, above the Quartzville-Detroit trail. Two parallel gouge seams trending N. 35° W. in iron-stained altered rock have been mined and the ore transported by aerial tram to the Chilean mill.

The Lincoln and Goodman tunnels are on Dry Gulch, about 1,800 feet northeast of the cabins, at an altitude of 3,035 feet, as measured with the aneroid. The Lincoln tunnel, on the north side of the gulch, has an average trend of N. 25° W. for 141 feet and follows a vein dipping 65°–75° NE. for most of its length. The vein contains a little quartz and small amounts of sulphides. The country rock is altered tuff or volcanic breccia. The Goodman tunnel, on the opposite side of the gulch, follows a curved course S. 5° E. It is probably on the same vein but reveals only gouge and silicified pyritic tuff. A caved tunnel, shaft, and open cut lie 100 feet northeast of the Lincoln tunnel and prospect a vein trending nearly due north. An outcrop at the caved tunnel reveals moderate amounts of sphalerite and galena and a little chalcopyrite with pyrite.

Bob and Betty or Smith and McLeary.—The property, long known as the Smith and McLeary, has recently been relocated as the Bob and Betty. It is on the north side of the divide between Dry Gulch and Canal Creek, north of Red Heifer Butte, where the Quartzville-Detroit trail crosses the divide. It is near the south line of sec. 14, T. 11 S., R. 4 E., and is reached by footpath from the Quartzville-Detroit trail.

Tunnels aggregating over 900 feet, of which 350 feet consists of drifts on the vein, have been driven on three levels. These workings prospect a vein that strikes N. 55°–80° W. and has an average dip of 70° S. A crosscut, running S. 47° W., cuts the vein 290 feet from the portal and continues 150 feet farther. The drift follows the vein, which consists of a gouge seam and reticulating quartz veinlets, for 70 feet S. 70° E. A short crosscut, 114 feet above the main crosscut, leads to a drift 106 feet long on the vein. A broader zone of gouge seams and quartz veinlets appears on this level. The drift curves, but the average strike is N. 72° W. An open cut 60 feet long lies west of the crosscuts and reveals quartz with a leached honeycomb structure indicating the former presence of sulphides. The Cabin tunnel, on the east side of the ravine, east of the crosscuts,

is 90 feet above the main crosscut. It is chiefly a drift on the vein, though it has several curves and crosscuts in its 250 feet of workings. Two crosscuts reveal reticulating quartz veinlets in altered tuff or volcanic breccia for a width of 50 feet. Small quantities of sulphides, chiefly sphalerite and galena, occur in this material. Pyrite is present, and chalcopyrite is largely limited to inclusions in the other sulphides. A few grains of tetrahedrite and bournonite were recognized. Clear calcite is a matrix for sulphides and fragments of pyritic altered rock. Open cuts on weathered vein matter on the slope southeast of the Cabin tunnel yielded wire gold.

Galena.—The abandoned Galena prospect is in a cirque basin at the head of Galena Creek, in sec. 11, T. 12 S., R. 4 E., at the south side of the district. Underground workings were not found, but a heap of ore at the cabin consists of vuggy comb quartz and altered rock with sulphides, chiefly sphalerite, with some galena and a little chalcopyrite. Yellowish lumps of sericite contain disseminated pyrite. Crystals of barite coat the vugs.

Golden Fleece.—The Golden Fleece workings are on the steep hillside east of the Munro mill, in the SW¼ sec. 23, T. 11 S., R. 4 E. Two tunnels are caved at the entrance, and the others are only partly accessible. The lowermost tunnel is a crosscut that extends N. 77° E. to a vein trending N. 40° W. A long drift 170 feet north of the crosscut runs 134 feet S. 40° E. on gouge seams and altered rock. An open cut and a caved tunnel 125 feet east of the portal of the crosscut are probably on the same vein as that reached by the crosscut. An open cut on a vertical vein trending N. 30° W. lies 100 feet S. 20° E. of the crosscut. A caved drift on altered rock lies 40 feet west of the long drift, and an open cut on a vein 6 feet wide trending N. 20° W. lies 60 feet northeast. All these workings are in iron-stained altered rock, largely rhyolite and andesite. The vein matter consists of a partly silicified breccia of altered rock with veinlets of cherty quartz. No sulphides were seen.

Hastings.—The Hastings workings are on the steep north slope of the ridge north of Dry Gulch, mainly in a ravine about 1,000 feet west of the Bob and Betty and largely in the SW¼ sec. 14, T. 11 S., R. 4 E. In the ravine at an altitude of 3,000 feet are remnants of a mill and cabin. In a large outcrop of andesite with reticulating veinlets of quartz, about 300 feet vertically above the cabin, is a cut on a vein 6 to 8 feet wide, trending N. 40°–50° W. and dipping 70° NE. It consists largely of brecciated country rock.

An open cut 100 feet above the cabin reveals a vertical vein with breccia and quartz veinlets trending N. 55° W. A crosscut below was inaccessible. Another inaccessible crosscut extending S. 12° W. lies 160 feet northeast of the cabin. A crosscut 150 feet below the

cabin extends 84 feet S. 45° W. without reaching a vein. The country rock is largely greenish tuff or volcanic breccia. No sulphides other than pyrite were seen.

Lawler.—The Lawler mine is credited with the largest production and most extensive development in the district. The property, outlined in plate 18, is patented and includes two large placer claims, each nearly a mile in length, along the course of Dry Gulch, a smaller placer claim, and 10 lode claims extending southeastward from Dry Gulch over the top of White Bull Mountain and down into the basin of Silver Creek. The property includes parts of secs. 21, 22, 23, 26, and 27, T. 11 S., R. 4 E.

The earliest discovery in the district was probably made on the Lawler ground, and the period of maximum development appears to have been in the early 1890's. The property is credited in the reports of the United States Mint with $400 (19.35 ounces) of gold assigned to the Red Bull in 1890 and $78,000 (3,773 ounces) assigned to the Lawler for 1896. Stafford[97] states that by 1903 a total of 2,000 feet of tunnel had been driven and that the 20-stamp mill was not in use. The ruins of the mill on the alluvial flat of Dry Gulch is all that remains of a former extensive surface establishment.

The vein at the Lawler mine crosses a spur extending northwest from White Bull Mountain. The main tunnel is about 1,500 feet southeast of the mill and 300 feet higher. The accessible workings consist of a crosscut running S. 30° W. for 50 feet to the drift on the vein, which extends 166 feet S. 50° E. to a cave-in and 60 feet northwest to another cave-in. Stopes extend from this level 155 feet to the surface. The crosscut extends 120 feet beyond the vein. Little could be learned of the nature of the vein on the lower level because of the lagging and stopes. Near the southeast cave-in the vein dips 78° NE. and consists of 38 inches of brecciated vein matter between two gouge seams. Quartz veinlets extend 2 feet farther into the footwall. The vein matter is chiefly brecciated country rock cemented by quartz veinlets, which in places are in turn brecciated and cemented by gouge. No sulphides were observed, and the vein matter appears to be thoroughly weathered. In the caved stopes at the surface the vein consists of 5 feet of brecciated country rock cemented by quartz and sheared country rock making a total width of 8 feet. Some of the breccia blocks are more than 1 foot in diameter. The country rock in the lower level is rhyolite, but tuff or volcanic breccia crops out on the ridge. Though the trend of the vein is directly toward the United States location monument, the dip of the vein and the slope carry the trace west of the spur, so that

[97] Stafford, O. F., op. cit. (Oregon Univ. Bull., new ser., vol. 1, no. 4), p. 58.

the projected position would be several hundred feet west of the monument.

There are many open cuts on gouge seams in altered rock and a few veins of brecciated country rock cemented by quartz on White Bull Mountain in the vicinity of the location monument. The vein in the 60-foot White Bull tunnel is probably the same as that at the monument. The vein trends N. 60° W. and dips 76° NE. in the tunnel and is vertical in the cut. It consists of weathered vein matter in a porous aggregate with some large quartz crystals. The wall rock is largely altered and bleached andesite. A caved tunnel north of the location monument starts on a vein 3 feet wide, trending S. 40° E. Some porous white comb quartz on the dump contains scattered grains of sulphides.

Below the trail southeast of the White Bull tunnel are other cuts and a caved tunnel, and in the steep ravine of Silver Creek is another group of cuts and tunnels known as Silver City. The country rock consists chiefly of tuff and rhyolite. Three drifts, now inaccessible, follow veins trending N. 53° W., N. 37° W., and N. 40° W. and dipping vertically, 78° NE., and 73° SW., respectively. They reveal 3 to 6 feet of sheeted altered rock and some quartz. The dump of one of the tunnels contains fragments of sphalerite, galena, chalcopyrite, and pyrite with quartz, all coated with brown ankerite.

Dry Gulch is filled with rubble throughout the placer claims. The depth is unknown throughout most of the ground, but probably exceeds 30 feet. Dry Gulch Creek disappears on entering this area and flows on the surface only in periods of heavy rain or melting snow. Most of the material has come from the immediate hillsides in the form of talus and wash and consequently contains pieces of vein matter as well as large boulders. Tests are reported to yield a few colors. A tunnel 150 feet long and 350 feet southeast of the mill was driven in this material. In the short distance the material has traveled there has been little opportunity for the concentration of gold.

Mammoth Reef.—The Mammoth Reef is on the south side of Red Heifer Butte, 600 feet west of the Quartzville-Detroit trail, near the line between secs. 14 and 23, T. 11 S., R. 4 E. It forms a bold outcrop that consists of a zone of massive quartz veins cementing a breccia of country rock consisting of tuff to the southeast and andesite at the top of the ridge to the northwest. The width of the outcrop ranges from 10 to 50 feet, and the strike is N. 65° W. Some of the quartz veins are over 1 foot wide and consist of solid fine-grained quartz with a minimum of vugs and comb structure. The quartz contains microscopic dust and blebs of sericite. No sulphides

were seen. This is apparently the source of the blocks of quartz that occur in the rubble in Dry Gulch.

Mule.—The Mule claim is just south of the Lawler claims, on the west side of Silver Creek near the east line of sec. 27, T. 11 S., R. 4 E. The main tunnel is below the Riverside trail. The average trend is N. 50° W., and the dip is vertical. The vein forms a prominent ridge, because the altered andesite is largely silicified. Sulphides on the dump fill fractures or are disseminated through altered rock. Sphalerite is the most abundant, but pyrite, galena, and chalcopyrite are present.

Munro.—Three claims and a fraction constitute the Munro property, which is largely on the west side of a ravine south of Dry Gulch, in sec. 23, T. 11 S., R. 4 E. The deposit was discovered about 1890, and the property has been held and developed by the present owner since that time. The owner reports a production of about $1,500 (72.56 ounces) in gold, but there are no official records. A prospector's mill was operated by the owner in 1931, and an old arrastre is largely dismantled. The total length of tunnel is about 480 feet, of which 263 feet is crosscut and 217 feet is drift.

A caved drift and a drift running S. 30° E. on a vein dipping 77° NE. are on the east side of the ravine. A crosscut on the west side of the ravine runs S. 41° W. under a group of tunnels 60 feet higher. The main tunnel of this group is a crosscut 40 feet long running S. 45° W. and a drift 96 feet long running S. 40° E., with two winzes about 20 feet deep. A short drift on a parallel seam lies 15 feet to the east. An inclined drift lies 100 feet northwest of these tunnels. An open cut on a vein trending N. 20° W. and a tunnel 15 feet long on a similar seam trending S. 36° E. are 40 feet apart and 800 feet southeast of the main workings. The country rock is largely altered and iron-stained andesite, but rhyolite occurs in the main crosscut. The vein matter is all iron-stained and leached and consists of brecciated, partly silicified country rock and sheeted zones of altered rock. Very little comb quartz and no sulphides other than pyrite were seen in place.

Paymaster.—The Paymaster property is near the head of the west fork of McQuade Creek, near the southwest corner of sec. 1, T. 12 S., R. 4 E. A trail to the cabin at an altitude of 3,650 feet, as measured with the aneroid, leaves the Chimney Peak trail a short distance east of the west fork of McQuade Creek. A new cabin was under construction in 1931. Some open cuts on altered rock are just south of the cabin. An altered zone 30 feet wide in tuff and trending N. 15° W. crops out in the creek at an altitude of 3,800 feet (aneroid). A short tunnel in the bank of the creek below the cabin follows a fracture trending N. 35° W. and dipping 73° SW. No sulphides other

than pyrite were observed in these excavations. Parks and Swartley[98] report a drift 130 feet long on a vein containing 14 inches of sulphide ore.

Riverside.—Four claims on the south slope of White Bull Mountain, at the east side of sec. 27, T. 11 S., R. 4 E., constitute the Riverside property, which is reached by a trail from Dry Gulch by way of the Lawler workings. It is equipped with a good cabin and a prospector's mill. The first location was made in 1912, and somewhat more than $1,000 (48.37 ounces) in gold has been recovered, according to the owner. There is no official record of production. The vein has been prospected by two drifts—one 248 feet and the other 55 feet long—and several open cuts on the slope above the mill for a length of 700 feet. Cuts both to the northwest and southeast indicate that the vein or similar veins en échelon extend much farther in both directions.

The longer drift trends N. 21° W. and exposes a lens of brecciated altered andesite 130 feet in length and 6 feet in maximum width between gouge seams. The breccia is cemented by quartz veinlets that contain sporadic lenses and spots of sulphides, chiefly sphalerite but also galena, chalcopyrite, and pyrite. The vein matter is partly weathered and leached. The gouge seams dip from vertical to 63° NE., and one southwest dip was noted. The shorter drift follows a breccia zone with lumps of quartz N. 35° W. The dip is 52° and 35° S. The open cuts reveal silicified iron-stained country rock.

Savage or Vandalia.—The Savage or Vandalia property is in the eastern part of sec. 34, T. 11 S., R. 4 E., on the steep mountain side east of Savage or Nye Creek. There is a cabin north of the tunnels and a 2-stamp mill at the creek. The workings are reached by trail from the mouth of Savage Creek. The principal vein trends N. 50° W. and dips 75°–80° S. It has been explored by five drifts and some open cuts (fig. 5) for a length of 600 feet and through a vertical distance of 300 feet. The vein matter in all the workings consists of brecciated and sheeted iron-stained country rock (andesite in all but the uppermost tunnel, where it is tuff), with a few quartz stringers. The uppermost tunnel exposes a nearly parallel vein that consists of altered tuff with a few seams of quartz. The vein matter is almost wholly weathered and leached, and no sulphides other than pyrite were seen.

Silver Signal.—Two open cuts and an inaccessible crosscut to the vein constitute the Silver Signal workings, which are on the north side of the ridge at Red Heifer Butte, 300 feet west of the saddle where the Quartzville-Detroit trail crosses the ridge and near the

[98] Parks, H. M., and Swartley, A. M., op. cit. (Mineral Resources of Oregon, vol. 2, no. 4), p. 178.

line between secs. 14 and 23, T. 11 S., R. 4 E. On the surface the vein trends N. 50° W. and consists of a breccia of altered tuff with a little cherty quartz. The vein matter on the dump at the crosscut is leached and porous and consists of white quartz in a network of quartz filaments, some of which are iron-stained. Some of the blocks have cores of sulphide remaining that consist chiefly of sphalerite with a little pyrite and chalcopyrite and a very little galena. The network of quartz filaments occurs in the sphalerite. A specimen of this material was collected by the writers and assayed. The sulphides yielded 0.32 ounce of gold and 4.90 ounces of silver to the ton, and the thoroughly leached material yielded 0.92 ounce of gold and 6.2 ounces of silver to the ton.

Snowstorm or Edson.—A large mineralized zone on the ridge northwest of Edson Gulch, which enters Dry Gulch opposite the Lawler mill, is largely in sec. 22, T. 11 S., R. 4 E. It has been prospected by numerous open cuts and short drifts, and it has long been known as the Edson property, though it was recently relocated as the Snowstorm and Pine Tree. The lowest and most extensive tun-

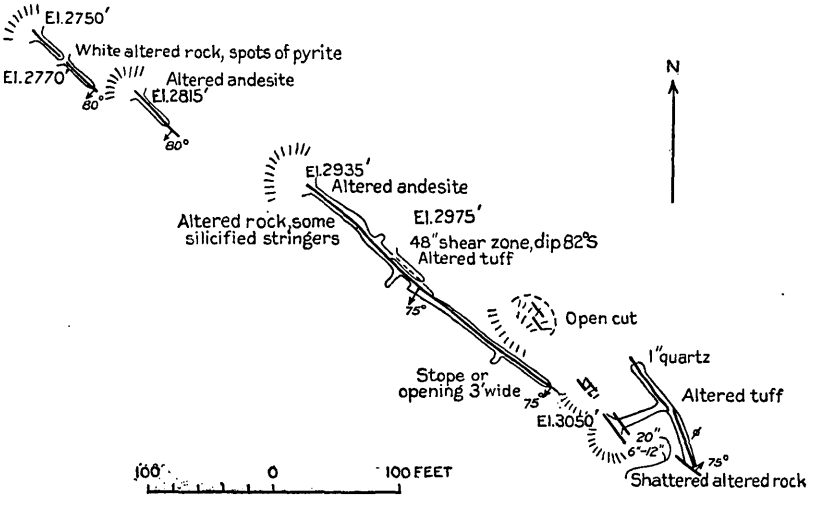


FIGURE 5.—Sketch map of Savage or Vandalia workings, Quartzville district. From tape and compass traverse.

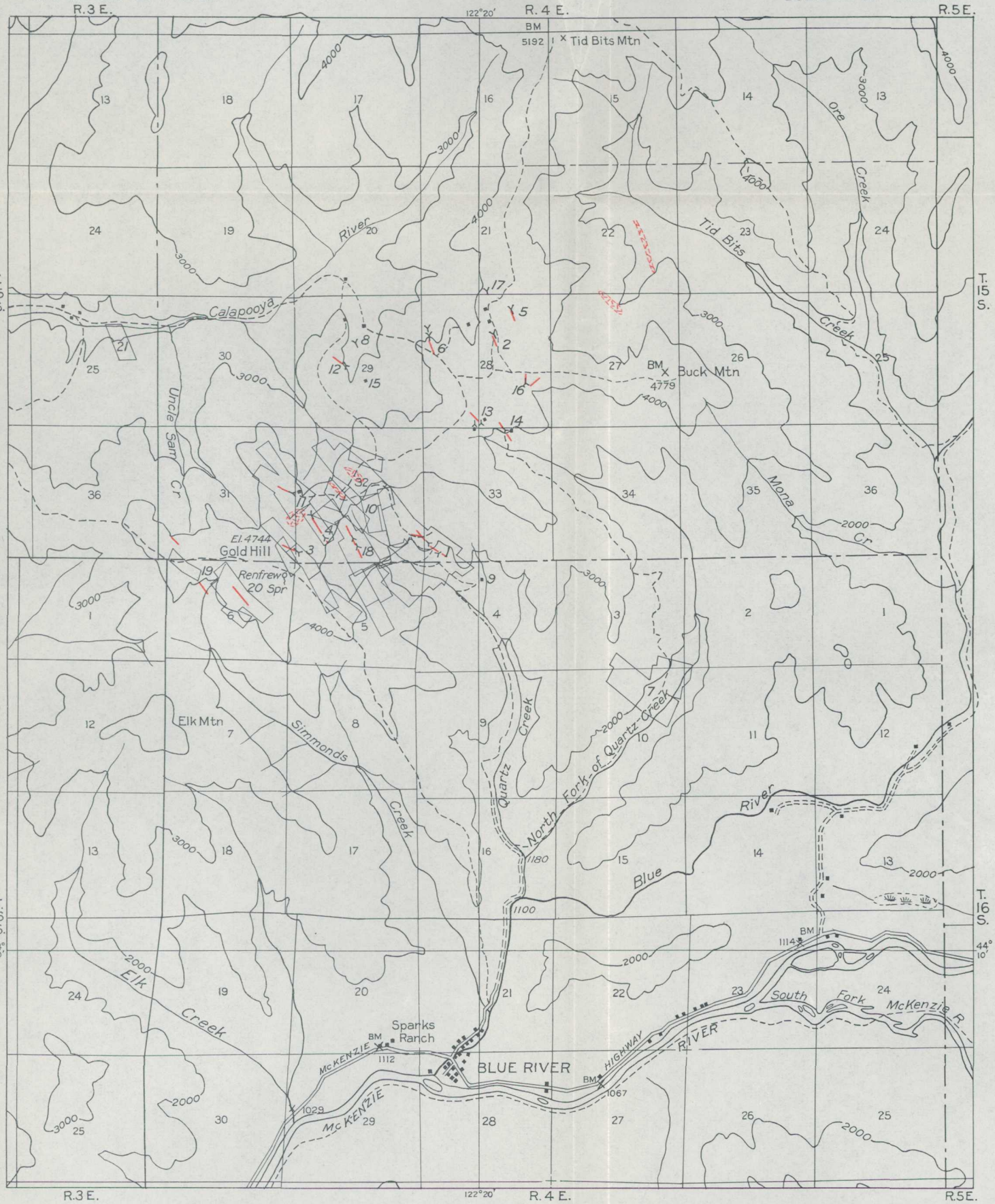
nel, which has an altitude of 2,400 feet, as measured with the aneroid, is 50 feet above the bottom of the gulch and 2,500 feet N. 30° E. of the Lawler mill. It follows a gouge seam trending N. 45° W. for 65 feet. At 50 feet from the entrance a crosscut extends southwest 18 feet to another drift 100 feet long following two gouge seams 3 feet apart trending N. 32°–43° W. and dipping 70° SW. Crosscuts extend 35 feet northeast and 27 feet southwest from this drift. Both crosscuts reveal a breccia of rhyolite cemented with quartz. No sul-

phides other than pyrite disseminated through the altered rock were observed. Mineralization of this kind is characteristic of the zone continuing to the top of the ridge, though the country rock is variously rhyolite, tuff, and andesite. Cuts in altered country rock with numerous veinlets of quartz and iron-stained gouge seams occur at an altitude of 2,960 feet. Some of these gouge seams yield gold on panning, and minute wires of gold were observed adhering to comb quartz facing one of these seams. The same zone continues over the summit, and there are cuts and short drifts on a closely parallel zone near a cabin on the west side of the ridge.

Other prospects.—Several prospects lie along Quartzville Creek, especially in sec. 26, T. 11 S., R. 4 E. An open cut 27 feet wide and a tunnel 54 feet long with a crosscut 27 feet to the east have been made in andesite on the south bank at Winter's cabin, half a mile west of the mouth of Gold Creek. The vein trends S. 35° E., and the various gouge seams dip steeply to both the northeast and the southwest. Some of the lenses of sulphides are 6 inches wide but seem to be confined to the bank of the stream, for the crosscut reveals gouge seams and breccia but no sulphides. Altered rock and some sulphides occur on the north bank. Sphalerite is the principal sulphide, but there is considerable galena, pyrite, and a few small lumps of chalcopyrite. The gangue consists of coarse quartz, angular lumps of sericite, ankerite veinlets later than the sulphides, and a few tabular crystals of barite in vugs in ankerite. On the south bank of the creek 1,000 feet west of Winter's cabin is a drift 57 feet long in tuff. It follows a seam of brecciated country rock trending S. 45° E. and dipping 50° SW., then turns and follows a fracture trending S. 10° W. No sulphides were observed. A crosscut 48 feet long trending N. 25° E. to a caved drift trending N. 35° W. occurs on the north bank of the creek 1,000 feet east of Winter's cabin. Only altered andesite and some silicified material were seen on the dump.

Several cuts on at least three narrow zones of altered rock in chloritic andesite have been made just west of the mouth of McQuade Creek, near the line between secs. 25 and 36, T. 11 S., R. 4 E. The trend is N. 30°–40° W., and the dip is 75° SW. The zones range from 2 to 4 feet in width and contain small streaks of vuggy quartz and sericite with pyrite and a little sphalerite. Barite occurs in some of the openings.

Several thousand dollars in gold is reported to have been taken from an open cut on the World's Fair claim, in the gulch south of the Golden Fleece, near the line between secs. 23 and 26, T. 11 S., R. 4 E. This prospect was not visited.



EXPLANATION

Vein

Dioritic intrusive bodies

Tunnel

LIST OF MINES AND PROSPECTS

1. Lucky Boy
2. Cinderella
3. Durango
4. Evening
5. Great Eastern
6. Great Northern
7. Great Western
8. Higgins
9. Lucky Girl
10. Merger
11. Poorman
12. Red Buck
13. Rialto
14. Rowena
15. Sochwich
16. Tate
17. Treadwell
18. Treasure
19. Uncle Sam
20. Union
21. Pearl

SKETCH MAP SHOWING APPROXIMATE LOCATION OF PROSPECTS, MINES, VEINS, AND DIORITIC INTRUSIVE BODIES, BLUE RIVER DISTRICT, LANE AND LINN COUNTIES, OREGON

1 0 1 MILE

There are several cuts on altered rock with cherty quartz veinlets in the basin of Gold Creek at an altitude of about 3,000 feet. The trend is N. 45° W., and the zone of alteration is about 200 feet wide.

Several cuts have been made in the saddle and along the trail southwest of the Silver Signal.

There are some pits in small zones of altered rock on Savage Creek south of the Savage prospect, and a zone of altered rock with quartz striking N. 55° W. occurs on the top of the ridge between Galena and Savage Creek, in the NE¼ sec. 3, T. 12 S., R. 4 E.

Some cuts have been made on altered rock on the ridge south of the Snowstorm or Edson, in sec. 22, T. 11 S., R. 4 E.

A prospect on Fourbit Creek, southwest of the Quartzville district, in sec. 34, T. 11 S., R. 3 E., is reached by trail from the main trail along Quartzville Creek. There is a good cabin, and a compressor has been installed at a cut on the bank of the creek. The vein matter consists of intersecting veinlets of pyrite and in a few places a little sphalerite with white calcite in andesite, which is bleached and altered to an aggregate of very fine grained quartz and some clay minerals. No comb quartz was observed. There appears to be no definite vein, but most of the fractures trend N. 20° W. and dip from vertical to 78° NE.

Some prospect pits have been opened in altered andesite on Elk Creek along the road to Gates.

Several placer claims have been located along Quartzville Creek. Gold is reported to be obtained from crevices in the bedrock. A large deposit of gravel known as Donica Bar, near the junction of Quartzville Creek and the Middle Santiam River, southwest of the district, has been worked at various times. According to records of the United States Mint it produced a total of $814.75 (39.4 ounces) in gold in the years 1892, 1895, and 1896.

BLUE RIVER DISTRICT

LOCATION AND ACCESSIBILITY

The Blue River district is in Lane and Linn Counties, 45 miles east of Eugene. Almost all the prospects are included in an area of about 14 square miles in Tps. 15 and 16 S., Rs. 3 and 4 E. (See pl. 20.) The Lucky Boy mine, the largest in the district, is 4½ miles north of Blue River post office, on the McKenzie Highway. A road formerly reached the mine, but only 2 miles of it could be traveled by car in 1930. A trail, formerly a road, extends from the mouth of Gate Creek, on the McKenzie River, along the divide between the McKenzie River and Calapooya River drainage systems throughout the district. Another trail follows the Calapooya River. Mines and

prospects are reached by short trails from one or more of the principal trails.

SURFACE FEATURES

The conspicuous topographic feature of this district is the high divide between the drainage areas of the Calapooya River on the north and the McKenzie River on the south. (See pl. 20.) The divide, though sharp and irregular, has an average altitude of about 4,400 feet. West of the district its trend is nearly east, but within the district the trend changes to north. The difference in altitude between Gold Hill, the highest point, with an altitude of 4,744 feet, and the McKenzie River, slightly more than 4 miles away, is 3,800 feet. Consequently, the headwaters of the streams have a steep gradient, about 1,500 feet to the mile. Glaciation has modified the heads of those valleys near the summit of the divide that slope to the east or north. Most of the mines and prospects are within 1,500 feet of the summit of the divide.

GEOLOGY

VOLCANIC ROCKS

The proportions of flows and fragmental rocks appear to be about equal. Tuffs and volcanic breccias range throughout the section from Blue River to Durango Flat, which is about 200 feet below the summit of Gold Hill. Normal andesites with phenocrysts of andesine or oligoclase are more abundant than the labradorite andesites, so far as could be determined. Some have a fragmental appearance and contain streaks of chlorite. This variety is particularly prominent in the vicinity of the Great Eastern and Tate properties, in the northern part of the district. The most conspicuous flow of labradorite andesite is that on the summit of Gold Hill, where it is about 200 feet thick. Rhyolite occurs on the north side of the divide, on the headwaters of Uncle Sam and Badger Creeks. Dikes of labradorite andesite occur in tuff or volcanic breccia in crosscut 7 of the Lucky Boy mine, and a dike of hornblende andesite occurs in the main drift of the Rowena prospect.

DIORITIC INTRUSIVE ROCKS AND CONTACT METAMORPHISM

Two groups of dioritic dikes and plugs occur in the district, one north and northeast of Gold Hill and the other on the south fork of Tid Bits Creek, in the northeastern part of the district The plug of porphyritic augite diorite on the north side of Gold Hill, between the Evening and Poorman workings, is the largest intrusive

body found. It was noted by Tuck.[99] Dikes of dacite porphyry crop out on the ridge to the east. One dike of moderately coarse diorite and two dikes of very fine grained diorite occur on the south fork of Tid Bits Creek.

Narrow aureoles of hornfels occur at the contacts of the intrusives. Metamorphosed tuff on the south fork of Tid Bits Creek retains its greenish-gray fragmental appearance but contains numerous nodules of loose specularite. No tourmaline hornfels was found, and the effects of contact metamorphism are not so prominent as in the other districts.

STRUCTURE

So far as could be determined, the bedding of the fragmental rocks is nearly horizontal. The flow on the summit of Gold Hill appears to have an irregular contact with the underlying rocks and to dip to the south. No faults were observed, and the amount of movement on the veins does not appear to have been sufficient to bring different types of rock into juxtaposition. Striations on vein walls are more nearly horizontal than vertical. Trends of veins range between N. 70° W. and north and average N. 40° W. The dip is 65° to vertical, mainly southwest. Elongate dioritic intrusive bodies trend toward the northwest.

MINERAL DEPOSITS

HISTORY AND PRODUCTION

The history and production of the Blue River district is largely that of the Lucky Boy mine. According to Tuck[99] the deposit on which it is located was discovered in 1887. Development was well under way in the 1890's, and the most productive period was in the early 1900's. Mills were installed at several of the mines and prospects other than the Lucky Boy, where there was a 40-stamp mill and elaborate equipment, but practically all activity ceased with the closing of the Lucky Boy in 1912 or 1913. Most of the area is patented and has lain idle, but a few prospectors have been active in the northern part of the district. The recorded production is given in the table below. Possibly the actual production prior to 1902 would increase this total by $50,000 or $100,000.

[99] Tuck, Ralph, The geology and ore deposits of the Blue River mining district (Oregon Univ. thesis), 1927.

Production of Blue River district

[Data of V. C. Heikes]

Year	Crude ore (tons)	Concentrates (tons)	Gold (ounces)	Silver (ounces)	Copper (pounds)
1896			[1] 2.42		
1902	[2] 10,350		2,247.12	1,007	
1903	6,700		1,499.63	972	
1904	[2] 10,000		241.87		
1905	19,983		2,162.65	1,160	
1906	28,275		1,427.00	12,784	
1907	1,000		28.97		
1909	1,000		50.02	1,000	
1911	14		.53	15	
1913	85	27	53.26	216	257
1918	8		4.98	5	
1924	Sluice		9.44	3	
Total	77,415	27	7,727.89	17,162	257

[1] From U. S. Mint report. [2] Estimated.

NOTE.—Approximate values: Gold ($20.67 an ounce), $159,749.66; silver, $8.601; copper, $39; total, $168,389.66.

MINERALOGY AND TYPES OF VEINS

Only the weathered parts of many of the veins are revealed in accessible workings, but there are several workings in which the nature of the primary vein matter is apparent. One vein, the Rowena, is characterized by chalcopyrite but contains minor amounts of sphalerite and pyrite and possibly a little galena. The Great Northern vein is characterized by massive calcite and minor quantities of the sulphides. Calcite is exposed in the Higgins workings, and its former existence in the Cinderella vein is indicated by a brown powder of manganese oxide. The other veins are of the usual type, with varying amounts of the sulphides, chiefly sphalerite. Vein matter from the Lucky Boy contains small grains of tetrahedrite and considerable pyrite in addition to sphalerite, galena, and chalcopyrite. Quartz is the dominant gangue mineral, occurring as coarse crystals or as cryptocrystalline aggregates with colloform structure, as at the Durango prospect. (See pl. 8, *B*.) Adularia is more abundant in the Blue River district than in any of the other districts, and at the Tate property it makes up nearly half of the vein matter in the main drift. A little barite occurs with calcite in vein matter from the Treasure mine. Vein matter in the weathered zones is leached, but in some places films of chalcocite and covellite remain, and there are very small amounts of chrysocolla, malachite, cerusite, and anglesite and larger amounts of limonite. A brown powder of oxides of iron and manganese occurs in the weathered parts of the carbonate veins.

The veins in the Blue River district are smaller and less persistent than those in the Bohemia district. The only large ore shoot was that at the intersection of the Lucky Boy and Daisy Creek veins, a favorable location for weathering. The sulphides appear to have a

low content of the precious metals. The Lucky Boy vein has been explored by drifts for more than 1,100 feet, and the drift on the Union vein is 700 feet long. According to Parks and Swartley [1] the main drift in the Treasure mine followed the vein for 1,800 feet.

Possibly some pockets or small shoots of gold ore from the weathered parts of the veins may be found, though considerable prospecting was done in the early days of the camp. Probably moderate quantities of sulphides with a low gold content remain in the Lucky Boy mine and might be extracted when prices of base metals become sufficiently high. The discovery of large ore bodies is not anticipated, and any newly developed ore should be blocked out prior to selection and installation of milling equipment.

MINES AND PROSPECTS

Cinderella.—The Cinderella workings are in the basin on the north side of the drainage divide in sec. 28, T. 15 S., R. 4 E. Ruins of a small stamp mill remain. The vein was explored by two levels; the upper level, 40 feet above the lower, was inaccessible. A shaft extends from the surface to the lower level, which consists of a crosscut running 50 feet to the vein and a drift running 90 feet southeast, which leaves the vein but returns to it near the face. The wall rock, probably andesite, is completely altered and iron-stained. The vein matter consists of altered rock containing a band 12 to 15 inches wide of brownish-black powder that is largely manganese oxide. No sulphides remain.

Durango.—The three patented claims of the Durango group cross Gold Hill near the summit. Several pits and at least one tunnel have been opened on the southeast slope of Gold Hill. The tunnel is 130 feet long and follows a vein trending N. 61° W. and dipping 71° NE. The vein is 1 to 6 feet wide and consists of brecciated iron-stained labradorite andesite with stringers of quartz in a wider zone of altered rock. Several cuts to the southeast, in Durango Flat, expose quartz. Other veins and areas of altered rock occur on both sides of the main vein. An open cut over 30 feet wide on the northwest slope of Gold Hill reveals stringers of quartz and brecciated country rock cemented by quartz. (See pl. 8, *B*.) Most of this material is weathered and leached, but some of the solid silicified material contains disseminated fine-grained pyrite.

Evening.—Two patented claims—the Evening and Morning—cross the east peak of Gold Hill. According to Stafford [2] the vein on the Evening claim is developed by two tunnels and a shaft 50 feet deep.

[1] Parks, H. M., and Swartley, A. M., Handbook of the mining industry of Oregon: Mineral Resources of Oregon, vol. 2, no. 4, p. 224, Oregon Bur. Mines and Geology, 1916.

[2] Stafford, O. F., Mineral resources and mineral industries of Oregon: Oregon Univ. Bull., new ser., vol. 1, no. 4, p. 59, 1904.

One tunnel is 110 feet and the other 240 feet below the summit of Gold Hill. Only the lower tunnel and what may have been the shaft were found. The lower tunnel is at the base of the cliff and follows the vein S. 30° E. for 500 feet. The vein consists of iron-stained altered rock with stringers of quartz. It dips 65°–75° SW. The vein is at least 6 feet wide near the portal and 4 feet wide 150 feet farther in, but only 6 inches wide 280 feet from the portal. At the face 1 foot of altered rock is exposed. The vein matter is weathered and leached throughout.

The Morning tunnel, on the south slope of Gold Hill, follows the vein and dips 80° SW. for 90 feet N. 40° W. A short crosscut at the face reveals 10 feet of altered rock with iron-stained quartz stringers as much as 3 inches wide. Both tunnels are in labradorite andesite.

Great Eastern.—The Great Eastern is northeast of the Cinderella, in sec. 28, T. 15 S., R. 4 E., on the north side of the drainage divide, and is connected with the Cinderella by a sled road. A partly lagged drift trending S. 45° E. for 330 feet follows a vein dipping 70°–85° SW. The vein consists of one or more seams of porous iron-stained quartz 1 to 12 inches wide in blocky altered rock. Five feet of altered rock with thin quartz seams occurs at the face.

Great Northern.—The Great Northern mine is on a spur in the western part of sec. 28, T. 15 S., R. 4 E. It was operated in the early days of the camp and was reopened and operated in 1917. The recorded production is small, though second to that of the Lucky Boy. The property is equipped with a 4-stamp mill in the valley east of the mine, an aerial tram line, and smaller buildings in a fair state of repair. The vein has been developed by at least two levels, raises, and stopes, but only the lower level was accessible. It is about 120 feet below the upper level and is connected with that level by a raise about midway in the drift. The tunnel parallels the vein to a point 135 feet from the portal. One of two crosscuts at this point extends 40 feet east to the main vein, which dips 74° E. and consists of 14 inches of brecciated rock without quartz or calcite. The other crosscut extends 54 feet southeast to a drift that follows the same vein 470 feet S. 23° E. The innermost 100 feet of drift leaves the vein and curves toward the west. Two short crosscuts from the main drift expose a parallel vein 20 to 35 feet to the east. The main vein dips from vertical to 72° E. Several stopes have been opened along the drift.

The vein on the lower level consists of brecciated andesite a few inches to 3 feet or more wide with lenses of massive white calcite generally less than 10 feet long and 1 foot wide. A minor amount of quartz is associated with the calcite. Pyrite occurs in the altered rock but was not observed in the calcite. The calcite gives a faint

test for manganese and is probably the source of the manganese oxide that occurs in leached vein matter. The leached vein matter consists of altered rock, porous quartz, and a brown powder containing oxides of iron and manganese.

Several cuts along the ridge southeast of the Great Northern reveal similar vein matter. The Cummins tunnel, north of the Great Northern and almost 300 feet lower, reveals white calcite.

Great Western.—Eight claims, patented or surveyed for patent, constitute the Great Western property. They lie in the valley of the east fork of Quartz Creek at the extreme southern margin of the district, largely in sec. 10, T. 16 S., R. 4 E., but including parts of secs. 2, 3, and 11. This property was not visited.

Higgins.—The Higgins claims are northwest of the Great Northern, in sec. 29, T. 15 S., R. 4 E. The main tunnel and a 2-stamp prospector's mill operated by water power are in a deep ravine. A cabin on the property is reached by a steep trail from the Great Northern. The crosscut runs N. 88° E. for 260 feet to a fracture striking N. 65° E., follows it for 30 feet, then turns to N. 70° E. and extends 33 feet to the face. A vein with soft altered rock and lenses of calcite 1 to 8 inches wide striking N. 62° W. and dipping 61° SW. is exposed in the face. The country rock is tuff except an andesite dike 3 feet wide 20 feet from the portal. Some open cuts have been made on the surface.

Lucky Boy.—The Lucky Boy group of 14 patented claims is largely on the east side of Quartz Creek and occupies parts of secs. 32 and 33, T. 15 S., R. 4 E., and secs. 4 and 5, T. 16 S., R. 4 E. According to Tuck[3] the deposit here was discovered in 1887 by Jonah Moore, George Dyson, and Nate Standish, who opened the mine and operated it in a small way until 1898, when it was taken over by Messrs. Zimmerman and Sharkey. Drifts were run on five levels, and a 15-stamp mill was constructed at the fifth level. Two lower levels were driven, the lower of which did not reach the vein. A 40-stamp mill was constructed later at the lowest level, a power plant installed on the McKenzie River, and a transmission line erected. As indicated by the records, the equipment at the end of operations in 1912 included a 40-stamp mill with crusher, 10 vanners, 5 ore tanks, 2 agitation tanks, aerial trams, mining equipment, power plant, transmission line, and various other buildings. The mill is in ruins, most of the buildings are gone, and practically all the machinery has been removed or destroyed.

The most productive period appears to have been 1900 to 1913, with most of the output concentrated in the first 6 years. The recorded production is nearly $159,000, almost entirely in gold.

[3] Tuck, Ralph, op. cit. (Oregon Univ. thesis).

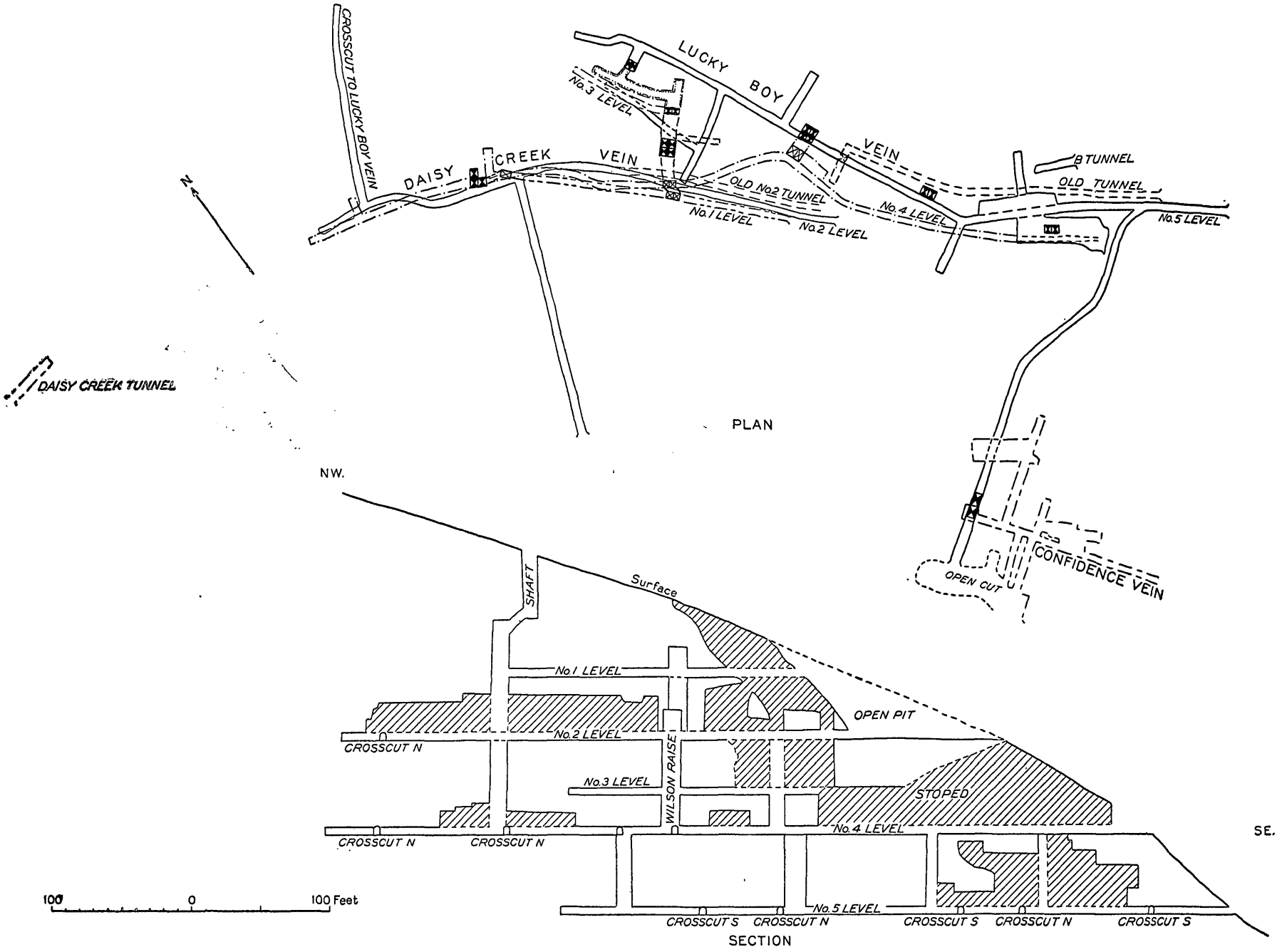
though the total production, including the years prior to 1902, may be greater by $50,000 or $100,000. According to fragmentary company records a gross return of $116,395 was obtained over a period of 3 years (1900–1902), the average value of the gold and silver recovered being $6.12 (0.30 ounce of gold) to the ton. A run of 600 tons in 1901 yielded $3,075.65 (148.78 ounces) in gold and $36.66 in silver, or $5.12 (0.25 ounce) in gold and 51 cents in silver to the ton. Assays of picked specimens supplied by the owners show in one sample 0.03 ounce of gold and 19.77 ounces of silver to the ton, 71.52 percent of lead, and 0.8 percent of zinc; and in another 0.07 ounce of gold and 18.50 ounces of silver to the ton, 65.1 percent of lead, and 0.9 percent of zinc.

Apparently the output of the mine came from the upper five levels (see pl. 21), all of which were inaccessible in 1930. According to the old maps these levels are spaced 30 to 60 feet apart, and the face of level 5 is about 250 feet below the surface. A glory hole revealing a belt of iron-stained altered rock more than 50 feet wide was opened for about 200 feet along the vein, and stopes were opened on all levels. The map indicates that the ore shoot occurred at the intersection of the Daisy Creek vein, which curves from N. 45° W. to west, and the Lucky Boy vein, which strikes N. 33° W. The vein south of the intersection on level 6 strikes N. 43° W. North of the intersection the veins appear to pinch out, for an open cut on the Daisy Creek vein some 560 feet from the intersection reveals only 5 feet of altered rock and no quartz. The country rock of all the workings is greenish-gray tuff or volcanic breccia except some labradorite andesite dikes exposed in crosscut 7 and possibly some thin flows.

Level 6 is about 300 feet below level 5 and consists of a crosscut 145 feet long from the east bank of Lucky Boy Creek and a drift running N. 43° W. for 800 feet. The soft altered rock has required timbering and lagging, especially in the southern part of the drift. The dip is 75°–85° NE. The vein on this level is as much as 25 feet thick, including masses of altered country rock. Lenses of silicified material are as much as 3 feet thick, and as many as four side by side were observed. Streaks of sulphides a few inches wide occur in the cherty quartz lenses and are distributed over a distance of 700 feet. Sphalerite and pyrite appear to be the predominant sulphides, but galena, chalcopyrite, and a little tetrahedrite are present.

Crosscut 7 is about 200 feet below level 6. It starts in along a gouge seam striking northwest, turns to a direction slightly east of north, then at a point 420 feet from the portal trends N. 40° E. It lacks about 450 feet of reaching the Lucky Boy vein.

The Confidence vein was not examined but is shown in plate 21 as 200 feet southwest of the Lucky Boy vein and approximately



PLAN AND SECTION OF UPPER FIVE LEVELS OF LUCKY BOY MINE, BLUE RIVER DISTRICT.

From old blueprints. Workings inaccessible in 1930.

parallel with it. The Imperial vein is probably the gouge seam at the portal of crosscut 7. The Gold Dollar vein is shown on old maps as lying northwest of the Confidence, as striking nearly north, and as being explored by open cuts and a short drift.

Lucky Girl.—The Lucky Girl group of seven claims lying southeast of the Lucky Boy group, in sec. 4, T. 16 S., R. 4 E., was not examined.

Merger.—The portal of the Merger tunnel, which was caved in 1930, is at the bottom of the deep ravine west of the Doctor claim, in sec. 32, T. 15 S., R. 4 E. It is reported to be about 1,600 feet long and to extend toward the Lucky Boy vein, which, because of its devious course, it does not reach. The country rock is andesite flow breccia.

Poorman.—Five patented claims lying mainly on the ridge extending northwest from Gold Hill in secs. 31 and 32, T. 15 S., R. 4 E., constitute the Poorman group, which was once equipped with a 2-stamp mill. Most of the development work is on the Poorman claim, on the east side of the ridge. A caved drift starts N. 70° W. on the vein and is reported to follow it for 600 feet. The vein dips 70°–80° SW. Material on the dump consists of silicified tuff and massive quartz. Sulphide ore is reported to have been found.[4]

Red Buck.—The Red Buck tunnel is within a wide area of iron-stained altered rock southwest of the Higgins property in sec. 29, T. 15 S., R. 4 E. The drift follows a vein for 145 feet N. 57° W. The vein is 1 to 2½ feet wide, without definite walls, and consists of iron-stained brecciated altered tuff cemented by quartz. Numerous cuts have been made in the altered rock, and some sluicing has been attempted.

Rialto.—A group of 12 claims includes the Rialto (formerly called the Blue Bird), the Great Northern, and other properties. The Rialto is at the head of the north fork of Quartz Creek, on the line between secs. 28 and 33, T. 15 S., R. 4 E. The surface plant includes a cabin, mill house, and water tank in good repair, and a prospector's mill. The veins are developed by four tunnels with an aggregate length of more than 800 feet. The lower tunnel, which has 420 feet of open workings, is parallel to the vein, which strikes N. 50° W. for the greater part of its length, but two crosscuts reach the vein. Drifts having a total length of 90 feet extend from each of the crosscuts, but they are caved. The vein matter consists largely of soft altered rock. Many narrow seams, faced with gouge and quartz and having various strikes and dips, are exposed in the main

[4] Parks, H. M., and Swartley, A. M., Handbook of the mining industry of Oregon: Mineral Resources of Oregon, vol. 2, no. 4, p. 48, Oregon Bur. Mines and Geology, 1916.

tunnel and crosscuts. A tunnel trending N. 9° W. lies 130 feet west of the main tunnel and intersects several seams, some of which are faced with quartz, in blocky, slightly pyritic andesite. Another tunnel about 70 feet higher follows a zone of altered rock 10 feet or more in width for 180 feet N. 14° W. A crosscut 30 feet to the west reveals 15 feet of seamy altered rock dipping southwest. The country rock at the face of the crosscut is dark andesite. The vein matter consists of iron-stained brecciated altered country rock with seams of quartz. About 50 or 60 tons of this material is reported to have been milled. Another tunnel, 200 feet higher, was driven 110 feet northeast to intersect a small vein that was found on the surface but was not identified in the crosscut.

Rowena.—The Rowena group of eight claims lies east of the Rialto, in secs. 28 and 33, T. 15 S., R. 4 E., and extends northwest to the Great Northern mill. Most of the workings and a good cabin are on the north fork of Quartz Creek. The main tunnel, 320 feet long, is north of the creek and follows the vein N. 10° W. to a point 70 feet from the portal, where the vein reaches an andesite dike and turns to an average strike of N. 34° W. The vein is in tuff or volcanic breccia except for 50 feet, where it lies against the dike. The dip ranges mainly between vertical and 78° NE. A crosscut running 45 feet N. 13° E. reaches the east wall of the dike. The vein consists of brecciated altered rock, ranging in width from 1 to 6 feet and containing stringers of quartz with sulphides, chiefly chalcopyrite. The sulphides are partly leached throughout the drift. The owner reported that a sample taken across a width of 6½ feet assayed 0.03 ounce of gold and 9.63 ounces of silver to the ton, 7.6 percent of copper, and 4.1 percent of zinc. Another assay yielded 0.8 ounce of gold and 7 ounces of silver to the ton, 5.2 percent of copper, and 3 percent of zinc.

A tunnel at the creek, nearly 300 feet below the main tunnel, consists of a drift in altered tuff without recognizable quartz or sulphides that runs 120 feet N. 24° W. and a crosscut 46 feet to the west. Another tunnel 10 feet long, 60 feet higher in the same altered zone, reveals small vertical lenses of quartz that strike N. 9° W. A tunnel 120 feet below the main tunnel and west of it has been driven 66 feet N. 44° W. and reveals a few irregular gouge seams. A drift 140 feet above the main tunnel is believed to be on the same vein, though the dip is southwest rather than northeast. The drift, 70 feet long, starts on a thin seam in tuff striking north but turns to N. 22° W. on a vein that consists of brecciated rock 6 inches to 1 foot wide with stringers of drusy quartz. A crosscut 50 feet in from the portal and running 70 feet N. 50° E. intersects two parallel veins, one of which consists of 3 feet of brecciated country rock and quartz at the top of the drift and 1 foot at the floor.

Sochwich.—Several tunnels on a ridge southeast of the center of sec. 29, T. 15 S., R. 4 E., constitute the Sochwich workings. There is a good cabin on the property. A drift east of the cabin follows altered tuff for 46 feet S. 13° E. but turns S. 35° E. and extends 24 feet to the face, where soft white pyritic material with thin seams of quartz is exposed. A soft gouge seam in the tunnel strikes N. 20° W. and dips 80° NE. Another tunnel near the cabin runs S. 26° E. for 50 feet to a cave-in. Vein matter on the dump at a caved tunnel in the valley to the southeast consists of brecciated andesite cemented with drusy comb quartz without sulphides.

Tate.—The Tate workings are in the valley of Tate Creek northeast of the Rowena workings, in sec. 28, T. 15 S., R. 4 E. A tunnel 20 feet long on the ridge south of Tate Creek follows a vertical vein that strikes due north. The vein consists of altered tuff 5 feet in average width containing lumps and stringers of quartz. The principal lens of quartz, 1 foot wide, consists of fragments of altered and silicified country rock cemented by vuggy quartz containing disseminated sulphides, chiefly sphalerite with minor amounts of galena, chalcopyrite, and pyrite. Sulphides not protected by quartz are leached. Several open cuts on altered rock occur on this ridge.

An open cut north of the creek above a caved tunnel exposes two seams of altered tuff 1 foot and 2½ feet wide separated by 3 feet of country rock. A tunnel 100 feet farther northwest and 30 feet higher trending N. 39° E. for 80 feet, crosses several fractures and reaches a vein striking N. 7° E. and dipping 88° NW. The vein matter consists of iron-stained altered rock and quartz with adularia. A crosscut to the northwest, 55 feet from the portal, reveals several parallel seams.

The main tunnel, 276 feet long, is on the steep southeast slope of the ridge, about 300 feet above the 80-foot tunnel. The strike is north, and the dip is vertical. The vein consists largely of fragments of andesite flow(?) breccia with stringers of iron-stained vuggy quartz and adularia about 1 foot wide, which pinch and swell along the drift. About 42 inches of this material is exposed at the face. A short drift to the northwest 70 feet from the entrance follows a 4-inch seam of quartz. Fractures are faced with black oxide of manganese.

Treadwell.—The Treadwell prospect is in the ravine northwest of the Great Eastern, near the line between secs. 21 and 28, T. 15 S., R. 4 E. The tunnel is reported to be caved and was not examined.

Treasure.—The three patented claims of the Treasure property are mainly on the south slope of the east peak of Gold Hill. All workings except the Shovel Blade tunnel were inaccessible in 1930, but offices, boarding house, and bunkhouse were still standing. A

12-stamp mill at the bottom of the ravine is in ruins. There has been a small production.

The main level is several hundred feet below the summit of Gold Hill and is said by Parks and Swartley[5] to be 1,800 feet long, whereas the upper tunnel, 200 feet higher, is said by the same authors to be 500 feet long. They state that the strike is N. 45° W., the dip 80° SW., and the length of the ore shoot 270 feet. According to McDaniel and Marshall[6] there are 3,000 feet of workings and four levels connected by raises. The width of the vein for the south stope on level 2 is 10 feet and for the north stope 5 feet. The vein averages 12 feet in width for 320 feet on level 3. The following table of assays is taken from this report.

Assays of samples from Treasure mine

Gold (ounces)	Silver (ounces)	Width of vein (feet)	Notes
0.06	0.48	----------	Coarse ore in bins.
.08	.06	5.7	North stope, level 2.
.04	.84	2.2	Upper raise.
.16	2.82	1.8	Do.
.09	.46	15.0	
.04	.36	8.5	
.06	.73	3.8	South stope, level 2.
.14	.82	10.0	

The vein matter on the dump consists of iron-stained altered rock and drusy quartz. Some blocks of massive quartz have unweathered cores that contain disseminated pyrite but scarcely any other sulphide. The country rock is tuff or volcanic breccia and andesite. The vein matter at the shaft on the summit of the ridge consists of brecciated country rock cemented with iron-stained vuggy comb quartz.

The Shovel Blade tunnel lies several hundred feet east of the boarding house and follows a vein for 145 feet that strikes N. 66° W. and dips 75° SW. The country rock is greenish andesite. The vein consists of a seam of iron-stained comb quartz 1 inch to 6 inches wide.

Uncle Sam.—The Uncle Sam workings are about 1,500 feet west of the Union mine, on the southern slope of the ridge west of Gold Hill, in sec. 6, T. 16 S., R. 4 E. There is a large mill house on the property. A drift in the bank of a small stream east of the mill house follows a vertical altered zone striking N. 50° W. for 90 feet. The main tunnel, 130 feet higher on the hillside, follows a vein for 288 feet. The strike changes gradually from N. 52° W. to N. 59° W.

[5] Parks, H. M., and Swartley, A. M., op. cit. (Mineral Resources of Oregon, vol. 2, no. 4), p. 224.

[6] McDaniel, D. L., and Marshall, C. L., Report on Treasure mine (Oregon Univ. thesis), 1911.

Most of the drift is in coarse volcanic breccia, but the face is in andesite. The vein averages 3 feet in width and consists mainly of iron-stained altered rock with a few bunches and stringers of quartz.

A prospect known as the Old Uncle Sam lies on the opposite side of the ridge on the steep slope of a cirque or cirquelike basin at the head of a stream flowing into the Calapooya River. The main tunnel follows an altered zone in rhyolite S. 40° E. for 165 feet. The zone is defined by clean hanging wall and footwall that at one point are 9 feet apart, but the zone contains only a few stringers of quartz. The dip of the footwall is 75° NE.

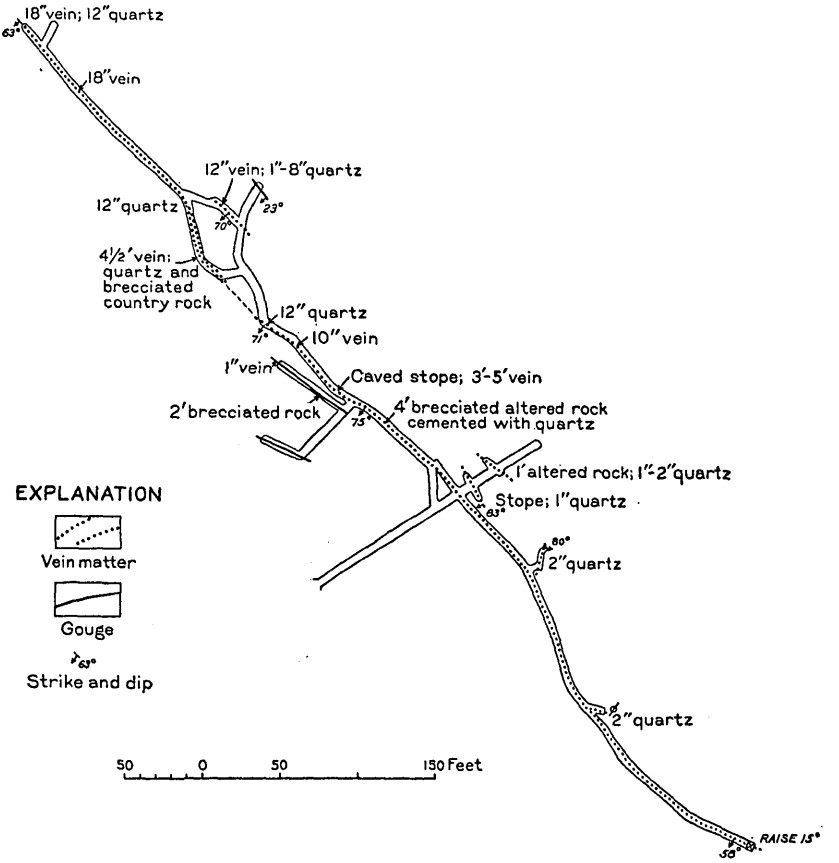


FIGURE 6.—Sketch map of workings of Union mine, Blue River district. From pace and compass traverse.

Union.—The Union mine is on the southern slope of the ridge west of Gold Hill, in sec. 6, T. 16 S., R. 4 E. The workings consist of 1,200 feet of crosscuts and drifts on one level. (See fig. 6.) All the buildings and a small stamp mill have been demolished. There has been a small output. A crosscut 100 feet long extends to the vein,

which is followed by drifts both ways for a total distance of 700 feet. An extension of the crosscut intersects two parallel veins that in places contain about 2 inches of quartz. One of these veins has been partly stoped. The strike of the main vein is variable but averages N. 43° W., and the dip is 58°–75° SW. The country rock is black extremely fine grained andesite. The vein consists of brecciated altered rock ranging in width from a few inches to 5 feet, which in some places is cemented by quartz but in others contains stringers and lenses of quartz as much as 1 foot wide. Some of the more massive quartz fragments contain disseminated sulphides, but most of the material is thoroughly weathered and leached.

Other prospects.—Several patented claims, in addition to those described, are shown on the map but were not investigated because the workings, if such exist, could not be found.

FALL CREEK DISTRICT

LOCATION AND ACCESSIBILITY

The Fall Creek district is in Lane County, 35 miles east-southeast of Eugene. It extends from the junction of Portland and Logan Creeks to Christy Creek (fig. 7) and includes parts of Tps. 18 and 19 S., Rs. 3 and 4 E. A mountain road extends from Lowell, on the Southern Pacific Railroad, to the junction of Portland and Logan Creeks, a distance of 20 miles. From this point it is 5½ miles by trail up to the summit of Sinker Mountain and 2½ miles down the southeast slope to the Ironsides prospect. The distance from Oakridge to the Christy and Ironsides prospects is about 18 miles, of which 8 miles is road and the remainder is trail.

SURFACE FEATURES

The surface is very rugged, and nearly all slopes are steep. The principal features are Alpine Ridge, which extends northeastward through the district, and Sinker Mountain, at an altitude of 4,752 feet, from which four high ridges radiate. The relief within a distance of 4 miles is 3,400 feet.

GEOLOGY

Most of the rocks are tuffs and volcanic breccias, which are especially prominent in the Portland Creek Basin. Volcanic necks and dikes of dark fine-grained labradorite andesite project through the fragmental rocks. Some of these are shown in figure 7. Flows of normal andesite and labradorite andesite occur at many places in the district. A labradorite andesite on Gold Point has a schistose appearance because of the perfection of the flowage orientation. Andesite flows occur on Nevergo Creek and in the vicinity of the prospects

southeast of Sinker Mountain. A remnant of an olivine basalt flow lies in the area between Perdue and Christy Creeks. It belongs to the large group of flows that once filled most of the valley of the North Fork.

On Portland Creek 2.1 miles above its confluence with Fall Creek is a plug or dike of dacite porphyry that trends N. 35° W. A dike

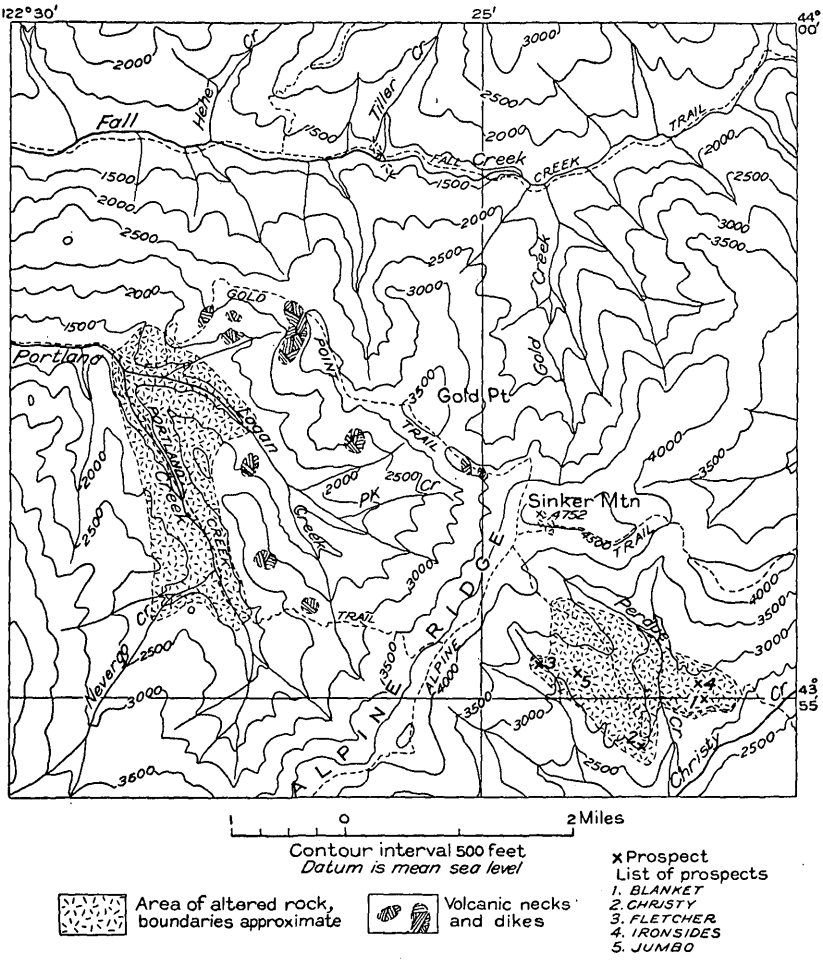


FIGURE 7.—Sketch map of Fall Creek district, Lane County. Base from Geological Survey map of Waldo Lake quadrangle.

of augite diorite occurs at the Jumbo, and at the contact of the dacite porphyry is a zone of spotted hornfels 10 feet wide.

So far as could be determined there has been little tilting or deformation in this area. Volcanic breccia was observed to dip away from one of the volcanic necks. Finely laminated tuff on Portland Creek strikes N. 60° W. and dips 10°–20° NE. Silicified zones in the vicinity of Nevergo Creek trend N. 70° W.

MINERAL DEPOSITS

According to a note by Dodwell and Rixon,[7] the deposit was discovered "last summer", presumably 1901. Stafford[8] mentions the district as being actively prospected in 1903. Apparently little was done after the initial prospecting, though the Ironsides has been operated on a very small scale for several years, and the Blanket claim nearby was being prospected in 1931. No production is recorded.

There are two large areas of altered rock and many smaller ones in the district (fig. 7). One extends from a point a short distance below the confluence of Logan and Portland Creeks 1½ miles up Logan Creek, 2½ miles up Portland Creek, and an undetermined distance up Nevergo Creek. The other large area includes most of the prospects and occupies the ridge between Perdue Creek and the creek to the south. There are smaller areas on Sinker Mountain, along the Alpine trail to the southwest, and a zone 15 feet wide trending N. 40° W. at the junction of Tiller and Fall Creeks. Most of the material in this zone is bleached or iron-stained and contains disseminated pyrite in the unweathered parts.

The mineral deposits in this district are of low grade and consist (1) of zones without definite veinlike appearance in weathered altered rock which, according to prospectors, yields a little gold on panning; (2) of silicified zones in altered rock that apparently do not yield any appreciable gold; and (3) of veins in altered rock with stringers of quartz in comb or cockade structure. Only leached vein matter was found on the dumps of caved workings, and pyrite was the only sulphide seen. No appreciable production is expected in this area.

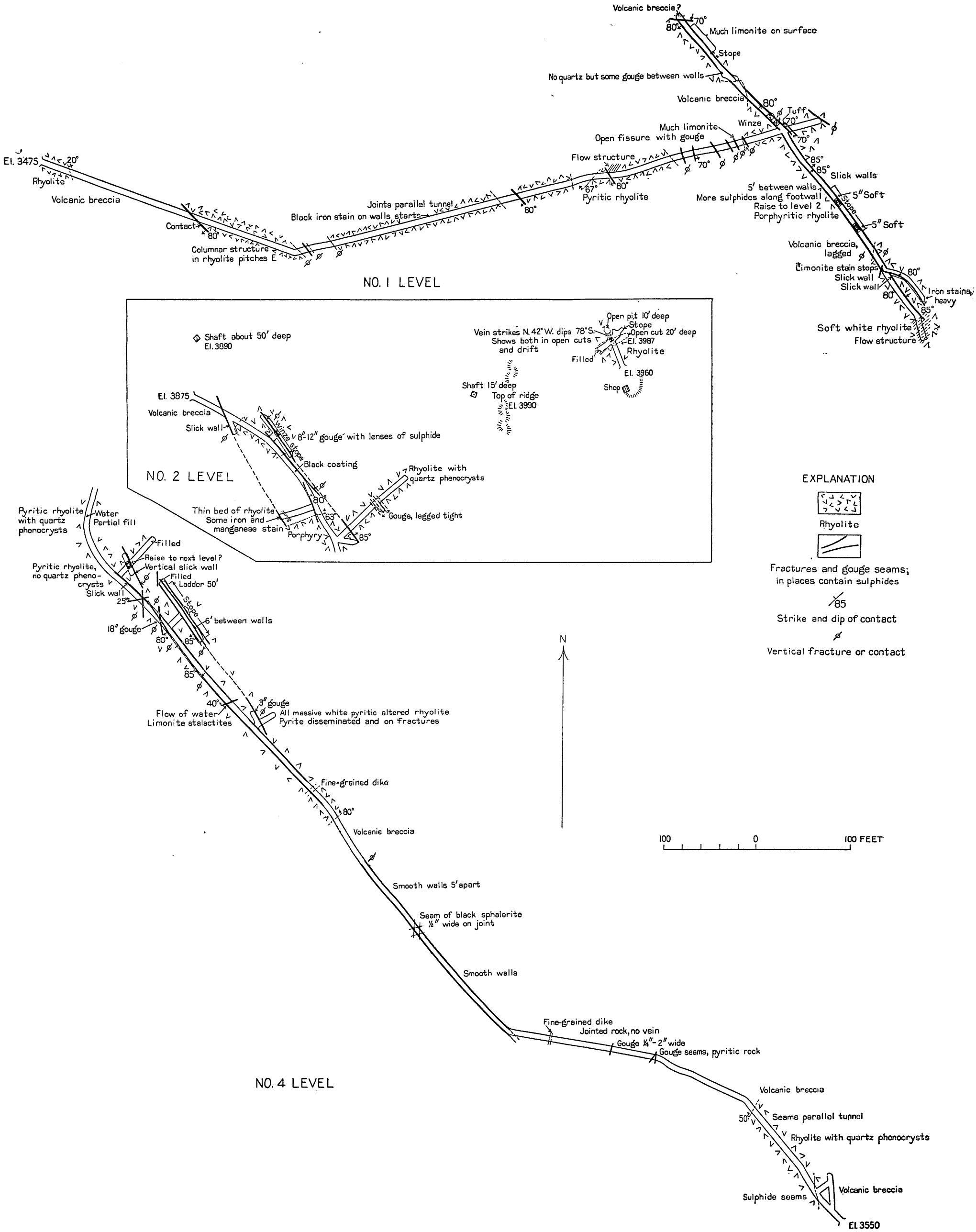
PROSPECTS

Blanket.—The Blanket claim lies southeast of the Ironsides prospect, about half a mile east of Perdue Creek, on a moderate southerly slope. It was being prospected in 1931. Numerous trenches and pits were excavated in deeply weathered iron-stained coarse volcanic breccia. No definite vein was observed, though one fracture was found to trend N. 10° W. The owner stated that he had discovered two zones with this same trend that yielded more gold on panning than the remainder of the rock. The gold content is very low.

Christy.—The Christy prospect is on the south side of the point of the ridge between Perdue Creek and the creek to the south and

[7] Langille, H. D., Plummer, F. G., Dodwell, Arthur, Rixon, T. F., and Leiberg, J. B., Forest conditions in the Cascade Forest Reserve, Oreg.: U. S. Geol. Survey Prof. Paper 9, p. 152, 1903.

[8] Stafford, O. F., Mineral resources and mineral industries of Oregon: Oregon Univ. Bull., new ser., vol. 1, no. 4, p. 61, 1904.



SKETCHES OF LEVELS OF BUZZARD MINE, JACKSON COUNTY.

From compass and tape traverse except crosscut to drift 4, which is from pace and compass traverse.

overlooks the deep canyon of Christy Creek. All workings are caved. The entrance of the main tunnel trends N. 10° W., and the south boundary of the altered zone trends about N. 50° W. The vein matter on the dump consists of altered and silicified tuff or volcanic breccia, some of which is brecciated and cemented by vuggy comb quartz in cockade structure. The altered material contains finely disseminated pyrite.

Fletcher.—On the creek south of Perdue Creek and about 1¼ miles in a straight line northwest of the Christy prospect are some caved workings known as the Fletcher. The trend of the caved tunnel is S. 23° E. The vein matter on the dump consists of light-gray altered rock with cherty quartz and pyrite, both disseminated and in veinlets. No comb quartz or other sulphide minerals were seen.

Ironsides.—The Ironsides property, which consists of four claims, has been worked in a small way for several years. It is on a moderately sloping surface about half a mile east of Perdue Creek. There are three tunnels with an aggregate length of 210 feet, a prospector's mill of five stamps, and a cabin. There appears to be no definite vein, but irregular streaks and masses have been mined from an area of altered and deeply weathered volcanic breccia that contains fragments as much as 3 feet long. No coarse-grained quartz or sulphides were seen, and there appears to have been little silicification.

Jumbo.—The workings of the Jumbo property, also known as the Hyland, are on the steep south slope of a spur between Perdue Creek and the creek to the south, about three-quarters of a mile northwest of the Christy prospect and near the line between the NW¼ sec. 13 and sec. 12, T. 19 S., R. 3 E. Three tunnels, 50 feet apart vertically, were driven on a vein on the west side of a ravine that slopes S. 70° W., and a fourth tunnel, apparently a crosscut 50 feet below the lowest tunnel on the west side, penetrates the east bank N. 75° E. The middle tunnel on the west side runs 50 feet N. 14° E. to what appears to be the intersection of two veins, one trending N. 50° W., the other N. 10° W., and both dipping south. The vein matter is leached and consists of numerous stringers of quartz in altered rock made up largely of clay minerals. No sulphides other than pyrite were seen. The vein in the upper tunnel trends N. 33° W. and dips 27°–40° NE. A pit over 100 feet east of the vein reveals pyrite in soft blue altered rock. Augite diorite appears in the dump, but the country rock is chiefly andesite and volcanic breccia.

Other prospects.—Several pits have been excavated in altered and partly silicified rock on the ridge south of Perdue Creek near the

United States location monument. Some prospects are reported to occur on Nevergo Creek, but only altered rock and an outcrop of resistant silicified tuff trending N. 70° W. was found on the creek in the east side of sec. 8, T. 19 S., R. 3 E. Prospect pits in altered rock occur along the Alpine trail on Sinker Mountain, a short distance east of the line between secs. 11 and 12, T. 19 S., R. 3 E. Some pits in yellowish tuff occur along the Portland Creek trail three-quarters of a mile southeast of the mouth of Nevergo Creek.

OAKRIDGE AREA

The area surrounding the confluence of the North Fork and Middle Fork of the Willamette River west of Oakridge is of interest because of extensive alteration of the country rock, though there are no mines or large prospects. No sulphides other than pyrite were observed, and no gold is known to have been obtained. The country is rugged with the exception of the bench known as High Prairie, which lies along the east side of the North Fork, nearly 1,000 feet above the river, and a few remnants at a corresponding altitude. These surfaces are on a valley flow of olivine basalt that is younger than the altered rocks. The older rocks include rhyolite, andesite, tuff, and volcanic breccia. An outcrop of bedded tuff at Westfir exhibits a group of small faults. It varies in dip and strike, though the dominant trend is N. 40° W. and the dip 15° SW.

An outcrop of resistant silicified rock trending N. 40° W. occurs on the east side of the valley of the North Fork about 1½ miles northeast of Westfir. Another similar zone, striking roughly N. 65° W. and dipping 85° SW., occurs on the same side of the valley about half a mile northeast of Westfir. Here tuff is altered to an aggregate of clay minerals and cherty quartz, and vugs are filled with crystals of barite averaging about 1 centimeter in length. A group of pits on a steep hillside about 600 feet above the south bank of the Middle Fork at Black Canyon, near the southwest corner of sec. 27, T. 20 S., R. 2 E., prospect a vein that strikes approximately N. 70° W. and dips 60° S. The vein is largely a seam in altered tuff, but it contains a small lens of dark, extremely hard cherty quartz that has been brecciated and cemented with comb quartz. No pyrite occurs in the coarse quartz, but it is both disseminated and in bands in the cherty quartz, which shows a colloform structure under the microscope. No appreciable production is expected in this area.

ZINC AREA

An isolated prospect on the South Umpqua River between Straight and Boulder Creeks, in sec. 23, T. 29 S., R. 1 W., and 13.3 miles by road east of the bridge at Tiller, in Douglas County, is known locally

as the Zinc mine. Drifts penetrate both banks of the river slightly above the stream. The country rock is volcanic breccia that has been cut by two dikes of augite diorite, each about 150 feet wide and 200 feet apart. They lie on both sides of the vein on the north bank of the river and strike about N. 20° W., though the vein, judged from an altered zone in the road, strikes N. 60° W.

The vein matter on the dump is chiefly altered volcanic breccia containing disseminated pyrite and composed largely of ankerite and clay minerals. Sphalerite occurs as irregular lenses associated with pyrite and galena. Some sphalerite contains blebs of galena and chalcopyrite visible only with the aid of the microscope. Calcite and marcasite are associated in vugs. Some of the calcite is black because of finely divided pyrite. No coarse quartz was observed, and there appears to have been little, if any, silicification. The precious-metal content is not known, but it is expected that the amount of any ore developed will be small.

BUZZARD AREA

The Buzzard mine is in northeastern Jackson County, and the 10 claims constituting the property are in secs. 19, 20, and 29, T. 31 S., R. 2 E. It is about 47 miles from Medford and 20 miles from the Crater Lake Highway at the mouth of Elk Creek. The first 11 miles of the Elk Creek road, which serves the Buzzard area, is surfaced, but the remainder is unimproved, and the last 5 miles is very steep.

The mine is on a heavily timbered ridge trending nearly north in rugged country near the divide between the drainage systems of the Rogue and Umpqua Rivers, on the headwaters of Elk Creek. The ridge is 4,000 feet in altitude, according to aneroid measurement, and slopes toward the south; the ravine on the east side is about 700 feet below the summit, and that on the west side is about 300 feet below the summit.

The rocks exposed in the mine workings are volcanic breccias and dikes of rhyolite and andesite, all altered and bleached. The vein appears to be near the center of a large area of altered rocks. Fragmental rocks appear to be dominant both in the vicinity of the mine and along the road to the south, though flows of rhyolite, andesite, and labradorite andesite occur. No dioritic intrusive rocks were found.

No evidence of folding or tilting was seen in the mine, as no bedding was revealed. Outcrops in the valley of Elk Creek suggest that the region has been only slightly deformed. The strike of the vein on which almost all the work has been done is N. 40° W., and the dip is vertical to 85° E. Most of the dikes trend to the northwest.

Gold was discovered in Elk Creek below the mine, and the claims

were located in 1897 by Peter and Mark Applegate, according to the latter. The Pearl Mining Co. was incorporated in 1898, but the first ore was not shipped until 1909. W. L. Freres, under an option, shipped ore in 1912 and 1913, and the Pearl Mining Co. was active in 1914 and 1915. The mine was leased in 1916 to Paul Wright, who drove tunnel 4 on the east side of the ridge and shipped considerable ore. The total production, 1909–18, was nearly $24,000, chiefly in gold, but it included some silver and lead.

According to the owners, the mine workings consist of 3,334 feet of drifts and crosscuts, 1,000 feet of raises and winzes, and 75 feet of open cuts and trenches. About 3,200 feet of drifts and crosscuts (pl. 22) were accessible, but only a few of the raises and winzes were examined. Levels 1, 2, and 4 reach the vein and expose it for lengths of 430 feet, 160 feet, and 720 feet, respectively. Small stopes were opened on all these levels. The difference in altitude between level 4 and the summit of the ridge is about 500 feet.

The vein matter consists chiefly of altered rock, gouge seams, very little cherty quartz, and no comb quartz, and contains streaks and lenses of sulphides, chiefly sphalerite, and smaller amounts of pyrite and galena. Chalcopyrite was observed only with the aid of the microscope as blebs in sphalerite (pl. 6, *A*). Arsenopyrite was found in a small seam on level 1. Sphalerite occurs as black crystals and aggregates ranging in size from a fraction of a millimeter to more than an inch. The occurrence of sulphide veinlets without quartz in altered rock is very different from that of the quartz veins characteristic of the larger districts. The original nature of the gold in the main vein is not known to the writers, but the specimen of dendritic gold shown in plate 3 was obtained, according to the owner, from a small lens or pipe, called level 6, which is 360 feet northeast of the main vein (pl. 22). Wire gold was also reported to have been found in a small pocket here, associated with manganese oxide and with sphalerite and pyrite nearby.

Apparently the veins shown in plate 22 are the only ones found up to the present time, though it seems possible that so large an area of altered rock might contain similar veins. No large production is anticipated.

GRAND COVE AREA

The Grand Cove prospect, in Jackson County, reveals native copper as nodules in volcanic breccia between vesicular flows of dark labradorite andesite or basalt without any vein or any indications of sulphides. It thus differs markedly from the mineral deposits previously described. The seven claims of the property comprise parts of secs. 29, 32, 33, and 35, T. 35 S., R. 2 E., 5 miles north of Lakecreek, on an open gently sloping upland bench. The distance

by road from Medford, by way of Brownsboro and Salt Creek, is 26 miles. The 1½ miles nearest the prospect could not be traveled by car in 1931.

The workings consist of an open cut 60 feet long with a maximum depth of 10 feet and a shaft reported to be 30 feet deep on a gently sloping open bench at an altitude of nearly 2,900 feet. The deposit was discovered in 1917 by L. A. Obenchain, the owner, while searching for manganese. A carload of ore is said to have been shipped to the Tacoma smelter, but no data on the shipment are available.

The copper is confined to volcanic breccia associated with vesicular black labradorite andesite or basalt that is nearly horizontal but dips slightly to the west at the prospect. The flow rock contains red spots that are iddingsite pseudomorphs after olivine and calcite amygdules that are stained greenish near the rock. The breccia is largely altered to clay minerals and contains little greenish spots and veinlets consisting mainly of chrysocolla with a little malachite and very little azurite. Limonite and some manganese oxide occur in irregular black spots and fracture fillings through the altered rock. The copper occurs in dendritic form in nodules, some of which are 6 inches long. The copper is partly changed to cuprite (pl. 7, *B*), which is in turn surrounded by opal and chalcedony, with small amounts of chrysocolla and malachite. Openings are partly filled with the chocolate-colored clay mineral beidellite.

Prospecting has not been sufficient to reveal the full extent of the deposit. The copper ore appears to be very erratic in its distribution.

CLIMAX AREA

Large areas of altered tuff and a vein of aragonite occur in the vicinity of Climax, on the headwaters of Antelope Creek, nearly 8 miles in a direct line northeast of Ashland, in Jackson County. Climax is reached by an unimproved road that follows Antelope Creek.

The aragonite vein is on a steep slope on the east side of the valley at Climax, in a coarse volcanic breccia. The vein is vertical and strikes N. 60°–70° W. It has been traced for several hundred feet and consists of irregular lenses of aragonite, some containing fragments of country rock and irregular small masses of chalcedony surrounding vugs or geodes lined with quartz crystals. Fragments of country rock are surrounded by calcite, rarely over 2 millimeters thick, from which the coarse acicular crystals of aragonite radiate. No sulphides were found, and no precious metals are known to occur.

Volcanic tuff and breccia over 1 mile west of Climax are changed to a soft brown and white aggregate of clay minerals and an isotropic substance, possibly a form of opal. Oxidation of dissemi-

nated pyrite has led to the formation of numerous crystals and crusts of gypsum. The altered tuff is leached by a secret process devised by one of the local residents to make a medicine.

Rhyolite underlying the oil shale in secs. 9 and 16, T. 38 S., R. 2 E., is bleached and contains chalcedony in openings.

BARRON AREA

The Barron mine is in Jackson County, nearly 8 miles in a direct line east-southeast of Ashland, and the property consists of three 40-acre tracts in sec. 23, T. 39 S., R. 2 E. It is reached by a steep mountain road 3 miles in length from the Green Springs Highway. The mine is in a gulch that slopes toward the valley of Sampson Creek at an altitude of 3,400 feet, or 1,200 feet above Emigrant Creek. The mountain slopes are open rather than thickly forested as in most of the other mineralized areas.

The country rocks are chiefly coarse andesite breccias, but there are flows and dikes of labradorite andesite, some basalt, and some rhyolite on the slope above the mine. A dike of dacite porphyry trending N. 30° W. is exposed in Sampson Creek over a mile south of the mine; the trend changes locally to N. 5° E. on the ridge north of the creek.

The breccias do not show bedding, and few data on structure could be obtained. A thin flow exposed in the crosscut strikes N. 52° W. and dips 16° NE. Observations at other points indicate that the regional strike is near N. 40° W. and the dip 10°–20° NE. Dikes in the mine strike north, N. 40° W., and N. 60° W., and dip both east and west. The belt of altered rock in which the vein lies strikes N. 40° W., and the vein has an average strike of N. 38° W. and dips variably but averages 80° NE.

The early history of the property has been lost. It is reported to have been patented on grazing rights in 1883, acquired by the Barron family in 1885, and held by them until recently. The Gold Mound Co. was renovating the plant in 1931. So far as could be learned the production, largely since 1917, has been about $9,000. According to an engineer's report, 59 tons was milled at the old Ashland mill, yielding $518, and later H. J. Sallee under lease shipped the ore recorded below. The main level is reached by a crosscut 390 feet long. The drift is 300 feet from the portal of the crosscut and 150 feet below the outcrop of the vein. Drifts follow the vein irregularly 175 feet N. 36° W. to a cave-in and 160 feet S. 38° E. A winze 15 feet from the crosscut is reported to be 35 feet deep with a drift 20 feet long at the bottom. A raise 25 feet northwest of the crosscut extends to the surface. Three short drifts extend from the raise, and two stopes lie south of the raise. The largest stope extends down 60 feet

from the surface. The equipment includes a 10-stamp mill engine, crusher, Wilfley table, and two slimers, track, and cabins in good condition.

Smelter returns from Barron mine, 1917–18

[From report by J. Carlton McDonald]

Ore (tons)	Gold		Silver (ounces)	Value per ton	Value of shipment
	Value	Ounces			
52	$15.01	0.73	20.11	$31.12	$1,618.24
15	66.31	3.20	34.11	100.42	1,506.30
39	5.31	.25	6.66	11.97	466.83
9	41.23	1.99	42.80	84.03	756.27
44	7.79	.36	13.08	20.87	918.28
43	11.78	.57	13.64	25.42	1,093.06
3	57.38	2.76	69.11	126.49	379.47
Total value					6,738.45

The vein, as shown on the lower level, consists of a series of branching and intersecting fractures, some of which are filled with gouge, some with fragments of altered rock, and some with altered rock cemented by cherty quartz, which in places contains sulphides. Comb quartz is inconspicuous. The vein is over 10 feet wide at the crosscut but pinches to 1 or 2 feet both to the northwest and to the southeast. This is essentially the lower limit of the ore shoot that has been partly stoped. An open cut reveals 40 feet of altered rock between the main vein and one lying to the west. Sulphides exposed in the drift occur in small stringers and consist chiefly of sphalerite with a little galena, chalcopyrite, pyrite, and arsenopyrite. Winchell[9] mentions in addition stibnite, malachite, wire silver, realgar, and probable pyrargyrite. Altered rock consisting chiefly of clay minerals and a little sericite and carbonate, cherty quartz, calcite, and a little barite occurs with the sulphides. Most of the gold has been obtained from the leached and iron-stained vein matter, and leaching has extended to the main level, though it has not been complete.

According to an engineer's report, assays in the upper workings range from $6.42 to $13.77 to the ton in gold and silver, with gold valued at $20.67 an ounce, for widths of 3½ to 12 feet. An assay on the south end of the stope just above the main drift shows minerals valued at $20.34 to the ton for 7 feet, and opposite it in the raise an assay shows $1.42 to the ton for 4 feet. An assay of 4 feet of the face of the south drift yielded 90 cents to the ton, but assays just

[9] Winchell, A. N., Petrology and mineral resources of Jackson and Josephine Counties, Oreg.: Mineral Resources of Oregon, vol. 1, no. 5, p. 123, Oregon Bur. Mines and Geology, 1914.

north of the raise yielded $6.56 to $8.40 to the ton for widths of 6 to 8 feet.

The zone of altered rock that contains the vein averages about 50 feet in width and was traced to the southeast and lost under soil, but a similar zone, 300 feet wide, appears on the ridge over half a mile to the southeast. It was traced to the northwest for more than 1,000 feet beyond the mine. Similar zones of altered rock occur on Sampson Creek, and a short drift was driven on one about 1,000 feet from the Green Springs Highway.

Apparently some ore that might be extracted at a profit remained in the mine in 1931, and possibly a similar vein or ore shoot might be found in this zone of altered rock or in one of the other altered zones.

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