UNITED STATES DEPARTMENT OF THE INTERIOR

QUICKSILVER DEPOSITS OF SOUTHWESTERN OREGON

Prepared in cooperation with the
STATE MINING BOARD OF OREGON

GEOLOGICAL SURVEY BULLETIN 850

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BY

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AND

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QUICKSILVER DEPOSITS OF SOUTHWESTERN OREGON

By Francis G. Wells and Aaron C. Waters

ABSTRACT

In western Oregon several deposits of quicksilver of sufficient size or richness to attract attention have been found along the western edge of the Cascade Mountains from Blackbutte, 15 miles south of Cottage Grove, to the Rogue River. As the eastern and southwestern parts of this quicksilver-bearing region lie within the Cascade and Klamath Mountains they partake of the rugged nature of these ranges. The northwestern part lies within the confines of the Coast Range and has an open hilly topography. Though the region is sparsely settled, most of it is served by a system of good gravel roads. The more rugged parts, however, are almost uninhabited and are traversed by roads passable only in summer and by trails.

Rocks of Paleozoic and Mesozoic age are found in the southwestern part of the region, but no Mesozoic rocks are exposed in the areas described in this report. The Paleozoic rocks are the highly metamorphosed crystalline schists of the May Creek formation, which are intensely deformed and have a northeast trend. The Mesozoic rocks also have been folded, though much less intensely, and trend northeast.

The gently folded Umpqua formation, of Eocene age, underlies the northwestern part of the region. It rests unconformably on the eroded surface of the older rocks and consists of bedded sandstones and shales with intercalated beds of conglomerate and tuff and flows of basalt.

Volcanic conglomerates, tuffs, breccias, and flows crop out throughout the eastern part of the region; they overlap all the older formations and dip at low angles toward the east. These rocks in the Blackbutte-Elkhead area have been named the Calapooya formation. They include a lower or predominantly sedimentary facies composed mostly of water-laid conglomerate and tuff and an upper or predominantly igneous facies composed mostly of andesitic flows with some interstratified breccia and tuff.

Sills, stocks, and dikes ranging in composition from norite to basalt intrude the Umpqua and Calapooya formations.

The quicksilver deposits are characterized by a distinct type of hydrothermal alteration by means of which the original rock has been bleached and softened and its constituent minerals have been partly replaced by an intergrowth of microcrystalline silica and a carbonate which may be either calcite, ankerite, or siderite. The introduction of silica has commonly not extended beyond borders a fraction of an inch wide on each side of closely spaced small fractures that form a reticulate or curvilinear network through the rock mass. Oxidation of the siderite and pyrite along these fractures imparts to them a dark-brown color. Because of their silica content they are more resistant than the rock mass to weathering and form a surface rubble that is a valuable guide to the prospector.

The ore minerals include cinnabar, a very little metacinnabar and native mercury, marcasite, and pyrite and are accompanied by chalcedony, calcite, siderite, and ankerite. The deposits are of two kinds—one in which the cinnabar occurs as small specks disseminated throughout the rock mass or as scattered threads and veinlets, and one in which the cinnabar and associated gangue minerals occur in small open fissures and gash veinlets or fault breccias. In deposits of the first type, exemplified by the Blackbutte mine, the ore bodies are usually large but of low grade, averaging from 4 to 6 pounds of mercury to the ton. In deposits of the second or vein-filling type, exemplified by the Buena Vista and War Eagle mines, picked ore may contain as much as 4 percent of quicksilver.

The ore deposits occur in formations ranging in age from Paleozoic to Miocene. Their localization is controlled by faults along which the mineralizing solutions moved and by the relative permeability of the rocks adjacent to such faults.

Five quicksilver-bearing areas are described—the Blackbutte-Elkhead area, containing the Blackbutte and Elkhead mines and other prospects; the Nonpareil-Bonanza area, containing the Nonpareil and Bonanza mines and other prospects; the Tiller area, containing the Buena Vista, Maud S., and other prospects; the Trail area, containing several undeveloped prospects; and the Meadows area, containing the War Eagle and Dave Force mines.

Records of quicksilver produced from these deposits are meager. The Blackbutte has a record of 3,723 flasks to 1929. The War Eagle is reported to have produced 565 flasks. No data for the other deposits are available, but their total product has probably not exceeded a few hundred flasks.

INTRODUCTION

FIELD WORK AND ACKNOWLEDGMENTS

An examination of the principal mercury-bearing areas of western Oregon was made by the United States Geological Survey in cooperation with the State of Oregon during the period June to October 1930. The field work was done under the general supervision of J. T. Pardee by the writers, assisted by Louis C. Raymond and Albert B. McElhoe. Available base maps for the region surveyed include the Geological Survey's topographic maps of the Roseburg, Riddle, and Ashland quadrangles, the township plats of the General Land Office, and a topographic map of a small area at the Blackbutte mine made by the mining company. These maps were supplemented by plane-table and stadia traverses of areas surrounding the Blackbutte, Elkhead, Nonpareil, and Bonanza mines and the mines of the Meadows district.

The writers gratefully acknowledge the help and courtesies extended to them in the field by all the operators. They are especially indebted to R. M. Betts, general manager of the Blackbutte mine, and C. E. Stowell, superintendent; C. N. Everett and Victor Allen, of the Nonpareil Quicksilver Co.; J. Wenzel, of the Bonanza mine; and H. E. Rogers, of the Buena Vista mine.

HISTORY OF QUICKSILVER MINING IN WESTERN OREGON

Cinnabar was first found in Oregon by the gold placer-miners working the alluvial deposits in the Jackson district. The heavy purple-red sand that accumulated in their sluice boxes hindered amalgamation, but when it was known that the red sand was a quicksilver ore, attempts were made to recover the metal by distillation in crude retorts, and some of it was won in this way. Lodes containing cinnabar were discovered on the Little Applegate River on the northwest slope of Siskiyou Peak in 1868 but were never extensively worked. About this time the Bonanza, Nonpareil, and Elkhead deposits were found, but after a brief period of development and production they were abandoned. The Blackbutte deposit was found in the early nineties and was worked intermittently until 1916 and continuously since. The War Eagle vein was discovered in 1916 and worked until 1922. The high price for quicksilver obtained from 1927 to 1930 stimulated production and caused some of the abandoned deposits to be reopened.

GEOGRAPHY

LOCATION AND EXTENT OF AREA

With the exception of a few scattered occurrences in Curry, Josephine, and southern Jackson Counties, the known deposits of quicksilver in western Oregon may be included in a belt 12 to 15 miles wide that extends along the foothills of the Cascade Range from the vicinity of Cottage Grove south-southeastward some 55 miles to the Rogue River. The northern 15 miles of this belt contains the Blackbutte, Elkhead, Nonpareil, and Bonanza mines. South of the Bonanza is a stretch of nearly 20 miles in which no quicksilver has yet been found. Beyond this barren stretch most of the deposits are grouped in small areas north of Tiller on Deadmans Creek, along the Rogue River above Trail, and at The Meadows, on Evans Creek. The location of these deposits is shown in figure 1.

TOPOGRAPHY AND DRAINAGE

The eastern and southern parts of the quicksilver belt lie within the Cascade Range and the Klamath Mountains and are characterized by the rugged topography of those areas. (See pl. 1.) The northwestern part, which lies within the Coast Range, is hilly and open. The principal streams cross the belt from east to west, across the structural trend of the mountains, and divide the area into ridges with a general east-west trend. The most northerly ridge, a westward-projecting spur of the Cascade Range known as the Calapooya Mountains, forms the divide between the Willamette and Umpqua drainage basins. South of Roseburg a rugged mountainous tract separates the Umpqua and Rogue River Valleys. The local relief is between 1,500 and 2,500 feet, though some of the peaks are as much as 3,500 feet above sea level.

The valleys of the smaller streams are mostly narrow and V-shaped; those of the larger streams are in places 1 or 2 miles wide.

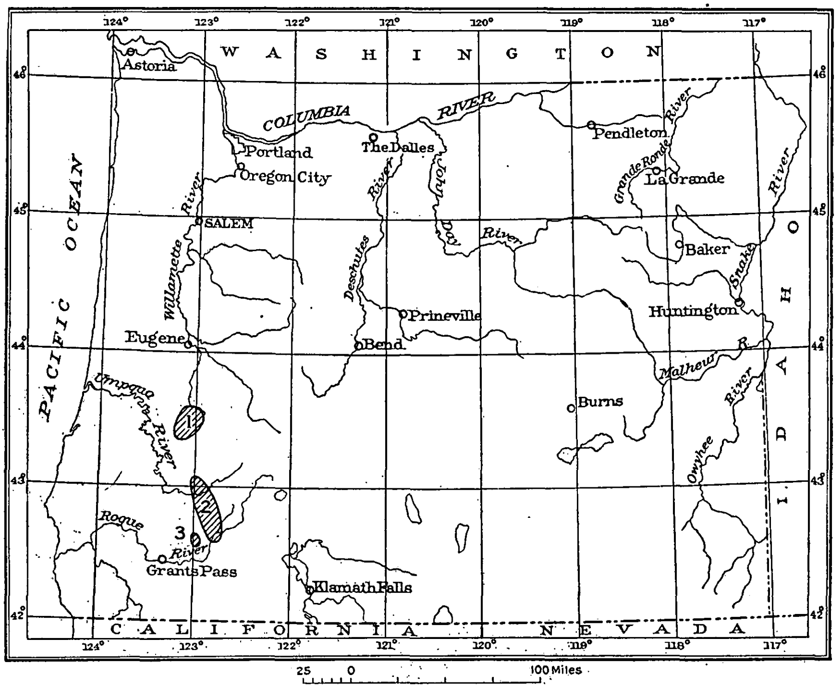

FIGURE 1.—Index map showing location of quicksilver deposits in southwestern Oregon. 1, Blackbutte-Bonanza area; 2, Tiller-Trail area; 3, Meadows area.

VEGETATION

The entire western slope of the central and northern Cascade Range receives a very heavy rainfall and is heavily timbered. Thick forests of Douglas fir and other evergreen trees tower above a matted undergrowth of vine maple, devilsclub, salmonberry, rhododendron, and other shrubs. At many places this undergrowth renders part of the forest literally impassable, and geologic work must be carried on by wading the streams that have channels clear of undergrowth. A few of the ridges can be traversed. Toward the south the rainfall is less abundant, the forest becomes more open, and much of the underbrush disappears.

SETTLEMENT AND COMMUNICATION

Most of the population is confined to the broad parts of the stream valleys, where farming is carried on. Only a few prospectors and persons engaged in logging occupy the ridges.

The Shasta line of the Southern Pacific Railroad and the Pacific Highway pass along the west edge of the quicksilver belt, and from them most of the deposits can be reached over good gravel roads suitable for automobile travel throughout the year.

GEOLOGY

GENERAL FEATURES

The quicksilver deposits of southwestern Oregon lie along the boundary between the Miocene (?) volcanic rocks of the Cascade Range and the folded early Tertiary sedimentary and older metamorphic rocks of the Coast Range and Klamath Mountains. The southwestern part of the area lies within the Klamath Mountains, an area of intensely folded and faulted rocks that range in age from Devonian to Upper Cretaceous. The May Creek schist, of probable Devonian age underlies the western part of the Meadows district. In the Rogue River Valley, Eocene sandstone and shale of the Umpqua formation lie unconformably on these rocks. In the northwestern part of the region, including the western part of the Blackbutte-Elkhead and Nonpareil-Bonanza areas, the underlying rocks are gently folded beds of sandstone, shale, conglomerate, and intercalated basalt flows of the Umpqua formation. The general trend of these rocks is northeast. Throughout the eastern part of the region volcanic flows, tuffs, and conglomerates rest unconformably on the eroded surface of the folded Eocene rocks. All these formations are cut by dikes and necks of intrusive rocks that range in composition from andesite to basalt.

The warm rainy climate of this region and the chemical and physical character of the formations hasten rock weathering, and the whole region is therefore covered with a thick mantle of residual soil. Even the steepest slopes, which are not protected by vegetation, are covered with soil, and in most road cuts and stream beds the rock exposed is not fresh. Owing to these conditions it is obviously difficult to determine closely the character, structure, and distribution of the formations, even when all available evidence, such as float soil, color, and texture, is considered.

STRATIGRAPHY

DEVONIAN (?) ROCKS

MAY CREEK SCHIST

The oldest rock exposed in any of the areas examined, the May Creek formation, underlies the western and southwestern parts of the Meadows district and the valley of Cow Creek. (See pp. 50–51.) As exposed in these areas the rock is variable, but most of it can be classified as quartz-biotite schist and hornblende-mica schist.

The quartz-biotite schist is light gray and consists of a mosaic of quartz with variable but minor amounts of muscovite and biotite and in some specimens microscopic rods of hornblende. The bedding is easily discernible and is parallel to the foliation. The average thickness of the beds is half an inch.

The hornblende-mica schist varies considerably in mineral composition and in texture. Where most typically developed the rock is dark green, fine-grained, and highly foliated, with large metacrysts of pyroxene (bronzite) as much as 1 centimeter wide and 2 centimeters long. In general the groundmass consists of about 23 percent of andesine, the remainder being hornblende with a little biotite, but it grades from this to a rock containing biotite, hornblende, and augite with a small amount of andesine.

In the Meadows district the May Creek formation is cut at many places by veins and irregular masses of pegmatite, which are composed of coarse-grained quartz and perthitic feldspar showing a little mica. In some places the pegmatite shows lit-par-lit structure; in others it contains hornblende near the contact with enclosed lenses of schist, which appear spotted owing to the development in them of large crystals (metacrysts) of feldspar. This material is probably related to unexposed intrusive masses of quartz diorite similar to those that cut the May Creek formation in the Riddle quadrangle, to the west.

The strike of the schistosity ranges from N. 40° E. to N. 58° W., and the corresponding dip from 27° SE. to 60° SW. The northeast strike is most common, and the dip usually exceeds 30°. In the larger areas of the May Creek formation mapped by Diller[1] the prevailing strike of the schistosity is likewise to the northeast.

The schists of the areas examined are continuous with those of the May Creek formation of the Riddle quadrangle, directly to the west. On the basis of fossils occurring in limestone lenses found in similar schists southwest of the Riddle quadrangle Diller[2] has classified the May Creek formation as Devonian(?).

TERTIARY ROCKS

UMPQUA FORMATION (EOCENE)

Diller[3] in several publications treating of the geology of southwestern Oregon described a series of sedimentary rocks composed of

[1] Diller, J. S., and Kay, G. F., U.S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), p. 2, 1924.

[2] Idem, p. 3.

[3] Diller, J. S., A geological reconnaissance in northwestern Oregon: U.S. Geol. Survey Ann. Rept., pt. 1, pp. 456–464, 1896 U.S. Geol. Survey Geol. Atlas, Roseburg folio (no. 49), 1898; The Rogue River Valley coal field: U.S. Geol. Survey Bull. 341, pp. 402, 405, 1909; Guidebook of the western United States, pt. D, The Shasta Route and Coast Line: U.S. Geol. Survey Bull 614, pp. 39–42, 50–51, 1915. Diller, J. S., and Kay, G. F.., U.S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), p. 4, 1924.

sandstone, shale, conglomerate, and intercalated volcanic flows and tuffs which he called the Umpqua formation, after the Umpqua River, in the valley of which these rocks are extensively exposed. Rocks of the Umpqua formation underlie much of the region considered in the present paper, including the west half of the Blackbutte-Elkhead area, the Nonpareil-Bonanza area, the Meadows district, and probably an area of the Buena Vista mine; but not all the different types of rock described in the following pages occur in any one of the districts mentioned.

SANDSTONE AND SHALE

The Umpqua formation characteristically consists of alternating shales and sandstones which show beautifully developed bedding. (See pl. 2, *A*.) Individual beds are usually from a few inches to 1 foot in thickness, but locally there are massive beds tens of feet thick. The shales are dark gray on fresh fracture and are characterized by an exceptionally well developed hackly jointing, which subdivides the rock into irregular fragments averaging little more than 2 inches in diameter. Some of the shale beds are more or less carbonaceous and locally contain lenses of coal. Fine-grained siltstone occurs as well as true shale, but there is no gradation of shale to sandstone in the sequence, each individual bed consisting of shale, siltstone, or sandstone alone, and the change from one to the other is abrupt. The color of the sandstone layers ranges from grayish white to light brown, depending on the amount of iron staining, but pale yellowish brown or buff is the most common. The grains are angular to subrounded, and the rock ranges in texture from a fine-grained sandstone to a coarse grit. It is usually poorly cemented and can be easily dug with a pick.

The material of which the sandstone is composed is largely of volcanic origin, and in places the rock could be properly called a tuff; but it everywhere contains considerable amounts of detrital quartz and mica. The mica is mostly muscovite, though in some places shiny black biotite foils are very conspicuous. The volcanic products consist in part of material related to the interstratified basalt, but some of the detritus appears to be derived from rocks of more acidic composition, as shown by the presence of fragments containing zonal crystals of andesine embedded in an altered glassy matrix. Small, sharply angular fragments of decomposed glass are common in the tuff.

Shale preponderates greatly in the lower part of the section; but in the upper part sandstone increases until it composes the bulk of the formation, in beds 100 feet or more thick with intercalated limy shale.

CONGLOMERATE

Conglomerate is exposed at many widely distributed places, especially near large areas of basalt flows. In the Blackbutte-Elkhead area conglomerate is scarce, but in the Nonpareil-Bonanza area it is sufficiently abundant to be mapped as a separate unit. In the Tiller area conglomerate occurs in the valley of Deadman Creek and in the Buena Vista mine.

The rock is composed of rounded to subrounded pebbles and cobbles ranging from a quarter of an inch to 7 inches in diameter, embedded in a sandy matrix similar to the material of the sandstone layers. Texturally the conglomerate may be separated into two groups, one consisting of beds in which most of the pebbles are less than 1 inch in diameter and none exceed 2 inches, the other consisting of beds made up mostly of pebbles about 2 inches in diameter but including material ranging in size from pebbles to cobbles with a maximum dimension of 7 inches. Stratification is generally indefinite.

Pebbles of basalt, quartz, chert, sandstone, shale, quartz diorite, metagabbro, and porphyritic felsite have been found in the conglomerate, the relative abundance of each varying considerably. Those of basalt are preponderant near some of the masses of this rock; those of quartz diorite are similar to the quartz diorite of late Jurassic or early Cretaceous age described by Diller;[4] those of metagabbro are similar to the metagabbro of Cretaceous age in the Roseburg quadrangle.[5] The presence of pebbles of these rocks and the absence of andesite in this conglomerate distinguishes it from the lower facies of the Calapooya formation, which is composed almost wholly of andesite.

LAVA FLOWS AND TUFFS

Flows of amygdaloidal and ellipsoidal basalt, mapped by Diller[5] as diabase, and beds of palagonite tuff and breccia, the Wilbur tuff lentil of Diller,[6] are intercalated with the sedimentary beds of the Umpqua formation. The "diabase" was regarded by Diller[7] as being partly of intrusive and partly of extrusive origin, but the writers, as shown elsewhere,[8] believe that it is entirely extrusive.

The structural relations of the lava flows are difficult to ascertain, but in the rare localities where dip and strike can be deter-

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[4] Diller, J. S., and Kay, G. F., U.S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), p. 5, 1924.

[5] Diller, J. S., U.S. Geol. Survey Geol. Atlas, Roseburg folio (no. 49), p. 3, 1898.

[6] Idem, p. 2.

[7] Diller, J. S., idem, p. 3; Guidebook of the western United States, pt. D, The Shasta Route and Coast Line: U.S. Geol. Survey Bull. 614, p. 41, 1915.

[8] Wells, F. G., and Waters, A. C., The extrusive igneous rocks of the Umpqua formation (in preparation).

mined, they appear to conform in a general way to those of the Umpqua formation.

Amygdaloidal basalt.—The amygdaloidal basalt is well exposed on Dickerson Mountain northwest of the Elkhead mine and at a point near the center of the mass where it is crossed by Elk Creek. Here exceptionally amygdaloidal material is arranged in definite layers separated by material of less amygdaloidal character. Several superimposed flows are present, each flow consisting of a highly amygdaloidal upper part and a less amygdaloidal base. In some flows the amygdules form more than 25 percent of the upper part of the rock.

The basalt is a dark greenish-gray to black dense rock with prominent white amygdules as much as 1 centimeter or more in diameter. Much of it is porphyritic, the phenocrysts of plagioclase commonly being segregated together in more or less conspicuous clots. A description of the microscopic characteristics of the rock is given elsewhere.[9]

Ellipsoidal basalt.—In the southeastern part of the Nonpareil-Bonanza area a very considerable part of the surface is underlain by basaltic lavas that were mapped by Diller as diabase. These lavas occur as separate, lenticular areas of northeast trend, separated by conglomerate or by igneous breccia and tuff. The most prominent and best-exposed area extends through secs. 12, 14, 23, 27, and 28, T. 25 S., R. 4 W.

Although some of the lava flows are massive, ellipsoidal or pillow structure is more or less in evidence at nearly every locality in which large continuous exposures of the lava are found. An exceptionally favorable locality to study the ellipsoidal structure may be found along the ridge east of Salt Lick Creek.

In these lavas the individual ellipsoids range in size from a little over 1 to 8 feet, but the usual size is about 2 feet. Though the masses generally have a fairly uniform globular or ellipsoidal outline, many of them show rounded extensions like the irregularities of a knotty potato. At some places adjacent pillows may be fused together, and at a point just outside the area mapped, near the north border of sec. 29, T. 25 S., R. 4 W., a zone of large ellipsoids merges upward into a massive flow, the area of transition being indicated by rows of thickly aggregated vesicles, which mark out an ill-defined ellipsoidal structure in the basal part of the massive lava. Individual ellipsoids show a very characteristic radial columnar jointing, which separates the globular mass into pyramidal blocks, few of them more than 2 inches across, arranged radially with their apexes at the center of the ellipsoid.

[9] Wells, F. G., and Waters, A. C., The extrusive igneous rocks of the Umpqua formation (in preparation).

Megascopically, specimens of the basalt show as a black aphanitic rock of nonporphyritic character. Small vesicles, commonly occupied by fillings of zeolite minerals, are sparingly present in most specimens. The cavernous areas existing between the ellipsoids and the closely spaced joints have greatly facilitated weathering, and as a result the margins of the ellipsoids are commonly stained and discolored. The microscopic features of the rock are described elsewhere.[11]

Palagonite tuff and breccia.—Intimately associated with the ellipsoidal lavas is fragmental material, composed largely of altered basaltic glass (palagonite) that ranges in texture from exceedingly fine grained tuff to breccias in which the individual fragments are 2 or 3 inches in length. At some localities, as near the southeast corner of sec. 35, T. 24 S., R. 4 W., this fragmental material fills the cavernous spaces between adjacent pillows, and individual exposures may show ellipsoids and pyroclastic material intermingled in all proportions. At other localities, as in the southern part of sec. 16, T. 25 S., R. 4 W., the fragmental material occurs as a definite stratum that is not in contact with lava (see pl. 14), but none of it has been found at an appreciable stratigraphic distance from the ellipsoidal lava, and the local intimate intermingling of the two, as well as the purely basaltic composition of the fragmental material, definitely establishes their contemporaneous origin. This fragmental material was separately mapped by Diller as the Wilbur tuff lentil.[12]

The finer-grained tuffs resemble rather closely a hard mudstone or argillite. On fresh fracture they are dark green or steel-blue, but they oxidize readily to dull black and then resemble a fine-grained carbonaceous sediment. The coarser breccias, as is well illustrated by the exposures on the small rounded hill in Salt Lick Valley, are locally transitional into the conglomerates of the Umpqua formation. The breccias vary greatly in color, but medium greenish-gray or light-brown material is the most common. The very fine-grained varieties are almost black.

Under the microscope these pyroclastic rocks are seen to be composed largely of palagonite, a tuff derived by hydration, through the agency of water or water vapor of exotic origin,[13] of clear, pale-colored basaltic glass which had been produced by drastic chilling of basalt magma. A detailed description of the palagonite tuff is given elsewhere.[14]

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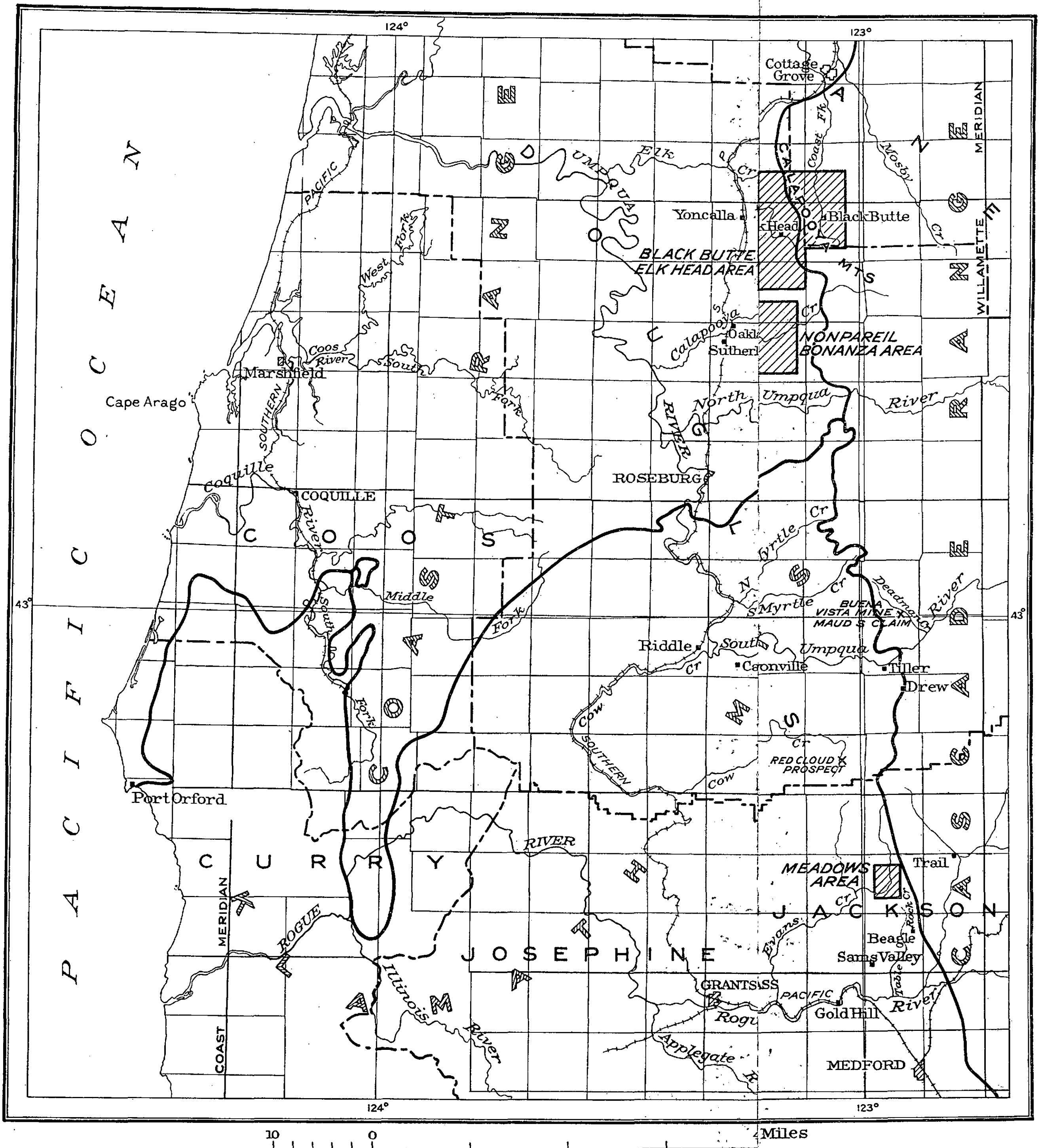
[11] Wells, F. G., and Waters, A. C., The extrusive igneous rocks of the Umpqua formation (in preparation).

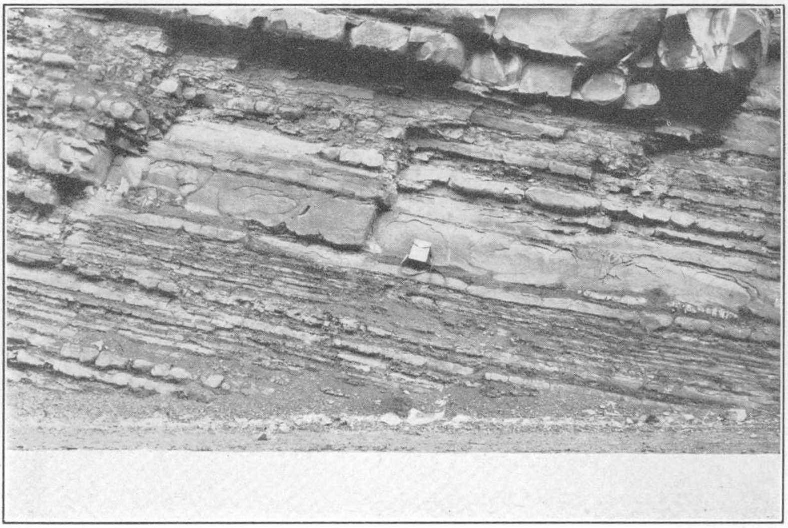
[12] Diller, J. S., U.S. Geol. Survey Geol. Atlas, Roseburg folio (no. 49), 1898.

[13] Peacock, M. A., and Fuller, R. E., Chlorophacite, sideromelane, and palagonite from the Columbia River Plateau: Am. Mineralogist, vol. 13, pp. 361, 373, 1928.

[14] Wells, F. G., and Waters, A. C., op. cit.

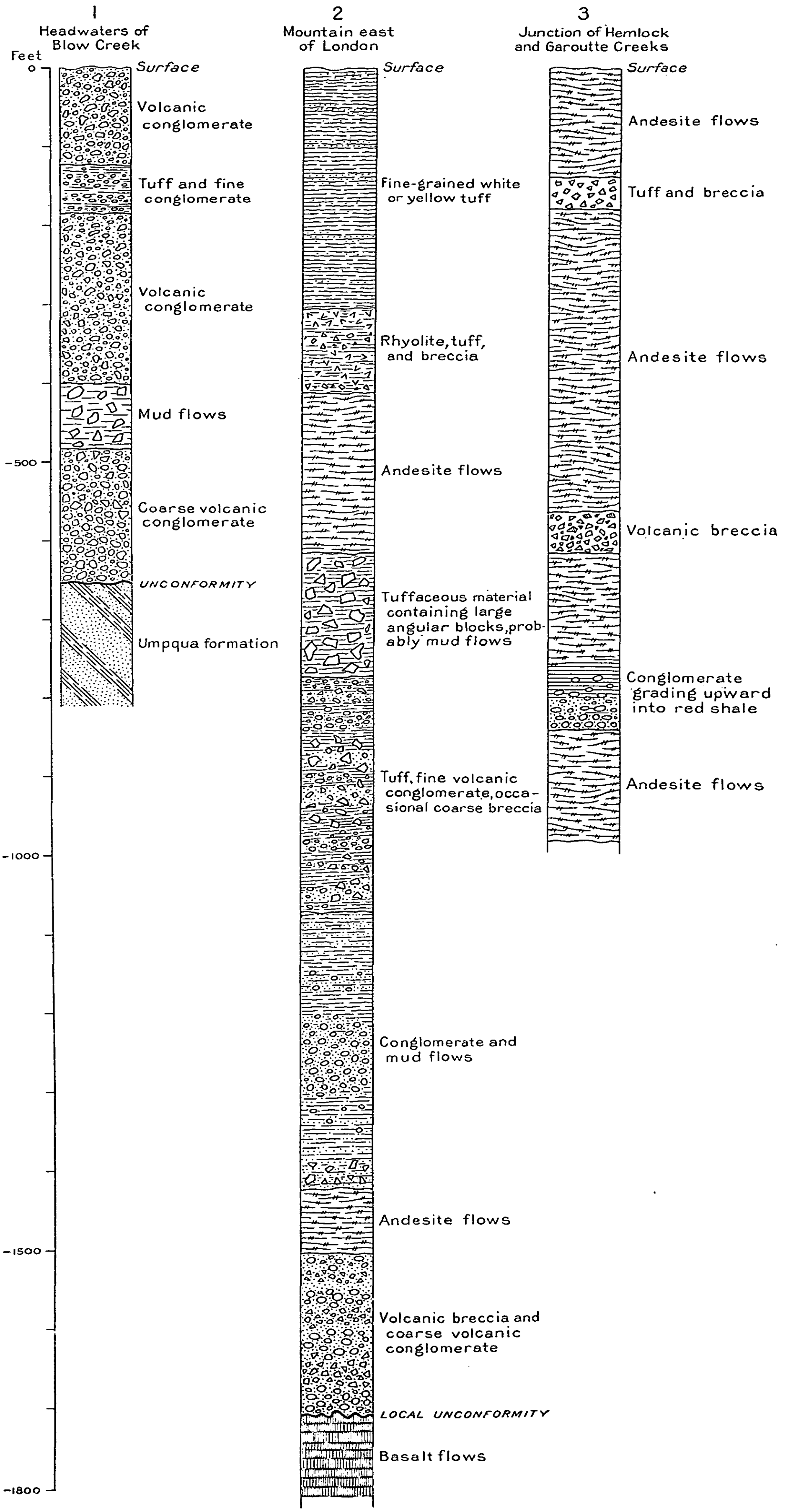


MAP SHOWING MINING AREAS AND PHYSIOGRAPHIC SECTIONS OF SOTHWESTERN OREGON.



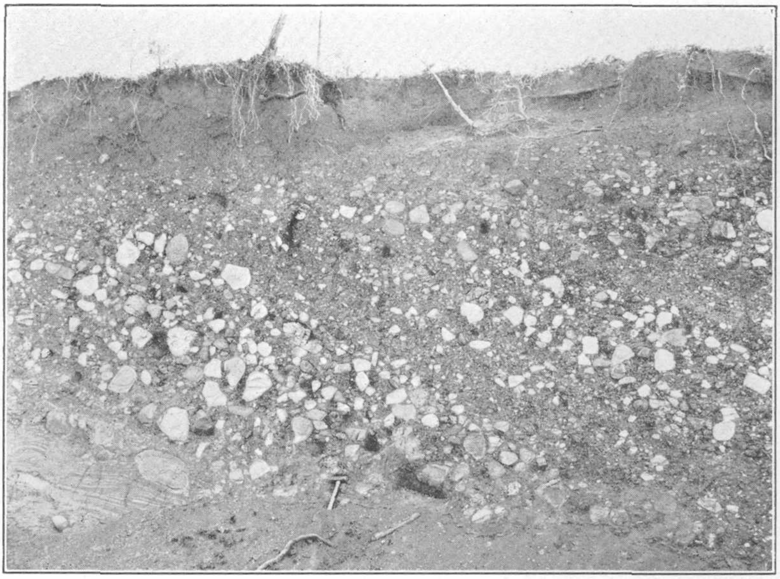
A. BEDDING IN UMPQUA FORMATION NEAR OAKLAND.

B. MUD FLOW IN LOWER PART OF CALAPOOYA FORMATION WEST OF LONDON.



SKETCH COLUMNAR SECTIONS OF CALAPOOYA FORMATION.

A. DECOMPOSED MUD FLOW IN LOWER PART OF CALAPOOYA FORMATION.



B. RUDELY STRATIFIED MUD-FLOW BRECCIAS IN LOWER PART OF CALAPOOYA FORMATION.

On the mountain east of London.

THICKNESS AND AGE

In the Roseburg quadrangle the Umpqua formation attains a total thickness of about 12,000 feet.[15] Probably only part of the formation is present in the areas under consideration, and owing to the lack of good exposures no estimate of thickness can be given, but it is doubtless several thousand feet.

Marine shells were found embedded in sandstone and conglomerate of the Umpqua formation in sec. 26, T. 23 S., R. 4 W., but they were in so poor a state of preservation that they are scarcely identifiable. In the Roseburg quadrangle Diller collected the characteristic Eocene fossils *Cardita planicosta* and *Turritella uvasana*, which definitely fix the age of the formation as Eocene.[15]

In the northwestern part of the Roseburg quadrangle the Umpqua formation is immediately overlain by the Tyee sandstone, of Eocene age, which differs from the sandstones of the Umpqua formation chiefly in being thicker-bedded and in containing more conspicuous scales of mica. This formation was not recognized in the Blackbutte-Elkhead or Nonpareil-Bonanza areas, and from its stratigraphic position it would probably not be present there.

Three small areas, each less than an acre in extent, of bluish shaly limestone that contains, among other marine fossils, *Lucina*, *Venus*, *Corbula*, *Natica*, and *Turritella*, were mapped by Diller[16] in the Roseburg quadrangle. To these areas of limestone he gave the name Oakland limestone lentils, and he says that they are of Oligocene age. These limestones are not present in any of the areas considered in this report.

CALAPOOYA FORMATION (EOCENE?)

DEFINITION AND GENERAL CHARACTER

After the Umpqua sedimentary rocks and interbedded lava flows were laid down they were gently folded into broad anticlines and synclines. Erosion subsequently beveled the folds, and later deposition, associated with the volcanism that formed the old Cascade Mountains, laid down a mass, over 5,000 feet thick, of exceedingly heterogeneous materials including conglomerate, tuff, breccia, and lava flows. (See pl. 3.) Such rocks make up the western, older part of the Cascade Range[17] and are extensively exposed in the Blackbutte-Elkhead area. (See pl. 7.) The name Calapooya formation is proposed for these rocks because of their occurrence along the crest of the Calapooya Mountains. In this area, as indicated above, an angular unconformity separates the Calapooya formation from

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[15] Diller, J. S., U.S. Geol. Survey Geol. Atlas, Roseburg folio (no. 49), p. 2, 1898.

[16] Idem, p. 3.

[17] Buddington, A. F., and Callaghan, Eugene, Metalliferous deposits of the Cascade Range, Oreg. (in preparation).

the underlying Umpqua formation; the top of the Calapooya is cut away.

Although they do not vary greatly in composition, the rocks of different parts of the Calapooya formation are strikingly dissimilar in appearance. This characteristic prevails throughout the formation, and even its individual members show marked local variations.

Evidently the Calapooya rocks were laid down under changing conditions. In some parts of the area, as for example on the road between London and Shoestring and near the headwaters of Blow Creek, there are conglomerates that show fairly good assorting, thus giving clear evidence of having been deposited in water. Associated with these conglomerates are beds that were probably deposited as mud flows.

In some places the Calapooya formation consists mainly of true volcanic breccias; in others it is made up largely of fine tuff. Certain layers of the tuff, as can be seen near the top of the mountain east of London, show a broadly curved cross-bedding, suggesting that the material was redistributed by the wind. The burial of forests by volcanic explosions is indicated by the presence of silicified tree trunks of considerable diameter, which are locally very common in the tuff and conglomerate.

Lava flows prevail in some places. The mountain in which the Blackbutte mine is located and the area south and east of it are underlain by superposed andesitic flows with little or no sedimentary or tuffaceous material. The flows range in composition from basalt to dacite, but nearly everywhere material of andesitic composition greatly predominates.

As might be expected in a group of rocks of such dissimilar composition, the individual members have small horizontal extent and possess little stratigraphic significance. The lavas are more abundant in the upper part of the formation, and the thick masses of conglomerate are confined largely to its base. There is also a very noticeable separation of the lavas and the clastic materials in geographic distribution. In the eastern part of the Calapooya Mountains the formation is composed mostly of sedimentary beds with conglomerate predominating, whereas farther east and southeast lava flows become increasingly abundant, until along the southeast border of the Blackbutte-Elkhead area only scattered thin beds of conglomerate can be found. In the Blackbutte-Elkhead area the predominantly igneous and predominantly sedimentary parts of this formation are separated by a comparatively narrow zone of transition. The upper or dominantly igneous part is well shown on Garoutte Creek, whose headwaters have cut into it deeply; and the lower or dominantly sedimentary part is well exposed near the Sehlin ranch, at the head of Blow Creek.

LOWER OR DOMINANTLY SEDIMENTARY FACIES

One of the best localities for observing the unconformity between the Umpqua and Calapooya formations is the amphitheater in which Blow Creek has its source. The amphitheater is partly walled by bold cliffs of the hard conglomerate at the base of the Calapooya and owes its form largely to the rapid erosion of the softer beds of the underlying Umpqua. Along the canyon of Blow Creek just above the Sehlin ranch the Umpqua beds dip 16°–20° N. The overlying conglomerate of the Calapooya in general dips only a few degrees east and in places is horizontal.

The conglomerate exposed in the bluffs above Blow Creek is well bedded and for the most part fairly well assorted. Its pebbles range from fragments little larger than sand grains to boulders 2 feet in diameter. They are composed almost entirely of a dark greenish-gray aphanitic andesite, some of which has a poorly developed flow structure. Even at the base of the formation pebbles derived from the Umpqua are exceedingly rare, and the mass is composed almost exclusively of volcanic material. Under the microscope most of the pebbles are seen to be hypersthene-augite andesite. There is more variation among individual pebbles than is visible to the unaided eye, but the chief differences are in texture rather than in mineral composition.

Associated with the conglomerates are beds of unusual appearance composed of a fine tuffaceous matrix with scattered large rounded or angular blocks of andesite. The unassorted character of the material of these beds suggests a glacial till (see pls. 2, *B*, and 4, *A*), but this suggestion is negatived by the facts that the material is all of local origin, is entirely volcanic, contains no striated or faceted pebbles, and occurs below the known limit of glaciation in the region. These beds were probably deposited as mud flows following volcanic activity of the explosive type.

Other conglomerates of the lower facies lying stratigraphically higher within the formation are well exposed on the road between London and Shoestring. Deep weathering of the formation prevents the obtaining of fresh specimens, however, except from a deep road cut about half a mile south of the Douglas County line. A thin section cut from a conglomerate at this locality shows that the constituent pebbles average about the size of a pea and are all of andesitic composition. Two varieties of andesite are very abundant. One contains phenocrysts of both augite and hypersthene, in a groundmass of feldspar microlites forming a thickly matted felt with very little interstitial glass. The other variety contains more glass, which encloses swarms of felted feldspar microlites, although varieties with a distinctly fluidal arrangement also occur. Hypersthene and plagioclase of the composition An_{42} occur as phenocrysts.

Altered fragments of andesite and isolated crystals of hypersthene, augite, and plagioclase are scattered in the matrix between the pebbles. An interesting thing about the rock is that it is cemented by gypsum. This has apparently not been introduced by solfataric action, because solfataric action normally completely alters igneous rocks, and the individual andesite pebbles are fresh and unaltered. The attack of the agents of weathering upon the easily soluble gypsum has undoubtedly caused the bleaching and discoloration of the surface of the rock within a few weeks after exposure. It has probably also in part caused the weathering of the formation to great depths at many localities.

Still higher stratigraphically within the formation occur thick masses of the unusual breccias that are probably mud flows. Associated with these in places are flows of andesite. Throughout this part of the formation fragments of fossil wood are common, and at the locality where the gypsum-cemented conglomerate was obtained excellently preserved leaf impressions can be found in a thin layer of fine-grained tuff interstratified with the conglomerate.

Farther east the gentle eastward dip of the formation brings to the surface beds that are stratigraphically higher and higher. On the mountain side east of London fine conglomerates with associated mud-flow breccias prevail, but near the summit of the mountain there is a zone about 100 feet thick in which the rock is a glassy dacite tuff, and still higher on the mountain very fine grained tuffaceous deposits are exposed. About 3 miles south of the exposures of dacite tuff and at nearly the same stratigraphic horizon there is a single flow of glassy dacite (vitrophyre).

In the Blackbutte-Elkhead area the lower volcanic sediments attain a total thickness of at least 3,500 feet, with the top not exposed.

In the Meadows district conglomerate similar to that of the lower facies but much better sorted crops out. The pebbles are rounded and range from half an inch to 3 inches in diameter. Most of them are aphanitic andesite, though some are porphyritic, with phenocrysts of zoned feldspars.

UPPER OR DOMINANTLY IGNEOUS FACIES

The thick series of horizontal or gently inclined andesite flows that constitute the upper or dominantly igneous facies of the Calapooya formation is well exposed near the headwaters of Garoutte Creek. There the lava flows are separated by layers of breccia or, rarely, fine-grained tuff; but water-laid sediments are absent. Downstream, however, interfingering layers of well-bedded conglomerate are present and increase in thickness and number toward the west. The westward thickening of the sediments is well illustrated by one layer of conglomerate that grades upward into a brilliant red shale and so is easily traceable. Where exposed at the level of the water a short distance above the mouth of Hemlock Creek this stratum is only about 30 feet thick, but downstream it thickens to 400 feet in half a mile before it is finally concealed by the thick forest mantle.

On the West Fork of Garoutte Creek lavas and conglomerates are present in nearly equal amounts, and the line separating the lower or dominantly sedimentary facies from the upper or dominantly igneous facies of the Calapooya formation has accordingly been drawn near the course of this fork.

Microscopically the lava flows of the upper facies show little petrographic variation. They are for the most part hypersthene-augite andesites with a feltlike interweaving of feldspar microlites exactly like the andesite found as pebbles in the conglomerate of the lower facies. In addition to the ferromagnesian minerals zonal plagioclase (andesine) commonly occurs as phenocrysts. Locally there are flows with a distinctly glassy groundmass enclosing phenocrysts of sodic andesine and minor amounts of hypersthene. The texture of the rock suggests that of a dacite, but quartz is not present in the mode. A flow of glassy dacite is interbedded with the conglomerates of the lower facies northeast of Blackbutte; breccias and tuffs composed of fragments of glassy dacite are exposed at more than one locality; and a single flow of basalt has been found interbedded with the lower conglomerates near London. Considered as a volcanic series, however, the upper lavas are composed almost entirely of andesite.

The flows of the Tiller district are similar to those of the Blackbutte-Elkhead area except for their low content of ferromagnesian minerals. The prevailing rock of the Trail region, however, is a basalt flow in which embedded phenocrysts of feldspar as much as 4 millimeters in length are so numerous that the rock appears to be almost holocrystalline. In thin section, however, the groundmass of interwoven microlites of feldspar and interstitial glass is clearly seen. The feldspar is a calcic bytownite. A few comparatively small phenocrysts of augite are scattered through the rock, and accessory apatite and magnetite are present.

AGE

Fossil leaves collected from a thin layer of tuff interstratified with the gypsiferous conglomerates of the lower facies of the Calapooya formation at a point on the road between London and Shoestring about half a mile south of the Douglas County line are described by R. W. Brown, of the United States Geological Survey, as follows:

The leaves are *Aralia*, probably *Aralia whitneyi*, a species described from the Yellowstone National Park and the auriferous gravel of California. The fossils described from those regions have been considered Miocene in age; but the tendency among recent students of these materials is to regard them as Oligocene, if not late Eocene. The fossil woods are sycamore (*Platanus*) and poplar (*Populus*). Much work needs to be done with fossil woods before they can by themselves be used as stratigraphic and time markers.

A flora containing *Aralia whitneyi* that occurs in tuffaceous sediments near Comstock, Oreg., and also directly along the strike of the lower conglomerates of the Calapooya formation not far northwest of the Blackbutte-Elkhead area is regarded by Dr. Ralph W. Chaney[18] as Eocene. It is probable, therefore, that the Comstock fossils occur in a continuation of the lower facies of the formation. Upon this evidence the Calapooya formation is tentatively assigned to the Eocene. Dr. Chaney expects to collect specimens from the locality near London, and perhaps the finding of a more complete flora at this locality will definitely settle the question of the age of the formation.

WEATHERING

One of the most characteristic things about the lower part of the Calapooya formation is the unusual depth and remarkable completeness of its decomposition by descending surface waters. Commonly hillsides that slope as steeply as 30° to 35° are completely covered with a mantle of soil through which no rock ledges project. As a rule all the rocks in this part of Oregon have a thick covering of soil, which is attributed to the absence of glaciation, the humid climate, the rather sharp relief, which causes a low ground-water table, and the presence of dense forests, which prevent rapid erosion. The lower conglomerates, furthermore, are more easily decomposed than any of the other rocks. It is practically impossible to obtain fresh specimens except from localities along tributaries of the Umpqua River and from the deeper road cuts. The road cuts on the newly constructed highway between London and Shoestring and those on the railroad of the W. A. Woodward Lumber Co. illustrate exceptionally well the decomposition of the formation. Commonly nothing but decomposed conglomerate of about the consistency of cheese is to be seen in cuts as much as 20 or 30 feet deep. Despite the complete alteration of the andesitic pebbles, there has been no large change in volume during decomposition and the original structure of the once resistant conglomerate is well preserved. (See pl. 4, *A*.) In many places feldspar phenocrysts that have been altered entirely to clay minerals retain their original sharp outline. Some of them swell slightly when placed in water, but not to the extent that characterizes bentonite.

Probably the factor of most importance in the decomposition of the lower conglomerates is the exceedingly porous character of the

[18] Oral communication.

formation. Where well-cemented conglomerate occurs the cementing medium is gypsum, which is readily dissolved by surface waters. The andesite fragments, which are made up of easily decomposed ferromagnesian minerals, glass, and feldspar, are then readily attacked.

SURFICIAL DEPOSITS

The Blackbutte-Elkhead area contains in some places a thin superficial deposit of volcanic ash of andesitic composition. Good exposures of this ash occur at the junction of the Coast Fork of the Willamette River and Garoutte Creek. A thin mantle of river alluvium occurs in some of the larger valleys. Over the greater part of the area, however, there is a deep residual soil derived from the decay of the immediately underlying rocks.

INTRUSIVE IGNEOUS ROCKS

The intrusive rocks found in the areas examined include quartz diorite, which occurs in the Meadows district and the Roseburg quadrangle northwest of it, and gabbro, norite, and related rocks, which form sills, stocks, and dikes in the Blackbutte-Elkhead and Nonpareil-Bonanza areas.

QUARTZ DIORITE

The only body of quartz diorite seen within the areas studied is penetrated by adits 1 and 2 of the Quicksilver Producers Co.'s mine, in the Meadows district. (See pl. 21.) As exposed in adit 1 for a distance of 310 feet the rock in general is so thoroughly disintegrated that it may be readily dug with a pick. It is gray and coarse to fine grained. In places it contains large patches of greenish-black hornblende that are roughly alined, giving the mass a gneissoid appearance. The material examined with the microscope consists chiefly of oligoclase with interstitial quartz and some biotite, but no hornblende was seen. In some specimens the oligoclase has been largely altered to clay minerals and the biotite is very dirty, whereas in others the feldspars have been altered completely to calcite with a little quartz, and the biotite has been changed to chlorite.

The quartz diorite is cut by stringers half an inch to 6 inches in width of coarse feldspar and almost completely chloritized mica.

The relation of the quartz diorite to the other rocks in the area is not revealed in the exposure described. It is probably to be correlated with a similar quartz diorite that crops out 3 miles to the southwest, in the Riddle quadrangle, and is regarded by Diller [19] as either late Jurassic or Cretaceous. It intrudes the May Creek schist but not the Umpqua formation.

[19] Diller, J. S., and Kay, G. F., U.S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), 1924.

GABBRO AND NORITE

At many places within the areas described the Umpqua and Calapooya formations have been intruded by small sills, dikes, and necks ranging in composition from gabbro to norite. These bodies are relatively resistant to erosion and form peaks such as Cozad Mountain, Harness Mountain, Bald Mountain, and Steens Butte, in the Blackbutte-Elkhead district.

NORITE SILLS IN THE UMPQUA FORMATION

Sills crop out in several places south and east of the Elkhead mine. (See pl. 7.) The upper part of Cozad Mountain is a norite sill about 400 feet thick, which dips eastward with the enclosing Umpqua beds. Along the crest of the mountain the beds immediately above the intrusion have been metamorphosed, as shown by hardening and by the development of a peculiar mottled appearance.

A sill that intrudes the Umpqua formation east of the Elkhead mine in secs. 26 and 35, T. 23 S., R. 4 W., has caused similar changes in the adjoining strata. Locally it breaks across the beds at a low angle.

The norite on Cozad Mountain has a granular texture and a medium gray color. Light-colored minerals appear to predominate, and this norite therefore resembles some dark-colored diorites. The microscope, however, shows that the rock consists of labradorite (An_{59}), augite, hypersthene, and magnetite, named in order of decreasing abundance. Hypersthene and augite are present in nearly equal amounts and together make up nearly half of the rock. The feldspar and hypersthene have typically euhedral outlines. Some of the augite shows similar boundaries, but most of it is interstitial to the other minerals. Magnetite, which occurs as large continuous anhedral plates, appears to have completed its crystallization late, for it encloses all the other minerals and sends minute fingerlike projections into cracks within the other minerals or into openings between them. Near the middle part of the sill there are segregated bodies of a very coarse grained, lighter-colored gabbroic rock. These differ microscopically from the norite of the main sill in the almost total absence of hypersthene and a corresponding increase in labradorite, augite, and magnetite.

VOLCANIC NECKS AND DIKES CUTTING THE CALAPOOYA FORMATION

The high peaks surrounded by the Calapooya formation consist of intrusive rock with the oval or elliptical outlines characteristic of volcanic necks or small stocks. Two such masses, on Bald Mountain and Harness Mountain, occur within the Blackbutte-Elkhead area, and a third forms Steens Butte, just beyond the east edge of the area. Steens Butte probably illustrates the nature of these intrusive bodies better than the others. It is a roughly cylindrical plug of dark-gray microgranular diabasic rock about a mile in diameter that has forced its way through the upper or dominantly igneous facies of the Calapooya formation. It has well-developed columnar jointing. In the central part of the mass the individual columns stand vertical, but toward the margin they curve outward to a horizontal position, approximately perpendicular to the surrounding walls. Curving columns of this character are developed to a less degree in the plugs of Harness Mountain and Bald Mountain. The Harness Mountain plug is elliptical, with its longer axis about 2½ times the shorter. The Bald Mountain plug is roughly circular.

The intrusive body of Steens Butte has a fine-grained subhedral gabbroic texture. In mineral composition it is closely related to the Cozad Mountain sill and may be designated a biotite micronorite. Its constituents, named in order of abundance, are labradorite (An_{56}), augite, hypersthene, biotite, magnetite, and apatite. Biotite is scarce and is invariably associated with hypersthene. A specimen collected within the border of the Bald Mountain intrusion consists of labradorite, augite, and minor amounts of hypersthene and well-formed magnetite, embedded in a glassy groundmass crowded with tiny microlites. The texture is like that of an intersertal basalt exceptionally rich in feldspar. As the feldspar is labradorite, the rock may accordingly be called a hypersthene basalt.

BASALT DIKES

A series of dikes differing in texture and component minerals but all of basaltic composition intrude the Umpqua and Calapooya formations in the Blackbutte-Elkhead, Nonpareil-Bonanza, and Meadows areas. A basalt dike exposed on the 900-foot level in the Blackbutte mine is typical of such dikes that cut the Calapooya formation in the Blackbutte-Elkhead area. Under the microscope it shows aggregates of augite and hypersthene embedded in a felt of roughly parallel labradorite laths. Well-formed magnetite is an abundant accessory. It is only slightly altered, in contrast to the adjacent andesite. Its hypersthene crystals have been changed to serpentine pseudomorphs, and its feldspars show some cloudiness, but its augite is very fresh. This general absence of alteration suggests that the dike was intruded after the deposition of the ore.

A basalt porphyry dike in the Meadows district should be classed with this rock, though it differs in color and texture and does not contain hypersthene. Where weathered it generally has a pink groundmass and green phenocrysts, whereas the fresh rock is light gray with light-green phenocrysts. Under the microscope the phenocrysts are seen to be almost entirely augite; they average 0.5 millimeter in diameter and occur mostly in clusters. A few olivine crystals are also present, in part altered to iddingsite, which in turn has been partly or completely replaced by calcite. The groundmass is generally quite unaltered and consists of a feltlike mass of labradorite crystallites.

Three large dikes and a few smaller dikes of olivine diabase cut the Umpqua formation in the northwest corner of the Nonpareil-Bonanza area. These dikes are very dark gray, rather coarsely crystalline, and very fresh. Under the microscope the diabase is seen to have a typical ophitic texture and to consist principally of nearly equal amounts of augite and labradorite in grains of varying size. Olivine was formerly common but has been changed largely to a light-brown, almost isotropic alteration product. Its remaining fresh grains have optical properties (negative, 2V close to 90°) that indicate a high iron content. Magnetite and apatite are accessory. A little chlorite is present.

The common occurrence of hypersthene suggests that the sills, plugs, and dikes bearing that mineral are related in age and origin to the upper or lava facies of the Calapooya formation. They are strikingly different from the olivine-bearing amygdaloidal lavas at the base of the Umpqua formation. The olivine-bearing dikes that cut the lower part of the Umpqua formation are also very different mineralogically from hypersthene-bearing intrusives of the Blackbutte-Elkhead area, and, as they have not been found to cut the Calapooya beds, they may mark the vents through which the amygdaloidal lavas rose.

STRUCTURE

The general structural trend of the older rocks throughout the region is northeast. Local changes in the strike of the May Creek and Umpqua formations are confined to the northeast quadrant. The May Creek formation dips from 3° to more than 75° SE. In the eastern part of the Nonpareil-Bonanza area the Umpqua formation has a homoclinal southeast dip ranging from 18° to 60°. To the northwest this structure gives place to open anticlines and synclines that trend northeast and show dips along the sides of 18° to 50°. In the Blackbutte-Elkhead area an elongate dome 12 miles wide and dipping 10° to 18° is developed in the Umpqua formation. In Sams Valley, just east of the Meadows district, and in the Rogue River Valley the prevailing dip of the Umpqua formation, according to Diller,[20] is toward the east. In the Meadows district the beds dip northwest as a result of faulting.

The volcanic conglomerates, breccias, and flows of probable late Eocene age, which rest unconformably on the Umpqua and older

[20] Diller, J. S., and Kay, G. F., U.S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), p. 4, 1924.

rocks, are characterized by a north or northwest strike and an east or northeast dip that is commonly as low as 2° or 3° and rarely exceeds 8° to 10°. Diller[21] states that in the region west of the Blackbutte-Elkhead area the lavas that cover the Calapooya Mountains dip both east and west, indicating that the Calapooya spur is an anticline. If this is true, the flows on the southwest limb of the anticline in the Blackbutte-Elkhead area have been removed by erosion, and only those on the northeast limb remain.

All the faults observed are normal and strike northeast. Two of the faults appear to have caused a displacement of several hundred feet each—one in the Blackbutte mine and another in the prospect of the Quicksilver Producers Co. in the Meadows district. The others are of small throw.

During the great epoch of mountain-building that formed the Klamath Mountains at the end of the Jurassic period the Paleozoic sediments of this region, among them the May Creek schist, were folded, overturned, and faulted. Again, at the end of the Cretaceous period, mountain-building forces deformed these rocks as well as the Mesozoic rocks. The third period of folding, which followed the deposition of the Umpqua formation, was much less intense than those of late Jurassic and late Cretaceous time, but each period produced folds with northeast trends.[22]

Smith[23] states that the homoclinal eastward dip of the lavas, conglomerates, tuffs, and flows is probably due solely to the sinking of the earth's crust along the Cascade Range under the great load of volcanic rocks piled up during late Tertiary time. Recent work by Callaghan,[24] however, shows that the structure of the range is more complex than stated by Smith, and though crustal sinking under great load may be a contributory cause, other forces, the nature of which is not yet fully understood, are operative.

GEOMORPHOLOGY

The northern part of the narrow belt in which quicksilver deposits occur lies along the boundary between two geomorphic subdivisions—the Oregon Coast Range and the Middle Cascade Mountains.[25] South of Roseburg the belt follows the boundary between the Klamath Mountains and the Middle Cascade Mountains. The

[21] Diller, J. S., The Bohemia mining district: U.S. Geol. Survey Twentieth Ann. Rept., pt. 2, p. 10, 1899. See also Fenneman, N. M., Physiography of the western United States, p. 433, New York, 1931.

[22] Diller, J. S., and Kay, G. F., U.S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), p. 6, 1924.

[23] 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, p. 45, 1917.

[24] Buddington, A. F., and Callaghan, Engene, Metalliferous deposits of the Cascade Range, Oreg. (in preparation).

[25] Fenneman, N. M., Physiography of the western United States, pp. 430–441, 459–472, 1931.

Middle Cascade Mountains have been maturely dissected into a series of narrow V-shaped valleys and sharp ridges. Individual peaks rise from 1,000 to 3,000 feet above the stream valleys and increase in altitude toward the east. A few peaks underlain by intrusive masses rise to still greater heights. The arrangement suggests an uplifted and maturely dissected peneplain with monadnocks of intrusive rock rising above it, but the significant details of the geomorphic history have not been fully worked out. The major streams flow west across the Coast Range.

The Oregon Coast Range is characterized by open though hilly topography. The general aspect of this range is that of a dissected plateau or up-raised peneplain, the former surface of which is determined by the hilltops and ridge crests that rise to accordant altitudes of 1,700 to 2,500 feet. The major streams—for example, the Umpqua River—are transverse to the present structure, but the minor streams show remarkable adjustment to structure and differences of rock hardness. The hills are elongate and smoothly rounded, each ridge consisting of resistant Umpqua sandstone, conglomerate, or ellipsoidal basalt. The valleys are for the most part floored by weaker shales and in such places are fairly broad and flat-bottomed; but where resistant rocks have been encountered in the process of down-cutting the valleys are narrow gorges.

The Klamath Mountains are extremely rugged, and their history is complex.[26] In their northern part the higher ridges rise to about 4,000 feet—the level of the Klamath peneplain. The major streams, such as the South Umpqua and Rogue Rivers, are transverse and flow toward the west. They show adjustment to the underlying rocks; where the rocks are hard and resist erosion the streams flow in narrow gorges, but where soft rocks predominate the valleys are broad.

The topography of the different districts is characteristic of the geomorphic section in which they are situated. The Nonpareil-Bonanza area is wholly in the Oregon Coast Range, and the Tiller-Trail area is wholly in the Middle Cascade Mountains; their physical features need no special comment. The Blackbutte-Elkhead area, however, lies in both the rugged Cascade Range and the more open Coast Range and presents some interesting developments of drainage. A few of the streams draining the area have reached grade and have developed narrow flood plains, but most of them are still actively cutting down. The Calapooya Mountains, which cross the central part of the area diagonally, form the divide between the Willamette and Umpqua drainage basins, and the descent from this divide to the Umpqua Valley is sharp and precipitous, whereas that to the Wil-

[26] Diller, J. S., Topographic development of the Klamath Mountains: U.S. Geol. Survey Bull. 196, 1902.

lamette Valley is much more gentle. The Coast Fork of the Willamette River, which flows to the north, is shifting eastward down the dip of a soft tuffaceous member interbedded with the more resistant conglomerates and lavas of the Calapooya formation.

The headwaters of the Umpqua, favored by a steeper gradient because of the shorter course to the sea, are vigorously eroding the southwest slope of the Calapooya divide, pushing it eastward and northward and encroaching on the drainage territory of the Willamette. This interpretation by the writers differs from that of Hodge,[27] who states that the Willamette River is encroaching upon the headwaters of the Umpqua, but it agrees with the earlier interpretation of Diller,[28] who has given an interesting account of the struggle of the two rivers for supremacy.

The Meadows district, in the Klamath Mountains section, also presents some interesting problems in stream development. The district is so named after the flat valley, half a mile wide, which upper Evans Creek has cut by rapid lateral erosion in the soft Umpqua sandstones. The lower, westward-flowing part of Evans Creek, which is superimposed on the hard May Creek schist, has been able to deepen its channel only slowly. It is probable that what is now the upper, southward-flowing part of Evans Creek was formerly the upper part of Table Rock Creek, flowing southward approximately along the edge of the Cascade volcanic rocks and impeded in its downward cutting by a basalt flow so that it was captured by the original Evans Creek, which had been working headward to the east until it invaded the valley of upper Table Rock Creek.

ROCK ALTERATION AND MINERALIZATION

The quicksilver deposits of southwestern Oregon are all characterized by the same type of hydrothermal alteration and the same simple mineralogy. They belong, like most of the other quicksilver deposits of the world, to the epithermal group described by Lindgren.[29]

The degree of rock alteration varies considerably in the different mines; it depends on the degree to which the rocks have been fractured, thereby permitting easy circulation of solutions.

The hydrothermal solutions that introduced the cinnabar have profoundly altered whatever rocks they entered. These solutions either were not everywhere mercury-bearing, or else conditions were not everywhere favorable for the deposition of cinnabar, for many highly altered rocks contain no cinnabar or not enough to make ore.

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[27] Hodge, E. T., Mount Multnomah, ancient ancestor of the Three Sisters: Oregon Univ. Pub., vol. 3, no. 2, p. 44, Eugene, Oreg., 1925.

[28] Diller, J. S., U.S. Geol. Survey Twentieth Ann. Rept., pp. 9–10, 1898: U.S. Geol. Survey Bull. 613, pp. 39–40, 1915.

[29] Lindgren, Waldemar, Mineral deposits, 3d ed., pp. 438–551, 1928.

The transformation of the original rocks by hypogene solutions produced striking changes in the appearance of the rocks. In many places adjacent to the principal ore bodies the rocks over areas of more than a square mile have been bleached and softened. At most localities the altered rocks are intersected by numerous small, relatively hard silica-carbonate veinlets that stand out on the surface as prominent ribs and strengthen and support the mass. Owing to the fact that these veinlets commonly contain much siderite and in some places a little pyrite, oxidation at or near the surface has stained them a dark, rich brown, causing them to stand out conspicuously against the light-colored matrix. These brown resistant veinlets are known to the miners as "iron ribs" and are perhaps the most reliable surface indication of an altered or mineralized zone. Because of their resistance to solution the ribs accumulate on the surface of the altered zone as a dark-brown rubble.

The most extreme effects of the ascending hydrothermal solutions are seen at Blackbutte, where the rocks are mostly andesitic lavas of the upper or dominantly igneous facies of the Calapooya formation. These rocks are much jointed and had been considerably broken and crushed by faulting before the solutions rose. The filling and enlargement of the anastomosing and intersecting fault fractures by silica-carbonate veins, together with the bleaching of the intervening material, has converted the rock into a mass resembling altered pyroclastic rocks more than flows (pl. 5, *A*). In some of the fault breccias the silica-carbonate material has been deposited around the fragments, outlining them in relief. Where the solutions rose through the conglomerates of the lower sedimentary facies of the Calapooya formation they deposited the silica-carbonate material in the spaces between the pebbles, and the pebbles were altered and softened.

As a result of the changes described, exposed masses of the altered conglomerate contain bleached, soft rounded bodies representing the original pebbles enclosed in a matrix of deep-brown oxidized siliceous material. At the Elkhead mine the solutions followed more or less definite sets of closely spaced joints in the tuff bed that occurs within the Umpqua formation immediately above the underlying amygdaloidal basalt. Therefore, the iron ribs, as exposed at the surface, define this joint pattern. The intervening rock material has been bleached and softened as at the localities described.

ORE AND GANGUE MINERALS

Quicksilver deposits everywhere are characterized by few ore and gangue minerals.[30] The deposits described herein are no exception

[30] Lindgren, Waldemar, Mineral deposits, 3d ed., p. 540, 1928.

to the rule and, in fact, have a simpler mineralogy than is usual. Cinnabar is their chief quicksilver mineral and the only one seen during the present examination. Metacinnabar and native quicksilver have been reported from the upper parts of the Blackbutte, Elkhead, Nonpareil, and Bonanza mines. The only other sulphides identified are marcasite and pyrite, of which marcasite is the more abundant. Arsenic in the marcasite from the War Eagle mine suggests the presence of arsenopyrite, but none was detected. The most abundant gangue mineral is calcite, and with it is usually found some ankerite or siderite. Silica occurs commonly as quartz, in places as chalcedony, and rarely as opal. Bituminous matter, common in the quicksilver mines of California [31] and elsewhere, is absent.

In the Blackbutte and nearby deposits cinnabar occurs either as small specks in the silica-carbonate veinlets (iron ribs) and the adjacent altered rock or as very small seams in crevices. In the Buena Vista and War Eagle deposits cinnabar, pyrite, and marcasite form a stockwork of stringers in fault breccia.

ORIGIN OF THE ORES

The close association of mercury deposits with volcanism is described by Becker,[32] who further observes that the cinnabar deposits of the Mount Shasta region in California and the deposits in Douglas County, Oreg., lie

> on a continuation of the group of profound dislocations which are marked by the ranges and deposits to the south [in California]. * * *. At the north, as to the south also, the deposits are formed at no great distance from lavas. The entire belt of country from the mines of Douglas County, Oreg., to Santa Barbara [Calif.] is thus structurally continuous and is marked by irregularly distributed volcanic phenomena and cinnabar deposits. In a broad sense the entire zone, 600 miles in length, may be considered as a quicksilver belt.

Since Becker's study quicksilver deposits have been found at Morton, Wash., about 300 miles north of those in Douglas County, Oreg., and his quicksilver belt may be considered as extending that much farther. Whether the deposits are connected by a continuous group of dislocations or not, it is quite true that they are associated with volcanic activity in the areas studied.

Here quicksilver is associated with late Tertiary igneous rocks, and the deposits are made up of such low-temperature minerals as chalcedony, cinnabar, marcasite, and carbonate. The constituents of these minerals were probably derived from the same general sources as the volcanic rocks of the region, which as a whole

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[31] Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U.S. Geol. Survey Mon. 13, p. 388, 1888. De Launay, Louis, Gîtes minéraux et métallifères, vol. 3, pp. 421, 439, 1913.

[32] Becker, G. F., op. cit., pp. 365–366.

have the composition of diorite. In the nearby Bohemia district diorites are exposed.[33]

RELATION OF ORE DEPOSITS TO STRUCTURE

All the quicksilver deposits in southwestern Oregon occur in rocks that have been fractured and opened by fault movements. According to Schuette [34] the localization of quicksilver deposits is always due to the presence of an overlying layer of impermeable rock. Such an impermeable bed is found at the Elkhead, Nonpareil, and Bonanza mines, where shale is interstratified with the sandstone, but there is no such impermeable layer at the Blackbutte, Buena Vista, or War Eagle mines, where the ore occurs in fault zones and is localized either within the sheared zone or else within the fault itself.

MINERAL DISTRICTS

BLACKBUTTE-ELKHEAD AREA

LOCATION AND ACCESSIBILITY

The Blackbutte-Elkhead area (see pl. 7) embraces 116 square miles in Lane and Douglas Counties and includes the villages or post-office stations of London (Calapooya Spring), Blackbutte, Elkhead, and Shoestring. It is accessible by a good road leading from Cottage Grove up the Coast Fork of the Willamette River to London and the Blackbutte mine. From London a road leads to Shoestring, and connecting roads lead from Shoestring by way of either Elkhead or Scott Valley to the Pacific Highway at Yoncalla.

TOPOGRAPHY

The Blackbutte-Elkhead area lies at the head of the Willamette Valley, mostly in the Coast Range province, though its eastern part is in the foothills of the Cascade Range. The topography of the eastern part of the area is rugged, owing to the predominance of narrow V-shaped valleys and steep, narrow serrate ridges; in the western part the valleys are open, and the ridges, though steep and narrow, are not serrate. The northeastern part of the area lies within the basin of the Willamette River and is drained by the northward-flowing Coast Fork of that stream. The western and southern parts are drained through Elk Creek and Oldham Creek to the Umpqua. The divide between the Willamette and Umpqua drainage basins is a spur of the Cascade Range known as the Calapooya Mountains, which enters from the east, turns north at Harness Mountain, and

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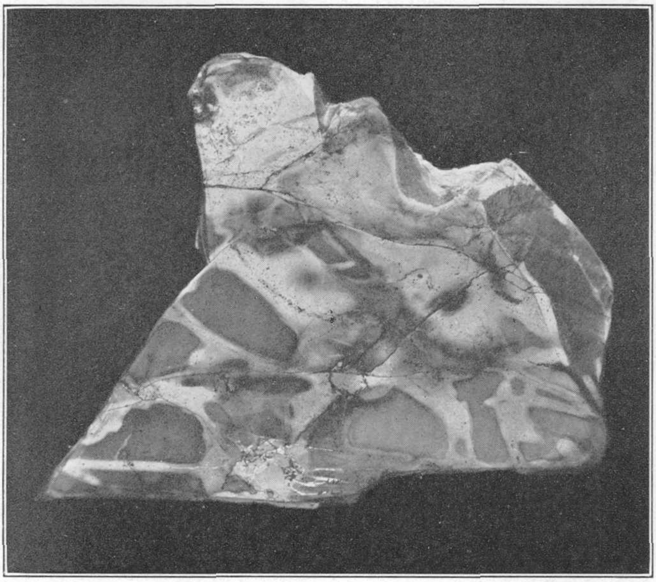
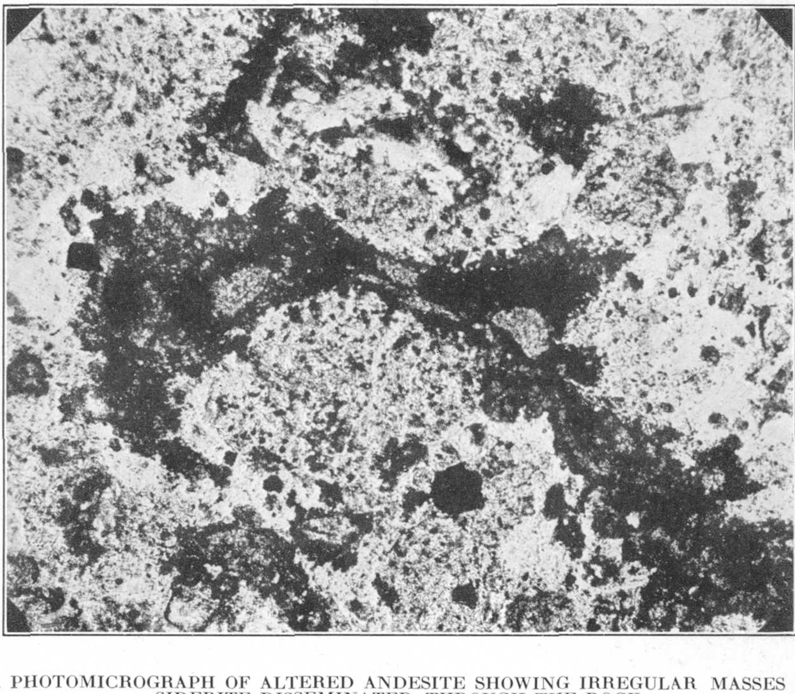
[33] Buddington, A. F., and Callaghan, Eugene, Metalliferous deposits of the Cascade Range, Oreg. (in preparation).

[34] Schuette, C. N., Occurrence of quicksilver ore bodies: Am. Inst. Min. Eng. Tech. Paper 33, pp. 8–10, 1930.

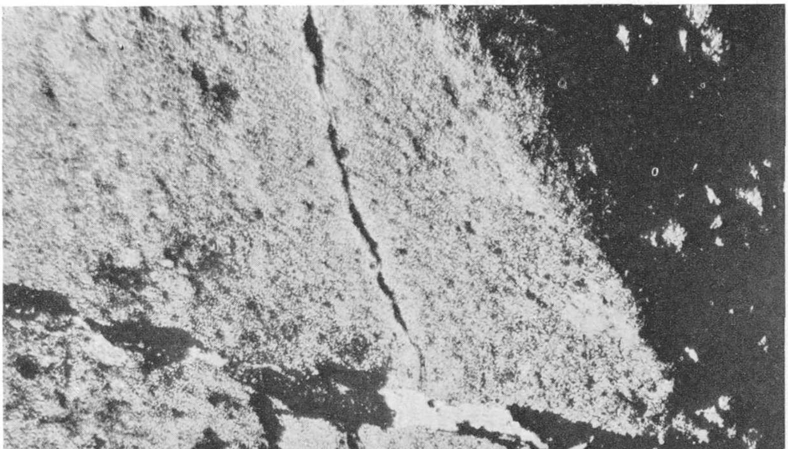


A. ANDESITE CUT AND REPLACED BY ANASTOMOSING VEINLETS OF SILICA-BEARING SIDERITE.

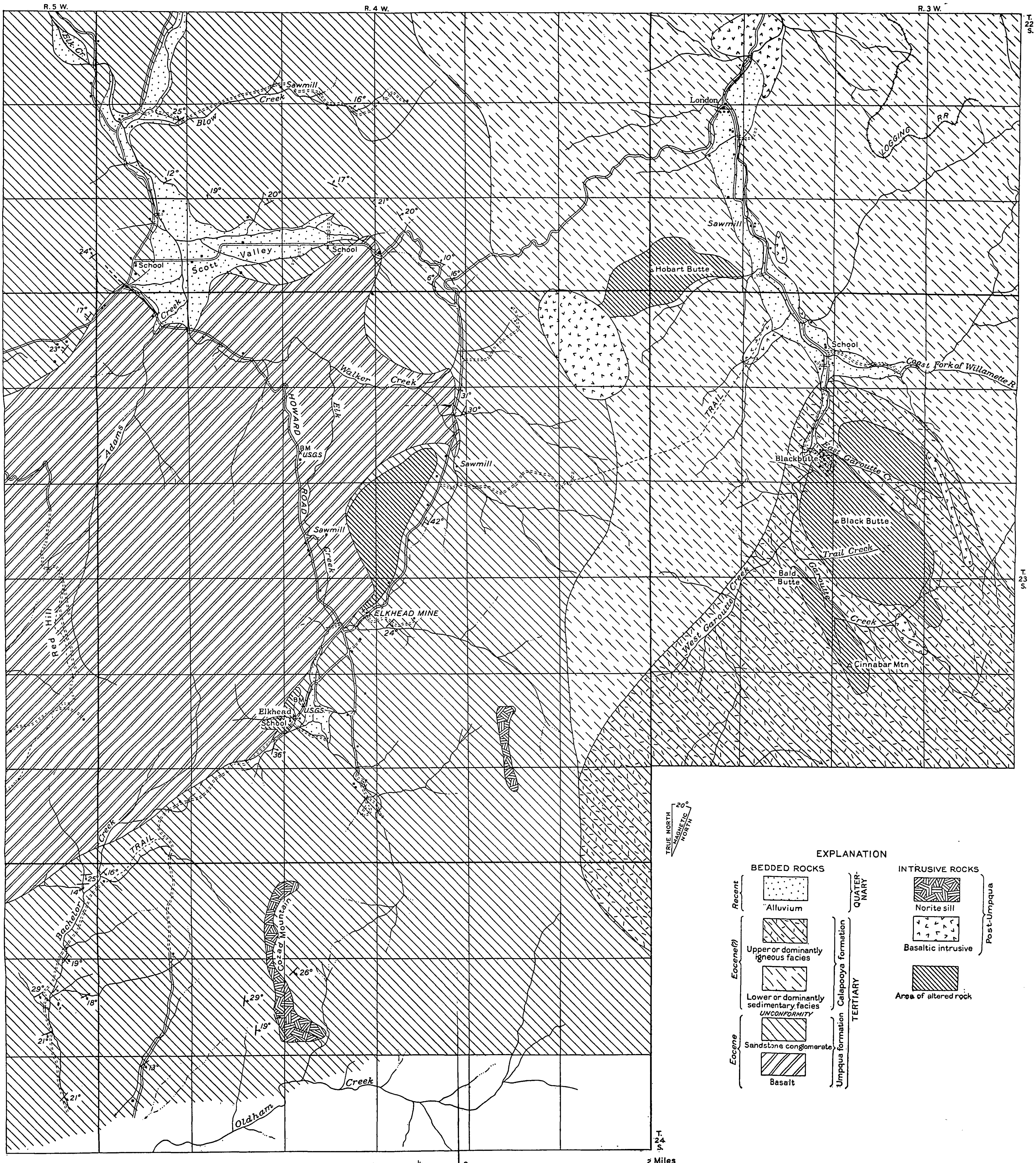


B. PHOTOMICROGRAPH OF ALTERED ANDESITE SHOWING IRREGULAR MASSES OF SIDERITE DISSEMINATED THROUGH THE ROCK.

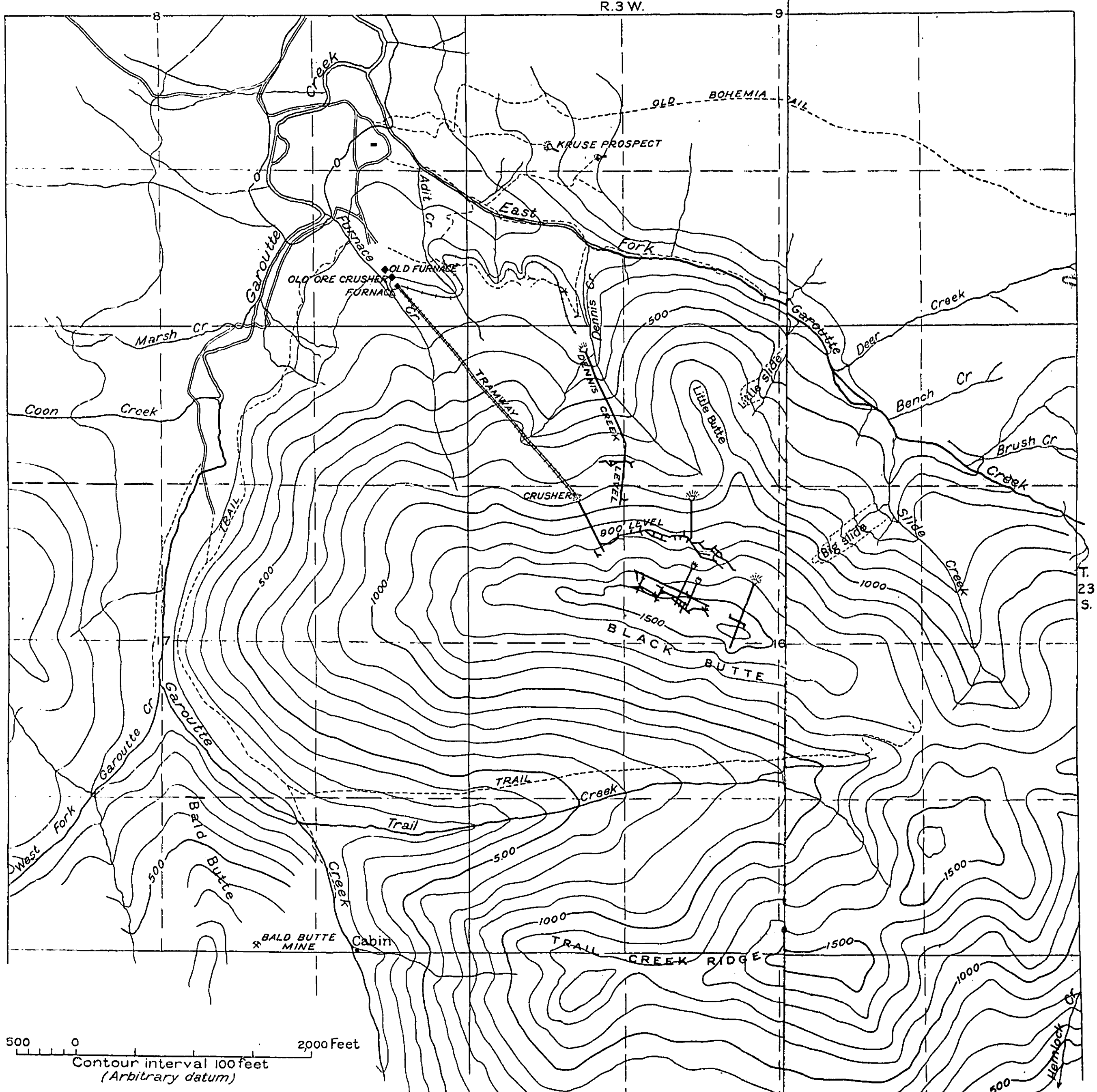
A. VEINLETS OF CALCITE AND SIDERITE CUTTING ALTERED ANDESITE.



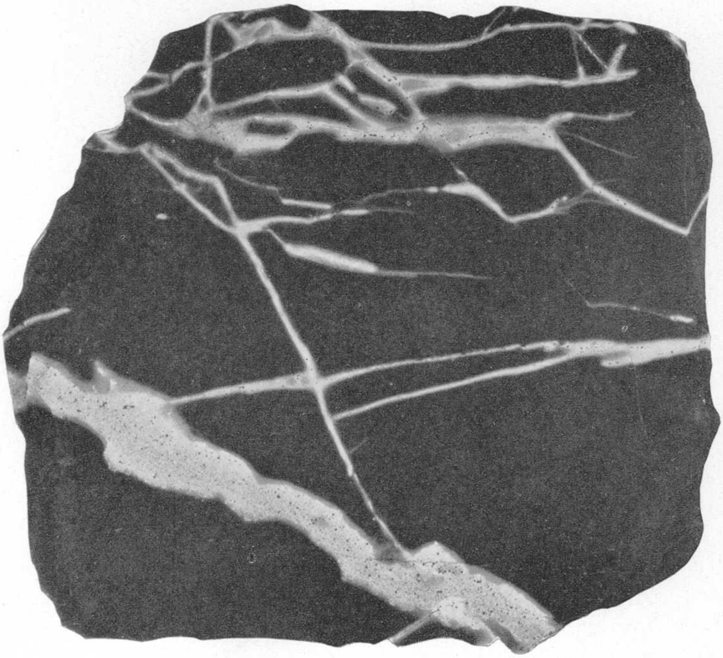
B. PHOTOMICROGRAPH OF A VEIN MADE UP PARTLY OF SILICA AND SIDERITE CUTTING ALTERED ANDESITE.



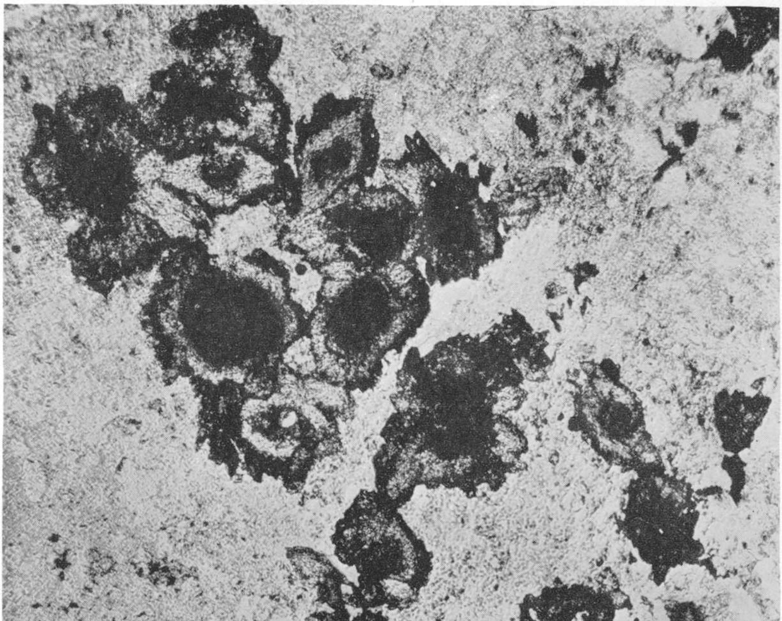
GEOLOGIC MAP OF BLACKBUTTE-ELKHEAD AREA.



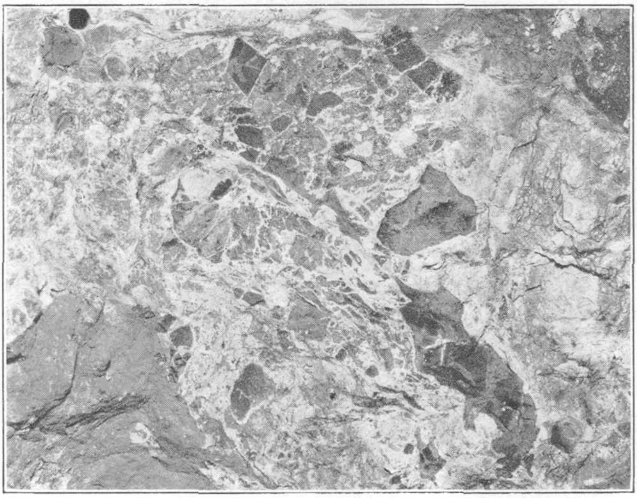
TOPOGRAPHIC MAP OF BLACKBUTTE MINE AND VICINITY.



A. SILICEOUS VEINLETS BEARING IRREGULAR SPECKS OF SIDERITE CUTTING SILICIFIED ANDESITE.

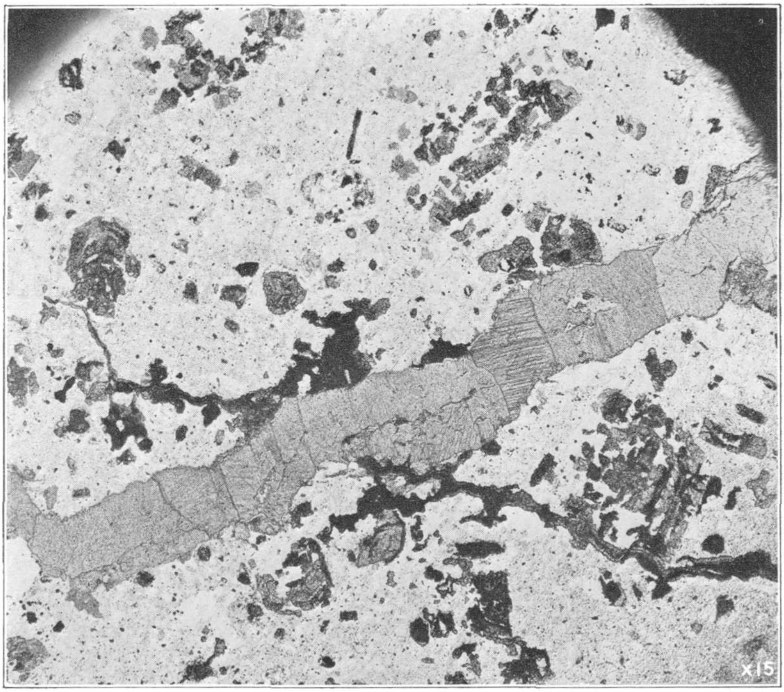


B. PHOTOMICROGRAPH OF RHOMB-SHAPED MASSES OF SIDERITE ENCLOSED IN ALTERED ANDESITE.



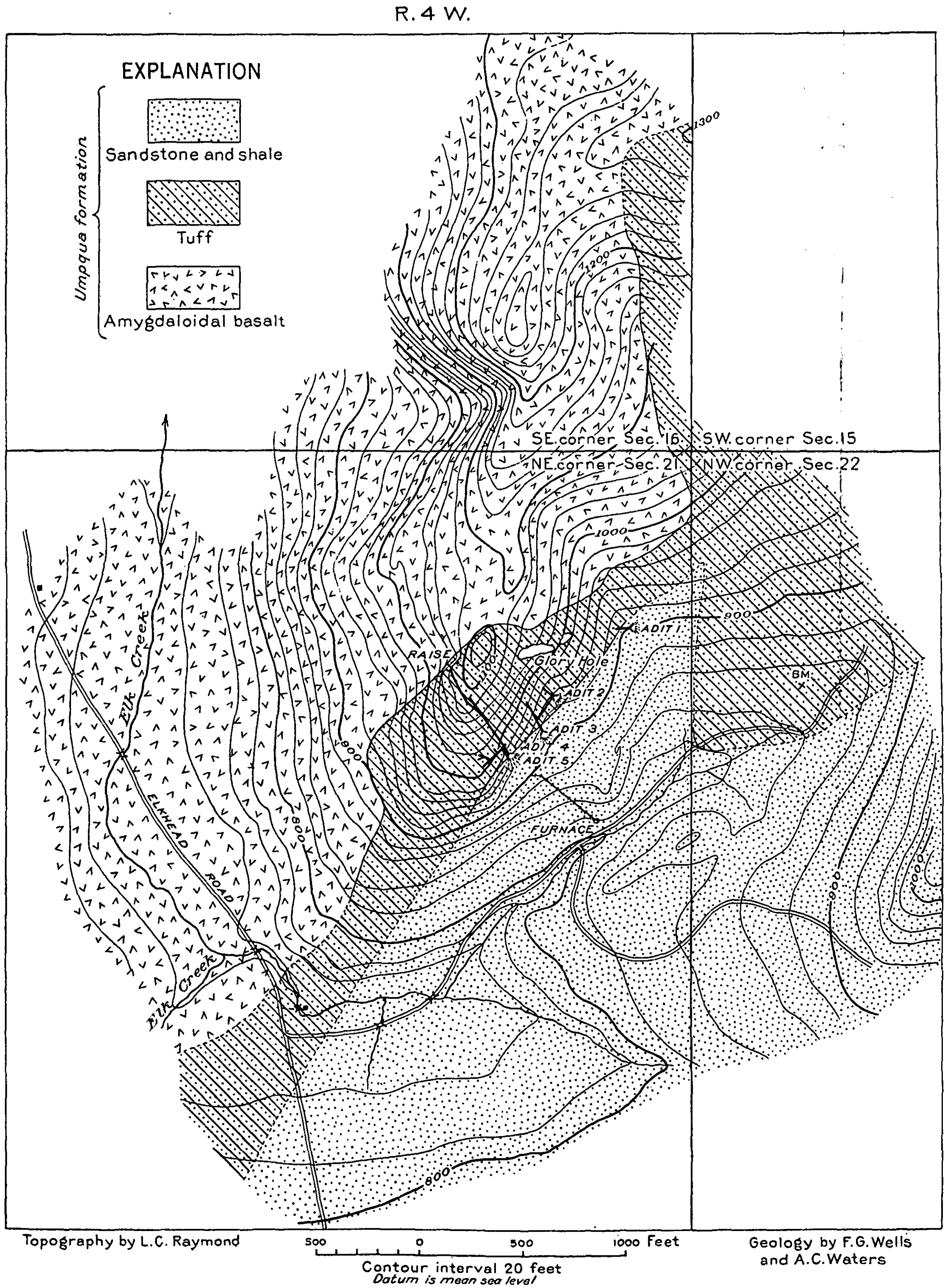
A. ANDESITE BRECCIA RIDDLED WITH VEINLETS OF CARBONATE.

Length of exposure about 6 feet. Dennis Creek tunnel, Blackbutte mine.



B. PHOTOMICROGRAPH OF ALTERED ANDESITE FROM DENNIS CREEK TUNNEL, BLACKBUTTE MINE.

The dark veinlet is siderite and the broader, lighter-colored one is calcite. The original phenocrysts of the porphyritic andesite have been replaced by pseudomorphs of siderite.



MAP OF ELKHEAD MINE AREA.

continues in that direction beyond the area under consideration. In general, the summits of the Calapooya Mountains accord in height with a surface that lies 1,000 to 3,000 feet above the stream valleys and declines toward the northwest, though a few peaks composed of resistant intrusive igneous rock rise above this surface. The altitude of this ridge as a whole gradually diminishes toward the northwest and at Divide, the lowest point, is 779 feet.

GEOLOGY

FORMATIONS

All the formations exposed in the Blackbutte-Elkhead area belong to the Tertiary system. The oldest and most extensive of these is the thick series of marine sandstones, shales, conglomerates, and intercalated basalt flows constituting the Umpqua formation. A thick series of amygdaloidal basalt flows lies at the base. Alternating beds of shale and sandstone typical of the Umpqua formation occur in the lower part. The higher sandstones become progressively arkosic and more sandy and thicker-bedded, and the shale decreases until the formation consists in its upper part of massive beds of arkosic sandstone, some of which are 100 feet or more thick, separated only by thin partings of shale. Locally, the thick sandstone layers are interbedded with well-assorted conglomerate, whose pebbles of quartz and siliceous volcanic rocks do not exceed 1 inch in diameter. Good exposures of the conglomerate occur in sec. 27, T. 23 S., R. 4 W.

An angular unconformity separates the Umpqua formation from the volcanic conglomerate, pyroclastic rocks, and lavas of the Calapooya formation. Dikes, sills, and volcanic necks of basalt and diabase intrude both the Calapooya formation and the older rocks. A thin coat of volcanic ash or of river alluvium locally forms a surficial mantle.

STRUCTURE

RED HILL ANTICLINE

The rocks of the Blackbutte-Elkhead area have been only slightly deformed. The principal structural feature of the area is an elongated anticlinal dome developed in the Umpqua formation. Its longer axis trends northeast and is indicated by the course of Red Hill. It is about 12 miles wide, and its limbs for the most part dip at angles between 10° and 18°. Near the Elkhead mine, however, the east limb of the anticline dips 30° to 50°.

The core of the anticline is made up of amygdaloidal lava, and the flanks and crest of shale and sandstone. Differential erosion of these rocks has caused the fold to be reflected in the topography. During the rise of the anticline differential movements occurred between the lavas and the sedimentary beds. Near the Elkhead mine, where the dips are relatively steep, these movements produced fractures in the tuffaceous member directly above the amygdaloidal lava, and these fractures served as paths for the ascending ore solutions. West of the junction of Adams and Elk Creeks the north limb of the fold is cut by a fault of small displacement.

The Red Hill anticline plunges to the northeast and disappears beneath the lavas and sedimentary beds of the Calapooya formation. These rocks are not involved in the folding but lie on a surface eroded across the anticline. This unconformable contact is well exposed near the headwaters of Blow Creek. (See p. 13.) The Calapooya formation, although locally warped, is characterized in most places by a gentle regional dip to the east and northeast. This dip is everywhere at a low angle, commonly about 2° or 3°, rarely more than 8° or 10°.

FAULTS

Much of the ore obtained from the Blackbutte mine has been taken from a block bounded on the southwest by a fault that strikes S. 69° E., dips steeply southwest, and cuts the upper or lava facies of the Calapooya formation. This fault has been mapped in the Blackbutte mine (pl. 9), but it and other faults in the vicinity are so obscured by wide zones of intensely altered rock that they have not been traced on the surface and are therefore not shown on plate 7, although the enclosing areas of altered rock are shown. The throw of this fault is unknown, but it is insufficient to bring the underlying formations to the surface or to expose them in the mine. Other faults cut the Calapooya, but they are very difficult to trace because of the absence of definite stratigraphic markers within the formation. Faults associated with the mineral deposits of the Blackbutte and Elkhead mines and the Bald Butte, Cinnabar Mountain, and Sullivan prospects are described on page 21.

MINES AND PROSPECTS

BLACKBUTTE MINE

Location, history, and production.—The Blackbutte mine is in the NW¼ sec. 16, T. 23 S., R. 3 W., about 15 miles south of Cottage Grove, on the slope of a sharp-crested butte, 1,650 feet in height. (See pl. 8.) The following account of the history and production is taken from a report by Elmer:[35]

> The principal vein in the district was discovered in the early nineties. Prior to 1900 only a small amount of development work was done on the property, and the equipment for the reduction of the ores consisted of a 40-ton Scott-Hutner furnace with series chamber condensers operated by natural draft. In 1898 the property passed into the hands of W. B. Dennis, who, in suc-

[35] Elmer, W. W., Mining methods and costs at the Blackbutte quicksilver mine, Lane County, Oreg.: U.S. Bur. Mines Information Circular 6276, p. 2, 1930.

ceeding years up to 1908, extended the workings of the former holders and opened new levels. A total of 15,000 feet of development work was done. The property lay idle until 1916, when, due to the high price of quicksilver, it was operated by a substantial mining organization under lease and bond until April 1919. During this active period the Scott-Hutner furnace was rehabilitated and the natural draft altered to an artificial down draft furnished by two 42-inch suction fans, increasing the capacity about 25 percent. An improved dust chamber, an intermediate water-cooled cast-iron pipe condenser, an elaborate supplementary condenser constructed of brick and concrete, and 18-inch clay pipes, water-sprayed, were also added.

Due to the fall in the price of quicksilver at the close of the World War, the property was closed down in 1919 and remained idle until 1927. Operations were resumed in the fall of 1927 under the management and ownership of the Quicksilver Syndicate. The old Scott-Hutner furnace has been dismantled and replaced by two rotary furnaces, each 60 feet in length and 4 feet outside diameter, having a normal combined capacity of 150 tons per 24 hours.

No records of production before 1916 are available. The subsequent production of quicksilver from the property has been as follows:[36]

	Flasks
1916–19	1,271
1927	139
1928	1,000
1929	1,313

Development and workings.—The ore body of the Blackbutte mine has been developed by six levels, connected with one another by raises and with the surface by a series of adits driven from the northeast side of the butte. (See pl. 9.) In 1928 and 1930 the Dennis Creek tunnel, 660 feet below the lowest or 900-foot level, was driven into the fault that joins the footwall of the main ore body, and in 1930 a drift was being driven on the fault and a raise was being put up along it toward the 900-foot level. Ore had been found in the Dennis Creek tunnel, but its limits had not been determined. Altogether the workings in 1930 had developed ore through a vertical range of about 1,250 feet and along the strike for a maximum distance of 1,200 feet. The production in 1930, which amounted to about 100 tons a day, came mostly from the 900- and 600-foot levels. New ore was being opened up along the fault by a southeast drift on the 900-foot level.

Rock alteration and mineralogy of the ores.—The mountain known as "Blackbutte" is composed of andesitic lavas and breccias of the upper facies of the Calapooya formation, which have been so profoundly whitened and bleached by hydrothermal solutions that the original character of the rock is almost unrecognizable in the field. Silica-carbonate veins, weathered at the surface to brown iron ribs,

[36] Elmer, W. W., op. cit., p. 3.

are of almost universal occurrence. They are thickly massed in the brecciated and locally silicified andesite adjacent to a well-defined fault that strikes approximately S. 69° E. (See pl. 5, *A*.) The trace of this fault lies along the summit of the mountain and is marked for a distance of over 1,000 feet by a series of conspicuous crags, commonly 100 feet or more in height. These crags are composed of silica-carbonate ribs and large masses of silicified rock, whose resistance to erosion has held up the jagged crest of the butte while the adjacent calcitized and softened rocks were removed. The crags have been illustrated and described by Dennis.[37] Rock containing sufficient amounts of cinnabar to constitute ore occurs in a zone adjacent to this fault.

In spite of the thorough alteration of the lavas at Blackbutte, close examination generally reveals the outlines of altered phenocrysts of feldspar or hypersthene, and under the microscope the original texture of the lava and the outlines of some of the original minerals are generally well preserved. Thus rod-shaped aggregates of cryptocrystalline silica and siderite suggest original crystals of hypersthene, and mats of sericitic and siliceous alteration products suggest original tabular crystals of feldspar. In places, however, volume changes that accompanied the alteration have obliterated the original structure and texture.

Two different alteration products, distinguished by their relative amounts of silica, may be recognized—the silica-carbonate veins and associated silicified rock (see pls. 5, *B;* 6, *A*, *B*) and a softer material containing sericite and abundant carbonates, especially calcite, with minor amounts of silica.

The silica-carbonate veins are composed chiefly of chalcedony, but locally considerable quartz may be present. Opal was identified in only one specimen. Siderite occurs in nearly all the veins and is in general closely mingled with the chalcedony, the two being of contemporaneous origin (pl. 10, *A*). In some specimens the siderite forms minute grains; in others it occurs as irregular bodies, rhombs (pl. 10, *B*), or rarely as spherulites. Adjacent to the veins the rock is largely replaced by chalcedony and siderite. Commonly the original form of hypersthene crystals that have been replaced by siderite is preserved. Cinnabar commonly occurs in the middle of the silica-carbonate veins or fills minute cracks in them or occurs as small grains entirely enclosed by the other minerals. It is thus indicated to have been introduced essentially at the same time as the chalcedony and siderite, though mostly during a late stage of the process.

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[37] Dennis, W. B., The quicksilver deposits of Oregon: Eng. and Min. Jour., vol. 76, pp. 539–541, 1903.

Calcite which caused the second type of alteration was introduced by solutions of deep-seated origin during and after the deposition of cinnabar. In places calcite fills fractures that follow the middle of cinnabar veinlets or branch across them. The large body of calcite described below encloses isolated grains of cinnabar. The calcite for the most part fills small fractures and also replaces original rock minerals, locally forming as much as 25 percent of the mass. Calcite veinlets cut veinlets of siderite (pl. 11, *B*), as shown on each level of the Blackbutte mine, particularly in the Dennis Creek tunnel, which is below the oxidized zone. Along the principal fault where exposed in the Dennis Creek tunnel calcite forms a body more than 30 feet thick. It contains inclusions of altered andesite, and irregular stringers branch from it on both sides (pl. 11, *A*). At the 900-foot level a cavern 10 to 20 feet wide in places opens along the fault. When discovered, this cavern, called the "China stope", was nearly filled with water. In August 1930, when the Dennis Creek tunnel, 666 feet below the "China stope", struck the calcite body, the cavern was suddenly drained. Evidently open fissures connect the two, and the cavern is assumed to have been formed by the solution of the upper part of the calcite body by descending surface water. The horizontal extent of the calcite body has not been determined.

The minor minerals in the Blackbutte deposit include sericite derived by decomposition from the feldspars, opaque iron oxides, and a little chlorite derived from augite and hypersthene. In addition, there is more or less claylike material. Small amounts of marcasite occur in ore from the 400 and 900 foot levels, but their relations to the other minerals have not been made out. Vugs in the silica-carbonate veinlets are commonly lined with small quartz crystals. In the oxidized ores from the upper levels metacinnabarite and native quicksilver are of rare occurrence. Neither alunite, which is common in cinnabar deposits in altered rhyolite in Nye County, Nev., nor jarosite,[38] which is common in California quicksilver ores, was identified at Blackbutte.

Oxidation.—Oxidation and leaching by surface waters have affected the silica-carbonate gangue of the Blackbutte deposit more or less to a depth of nearly 1,000 feet, and very noticeable changes in the appearance of the rock have been produced. Secondary limonite has stained the silica-carbonate veinlets a deep-brown color, converting them into the iron ribs. Commonly the rock between the ribs is stained a dull yellow or light brown with the same material. In general, however, the iron ribs contrast so strongly with the lighter-colored groundmass that they appear to be veins of

[38] Knopf, Adolph, Some cinnabar deposits in western Nevada: U.S. Geol. Survey Bull. 620, pp. 55–60, 1920.

primary oxides. Close examination of the material from different parts of the mine shows that all stages of transition from unaltered siderite to iron oxides occur. In some parts cavities are filled or lined with the oxides. In the "China stope" at the 900-foot level a coating of iron oxides is 1 foot thick. In the partly oxidized veins the microscope shows that the limonite is a film deposited on the surfaces of other minerals. Locally it has wandered into the adjoining rock, but most of it has not migrated beyond the limits of the original veins.

Unoxidized silica-carbonate veins found in the Dennis Creek tunnel are light-colored. Except for a very small amount that may have been derived from marcasite, the limonite has had its source entirely in the oxidation of siderite.

Relation of the ore bodies to faults.—The altered and more or less mineralized bodies in the Blackbutte-Elkhead area are associated with zones of folding and faulting. Instead of being long and narrow, however, as is common to deposits related to fractures, the bodies in this area are relatively wide. The one at Blackbutte is 1 mile wide and 2 miles long. This condition is apparently due to the fact that the andesite adjacent to the fault was easily permeable. In passing through the denser formations that underlie the Calapooya formation the mineralizing solutions were probably closely confined to the fault fracture. Having reached the permeable rocks, however, they spread out, but were still most effective along and near the main fracture. Therefore, the best ore has been found in brecciated rock along or near the fault plane.

The ore forms indefinitely bounded shoots that trend northwest. Beyond the limits of the material classified as ore small amounts of cinnabar are disseminated through the entire mountain.

A postmineral fault with a slickensided surface that strikes S. 69° E. and dips 58° NE. forms a wall of an ore body in the upper levels. As shown on the 200- and 400-foot levels this fault plane cuts across the mineralized breccia. In the Dennis Creek tunnel it is in places smeared a brilliant red with cinnabar. The fault is evidently later than the ore and is probably due to a recurrence of movement along the earlier fracture. The displacement caused by movements along this fault cannot be definitely determined, but it was not extensive enough to elevate the beds beneath the Calapooya formation to the level of the Dennis Creek tunnel.

Ore shoots.—Though a large mass of rock has been altered and impregnated with minute quantities of cinnabar, mining operations at Blackbutte have disclosed indefinitely bounded ore shoots distributed along the fault for several thousand feet horizontally and about 1,200 feet vertically. The larger of these bodies are on the upper levels. The boundaries of the shoots are determined by the tenor of the ore. The difference in quicksilver content between the richest ore and waste is only 2 or 3 pounds to the ton. With the exception of a little bonanza ore (see p. 25), found at the highest level, few of the ore bodies run more than 5 pounds of quicksilver to the ton. Under the conditions prevailing before 1931 material as low in grade as 3½ pounds could be profitably worked. Because the change from richer to poorer material is gradual, the size of bodies large enough to be classified as ore varies with changes in costs, market value of quicksilver, or other conditions. Frequent sampling is obviously necessary to delimit workable material.

The vertical extent of the quicksilver deposit at Blackbutte is noteworthy. Mining operations have disclosed the presence of workable material at a depth of 1,200 feet along the dip of the fault, though this ore has not yet been proved to be continuous with the ore at higher levels.

BALD BUTTE, CINNABAR MOUNTAIN, AND SULLIVAN PROSPECTS

On the southwest side of Garoutte Creek in secs. 17, 20, 21, and 28, T. 23 S., R. 3 W., a zone of altered andesitic lavas about 2 miles long and a quarter of a mile wide marks the outcrop of a fault zone that trends N. 15°–35° W. At Cinnabar Mountain, in sec. 21, and on Bald Butte, in secs. 17 and 20, the rock of the fault zone, because of the resistant iron ribs in it, forms a steep wall-like ridge locally crowned by a series of jagged crags. These crags present the same features of alteration as the rock at Blackbutte. More than a dozen prospects have been made in the outcrop of the iron-ribbed material on both Cinnabar Mountain and Bald Butte without finding any cinnabar. None of them reveal unoxidized carbonate-bearing rock.

A similar wall of iron-ribbed crags that occupies the crest of the mountain between Trail Creek and Garoutte Creek is probably the outcrop of another altered fault zone in the upper or lava facies of the Calapooya formation, although the only evidence of faulting obtained in the field was the presence here and there of masses of slickensided rock and the occurrence of highly altered breccias in some of the crags. No prospect pits were found along this ridge. The iron ribs are as abundantly developed as they are along the trace of the fault at the summit of Blackbutte, and it is possible that development work may yet reveal the presence of ore.

Many claims have been located on a mass of altered rock on the north side of East Garoutte Creek, which roughly parallels the zone containing the Blackbutte mine. A small amount of prospecting work, done chiefly on the Sullivan claims, shows highly altered andesite cut by a few silica-carbonate veinlets now oxidized to iron ribs. No cinnabar was seen, but panning and assay tests are reported to show small quantities.

HOBART BUTTE

Hobart Butte is a rounded upstanding mass of altered rock on the west side of the Willamette Valley about midway between Blackbutte and London. No cinnabar has been found in it, but the outcrops show pronounced iron ribs and other evidences of rock alteration similar to those at Blackbutte. The material at Hobart Butte, however, differs from that at Blackbutte in that it is a coarse conglomerate in the lower or dominantly sedimentary facies of the Calapooya formation. The oxidized deep-brown silica-carbonate material forms a cement that binds the altered andesite cobbles together.

ELKHEAD MINE

History, production, and workings.—The Elkhead mine is in the NE¼ sec. 21, T. 23 S., R. 4 W., about 6 miles east of Yoncalla, a station on the Southern Pacific Railroad. The deposit was discovered about 1870, and for many years the ore was mined from an open pit and retorted in primitive furnaces. In 1895 a 10-ton Scott furnace was built, but shortly after the erection of the furnace the principal owner died and the property was shut down. Since that time the mine has been worked by different lessees, who have mined and retorted some ore. Newland [39] states that the mine had yielded $30,000 worth of quicksilver up to 1903, but no figures for later production are available. Much of the production came from two glory holes. These and the other workings, which consist of a tunnel about 1,000 feet long and a raise, are shown in plate 12.

Rocks.—The Elkhead mine is on a zone of altered rock that follows the contact between tuffaceous sandstone and underlying amygdaloidal basalt that marks the boundary between upper and lower members of the Umpqua formation. (See pl. 13.) The tuffaceous sandstone is about 100 feet thick and is overlain by a bed of shale. These beds lie on the east limb of the Red Hill anticline (see p. 27) and dip about 40° SE. A fault that strikes N. 50° E. and dips 58° SE. is crossed at the entrance to adit 5. (See pl. 12.) This fault causes the shale to abut against the tuffaceous sandstone.

Rock alteration and mineralization.—Although the rocks at this locality differ somewhat from those at Blackbutte, the net result of their alteration has been the same. In the Elkhead area the out-

[39] Newland, D. H., Mineral Industry, vol. 12, p. 311, 1904.

crop of the altered zone is marked, as at Blackbutte, by a covering of hard brown rubble derived from the disintegration of the resistant oxidized silica-carbonate veinlets. These veinlets cut both the amygdaloid and the overlying tuffaceous sandstone, but they are most abundantly developed along joints and fractures in the sandstone. The amygdaloid has been bleached to a light gray or pale purple, but the sandstone preserves its original color except where oxidation of the siderite has changed it to dark brown.

The original microscopic textures have been very well preserved in the altered amygdaloid. In ordinary light the original outlines of the feldspars and ferromagnesian constituents of the rock and of the amygdaloidal fillings can be very clearly seen, although under crossed nicols nothing but a minutely granular mat of cryptocrystalline silica, siderite or limonite, and other alteration products is visible. As most of the workings are in the oxidized zone, most of the original siderite is represented in the specimens studied by films of limonitic material. Cinnabar is disseminated throughout the altered amygdaloid in very minute irregular grains. Locally the rock is so thoroughly impregnated with these minute masses of cinnabar that it has a dull-red appearance, but large masses of pure cinnabar are never found.

Iron ribs are conspicuously developed in the thoroughly altered and much fractured tuffaceous sandstone, but here and there microscopic remnants of siderite can be seen. Locally these ribs branch irregularly from the main fissures.

Relation of mineralization to structure.—In the Elkhead district rock with sufficient cinnabar to form ore is confined, so far as known, to a relatively small area, but outcrops of altered rock containing iron ribs can be found along a zone of variable width nearly 4 miles long. This zone closely follows the contact between the amygdaloid and the overlying tuffaceous sandstone. This contact afforded a place for the deposition of the ore, partly because the fractures that were developed along it during folding later admitted the ore-bearing solutions and partly because the overlying shale formed an impermeable cover.

Ore reserves.—The ore found in the Elkhead mine, like that at Blackbutte, is of low grade, generally running 5 pounds or less of quicksilver to the ton. As the adits are not far below the summit of the ridge, the amount of ore to be developed above them is correspondingly limited. The amount of ore below them may be large but it must be hoisted, thereby adding to the cost of mining. There is nothing to indicate that the ore below the adit is richer than that above.

NONPAREIL-BONANZA AREA

LOCATION AND ACCESSIBILITY

The Nonpareil-Bonanza area lies in northern Douglas County, in T. 25 S., R. 4 W., and is easily accessible by a good road from Sutherlin, on the Southern Pacific Railroad, which lies about 6 miles to the west.

TOPOGRAPHY

The Nonpareil-Bonanza area is characterized by elongate, smoothly rounded hills and fairly broad, flat-bottomed valleys. The maximum relief is a little less than 2,000 feet, and the average is between 500 and 1,000 feet. The topography shows remarkable adjustment to structure. Each ridge is composed of resistant Umpqua sandstone, conglomerate, or ellipsoidal basalt. The valleys are floored for the most part by shale.

GEOLOGY

Except possibly for a few diabase dikes in its northwest corner, the Nonpareil-Bonanza area is underlain entirely by rocks of Eocene age. These rocks constitute a part of the Umpqua formation and associated igneous rocks as mapped and defined by Diller. Although most of the rocks are bedded sandstones and shales, in all respects similar to the Umpqua strata in the Blackbutte-Elkhead area, there are several beds of conglomerate and a considerable thickness of ellipsoidal basaltic lavas as well as local masses of palagonite tuff and breccia. The conglomerate and the palagonite-bearing rocks all lie adjacent to the masses of ellipsoidal basalt. The distribution of the different rocks is shown on plate 14.

ROCKS

Umpqua formation.—All of the central and northwestern part of the area is underlain by typical interbedded shale and sandstone of the Umpqua formation. Sandstone is perhaps a little more abundant than in the Blackbutte-Elkhead area, but there is no single stratum of massive sandstone equal in thickness to the one exposed in that area. Local beds of tuffaceous material occur at a few horizons interbedded with the shales and sandstones. One of them is well exposed in the western part of sec. 26, T. 24 S., R. 4 W. A similar bed or possibly a continuation of the same bed is exposed in the tunnels of the Nonpareil mine. This tuffaceous stratum contains considerable glauconite, a potash-bearing mineral commonly found in marine sediments. Most of the strata, however, consist of the alternating gray shale and micaceous sandstone.

Interstratified conglomerate, basalt, and palagonite tuff of the Umpqua formation underlie most of the southeastern part of the area. The conglomerate crops out in long bands that have a northeasterly trend. The general description of the conglomerate given on page 8 is completely applicable to that in the Nonpareil-Bonanza area, except that here the conglomerate is mostly characterized by pebbles 1 inch or more in diameter. The basalts, though irregular in area, occur in general in lenticular masses with their longer axes trending northeast. They are dense black rocks, mostly discolored in the outcrops. Most of the flows are ellipsoidal in structure, though massive flows are present. Amygdaloidal basalt is rare.

The palagonite tuff and breccia are closely associated with the ellipsoidal lavas. They may occur intimately intermingled with ellipsoids in all proportions or as definite strata not in contact with the lavas, though nowhere far distant from it. The distribution of the beds of tuff is shown on plate 14. The fine-grained tuff resembles a hard mudstone. On fresh fracture it is dark green or steel-blue, but it very quickly turns to dull black and resembles a fine-grained carbonaceous sediment.

Olivine diabase dikes.—The only intrusive rocks in the Nonpareil-Bonanza area are the three large olivine diabase dikes in the northwestern part of the area and a few small, poorly exposed dikes that are not shown on plate 14. The large dikes strike northeast and are nearly vertical. The rock composing them, even at their outcrops, is dark gray to black, very fresh, and rather coarsely crystalline.

STRUCTURE

Except in the extreme northwestern part of the area, where a small anticline is well developed, and in a few other places, the strata of the Umpqua formation dip 20°–65° SE. and average about 30°. This dip is expressed in the northeast trend of the ridges and valleys.

Over small areas the structure of the Umpqua formation is highly complex. Along the valley of Calapooya Creek in secs. 7 and 8, T. 25 S., R. 4 W., there has been a considerable amount of crumpling of the sandstone and shales into small, rather symmetrical anticlines and synclines, which plunge southwest. In sec. 8 the axes of 16 of these folds are crossed by the creek in a distance of about three quarters of a mile.

An obscurely defined fault or shear zone runs through the hill on which the Nonpareil mine is located.

MINERALIZED AREAS

A rather definite linear zone of altered rock with a northeast trend crosses the Nonpareil-Bonanza area, lying in most places about a quarter of a mile to 1 mile northwest of the ellipsoidal lavas and associated tuff. This zone swells and pinches irregularly and, as shown on plate 14, is by no means continuous across the entire area. In general it appears to follow a zone of shearing, but no evidence of marked displacement has been found along it.

In the four areas shown on plate 14 the sandstone has been greatly bleached and discolored by hydrothermal solutions, and at each of these areas quicksilver ore has been mined or prospected for. These areas, in order from north to south, are (1) the southern part of sec. 26, T. 24 S., R. 4 W., containing the Butte prospects; (2) the south end of the ridge separating Long Valley Creek from Calapooya Creek, on which is the Nonpareil mine; (3) the eastern slope of the isolated hill in sec. 16, T. 25 S., R. 4 W., in which is the Bonanza mine; (4) a continuation of the zone about 1½ miles southwest of the Bonanza mine, containing the Sutherland prospects. In each of these areas the superficial appearance of the altered rock is much the same, but so far only the bodies upon which the Nonpareil and Bonanza mines are located have been productive.

BUTTE PROSPECTS

A series of abandoned prospects, known as the Butte prospects from the conspicuous mountain rising northeast of them, are located in the southeastern part of sec. 26, T. 24 S., R. 4 W. The principal tunnel has caved, but material collected from the dump is a broken and brecciated tuffaceous sandstone cemented by iron ribs. A short tunnel nearby exposes the same rock in place. No cinnabar was seen. The zone of altered rock in which the prospects are located is little more than 100 yards wide, but it is nearly a mile long. (See pl. 14.)

NONPAREIL MINE

History, location, and workings.—The Nonpareil mine was discovered some time prior to 1870, when the New Idria Co. was formed to work the property. The Oregon Cinnabar & Silver Mining Co. was incorporated in 1882, and the property remained in its hands until acquired by the Nonpareil Quicksilver Co., which started work in the fall of 1928. Nothing concerning production prior to 1928 could be learned, although the old workings and the ruined remains of a Scott furnace indicate that considerable ore was mined and treated.

The mine is in secs. 3 and 10, T. 25 S., R. 4 W., on the southeast slope of a long ridge that trends N. 45° E. The old workings (pl. 15) are all at the south end of the ridge, but during 1929 and 1930, eight short adits were driven into the east slope of the ridge from 1,800 to 3,200 feet northeast of the old mine and at altitudes of 1,000 to 1,200 feet, thereby extending the prospected area to a belt about 3,600 feet long.

The old mine comprises about 2,000 feet of workings and consists of three adit levels which have explored the mineralized area to a depth of about 175 feet. (See pl. 16.)

The deposit occurs in a bed of arkosic sandstone of the Umpqua formation. The sandstone is about 155 feet thick and is overlain and underlain by shale. Within this bed is a tuffaceous variant which was probably originally of andesitic composition but is now too badly altered to permit precise determination. The formation strikes N. 35° E., dips about 41° SE., and contains at several places what appear to be bedding-plane faults.

With the exception of adit 3 north all the adits northeast of the old mine are in altered tuffaceous sandstone. Adit 3 north, however, passes from shale into altered sandstone and back into shale; the sandstone bed is 60 feet wide and dips 41° SE. The shale that formerly covered the sandstone at the other adits has been removed by erosion, and the sandstone crops out in very steep slopes and crags. Evidence of the usual type of alteration (see below) is found in all the adits. Bedding-plane faults also occur.

Rock alteration and mineralization.—The arkosic sandstones have been profoundly altered, and the shales were locally affected. There is no essential difference in the character of the alteration from that shown at Blackbutte and Elkhead, except that relatively more siderite and less calcite and silica may have been introduced. Veins of siderite almost free from silica or calcite cut the rock in all directions. They are especially conspicuous in the upper part of the mine, where oxidation has converted them to the characteristic iron ribs. The relatively smaller amount of silica caused the outcrop to be less resistant and the rubble derived from it to be thinner than at Blackbutte. Crags comparable to those at Blackbutte are found only at the outcrop above the Nonpareil mine.

In the rock penetrated by adit 2 of the Nonpareil mine siderite veinlets have filled a multitude of closely spaced joints. Oxidation has converted the veinlets to a network of iron ribs that stand out prominently from the bleached sandstone groundmass. (See pl. 17, *A*.) Commonly where two siderite veins cross, the oxidation products have soaked into the adjacent sandstone, forming large, conspicuous brown smears at the point of intersection. (See pl. 17, *B*.) Calcite also occurs in definite veins, which are leached and discolored in the oxidized zone; it is locally absent from the ores. In contrast to the altered zone at Blackbutte, veins of silica are exceedingly rare.

In the deeper parts of the mine, below the zone of oxidation, the altered sandstone is a very firm, resistant medium-gray rock, tightly cemented by siderite, silica, and locally calcite; it has been called andesite in previous descriptions of the mine. This rock effervesces slowly in acid, showing that the carbonates are finely disseminated throughout. Under the microscope it appears as a mass of alteration products enclosing unmodified fragments of detrital quartz. The original feldspars of the sandstones have been converted to masses of sericite or have been replaced by pseudomorphs of siderite or silica. Minute veinlets of siderite or more rarely of calcite penetrate the rock in all directions and connect with the larger veinlets.

The bed of tuffaceous material exposed in the mine appears to have originally consisted largely of grains of some ferromagnesian mineral, feldspars, and probably large amounts of glass. It also contains fragments of foraminifers and echinoids. Under the action of the hydrothermal solutions the ferromagnesian minerals and a part of the groundmass have changed to a deep-green chlorite, the feldspars have been largely converted to carbonates and other decomposition products, and the original glassy material has been converted to a turgid semi-isotropic mass of siliceous material crossed by numerous siderite veins.

The ore occurs in beds of tuffaceous sandstone as irregular shoots that pitch toward the southeast. Cinnabar, the ore mineral, may occur disseminated through the sandstone in minute grains, or it may occur in distinct veinlets of megascopic size and in small irregular blebs. The limits of the ore are very irregular in outline and do not follow any definite structure. Furthermore, the ore is not confined to a single bed in the sandstone but is found in any bed showing the alteration described above. The rocks exposed in 1930 in adits 1 and 2 north showed an unusually heavy impregnation with cinnabar and averaged about 2 percent of quicksilver.

BONANZA MINE

The Bonanza mine was discovered about the same time as the Nonpareil, between 1860 and 1870. Nothing could be learned of its early history or production, the only record of its former activity being the old workings and the remains of an old Scott furnace still standing.

The mine is in sec. 16, T. 25 S., R. 4 W., about a mile southwest of the Nonpareil mine, on the southwest extension of the same mineralized belt. The workings, which consist of a glory hole and 8 adits, all less than 250 feet long, are on the east slope of a ridge between altitudes of 900 and 1,120 feet. (See fig. 2.)

The ore occurs in beds of altered tuffaceous sandstone of the Umpqua formation, which are interstratified with layers of shale. (See pl. 18.) The beds of sandstone do not exceed 50 feet in thickness and contain scattered shaly layers a few inches thick. They strike northeast and dip 40°–55° SE. Bedding-plane faults are present.

The rock alteration and mineralization are similar to those at the Nonpareil mine. All the workings are in the oxidized zone, however, and so the fresh, unweathered calcitized rock is not exposed. The ore is of the low-grade, disseminated type, though small veins of very rich ore as well as the mineral metacinnabar and native mercury are reported to have been found in the old workings.[40]

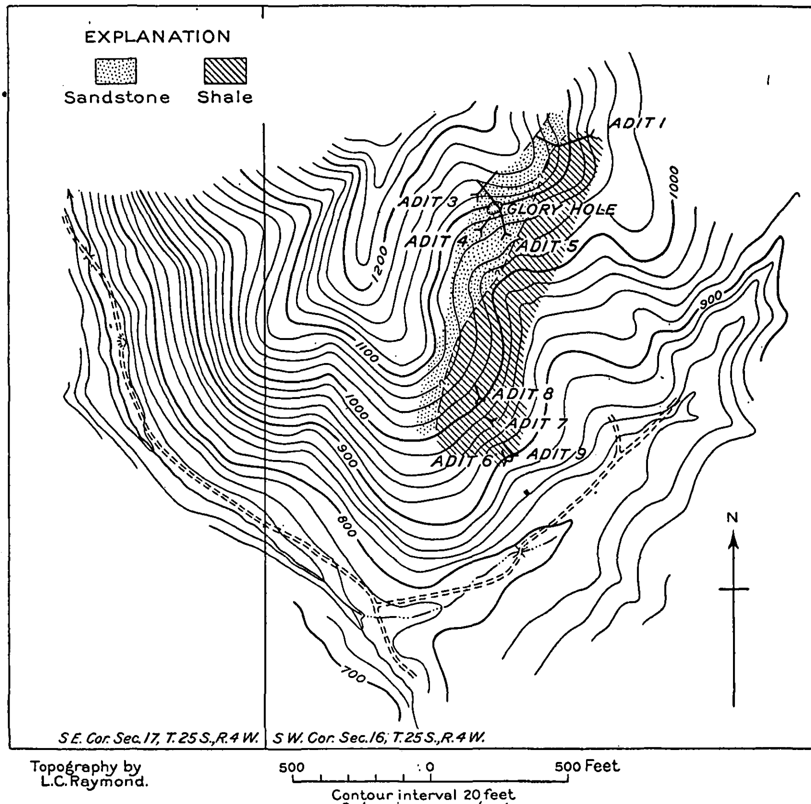


FIGURE 2.—Topographic map of Bonanza mine.

SUTHERLAND PROSPECT

The Sutherland prospect is developed by a 30-foot tunnel driven N. 15° W. from a small gully southwest of the Bonanza mine, in sec. 20, T. 25 S., R. 4 W. The surrounding surface is covered by a rubble of iron ribs, which have been formed in a coarse tuffaceous grit, most of which seems to be little altered, as grains of quartzite are clearly visible in the silica cement. The tunnel is in fine-grained sandstone that has been slightly altered and cut by a few iron ribs. No cinnabar was seen.

[40] Todd, Aurelius, Quicksilver mines of Oregon: West Am. Scientist, vol. 7, pp. 137–138, March 1891.

TILLER-TRAIL AREA

No occurrences of quicksilver have been reported in the area between the Bonanza mine and Deadman Creek, 23 miles to the south. From Deadman Creek, about 6 miles north of Tiller, to Trail, on the Rogue River, there is a belt about 25 miles long in which quicksilver is known to occur. This area is very rugged, having been completely dissected into narrow, steep-walled valleys separated by narrow ridges. The South Umpqua River and the Rogue River, the two major streams crossing the area, are at altitudes of 1,000 feet and 1,400 feet at Tiller and Trail, respectively; the peaks in the region rise to altitudes between 4,000 and 5,000 feet. The surface is covered with dense forest except in the valley of the Rogue River.

The belt of quicksilver deposits follows the line of contact of the lavas with the underlying formations along the Cascade Range. Most of the deposits are in the volcanic rocks, though some occur in the older rocks a short distance west of the contact.

The contact, though irregular in detail, trends in general a few degrees west of north. As the volcanic rocks dip toward the east, the line of contact retreats to the east up the valleys of the westward-flowing streams and projects to the west along the ridge tops. An exception to this is found in the valley of the Rogue River, where the younger basaltic lavas flowed down the valley of the old Rogue River, which had been excavated in the earlier andesitic volcanic rocks.

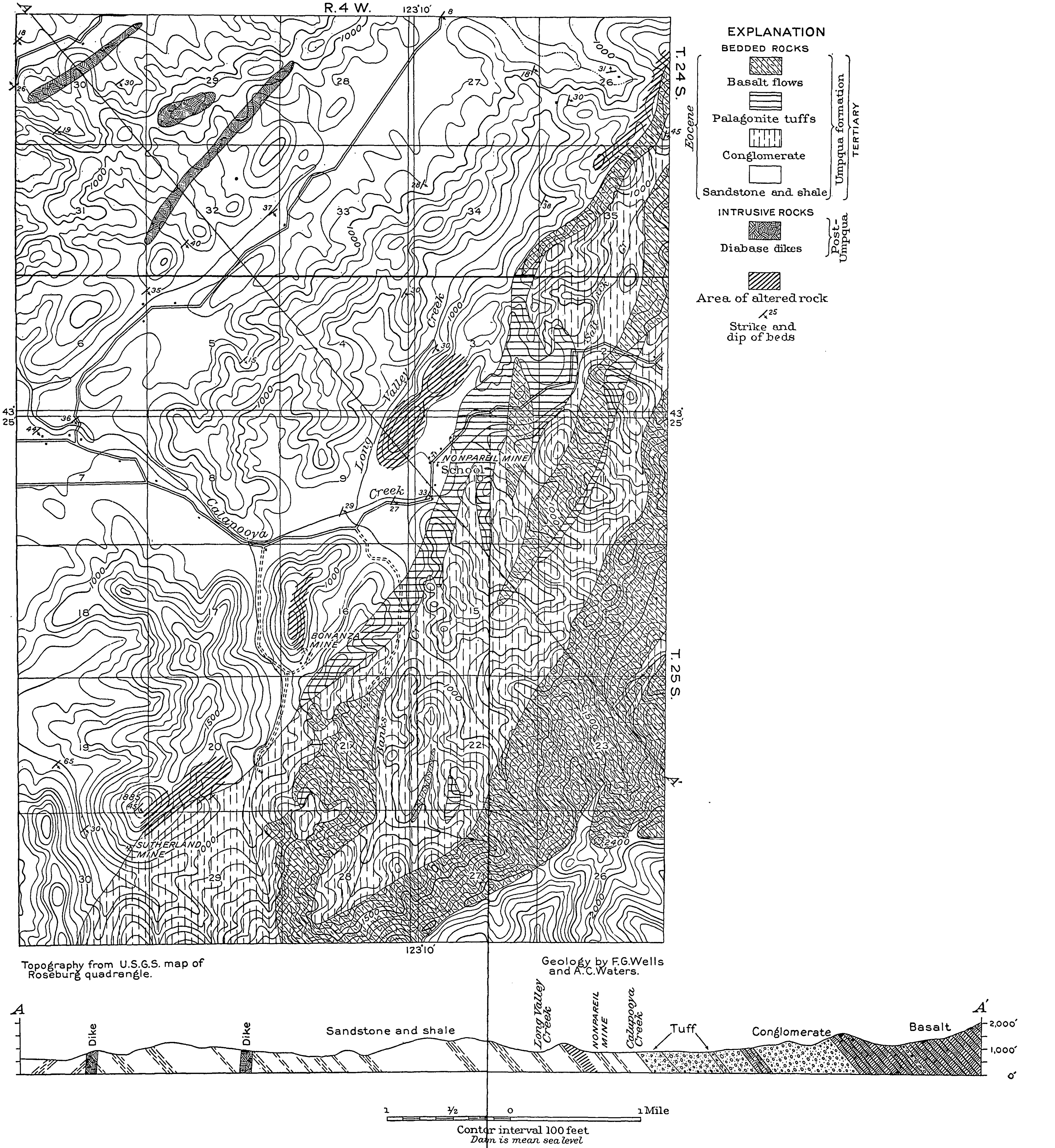
OCCURRENCES OF QUICKSILVER NEAR TILLER

LOCATION AND MEANS OF ACCESS

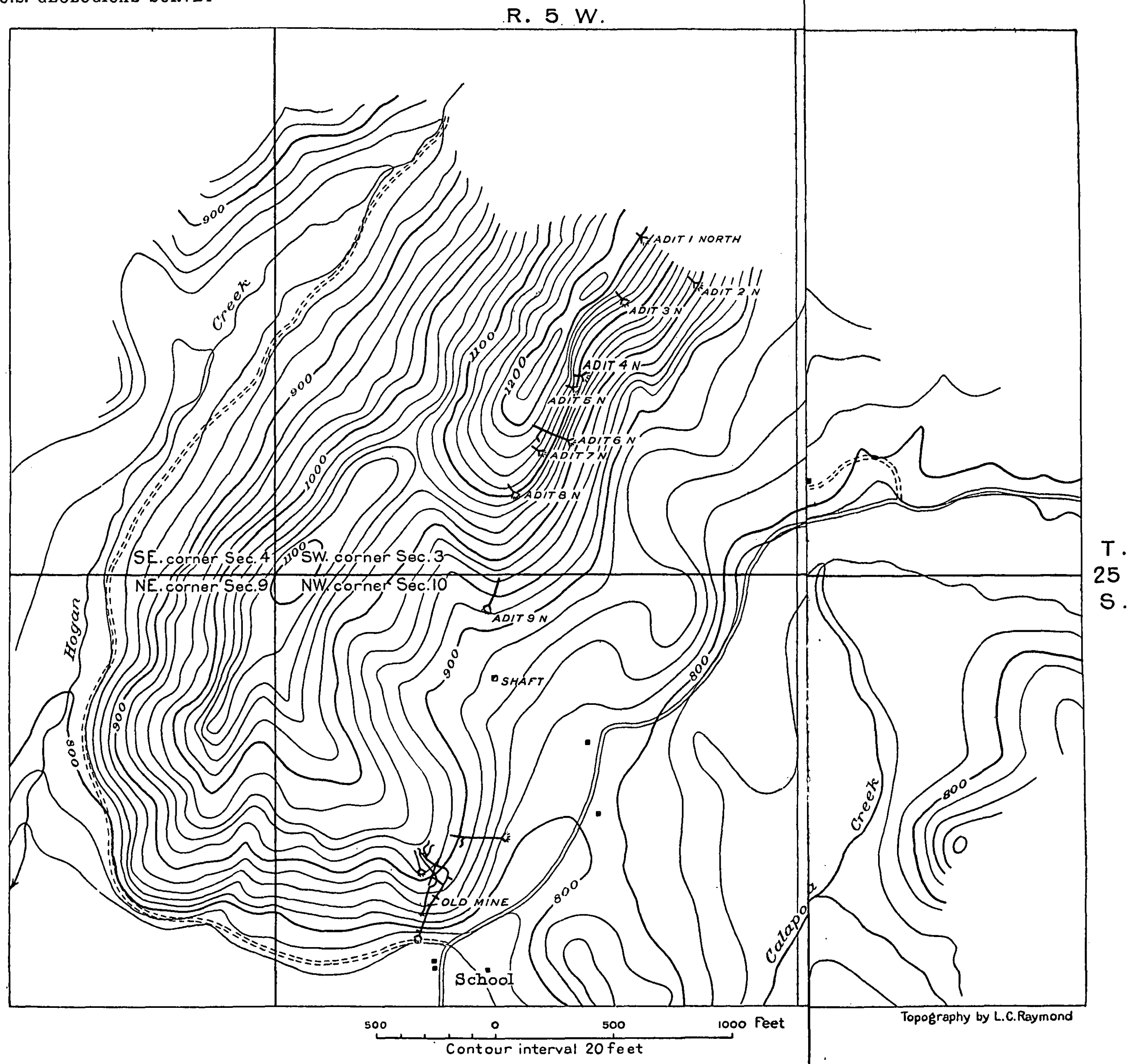
The Buena Vista and Maud S. mines and the Pollanz prospect are about 8 miles north of Tiller, on the south side of Deadman Creek. The Red Cloud claim is about 10 miles south of Tiller. Tiller, at the confluence of Elk Creek and the South Umpqua River, can be reached from Canyonville, about 20 miles distant on the Pacific Highway, by a good road that is traveled by automobiles throughout the year. The road north from Tiller to the mines is crooked, narrow, and steep; it climbs 2,100 feet from the river level to the top of the ridge and then descends to the mines, which are part way down the south slope of the gulch of Deadman Creek. This road is impassable for automobiles throughout the rainy season.

GEOLOGY

Outcrops are poor in the vicinity of the mines near Tiller, and time was not available for careful areal mapping. Below the Buena Vista mine and for half a mile to the east along Deadman Creek

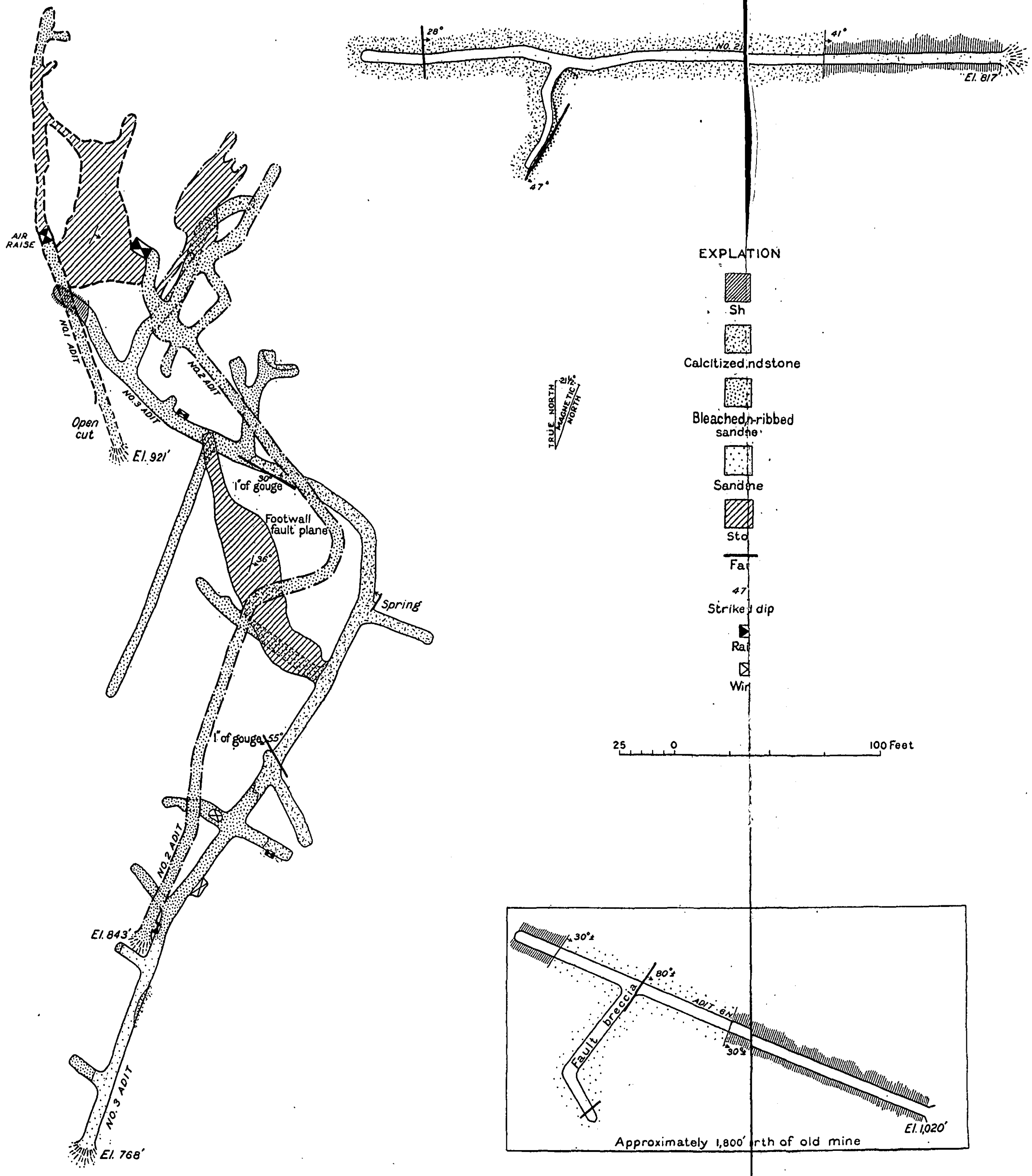


GEOLOGIC MAP AND SECTION OF NONPAREIL-BONANZA AREA.

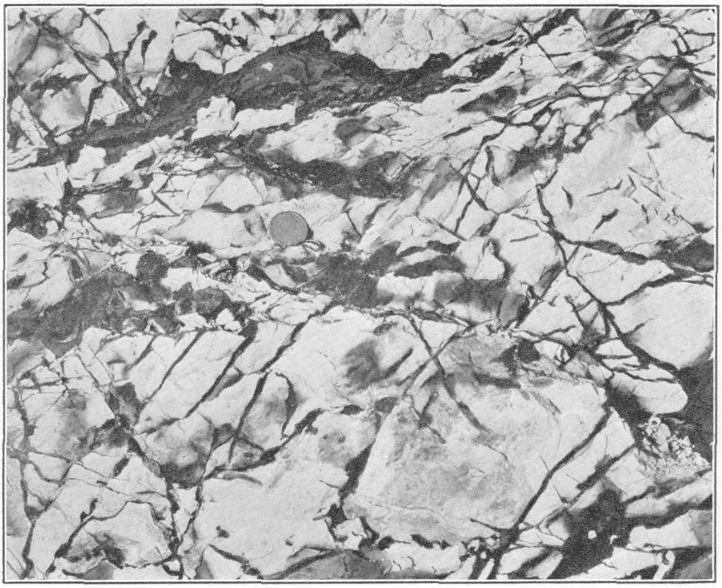


TOPOGRAPHIC MAP OF NONPAREIL MINE AREA.

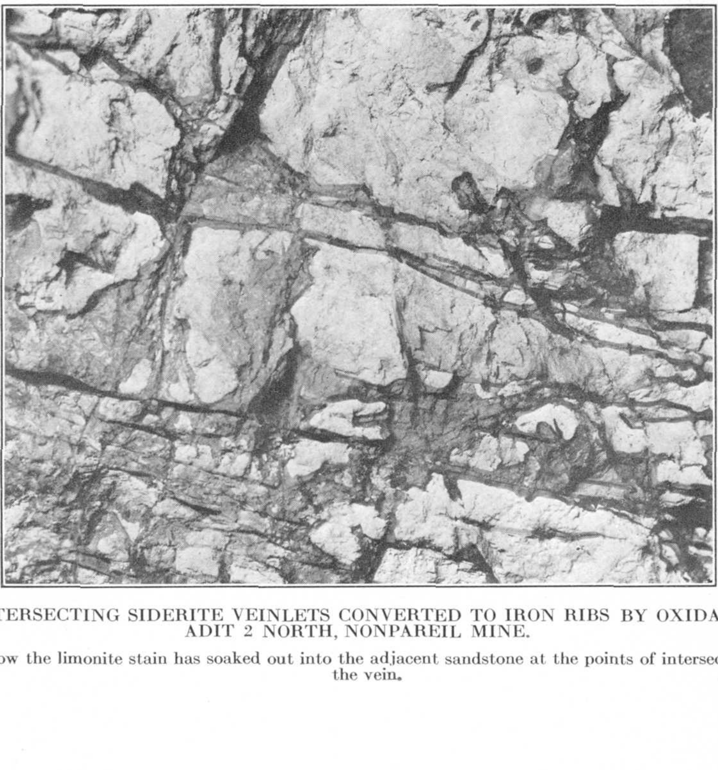
Elevations based on an elevation of 1,100 feet at the corner of secs. 3, 4, 9, and 10, which is approximately correct.



PLAN OF NONPAREIL MINE AND ADIT 6 NORTH.

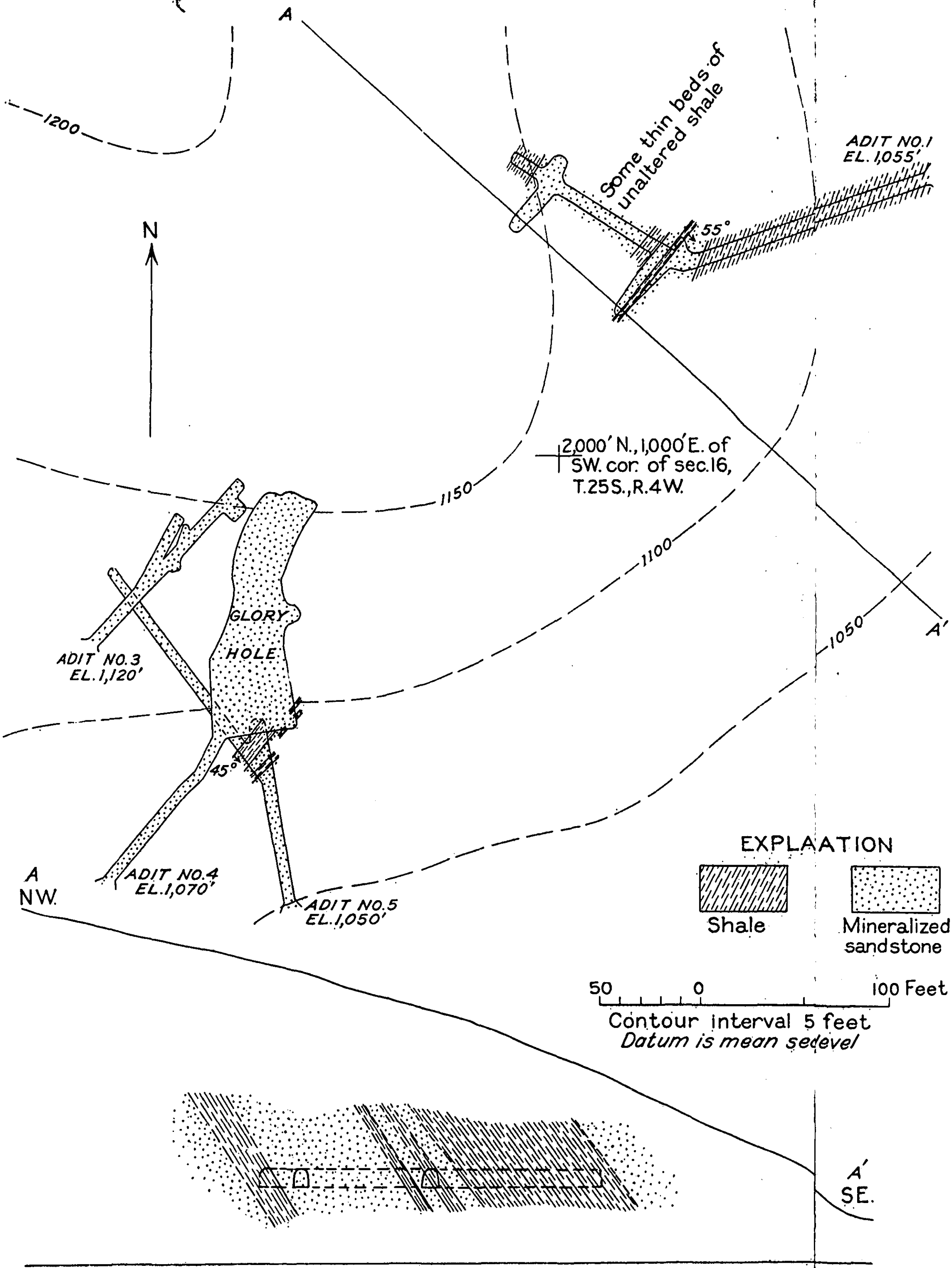


A. RETICULATED IRON RIBS, ADIT 2, NONPAREIL MINE.



B. INTERSECTING SIDERITE VEINLETS CONVERTED TO IRON RIBS BY OXIDATION, ADIT 2 NORTH, NONPAREIL MINE.

Note how the limonite stain has soaked out into the adjacent sandstone at the points of intersection of the vein.



PLAN AND SECTION OF BONANZA MINE.

conglomerate with intercalated beds of dark-gray fine-grained poorly stratified carbonaceous sandstone crops out prominently. The conglomerate also crops out here and there along the side of the gulch as far as the lower adit of the mine, where it is well exposed. Its general strike is N. 30° E. and its dip 25° SE. It consists mainly of rounded pebbles of black shale, quartz diorite, and quartz, named in order of abundance.

The absence of pebbles of volcanic rock, which characterize conglomerates younger than the Umpqua formation (p. 13), and the presence of pebbles of quartz diorite, which are found in conglomerates of the Umpqua formation, suggest that this conglomerate is part of the Umpqua and unconformably overlies the older rocks that crop out along the South Umpqua River near Tiller.

Volcanic rocks (Miocene?) of the Cascade Range are found higher on the south side of the gulch and therefore probably overlie the conglomerate. The rock exposed in the lower adit of J. L. Pollanz's prospect, the only one where the rock was fresh enough to be determined, is a porphyritic andesite, and the flows in the Buena Vista and Maud S. mines, though much altered, are sufficiently like it to be similarly classed. Volcanic breccia interstratified with the flows is exposed in the south crosscut of the main level and sublevel of the Buena Vista mine and in the crosscut of the intermediate level of the Maud S. mine. It was impossible to determine the dip of the volcanic rocks, but they probably dip at low angles to the east.

BUENA VISTA MINE

The Buena Vista mine consists of eight claims in sec. 34, T. 29 S., R. 2 W. The discovery claim was staked by W. S. Webb in 1918. At present the property is owned by H. E. Rogers, Guy Crodon, and H. A. Jensen. A few flasks of quicksilver have been produced. The mine contains about 850 feet of workings, which have opened the vein for a maximum distance of 220 feet along the strike and for a vertical distance of 89 feet. (See fig. 3.)

On the main level porphyritic andesite occurs as a narrow strip about 17 feet wide, bounded on the south by volcanic breccia and on the north by a fault that brings it into juxtaposition with conglomerate. The porphyritic andesite here appears to be a fault block dropped into its present position. Volcanic breccia is also present in the sublevel, but only andesite is exposed on the top level. The fault, which has gouge about 1 foot thick, is normal and premineral, but some postmineral movement has taken place.

Ore occurs in a shear zone in the porphyritic andesite, which strikes N. 81° E. and is either vertical or dips at high angles toward

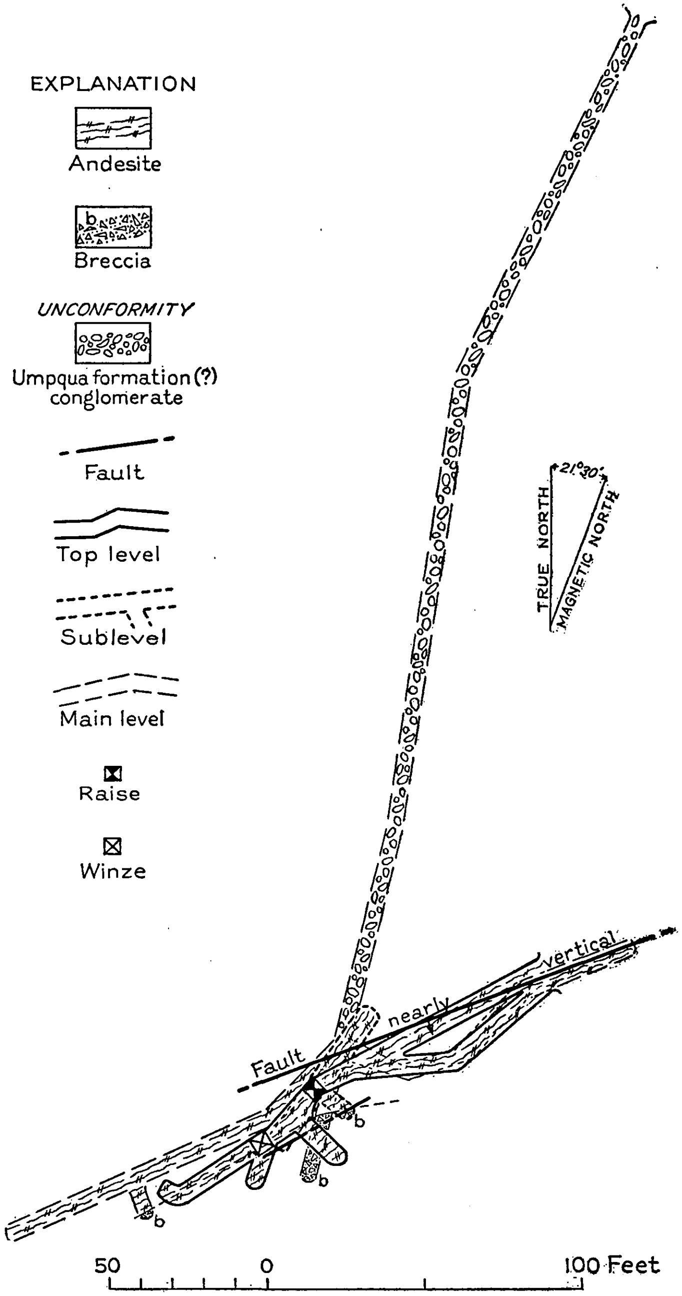


FIGURE 3.—Map of Buena Vista mine.

the south. The ore occupies many closely spaced veinlets that are roughly parallel, though converging and branching in places, and also isolated short-gash veinlets. The veinlets range in width from a quarter of an inch, the usual width, to 6 inches and contain cinnabar, calcite, marcasite, and a little pyrite. Some radial fibrous chalcedony has also been seen. Some veinlets are composed entirely of one mineral, either cinnabar, calcite, or marcasite, but most of them contain two or more minerals and commonly show banding and crustification. Some of the larger veinlets consist of small angular fragments of andesite cemented by cinnabar, calcite, and a little marcasite. (See pl. 19, *A*.) Scattered specks of cinnabar occur in the wall rock. The tenor of the ore diminishes gradually from the vein into the wall rock, and therefore the boundaries of the ore body are indefinite and must be determined by assay. At present the stoping width averages about 5 feet. The reported results obtained from retorting the ore in 1929 and 1930, together with the amounts of cinnabar that are visible, indicate that parts of the lode as much as 5 feet wide may average from 1 to 2 percent of quicksilver. There is no indication that the end of the ore has been reached, and mining at greater depth as well as to the west along the fault should develop more ore.

MAUD S. MINE

The six claims of the Maud S. mine were staked in 1926 by Ralph Young, H. H. Pennd, J. Leach, and Mrs. J. Darling. A few flasks of quicksilver have been produced. The workings are situated 1,400 feet S. 26° E. of the Buena Vista mine and several hundred feet higher up the side of the gulch. The mine has 600 feet of workings distributed between 3 adits and 2 raises, one raise connecting the lower level with the intermediate level and the other connecting the intermediate with the upper level. (See fig. 4.)

The adits have been driven along a fault that strikes N. 25° W. and dips 70° SW. They are all in sheared and altered porphyritic andesite cut by veinlets of calcite. A vein 3 to 4 feet wide of cellular rock incrusted and stained by hydrated oxides of iron and containing cinnabar and a little unoxidized marcasite has been followed by the upper adit. According to Mr. Leak, the vein material assayed about 2½ percent of quicksilver. In the intermediate adit, 29 feet below the upper adit, the vein material has pinched to a width of a few inches and is not oxidized. The pinching of the ore is probably due to the presence of a large amount of gouge in the fault zone, for although some calcite and marcasite have been deposited in the gouge the conditions are not favorable for mineralization. The fact that oxidation has not reached the intermediate adit should be emphasized. The rock exposed in the lower adit is cut by many anastamosing veinlets of calcite that range from a quarter of an inch to 2 inches in width. A little cinnabar and marcasite are associated with the calcite in the veinlets, and these minerals are also found disseminated through the rock. Part of the rock in the lower adit may assay 3 or 4 pounds of quicksilver to the ton, but not more.

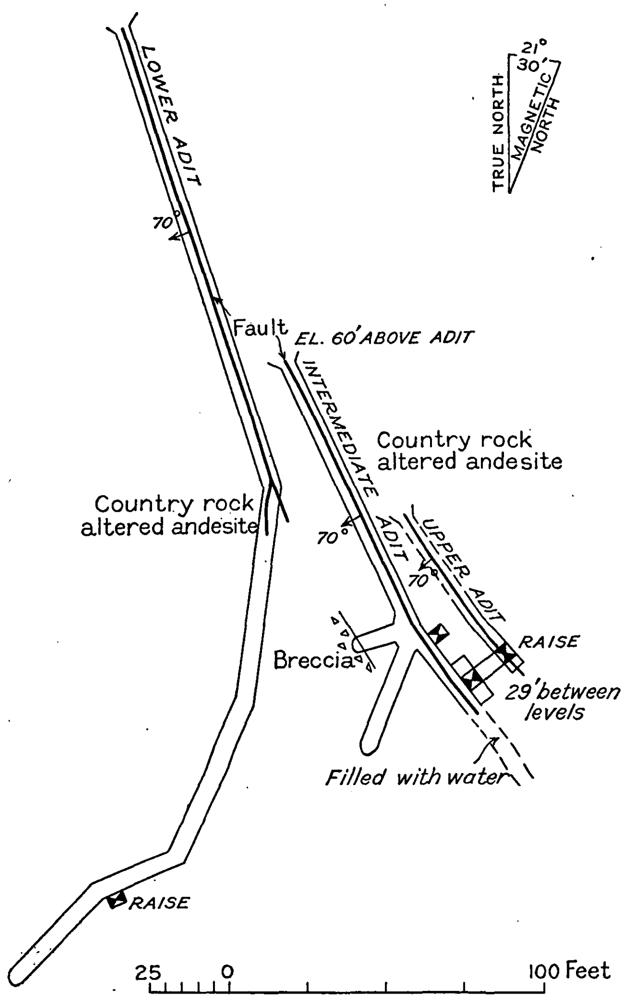


FIGURE 4.—Plan of Maud S. mine.

POLLANZ PROSPECT

J. L. Pollanz staked the Hope, Faune, and Glory claims, in sec. 35, T. 29 S., R. 2 W., in 1927. These claims have been prospected by means of two adits, one 140 feet long in the Hope claim and one 80 feet long in the Glory claim. Both adits trend a few degrees east of north. The 140-foot adit, which is well down the side of Deadman

Gulch, is in porphyritic andesite. No cinnabar was seen, but the rock was cut by a few veinlets of calcite and a little gray chert. The 80-foot adit is several hundred feet higher on the side of the gulch. It is in altered andesite, which is stained by oxides of iron produced by weathering. A few stringers of calcite and a very little cinnabar associated with the calcite were seen.

RED CLOUD CLAIM

The Red Cloud claim is on the headwaters of Cow Creek, in sec. 16, T. 32 S., R. 2 W., at an altitude between 3,000 and 4,000 feet. It is most readily reached from the Tiller-Drew road by means of the Forest Service road to the Diamond Rock ranger station, 6.4 miles, and thence by trail 1.6 miles to the prospect. The Tiller-Drew road is open to automobiles throughout the year, but the road to the Diamond Rock ranger station is open only through the dry summer; some stretches are so steep as to be only barely passable by an automobile.

The May Creek formation, which is here a quartz-hornblende schist, crops out throughout this part of Cow Creek Gulch, though half a mile to the east the top of the ridge consists of volcanic flows.

The present workings on the Red Cloud claim consist of two adits several hundred feet above the level of Cow Creek on the south slope. The lower adit is 50 feet long and trends S. 26° E. The face of the adit is a mass of fault gouge cut by many stringers of calcite about a quarter of an inch wide, but no cinnabar was seen. The fault strikes S. 36° E., but the dip could not be determined. The upper tunnel is 18 feet vertically above the lower tunnel and for 25 feet has the same trend, S. 26° E.; then it forks; one fork, 10 feet long, trends S. 57° E.; the other, 15 feet long, trends south. The rock is fractured and weathered, but no fault gouge is exposed nor was any evidence of calcite or other mineralization seen. An old adit 50 feet above the creek was caved and inaccessible.

NIVINSON PROSPECT

The adits of Henry Nivinson are on the south slope of Cow Creek Gulch, several hundred feet northeast of the Red Cloud workings. Two of the adits are at the same altitude and within 15 feet of each other; the third is 200 feet farther up the slope. The adits are 30, 40, and 48 feet long. They are all in mica schist and follow for parts of their courses fractures that strike N. 27° E. A few small stringers of calcite were seen but no indications of cinnabar. Farther up the ridge a few shallow pits were examined, but none of these were sufficiently deep to pass below the weathered zone.

OCCURRENCES OF QUICKSILVER NEAR TRAIL

LOCATION AND TOPOGRAPHY

Some prospecting for quicksilver has been done on both sides of the Rogue River Valley in Tps. 33 and 34 S., Rs. 1 W. and 1 E., about 24 miles north and a little east of Medford, on the Crater Lake Highway. The Rogue River here flows in a direction a little south of west, but a few miles downstream it turns abruptly and flows almost due south. The river has a steep gradient. Its valley and that of Elk Creek, a tributary from the north, are narrow, and their sides slope steeply from the river level, at an altitude between 1,440 and 1,460 feet, up to 1,800 feet, from which the rise to the tops of the adjacent peaks, at altitudes of 3,400 to 4,000 feet, is abrupt and in places precipitous. A narrow gravel-covered terrace with a maximum width of a fifth of a mile extends along the north bank of the Rogue River and the west bank of Elk Creek at an altitude of 1,480 to 1,500 feet. The rocks near the river consist of volcanic flows of varying composition with some interstratified agglomerate and belong to the volcanic rocks of the Cascade Range, of Miocene (?) age.

ASH PROSPECT

E. E. Ash has some claims in secs. 35 and 36, T. 33 S., R. 1 W., and sec. 1, T. 34 S., R. 1 W. These claims are on the south side of the Rogue River, across the river from the highway, but a small bridge was being built in 1930. The workings include an open cut and three short adits, each about 50 feet long, at vertical intervals of about 200 feet, on the northwest side of a gulch. The open cut is about 100 feet above the Rogue River, and the top or no. 4 adit is about 700 feet above the river. About 50 feet above the top adit there is a shaft 36 feet deep with a short drift about 12 feet long at the bottom.

The rocks in all these workings are altered volcanic flows, in which the original feldspar phenocrysts have changed to white spots of clay in a gray-lavender groundmass. Very irregular iron ribs as much as 1½ inches wide cut the rock. Limonite-stained chalcedony similar to that of the iron ribs occurs also as spherical masses 2 to 3 inches in diameter with a hollow center filled with powdery limonite. A fault that strikes S. 74° E. and dips 85°–90° SW. has been explored by adit 4 and by the shaft and the 12-foot drift. Some smeared cinnabar was seen on the slickensided fault plane.

POOLE PROSPECT

The prospect of J. L. Poole is in the SE¼ sec. 25 and NE¼ sec. 36, T. 33 S., R 1 W., a few hundred feet north of the Crater Lake highway, which follows the north bank of the Rogue River. The workings, comprising a pit and 6 open cuts, extend up the hillside for a distance of about 700 feet from the terrace level, at an altitude of about 1,500 feet. They lie along a line that bears a few degrees east of north.

The open cuts have been made along the trend of the vein, which strikes N. 2° E. and dips 64° SW. The vein has a maximum width of about 1 foot. It is a siliceous mass composed of small angular silicified fragments of gray rock cemented by gray-white chalcedony. The rock fragments are composed of a microcrystalline quartz mozaic fringed by coarser-grained quartz and embedded in cryptocrystalline quartz. They are cut by cracks filled with a coarser-grained quartz and locally a little calcite. Small vugs, some of which are filled with a white claylike powder, occur in the vein. The vein is irregularly stained with limonite. The country rock contiguous to the vein has been altered to a white friable mass cut by a network of narrow limonite ribs. The alteration fades out in a short distance, the white friable rock grading into a gray-purple rock, somewhat iron-stained, which in turn grades into the fresh basalt. No cinnabar was seen by the writers, but J. T. Pardee,[41] who visited the prospect in the summer of 1929, reports a stringer of massive cinnabar a quarter of an inch wide in view at that time.

RED CHIEF PROSPECT

About 2½ miles east of the Poole property on the south bank of the Rogue River in sec. 33, T. 33 S., R. 1 E., is the Red Chief claim, owned by G. C. Cottrell, William Cottrell, and Sprat Wells. The only way of crossing the river is by boat. Two short adits, both trending a few degrees east of south, have been driven into the hill, about 100 feet south of the river. The lower adit is 50 to 100 feet above the river, and the upper adit is about 70 feet above the lower adit. These adits are in thoroughly altered rock cut by a few iron ribs. The lower adit is cut by a fault that strikes S. 20° E. and dips 82° SW. In the face of this adit is an 8-inch zone of gray chalcedony that lies along the fault. A little cinnabar was seen in the lower adit.

Many open pits are scattered over the prospect, none of which are more than 10 feet deep or penetrate below the surface mantle of soil and disintegrated rock. They show that a bed of pyroclastic material separates two flows, but all the rocks were too much altered to permit definite determination. It is said that much of this soil will show cinnabar on panning.

[41] Oral communication.

MEADOWS DISTRICT

LOCATION AND TOPOGRAPHY

Scattered occurrences of quicksilver have been reported in a belt 10 to 15 miles wide that follows in general the boundary between the Klamath and Cascade Mountains and extends northward from a point about 8 miles north of Gold Hill for a distance of about 5 miles. The Meadows district is in the northern part of this belt. The area examined includes the Dave Force mine of the Quicksilver Producers Co., the War Eagle mine, and the prospects of W. P. Chisholm, all of which are on Evans Creek, Josephine County, T. 34 S., R. 2 W., in what is commonly called The Meadows. The district is reached from Gold Hill by about 13 miles of good gravel road and can also be reached from Medford by the road through Sams Valley. The area mapped is 2½ miles wide and extends north along Evans Creek for a distance of 3 miles. (See pl. 20.)

Evans Creek enters the district from the north, continues in a direction slightly west of south for about 2 miles through a valley half a mile wide, then turns northwest and enters a narrow, steep-sided ravine. Morrison Creek, the only perennial tributary of Evans Creek, enters through a steep ravine near the northern boundary of the district. Both streams head against a divide to the northwest.

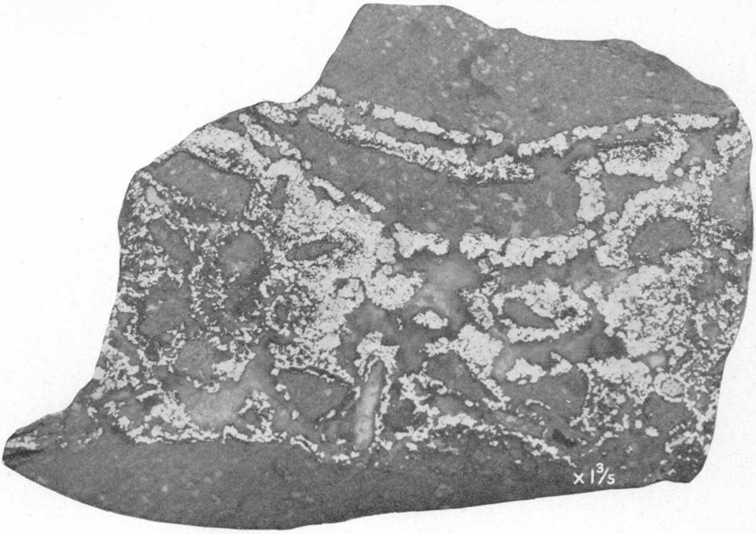
The floor of the Evans Creek Valley at its lowest point is about 1,600 feet above mean sea level and rises to about 1,800 feet at its upper end. To the east the surface rises with a fairly even slope from the valley bottom to an altitude of about 3,000 feet, then steepens and rises abruptly to the summit of the divide at 3,600 feet; but to the west the surface rises abruptly with very steep slopes to about 4,400 feet, the level of the Klamath peneplain.

GEOLOGY

ROCKS

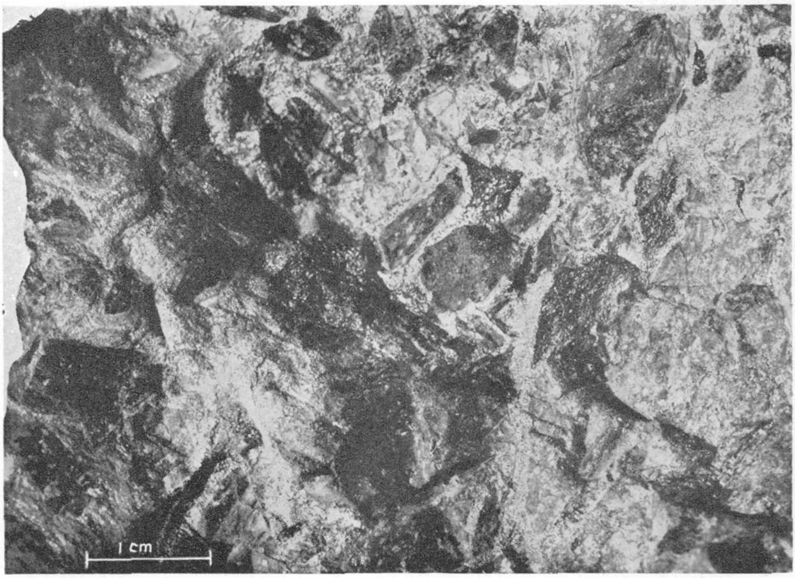
The rock formations in the Meadows district are few, although they are varied in kind and cover a long period of geologic time. The oldest rock is the May Creek schist, which varies considerably in mineral composition and texture but where most typically developed is a dark-green fine-grained, highly schistose rock. This formation has been intruded by quartz diorite.

The next younger rocks are tuffaceous sandstones and shales of the Umpqua formation, which occupy the eastern part of the area and are best exposed along the east bank of Evans Creek in sec. 16 and in the hills to the east. The sandstone is characteristically tuffaceous and coarse-grained, and in some outcrops well-rounded pebbles of black or white vitreous quartz about half an inch to 1



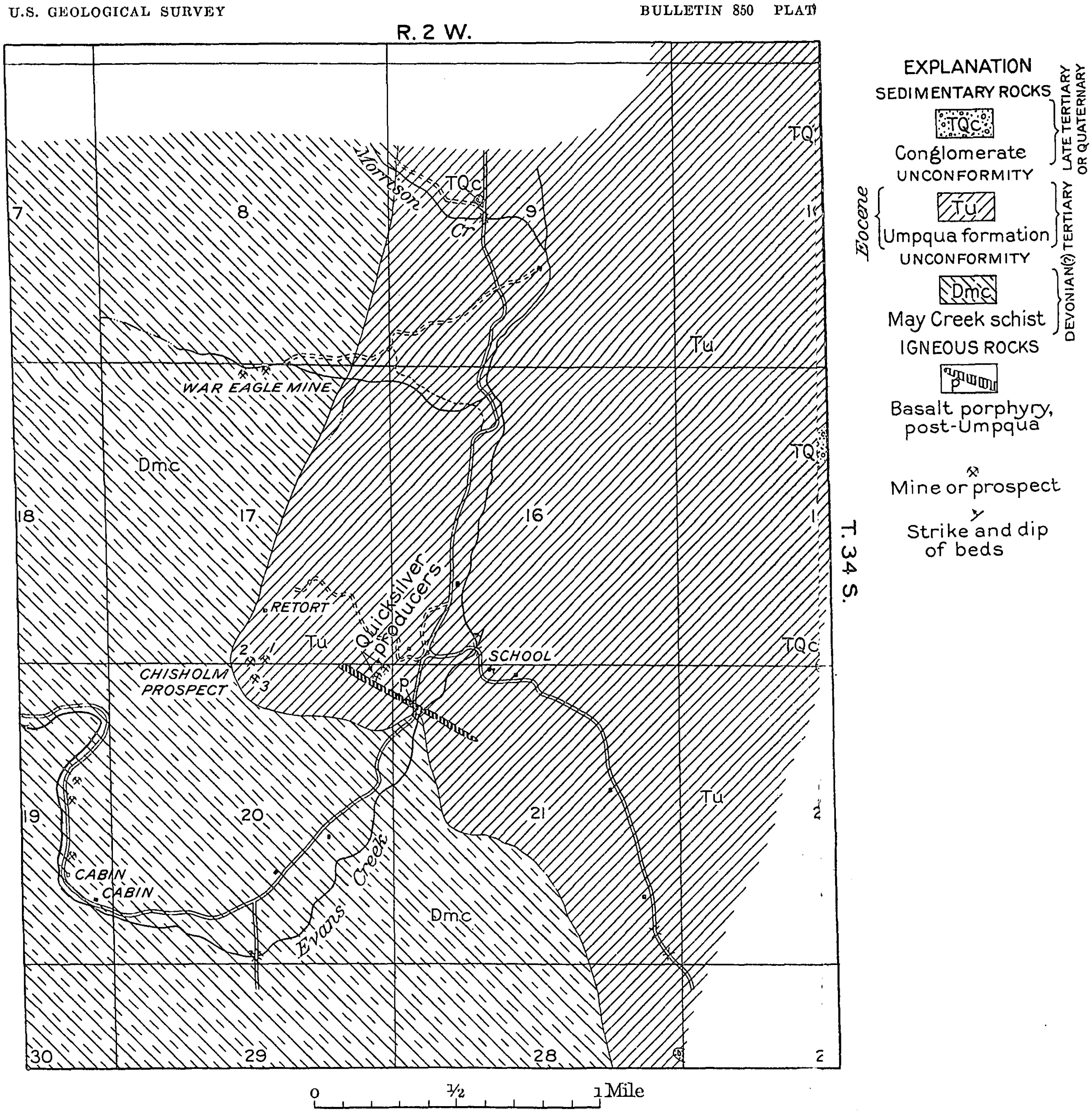
A. ORE FROM BUENA VISTA MINE.

Showing fragments of altered andesite cemented by calcite, cinnabar (white), and marcasite (black).

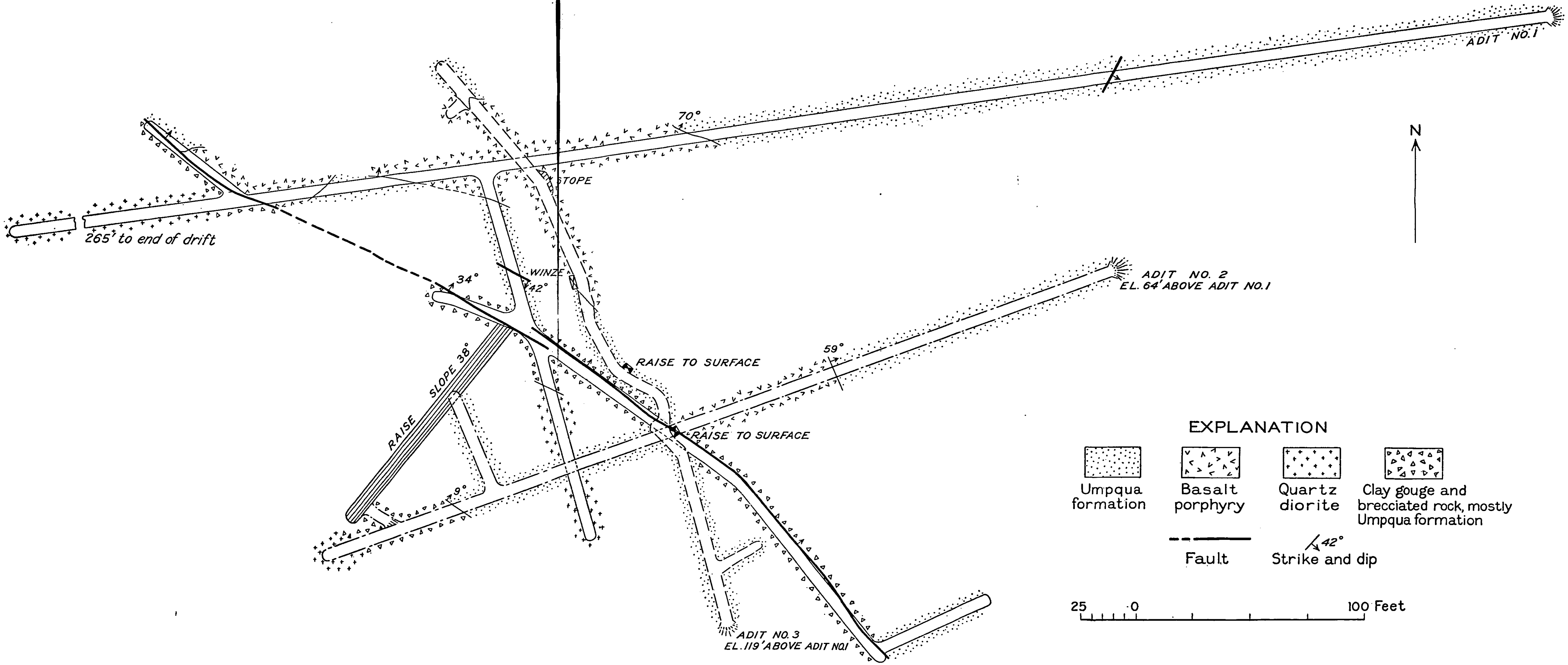


B. FAULT BRECCIA OF ANGULAR CHERT FRAGMENTS CEMENTED BY MARCASITE.

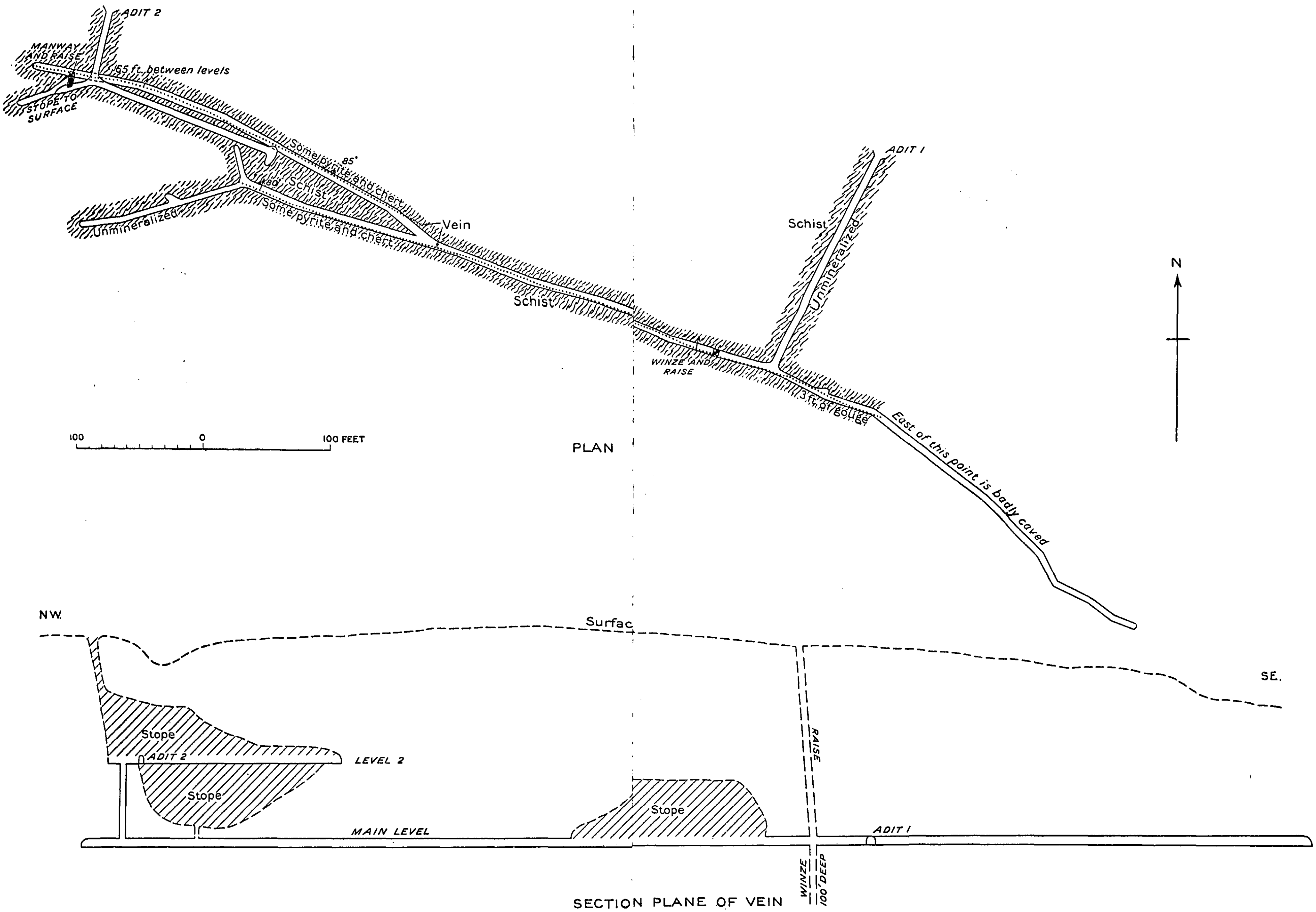
From War Eagle mine.



GEOLOGIC MAP OF MEADOWS DISTRICT.



MAP OF DAVE FORCE MINE.



PLAN AND SECTION OF WAR EAGLE MINE.

ORE FROM WAR EAGLE MINE.

A, Chert fragments (black) fringed with cinnabar (white) and cemented by marcasite (gray). *B*, Patches of cinnabar (black) veined and bounded by marcasite (gray).

inch in diameter are found here and there. These pebbles may be scattered irregularly or may occur in definite layers. A thin-bedded carbonaceous shale of the Umpqua formation crops out in Evans Creek at the bridge near the school house. The thickness of the sandstone could not be definitely determined, but it exceeds 500 feet.

A few patches of conglomerate of late Tertiary or Quaternary age rest unconformably on the sandstones. They are most numerous on the eastern border of the area, especially in sec. 16, but crop out also at the junction of the main road and the wagon road up Morrison Creek, in sec. 9. The rock consists of pebbles of dense andesite mostly from half an inch to 1 inch in diameter. As the outcrops are small and disconnected it was impossible to determine either the thickness or the strike and dip of the conglomerate.

Quartz diorite is found in the workings of the Quicksilver Producers Co. This is a coarse-grained granitoid rock composed of oligoclase, hornblende, and biotite in about equal amounts and about 20 percent of quartz.

A dike of basalt porphyry 80 feet wide (see p. 19) crops out prominently in secs. 17 and 21 and is well exposed in the workings of the Quicksilver Producers Co. The dike, which is composed of a light-gray dense rock with green phenocrysts, strikes N. 50° W. and dips 59° NE. Flows of basalt and pyroclastic rocks crop out on the ridge just east of the area.

STRUCTURE

Though the May Creek schist shows considerable variation in attitude, the prevailing strike is northeast and the dip southeast at angles greater than 30°. The Umpqua formation rests unconformably on the May Creek schist, strikes northeast, and dips northwest at angles less than 18°. All the rocks in the district are cut by normal faults, which strike N. 54°–75° W. and dip 38°–70° NE. The faulting has tilted the Umpqua formation from its normal homoclinal dip toward the east.

MINES AND PROSPECTS

QUICKSILVER PRODUCERS CO.

Location, history, and workings.—The principal claims of the Quicksilver Producers Co., formerly known as the Dave Force mine, are on the east slope of a spur of the Umpqua Range at an altitude of about 1,900 feet, in the northeast corner of sec. 20, T. 34 S., R. 2 W. Two other claims, the Atlas lode and Apex lode, are in sec. 5, T. 34 S., R. 2 W. The original claims were staked by D. S. Force, who drove adit 3 and is reported to have obtained several flasks of quicksilver from the ore derived from this working. In 1924 the Quicksilver Producers Co. was incorporated and took over the property. Adits 2 and 1 were driven in 1928 and 1929. In 1930 the prospect consisted of 2,110 feet of tunnel distributed as follows: Level 3, 1,375 feet; level 2, 430 feet; level 1, 305 feet. Level 2 is 64 feet above level 1, and the two are connected by a raise that slopes 30°. Level 3 is 119 feet above level 1. From level 3 two raises formerly extended to the surface, but both are now caved. A winze 20 feet deep was sunk from level 3, and a small stope 10 feet long and 15 feet high was mined from this level. A plan of the workings is shown on plate 21.

Rocks.—The geology of the mine is best exposed in level 1. The adit traverses 375 feet of Umpqua formation, cuts across a dike of basalt porphyry, passes through a fault, and penetrates quartz diorite for a distance of 310 feet.

The Umpqua formation as here exposed is typical of the formation in this district, being a medium-grained thick-bedded tuffaceous sandstone, which strikes northeast and dips at a low angle to the northwest. Along the southeast drift carbonaceous shale is found, and in the northwest crosscut and also at the head of the raise in level 2 some low-grade coal faulted into place from another horizon is exposed. The basalt porphyry dike is 80 feet wide, strikes N. 50° W., and dips 59° NE. It consists of gray fine-grained porphyritic rock, a petrographic description of which is given on page 19. The quartz diorite is a coarse-grained granitoid rock so completely decomposed that it can be readily dug out with a pick. It is cut by many veinlets of pegmatite half an inch to 6 inches in width, made up of coarse feldspar, quartz, and much altered mica.

The fault, which has been drifted on for 300 feet, shows minor variations in strike and dip, but its prevailing trend is N. 54° W. and its dip 34° NE. The fault zone, which ranges from 2 feet to several feet in width, contains fractured basalt porphyry, some chalcedony, sandstone, crushed shale, and gouge. The fault is normal, the northeast block having moved down with reference to the southwest block. There are minor slips diverging from the main fault. It is along one of these slips striking N. 20° W. that level 3 was driven.

Ore.—The ore is of two types—(1) small crustified veinlets of cinnabar with calcite and quartz gangue and (2) chalcedony breccia containing cinnabar. Ore of the first type is confined to the basalt porphyry on level 3. Here fractures in the dike, the general trend of which is N. 20° W., are mineralized with calcite, quartz, and cinnabar. The veinlets range from mere lines to seams 1 inch in width and are nowhere very persistent, pinching out within a few inches or at most within 2 or 3 feet. They may branch or join with other veinlets, but as far as observed they do not make up the larger portion of the rock. Some veinlets contain drusy vugs lined with quartz crystals, but most of them are crustified with long prismatic crystals of calcite, which project into the veinlets, the center of the veinlet being filled with chalcedonic quartz. Cinnabar occurs more abundantly with the calcite than with the quartz. Neither marcasite nor pyrite was observed. Under the microscope the dike rock contiguous to the veinlets is seen to have been largely replaced by quartz. The tenor of the ore for a working width is low. It was impossible to determine whether there were rich shoots in the ore, but the workings suggest that the ore was richer near the edges of the dike. Some limonite staining is found on this level.

Chalcedony breccia ore averaging 2 feet in width was exposed in the fault zone on level 1 for a length of 20 feet and along the side of the raise for 25 feet. The breccia contains angular fragments of fine-grained dark-gray chalcedony from a sixteenth of an inch to 1 inch in diameter, cemented by later chalcedony. In some places the interstitial spaces have been only partly filled, and the remaining openings are commonly lined with quartz crystals. Under the microscope the chalcedony appears as a mass of cryptocrystalline quartz in which are irregular patches and veinlets of later quartz mosaic, and within the mosaic are scattered euhedral quartz crystals. Cinnabar occurs as small irregular patches between the mosaic grains. In no place was marcasite seen. Except for the total absence of marcasite, this ore resembles ore from the War Eagle mine. The cinnabar content is very small. This breccia shows that movement took place along the fault during mineralization. The only pyrite found in this mine was in small seams in the coal.

In conclusion it may be said that the Umpqua formation and granodiorite show no signs of mineralization whatever. The best ore was found in the basalt porphyry dike on level 3, but where this dike was crosscut on levels 2 and 1 no signs of mineralization were found. Additional ore similar to the breccia ore might be developed in the fault zone, but the quicksilver content of this material is very low, and the cinnabar is so intimately associated with the chalcedony gangue that any process of beneficiation would be difficult.

WAR EAGLE MINE

Location, history, and workings.—The War Eagle mine, formerly known as the Rainier mine, is in secs. 7, 8, 17, and 18, several hundred feet above the valley of Evans Creek, on a short tributary that flows into the creek from the west. The vein was discovered by Carl Burtelson about 1916 and was developed by the Rainier Mining Co., a subsidiary of the Utah Sugar Beet Co., until 1919, when the War Eagle Mining Co. was incorporated and took over the property. Some quicksilver is said to have been retorted prior to the erection of a 25-ton Scott furnace in 1920, and a small output was maintained in 1921 and 1922, but since then the property has remained idle, except for some work done in the winter of 1927 and the spring of 1928. Kellogg[42] gives the production to September 1927 as 565 flasks, or 42,375 pounds, which was sold for $59,325. He estimates that this was won from 1,500 tons of ore, whose average tenor was about 1.1 percent.

The present workings consist of the main level, comprising an adit 180 feet long and 1,230 feet of drift along the vein; a winze sunk from this level, now full of water but reported to be 100 feet deep; and a second level 65 feet above level 1, composed of 180 feet of drift along the vein and a crosscutting adit 53 feet long. Most of the vein above level 1 has been mined from two stopes, one between levels 1 and 2, the other from level 2 to the surface. There is another stope above level 1, but this was inaccessible when the mine was visited. A plat of the workings is shown in plate 22.

Ore.—The ore occupies a fault zone in the May Creek schist, which is here a hornblende-biotite schist containing quartz and a little pyroxene; the schistosity trends northeast. The fault strikes N. 70° W. and ranges in dip from 80° NE. to vertical. The ore zone is 3 to 6 feet wide (average 4½ feet) and is bounded on both sides by gouge-covered fault surfaces. The clay gouge on the main fault is usually but a few inches thick, though it may be as much as 1 foot, and in the drift east of the adit of level 1 the fault zone consists largely of gouge and altered rock, in places as much as 6 feet thick. Here and there the gouge contains small stringers of calcite, also a little pyrite and some cinnabar. Smeared cinnabar is seen in places on the slickensided fault plane, showing that some postmineral movement took place.

The ore occurs as a composite vein in the fault zone and consists of a fault breccia of chalcedony and a little silicified schist cemented by marcasite. The breccia fragments range from a fraction of an inch to 2 inches in largest dimension and are usually of dark-gray cryptocrystalline chalcedony, though some fragments of white banded chalcedony are found, and fragments of silicified rock are common. These fragments are cemented together by marcasite, which usually forms around the chalcedony fragments an aureole of euhedral crystals about 3 millimeters wide, and the remaining interstitial space is filled with microcrystalline marcasite. In many

[42] Kellogg, A. E., Min. Jour. (Arizona), vol. 11, pp. 7, 14, 15, September 1927.

parts of the breccia the microcrystalline marcasite is absent and the remaining interstitial space is void, with the result that the breccia is cavernous. (See pl. 19, *B*.)

Cinnabar occurs in the marcasite. Some rich ore collected by J. T. Pardee in 1917 shows the chalcedony fragments surrounded by a rim of cinnabar 2 to 4 millimeters wide, which in turn is surrounded by microcrystalline marcasite; other specimens show lumps of cinnabar as much as 15 millimeters in diameter surrounded by microcrystalline marcasite. (See pl. 23.) Under the microscope the marcasite is seen to contain small subhedral grains of pyrite. Arsenic and silver are reported to occur in the ore. A qualitative analysis showed considerable arsenic to be present in the marcasite, but under the microscope no arsenical mineral could be detected. Furthermore, no arsenic occurs in the cinnabar. It is interesting to note that calcite is absent.

The accessible parts of the workings give reasons to believe that the ore continues in depth. It should be borne in mind, however, that what was found in the winze is not known. Although the face of the northwest end of the main drift does not show ore, further drifting along the fault zone might uncover new ore shoots. It is reported that the arsenic in the ore caused trouble in retorting. As the arsenic occurs with the marcasite and not with the cinnabar, the problem could be met by separating the two minerals either by gravity methods (the specific gravity of the cinnabar is 8.0–8.2, pyrite 5.0) or by flotation. By either method a cinnabar concentrate and marcasite concentrate could be obtained.

CHISHOLM CLAIMS

W. P. Chisholm, of Gold Hill, owns several claims in secs. 17 and 20, T. 34 S., R. 2 W., which he has prospected by means of pits and short adits. These workings are scattered down the ridge from a point near its crest to a point about 200 feet above the valley bottom. Many of the older pits and adits were caved at the time of this study, but three adits that have a total length of 380 feet were accessible. Adit 1 (see pl. 20) is 90 feet long, trends N. 43° E., and opens out at its end into a small inclined stope 25 feet long at right angles to the drift. Adit 2, about 300 feet west of adit 1, is 140 feet long, trends N. 53° E., and has a small winze 15 feet deep at the end. Adit 3, several hundred feet south of adit 2, is 150 feet long, and its trend, though irregular, is generally to the north.

All these adits as well as the caved workings are in the Umpqua formation. The sandstone has been much sheared and faulted, and the strike of the slickensided surfaces is 15° NE. The rock shows the usual iron staining as a result of weathering, and a few narrow seams of limonite-stained silica are found. Cinnabar can be panned out of the rock, although it is hardly ever recognizable by the unaided eye in the unworked rock. Mr. Miller, who was leasing these claims in 1930, stated that some of the rock ran as high as 4 pounds to the ton.

On other claims of Dr. Chisholm in secs. 19 and 20 a few short adits have been driven on quartz seams in the schist. In one adit a little rhodonite was found.

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