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QUICKSILVER DEPOSITS OF THE BONANZA-NONPAREIL DISTRICT DOUGLAS COUNTY, OREGON

By

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By R. E. Brown and A. C. Waters

ABSTRACT

The Bonanza-Nonpareil quicksilver district of Douglas County, Oreg., occupies a narrow belt, about 8 miles long, trending north-northeast. It lies entirely within the Umpqua formation of Eocene age. Mining began between 1865 and 1870 at both the Bonanza and Nonpareil mines, but both were abandoned after a small production. They were reopened at intervals, but until the Bonanza mine was acquired by the present operators in 1936 only a small tonnage of ore had been treated. Reliable figures for the early production are not available, but the total to 1937 did not exceed 2,000 flasks. The main (north) ore body at the Bonanza mine was discovered in 1939 and has supplied all the ore mined since that date. From 1937 to the end of 1944 the mine produced 24,471 flasks of quicksilver, of which approximately 22,500 flasks came from the newly discovered north ore body. Some of the ore ran as high as 120 pounds of mercury to the ton, but it averaged only 7 to 8 pounds.

Most of the ore was concentrated in a lens-shaped shear zone in tuffaceous sandstone that lies just beneath a shale and siltstone member of the Umpqua formation. These rocks form part of the east limb of an anticline. Differential movement during the formation of the anticline developed fractures in the tuffaceous sandstone that were later mineralized. The most productive (hanging-wall) ore shoots lie along the upper surface of the bedding-plane shear zone near the contact between the tuffaceous sandstones and the overlying shale. Less productive (footwall) ore shoots lie along bedding-plane shears or other fractures in the footwall of the shear zone a short distance from the shale contact.

The rich north ore body of the Bonanza mine is apparently bottoming at a depth of approximately 500 feet vertically below the surface. The chances of finding new ore shoots in the district, however, appear favorable. The contact zone between the shale and the tuffaceous sandstone, which was the main ore-bearing zone at the Bonanza mine, is hidden under soil or landslide debris nearly everywhere throughout the area. Prospectors and miners have been attracted by the bold outcrops of altered sandstone that lie a short distance west of this contact. As a result, practically all the exploration work in the district, except that at the Bonanza mine during the last 6 years, has been concentrated on ore shoots in the sandstone, and the more favorable area close to or directly beneath the contact has been little explored.

The Nonpareil area has produced approximately 340 flasks of quicksilver, chiefly from shallow workings at the South Nonpareil mine. The mineralization is closely related to cross faults that cut the contact of the shale and tuffaceous sandstone. Drilling has shown that the actual contact is not sheared and mineralized as it is at the Bonanza mine.

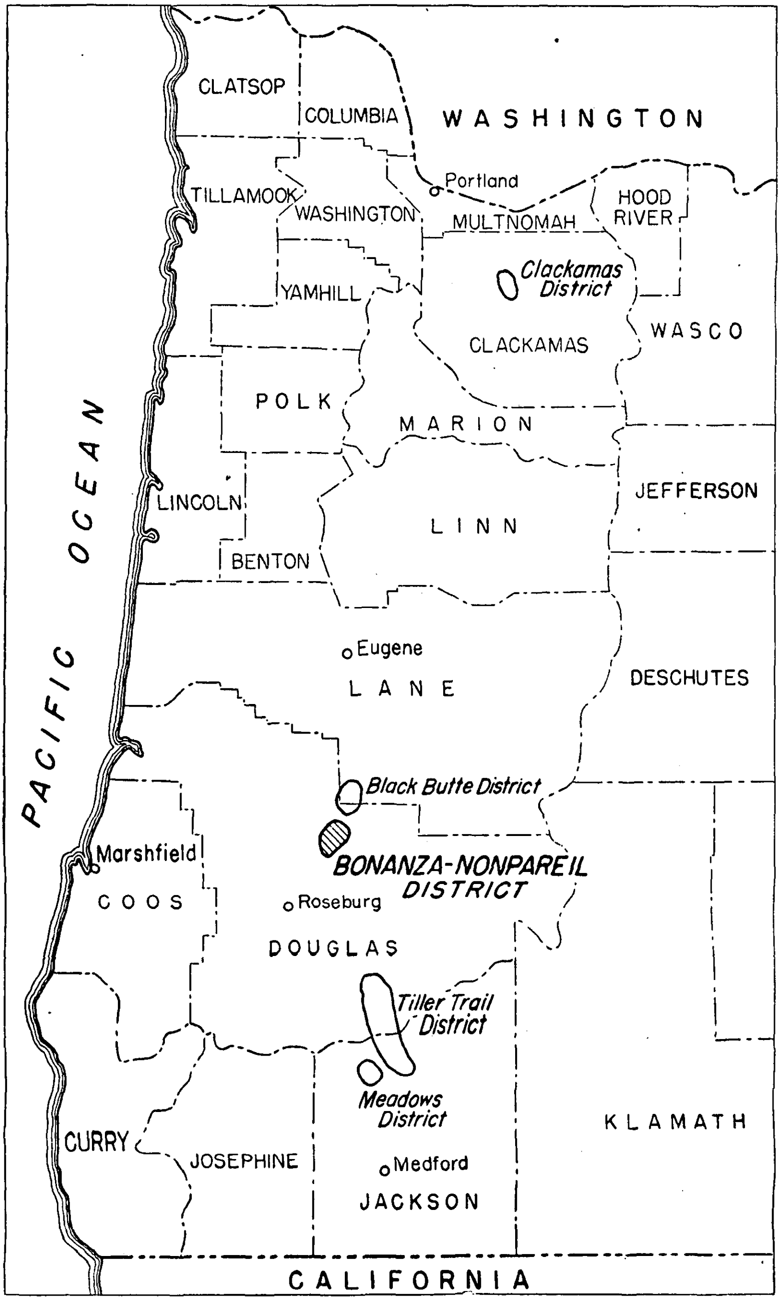

FIGURE 10.—Index map of western Oregon, showing the location of the Bonanza-Nonpareil district with reference to other quicksilver districts.

INTRODUCTION

GENERAL SETTING

The Bonanza and Nonpareil mines are in northern Douglas County, Oreg. (fig. 10). They lie near the central part of a northeastward-trending zone of altered rocks that has been traced almost continuously from sec. 20, T. 25 S., R. 4 W., to sec. 25, T. 24 S., R. 4 W. The Butte prospects are near the northeast end of this zone, and the Sutherland prospect is near the southwest end. The zone of mineralization may extend farther to the southwest and to the northeast, but it has not been traced in the heavy forests that cover the region.

A good graveled road connects the mines with Sutherlin, a small town 9 miles to the west on U. S. Highway 99. Branch roads make most parts of the mineralized area fairly accessible, but only the graveled roads can be traveled in wet weather. Sutherlin is served by the Southern Pacific Railroad; supplies must be trucked from there to the mines.

HISTORY AND PRODUCTION

The Bonanza and Nonpareil mines were discovered between 1865 and 1870, and a Scott furnace was erected on each property. Both mines were abandoned after a brief period of production during the 1870's. They were reopened at intervals (see table 1), but before the acquisition of the Bonanza mine by Bonanza Mines, Inc., the production of the district was not large. In May 1939, however, a large rich ore body was discovered at the Bonanza mine. By the end of 1944 this mine had become Oregon's largest all-time producer of quicksilver and had accounted for more than a quarter of Oregon's total quicksilver production. The Nonpareil mine was last worked systematically in 1932; in that year it produced 61 flasks of quicksilver.

FIELD WORK AND ACKNOWLEDGMENTS

The geology, history, and early development of the Bonanza-Nonpareil district are treated in Geological Survey Bulletin 850,[1] for which the field work was done in 1930. No other detailed investigation of the district has been made, although numerous short summary reports have been published from time to time.

The purpose of the present report is to bring Bulletin 850 up to date by recording developments since 1930, particularly those at the Bonanza mine, and to point out how the new findings may assist in delimiting other areas in the district that are favorable for exploration. Material for the report was gathered by A. C. Waters, Randall E.

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

Brown, and Robert R. Compton. The party spent approximately 1 month in the field during the summer of 1942. An area of about 10 square miles along the mineralized zone was mapped on aerial photographs on a scale of about 1 inch to 1,900 feet, and the underground

TABLE 1.—*Summary of history and production, Bonanza-Nonpareil quicksilver district, Douglas County, Oreg.*

[Data from Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, p. 36, 1888; Schuette, C. N., Quicksilver in Oregon: Oregon Dept. Geology and Min. Industry Bull. 4, pp. 128-139, 1938; Parks, H. M., and Swartley, A. M., Handbook of the mining industry of Oregon, vol. 2, no. 4, p. 218, Oregon Bur. Mines and Geology, 1916]

BONANZA MINE [1]

Year	Production, in flasks	Remarks
1865-70		Mine discovered.
1870		Small Scott furnace erected.
1870-87	(2)	
1887	15	
1916	(2)	Sutherlin Quicksilver Mining, Refining & Development Co. formed to concentrate ore before retorting.
1928	(2)	Property sampled, disclosing large tonnage of low-grade ore. Held by J. W. Wenzel, F. S. Skiff, and C. Scherer.
1931	(2)	Property controlled by Northwestern Quicksilver Co., J. W. Wenzel, manager.
1935	(2)	Property sold to H. C. Wilmot, who organized Bonanza Mines, Inc.
1937	148	Bonanza Mines, Inc., began operations with 50-ton Herreshoff furnace.
1938	1,183	
1939	2,199	North ore body discovered. Two 100-ton rotary furnaces installed.
1940	5,733	Bonanza mine led all domestic producers in annual production.
1941	5,548	
1942	3,940	One 100-ton furnace removed.
1943	3,294	
1944	2,426	Only one 100-ton furnace operating.
Total, 1937-44	24,471	

NONPAREIL MINE

Year	Production, in flasks	Remarks
1865-70		Mine discovered.
1870		New Idria Co. formed to work mine known as New Idrian. Small Scott furnace erected.
1870-80	33 or 34	
1882	50	Mine operated by Oregon Cinnabar & Silver Mining Co. Production cited is from district, probably all from Nonpareil mine.
1925	Several	Small retort operation by individuals.
1928		Nonpareil Quicksilver Co. took over control from Oregon Cinnabar & Silver Mining Co. Leased to C. M. Everett.
1931		Four-hearth Herreshoff furnace erected.
1932	61	
1933	Several	Small retort operations.
Estimated total [3]	340	

[1] Production figures published with the permission of Bonanza Mines, Inc.
[2] No production figures available.
[3] Based on volume of rock mined and probable grade of ore.

workings of the Bonanza and Nonpareil mines were mapped on a scale of 1 inch to 40 feet. The surface mapping of the area was done by A. C. Waters and the underground mapping by R. E. Brown and A. C. Waters assisted by R. R. Compton. In February and March 1944, the Nonpareil mine was remapped on a scale of 1 inch to 20 feet in conjunction with a U. S. Bureau of Mines diamond-drilling program, and the workings of the Bonanza mine were brought up to date. This mapping was done by R. E. Brown and George W. Walker.

The field work was aided throughout by the officials and miners of Bonanza Mines, Inc., who furnished much valuable information, freely permitted the use of considerable equipment, and helped greatly in many other ways. F. G. Wells and E. B. Eckel, of the Geological Survey, gave helpful advice both in the field and during the preparation of the report.

GEOLOGY

The general geology of the region that includes the Bonanza-Nonpareil district has been described by J. S. Diller.[2] The area immediately adjacent to the mines is described in more detail in U. S. Geological Survey Bulletin 850, plate 14 of which is a geologic map showing the distribution of the formations over an area of 35 square miles in the vicinity of the mines. A more detailed geologic map (pl. 29 herein), covering an area of about 10 square miles along the mineralized zone, was prepared in 1942. Dense forests and a thick soil mantle make surface mapping difficult, and some of the rock units shown in the cross sections and on the mine maps could not be traced at the surface.

STRATIGRAPHY

UMPQUA FORMATION

With the possible exception of a poorly exposed intrusive mass of diabase in the northeastern part of the area, all the rocks except the alluvial fill in the valleys are of Eocene age and belong to the geologic unit that Diller named the Umpqua formation. In this area, however, the Umpqua formation consists of two parts: an upper part made up dominantly of volcanic rocks, particularly pillow basalt and palagonite tuff interstratified with irregular lenses of conglomerate, and a lower part made up principally of arkosic sandstone, siltstone, and shale but containing occasional lenses and interbeds of tuff. The contact between one of the tuffaceous sandstones and an overlying series of shales and siltstones is of particular economic importance because shearing along or near this contact has permitted the rise of the hydrothermal solutions that deposited the quicksilver ores.

The sequence of the rock types that make up the Umpqua formation in the Bonanza-Nonpareil district is indicated graphically in figure 11, and the areal distribution of the larger units is shown on plate 29. Brief descriptions of these units follow.

Arkosic sandstone.—The base of the Umpqua formation is not exposed in the Bonanza-Nonpareil district, but in the central part of the Roseburg quadrangle Diller found localities where the Umpqua rests unconformably on the upturned edges of the Myrtle formation (Lower Cretaceous) and older strata. In the Bonanza-Nonpareil area the low-

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

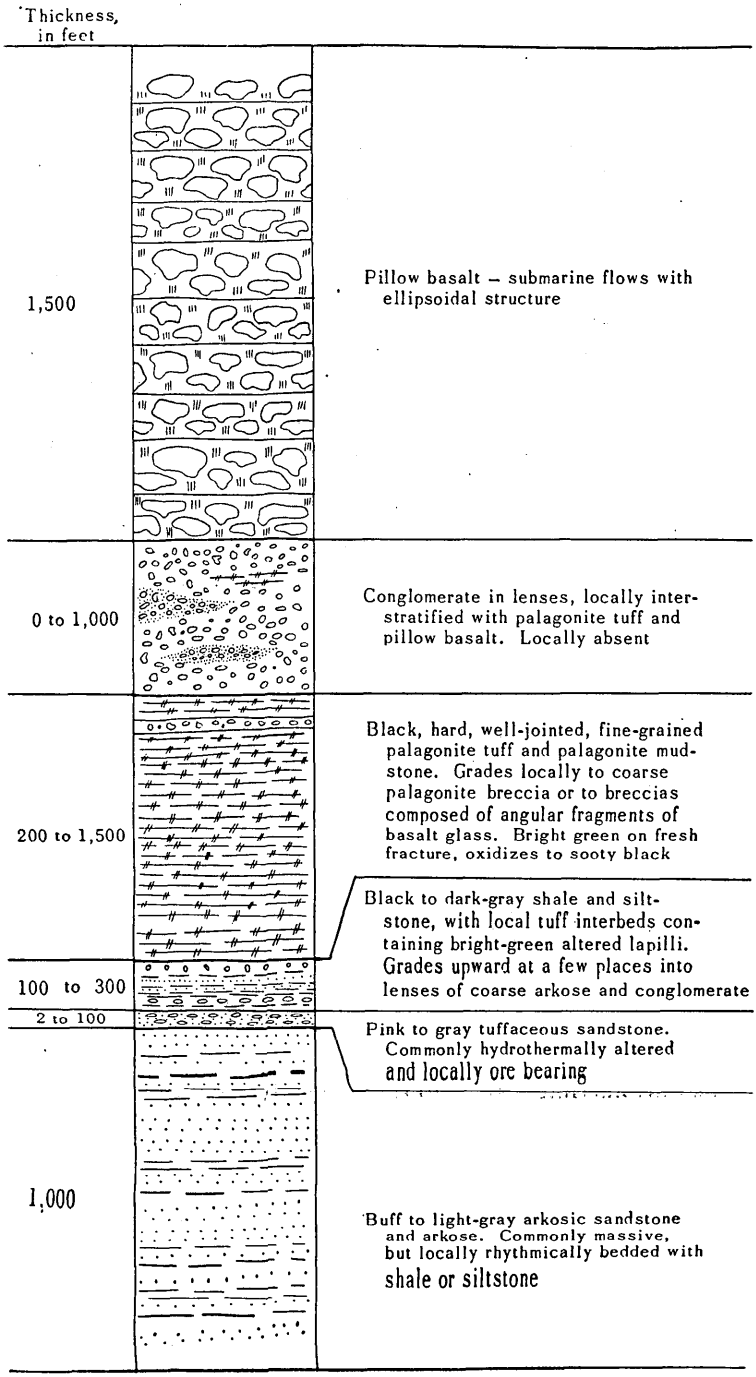

FIGURE 11.—Columnar section of the Umpqua formation, Bonanza-Nonpareil district, Douglas County, Oreg.

est exposed beds of the Umpqua formation are medium-grained, well-sorted, buff to white rocks that are well cemented at most localities and contain occasional thin interbeds of shale and siltstone. Quartz and feldspar are the principal mineral constituents, but the rock contains muscovite and bleached biotite in abundance and some beds contain appreciable quantities of volcanic material. The beds are massive and widely jointed; where they are of considerable thickness, they resist erosion and form long ridges such as the hill on which the Nonpareil mine is located. Elsewhere thin sandstone beds are rhythmically interlayered with shale and siltstone. At such localities the formation erodes easily and long strike valleys are formed. The valley of Long Valley Creek is typical.

Tuffaceous sandstone.—Of special economic interest is a series of lenticular beds of tuffaceous sandstone within the extreme upper part of the arkosic sandstones just described. The ore bodies at both the Bonanza and Nonpareil mines are largely confined to sheared zones within these lenticular beds of tuffaceous sandstone. One of the tuffaceous sandstone lenses, where exposed in the workings of the Bonanza mine, is as much as 20 feet thick and lies directly above the arkosic sandstone beds and beneath the shale and siltstone. A similar lens, about 55 feet thick and overlain by shaly sandstone, occurs in the workings of the South Nonpareil mine. Another bed of this kind occurs at approximately the same stratigraphic horizon near the Butte prospects about 2½ miles to the northeast. The tuffaceous sandstone has been thoroughly altered by hydrothermal solutions but appears originally to have been made up chiefly of lithic fragments (andesite and fine-grained feldspathic basalt) and fragments of altered glass (palagonite) mixed with minor amounts of the minerals that occur in the adjacent sandstones. Glauconite, a mineral found in marine sediments but an unusual constituent for a tuff, is locally abundant. Foraminifera and echinoderm fragments are present. Glauconitic beds occur, also, in the adjacent sandstone and shale; other beds are highly carbonaceous in character, and some contain stringers of lignite.

Shale and siltstone.—The tuffaceous sandstone is overlain by shales and siltstones that alternate in thin beds. Thin beds of sandstone and tuff containing bright-green altered lapilli also occur in this unit. The shales are usually black to dark gray, the siltstones lighter in color, and the tuffs green or black. At most localities these fine-grained sediments are overlain conformably—though abruptly—by palagonite tuff, but in the eastern part of sec. 16, T. 25, S., R. 4 W., and in the southwestern part of sec. 35, T. 24 S., R. 4 W., they grade upward into coarse gritty sandstone and fine granule conglomerate that is in turn overlain by palagonite tuff and by basalt.

Outcrops of this unit of the Umpqua formation are rare. The unit occurs mainly in the valleys and is covered by recent stream deposits or by creep and landslides from the adjacent hills. Its contact with the underlying tuffaceous sandstone, which is the ore-bearing horizon, was observed directly only in the workings of the Bonanza mine and at two places on the surface.

Palagonite tuff.—Above the shale and siltstone is a unit, 500 to 1,200 feet thick, of palagonite tuff and palagonite mudstone. The palagonite tuff is a black, closely jointed, very fine grained rock that is resistant to erosion and so forms good outcrops. It is composed largely of minute shards and fragments of palagonite, which is an altered yellow to orange basaltic glass. Palagonite is formed by the hydration of sideromelane, a clear, pale basaltic glass usually formed by the aqueous chilling of basalt magma. The origin and petrography of the palagonite tuff have been fully described in another publication.[3] The palagonite tuff is commonly found a quarter of a mile or less southeast of the sandstone-shale contact along which the ores were deposited; because of its good outcrops and unusual characteristics it makes a good marker for locating the ore zone.

Palagonite, the chief original constituent of the fresh rock, has in most places broken down to chlorite, carbonate, and other decomposition products; in other places the altered basaltic glass is admixed with shaly material. Locally the rock contains abundant marine microfossils. The unweathered parts of the rock are bright green to earthy yellow on fresh fractures, but the green variety oxidizes in a few hours or days to a sooty black. The fine-grained palagonite tuff grades locally into coarse-grained palagonite breccias, and these at places grade into flows of pillow basalt. Such gradations are well shown in sec. 35, T. 24 S., R. 4 W.

Conglomerate.—Irregular lenses of conglomerate are intimately associated with the palagonite tuff and pillow lavas in this area. The conglomerate forms a discontinuous zone that lies along the contact of the volcanic rocks with the normal clastic sediments of the Umpqua formation. Some of the conglomerate lenses are made up chiefly of subrounded pebbles of basalt; others consist largely of well-rounded pebbles of andesite, vein quartz, quartzite, chert, metagabbro, altered granitic rocks, felsite, altered porphyries, sandstone, and shale.

Basalt.—Submarine extrusions of basaltic lava into the Umpqua sea formed many flows of pillow basalt and local masses of basalt breccia.[4] The basalt is closely jointed and, near the surface, deeply

[3] Wells, F. G., and Waters, A. C., Basaltic rocks in the Umpqua formation: Geol. Soc. America Bull., vol. 46, pp. 961–972, 1935.

[4] Idem.

weathered. On fresh fractures the rock is black, but outcrops are often dark brown or buff from iron staining. The total thickness of the lava flows cannot be determined because of younger cover, but it is great. The flows extend eastward a few miles before disappearing beneath the more recent volcanic cover of the western Cascades.

OLIVINE DIABASE

In the northeastern part of the area the sandstone of the Umpqua formation is injected by an intrusive mass of olivine diabase. This mass, although poorly exposed, appears to be a broad dike similar to the dikes of olivine diabase that appear in the Umpqua formation a short distance west of this area. (See pl. 14 of U. S. Geol. Survey Bull. 850.)

SURFICIAL DEPOSITS

Calapooya Creek, the largest stream in the region, flows in a narrow gorge cut below a wide valley with an alluviated floor. The sharpness of the inner canyon indicates very recent rejuvenation of the stream. Tributary creeks flow in broad alluviated valleys in which rejuvenation has hardly started. The interstream divides are rounded and except on the more resistant rocks are deeply mantled by residual soil. Creep is an important morphological process in the region; the lower slopes of the hills are usually covered by thick accumulations of creep and landslide debris.

STRUCTURE

The mines are located in the southeastern limb of a broad anticline in the Umpqua formation. (See pl. 29, cross section.) Dips in the more competent members of the formation are 20° to 65° SE. Along Calapooya Creek, in the western part of the area, the uniform homoclinal structure is varied by the appearance of many small folds, seldom more than 100 feet in width, which pitch to the southwest.

An economically important zone of structural disturbance occurs at a definite stratigraphic horizon in the Umpqua formation. Between the lower massive sandstone and the overlying palagonite tuffs, pillow basalts, and conglomerates is a thin zone of incompetent shale and siltstone and the underlying tuffaceous sandstone. During the formation of the anticline the incompetent shale was sheared and thrown into drag folds, and the tuffaceous sandstone was sheared along bedding planes and cut by a few minor thrust faults that dip southeast at lower angles than the bedding. Cross faults, including the Nonpareil and Crag faults at the Nonpareil mine, trend from due north to N. 45° W. and cut and displace the contact of the shale and sandstone. All the displacements are small, but the sheared and faulted zone localized and guided ascending hydrothermal solutions that have altered the rock for some distance from the sheared contact zone and have deposited cinnabar, siderite, and marcasite along it. As a result of the oxidation of the iron-bearing minerals, outcrops of the zone are marked by limonite-stained sandstone and reddish to brown rubble derived from the weathering of carbonate-bearing siliceous veinlets.

In few places is the contact between the shale and the sandstone exposed. It usually lies at or near the southeast base of a ridge eroded from the adjacent massive arkosic sandstones and is obscured by landslides, creep, and wash from the ledges of sandstone above.

ORE DEPOSITS

Hydrothermal solutions followed upward along the sheared zone in the tuff and tuffaceous sandstone and deposited the ore minerals. The first solutions impregnated the sandstone and altered it to clay, chlorite, and other hydrothermal minerals. Simultaneously quartz, chalcedony, and carbonates were introduced. Cinnabar and siderite were then deposited as veinlets and impregnations. Chalcedony and quartz were also precipitated at this stage; in some of the ores much marcasite was deposited, but this mineral is not abundant at most points throughout the zone. Still later, calcite and other carbonates were introduced into the rocks in considerable quantities. Although this sequence indicates the general order of mineralization, evidence in some parts of the ore zone indicates that oscillations occurred, causing repetitions of the cycle. Realgar (AsS) and orpiment (As_2S_3) are rare constituents of the altered rocks at both the Nonpareil and Bonanza mines. Melanterite ($FeSO_4.7H_2O$), the hydrous ferrous sulfate, is now being deposited at several places in the Nonpareil mine.

The only mineral of economic importance is cinnabar (HgS). Metacinnabar, the black mercury sulfide (HgS), and native mercury have been seen in the upper workings of the Bonanza mine, and native mercury and calomel (Hg_2Cl_2) have been identified at the Nonpareil mine.

Deposition of cinnabar was controlled to a large degree by the original permeability of the beds and by the induced permeability brought about by shearing within certain well-defined zones. The ore shoots lie within lens-shaped bedding-plane shear zones in the tuffaceous sandstone, and only rarely do they extend into the unsheared, massive, locally coarse-grained sandstones along the margins of the shear zones. Some of these shear zones are only a few feet long and 3 feet thick; the largest, in which the north ore body of the Bonanza mine is located, is 1 to 60 feet thick, 800 feet long, and more than 700 feet deep. The shear zones generally follow the bedding in the sandstones but locally dip more steeply than the bedding, so that—particularly at the Nonpareil mine—they pass through the tuffaceous sandstone into the older, less sheared and less permeable sandstones and siltstones. At the Bonanza mine the shear zones are directly beneath or close to the contact between the shale and tuffaceous sandstone, whereas at the Nonpareil mine the shear zones are stratigraphically lower in the sandstones and therefore some distance from the contact. In general the shear zones have been uniformly highly altered by hydrothermal solutions and have been locally mineralized with cinnabar. At the Nonpareil mine the shear zones are generally mineralized throughout with cinnabar in small amounts, but at the Bonanza mine, in the north and south ore bodies, the commercial ore is concentrated in hanging-wall and footwall ore shoots, the former in the upper part of the shear zone and close to or directly beneath the contact of the shale and tuffaceous sandstone and the latter stratigraphically lower in the formation, in the footwall of the shear zone and as much as 60 feet from the shale contact.

Mineralizing solutions were localized at the Bonanza mine almost exclusively by the shear zones and by the overlying shale contact, but at the Nonpareil mine they were controlled in part by cross faults that cut the shear zones. At both the South and North Nonpareil mines, all the ore bodies mined were adjacent to or within a short distance of two cross faults: the Crag fault at the North Nonpareil mine (pl. 37) and the Nonpareil fault at the South Nonpareil mine (pl. 35). These faults, although of small displacement, are traceable for several hundred feet, contain considerable sandstone breccia, and are well mineralized with carbonates, silica, limonite, marcasite, and—locally—cinnabar. These cross faults apparently were the chief channelways for the mineralizing solutions at the Nonpareil mine.

At some places in the Bonanza mine, rich pockets of ore occur beneath flat, gouge-filled thrust faults that transect the bedding shears at an angle. Some steeply dipping shears also contain films and crusts of cinnabar, not only at points where they cut the tuffaceous sandstone, but also where they transect the massive sandstone beneath. This suggests that at least some of the solutions rose along steeply dipping shears until they reached the upper limit of the shear zone or the shale. Here, slowed and diverted by the overlying, less permeable rock, they deposited the ore minerals beneath it or below the gouge along flat shears. The bedding-plane shears in the tuffaceous sandstone have clearly been the main channelways followed by the ascending solutions at the Bonanza mine, but the steeply dipping faults and flat thrust faults served to spread the solutions throughout the fractured and sheared zone.

Schuette [5] has given a different analysis of the geology and ore controls of the Bonanza and Nonpareil mines. He says:

> Apparently both [mines] lie on the same dike of greatly altered andesite, which parallels the diabase intrusion east of it. The dike of altered ore-bearing rock strikes N. 20° E. at the Bonanza and N. 35° E. at the Non Pareil. * * * The intrusion apparently came up in the stratification of the eastern leg of an anticline in the Umpqua formation. This suggests that the later andesite came up along the plane of weakness along the diabase-Umpqua contact, and then pushed out along the stratification as indicated in the sketch, Fig. 9c. * * * The ore-bearing dike seems to parallel the diabase intrusion some 7 miles, and other prospects are known south of Bonanza.

The andesite dike referred to by Schuette was not recognized by the present authors. No intrusive igneous rocks were seen in either the Bonanza or Nonpareil mines. The tuffaceous sandstone contains small andesitic fragments but does not resemble an intrusive igneous rock. It shows excellent stratification, is composed of quartz, glauconite, palagonite, and other mineral grains in addition to the andesitic debris, and locally contains abundant Foraminifera, echinoderm fragments, and other fossils.

MINES AND PROSPECTS

BONANZA MINE

The Bonanza mine is in sec. 16, T. 25 S., R. 4 W., Douglas County, Oreg. The mill is on the eastern slope of a hill that rises approximately 600 feet above the adjacent valleys (pl. 30). Ore has been mined from two bodies, called the south ore body and the north ore body (pl. 31). The south ore body has been developed by four adits, by about 1,200 feet of drifts, and by two glory holes. Ore was extracted from the north ore body on five different levels spaced 50 to 120 feet apart vertically. They are known as the 200-, 370-, 500-, 630-, and 700-foot levels. The 370-foot level is the main haulage adit and is connected by raises and winzes with the other levels. Several raises extend to the surface, and in the summers of 1942 and 1943 considerable open-pit mining was in progress, the ore being dumped into chutes and hauled from the mine on the 370-foot level. Altogether, in March 1944, there was a total of approximately 7,000 feet of drifts, crosscuts, and adits in the mine. Only about 1,600 feet of workings existed when Bonanza Mines, Inc., took over the property in 1936.

The Bonanza mine was first operated on float and surface ore from the glory hole in the north ore body and from several short adits. From the date of discovery until the mine was acquired by the present operators, however, little mining and treating of ores took place.

In 1937 the present operators installed a 50-ton Herreshoff furnace

[5] Schuette, C. N., Occurrence of quicksilver ore bodies: Am. Inst. Min. Met. Eng. Tech. Pub. 335, p. 48, 1930.

and began mining the south ore body. Following the discovery of the rich north ore body in 1939, two 100-ton Gould rotary furnaces were installed. One of them was dismantled and moved to the company's new property at Hermes, Idaho, in the summer of 1942. In 1944 only the remaining Gould rotary furnace was operating at the Bonanza mine.

ORE BODIES

Ore shoots at the Bonanza mine are confined to the altered tuffaceous sandstone already described. At most points in the mine the contact of the shale and tuffaceous sandstone is the hanging wall of the shear zone, but in the upper workings the shear zone is locally as much as 30 feet west of the shale contact. As a result the ore shoots within this zone, although commonly near the contact of the shale and tuffaceous sandstone, are at many places not directly capped by the shale. The shear or shear zone near the contact of the shale and sandstone can be traced from adit 6 of the south ore body to adit 12, the location of which is shown only on plate 29. Throughout most of this distance, about 3,100 feet, the shear is a thin zone, which in the south and north ore bodies widens to form the lens-shaped zones in which the ore bodies occur. Cinnabar can be panned throughout most of this distance, but nowhere has any evidence been found to indicate that the shear may widen with depth into other large ore bodies. At the north end of the 370-foot level of the Bonanza mine the shear leaves the sandstone and passes into the shale. With its entry into this less permeable rock the ore shoots end. Another possible reason for the decrease in permeability northward is, as shown by drilling farther to the north (pl. 32), that the shale-sandstone contact there is not the same sharp separation shown in the mine workings, but is locally a transitional contact between a black shale containing abundant sandstone lenses and a sandstone with thin interbeds of siltstone, shale, and sandstone.

Many of the workings in the south ore body are caved. From the accessible parts it is evident that the ore body consisted of a hanging-wall ore shoot and a footwall ore shoot, the former lying directly beneath the shale-sandstone contact and the latter in the footwall of the shear zone 20 to 40 feet below the contact (pl. 33). The ore shoots ranged in thickness from 3 to 12 feet; they were mined out along the strike for a distance of approximately 250 feet and for 165 feet down the dip. One small ore shoot is on a steep shear. The ore was spotty; some of it is reported to have assayed as high as 60 pounds of mercury to the ton, though the average was probably 6 pounds. The south ore body has been largely mined out, but an unestimated, though small, amount of low-grade ore was left in the area between the adit 7 and

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adit 9 levels and can be mined when needed. A small amount of ore probably lies beneath the adit 9 level.

The north ore body was much larger and richer. The zone of shearing along the contact here widens into a large, lens-shaped zone that tapers and thins both laterally and downward. The top of the lens has been truncated by erosion, but the lens probably thinned and

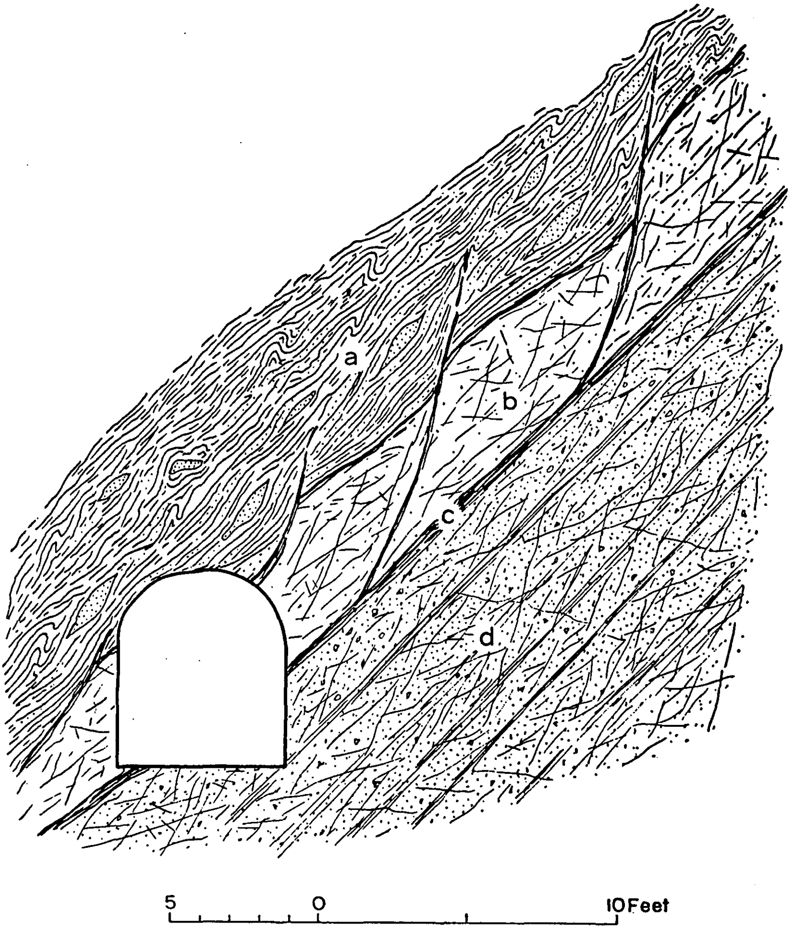

FIGURE 12.—Section through raise 2, on the 370-foot level, Bonanza mine, Douglas County, Oreg., showing (*a*) shale hanging wall, (*b*) mineralized shear zone, (*c*) bedding-plane shear, and (*d*) unaltered sandstone.

tapered out upward. The shear zone is as much as 60 feet thick and 800 feet long; it extends more than 700 feet down the dip. The hanging wall of this fractured zone is formed by the contact of the shale and tuffaceous sandstone, which at most places is a bedding-plane shear. At some localities evidence of movement along the contact is absent, and the bedding-plane shear lies a few feet from the contact within the sandstone (fig. 12). Even at such localities, however, the shale may form the hanging wall of the ore shoot, because cinnabar has impregnated the permeable but unsheared tuffaceous material between the shale and the bedding shear. Locally, as at the 630-foot level, the hanging wall of the ore is a smooth, slickensided surface on or very near the shale contact.

The footwall of the fractured zone, and hence of the ore body, is less distinct than the hanging wall. In most places it is an inconspicuous fault surface. In a few localities evidence of faulting is lacking. Although the shale contact is in most places the hanging wall of the ore body, it is only rarely that the footwall coincides with the contact between the tuffaceous sandstones and the underlying massive sandstones and interbedded fine-grained sandstones and siltstones. Where the lower limit of the ore is not delimited by a bedding-plane shear, it must be determined by assay or by panning. The fading out of the ore into the footwall is complicated by the fact that in many places in the Bonanza mine the tuffaceous sandstone grades into massive sandstone below. Further, this lower sandstone is not as massive as at most points along the mineralized zone. It contains numerous thin siltstone and fine-grained sandstone interbeds at some localities. Good examples of this interlayering can be seen along the haulage drift of the 370-foot level and at the 630-foot and the 700-foot level stations. Because the interlayered sandstone and siltstone unit is adjacent to the shale contact on the 630- and 700-foot levels, it is evident that the tuffaceous sandstone unit exposed on the 370-foot level has pinched out downward.

Between the hanging wall and the footwall of the ore body is the zone of shearing; in it three closely related fracture systems, nearly parallel in strike, can be distinguished. The first is a system of bedding-plane faults dipping about 45° SE.; this includes the contact shear and roughly parallel faults, some of which cut the bedding at low angles. The second system consists of fractures, most of which are thrusts dipping less than 30° SE.; a few of these faults dip to the northwest. Third and last is a system of faults ranging in dip from 59° E. to vertical; at several localities this set has been observed to merge with the bedding-plane faults by a change of dip. Although several periods of movement, both premineral and postmineral, are evident, the three fracture systems were apparently closely related in time. Evidence as to the amount of movement on individual faults and shears is usually indeterminate. The maximum movement observed on any one fault was about 20 feet; at most places where the displacement is determinable it is approximately 2 to 5 feet. In practically all instances where the direction of movement is evident, it is reverse. This is indicated by the attitude of the abundant drag folds in the adjacent shale and by the drag of the beds adjacent to the faults.

Mineralization was controlled to some extent by all three shear systems, but the primary feeding channel for the quicksilver-bearing solutions was the bedding shear at or near the contact of the shale and tuffaceous sandstone. Below the 370-foot level, where the bedding shear coincides with the contact, the ore values are the highest and persistent ore shoots occur in the hanging wall of the shear zone. On the 370-foot level, the entire shear zone was minable ore, but on the north end of this level the ore body split into a distinct hanging-wall ore shoot and a footwall ore shoot. Above the 370-foot level the hanging-wall ore shoot grades out, and on the 200-foot level it is replaced by a flat-lying, tubular ore shoot between the hanging wall and the footwall. The footwall ore shoot continued upward above the 200-foot level to the surface, where it was mined in an open pit (pl. 33). Distinct footwall ore shoots occur, also, below the 370-foot level at a few localities. Raise 30 on the 500-foot level had a high-grade hanging-wall ore shoot and a low-grade footwall ore shoot; raise 24 on the 500-foot level showed high-grade ore on both walls and lower-grade ore between. These two ore shoots merged into a single hanging-wall ore shoot below the 500-foot level and continued as one ore shoot below the 630-foot level.

As shown on the level maps, the maps of the stoped areas, and the cross sections and longitudinal sections, the fractured and mineralized zone decreases in maximum thickness from 60 feet on the 200-foot level to 40 feet on the 370-foot level, to 20 feet on the 500-foot level, to 5 feet on the 630-foot level, and to 4 feet on the 700-foot level. The length of the ore body also diminishes downward from 400 feet on the 200-foot level to 350 feet on the 370-foot level, to 250 feet on the 500-foot level, to about 200 feet on the 630-foot level, and to 150 feet on the 700-foot level. Thus the lens-shaped shear zone pinches out downward. At or slightly below the 700-foot level it probably pinches to less than stoping width. Therefore, although the mineralized shear zone may extend some distance farther, the decreasing grade of ore on the 700-foot level and the gradual pinching out downward of the shear zone will probably combine to make mining at greater depth unprofitable. Either the grade of ore or the thickness of the shear zone must increase if the ore shoot is to be worked profitably below the 700-foot level.

Further conditions make exploration below the 700-foot level of doubtful value. The ore body on the 630-foot level divides into distinct and separate higher-grade rootlike ore shoots along the strike of the shear zone. On the 700-foot level the ore body splits into two definite, rootlike shoots that apparently diverge and taper downward (pl. 34).

The rather abrupt ending of the ore body to the north occurs where the bedding shear leaves the tuffaceous sandstone and passes into the shale. The shale is highly brecciated along this shear, but the shale fragments fit tightly together and the zone is nearly impermeable. The shear zone passes into the shale on the north end of the 370-foot level and on the 700-foot level. Later work, during 1944, on the 700-foot level to the north shows that the shear reenters the sandstone and follows the contact northward, but nowhere does it widen to minable width. A small but high-grade pocket of cinnabar lies about 150 feet north of the mapped north drift of the 700-foot level. It is probably an isolated pocket, but its presence may indicate a widening of the shear zone and a new ore body below and to the north of the main ore body. To test this possibility, the winze was sunk to the 800-foot level and a drift was being driven northward along the shear zone during late 1944.

To the south, the north ore body and the shear zone taper and die out. At this end the shear zone remains in the sandstone, but the amount of fracturing gradually diminishes. Thus lack of permeability appears to be another reason for the termination of the north ore body in this direction.

RESERVES

Ore reserves, estimated by Bonanza Mines, Inc., as of April 1, 1944, totaled 34,000 tons of measured ore. Of this total, approximately 20,000 tons of ore is in pillars within the mine and therefore is not minable at present. A total of 14,000 tons of ore is readily accessible, most of it lying between the 500- and 700-foot levels. Less than 1,000 tons of low-grade ore remains in the open pit above the 200-foot level, and this cannot be mined in wet weather. An undetermined but probably small amount of low-grade ore remains in the south ore body between the adit 7 and adit 9 levels; it can be mined with relatively little development work from adit 10.

Considerable ore is present in pillars in the stopes on the 370-foot level and above and in winze pillars between the 200-foot level and 40 feet above the 500-foot level, where the winze passes into the footwall of the ore body. Obviously this ore cannot be mined until plans are made to abandon the mine. A small part of the pillars, however, can be mined without endangering the workings.

SUGGESTIONS FOR EXPLORATION

The possibility of finding new high-grade ore bodies at the Bonanza mine is not very promising. Marked tapering of the north ore body at depth indicates that it has bottomed, for, as previously mentioned, at or slightly below the 700-foot level the shear zone becomes of less than stoping width and the grade of ore gradually decreases. There is, of course, the possibility that the ore shoot may cease to taper and may widen again at depth, but the fact that the tapering occurs not only in cross section but also longitudinally is not encouraging. Exploration work on or slightly below the 800-foot level, however, is warranted to explore thoroughly the downward extension of the shear zone and to investigate the possible downward extension of the previously mentioned ore showing on the 700-foot level.

Exploration within the area between the north and south ore bodies appears to hold little promise. There is no evidence to indicate a widening of the shear zone within this area. Before the mine is abandoned, however, this area should be tested either by driving the 500-foot or the 630-foot level south 200 to 250 feet or by diamond-drilling the area.

The ore body terminates to the north both by pinching out and by the passing of the shear zone into the shale. Where the shear zone reenters the sandstone, as the new exploration work shows it does on the 700-foot level, the conditions for ore are more favorable. The ground in this direction has been tested by the 700-foot level, by adit 12, and by three drill holes (pl. 32). Although some shearing was seen both at the contact and within the shale, and some cinnabar was noted in holes 11 and 15 about 40 feet from the contact, the showings are not encouraging.

The most favorable area for exploration is apparently along the strike of the zone of alteration to the south of the south ore body. Float and other surface features indicate that a zone of hydrothermal alteration extends from the Bonanza mine to the Sutherland prospect. In adit 9 (pl. 31) the contact shear is in the tuffaceous sandstone and is strongly developed, but it has not been explored by workings farther south. Adit 6 misses the shear zone entirely; the mouth of the adit is west of the shear, and the entire 200 feet of the adit is in the massive sandstone of the footwall. The ground down dip from the south ore body also has not been prospected.

Prospecting in the area south of the south ore body can be done either by trenching and test pitting to uncover the surface trace of the shear zone or by drilling or crosscutting to cut it at some depth below the surface. Prospecting of the ground down dip from the south ore body can be done either by drilling or by driving a lower adit.

A heavy soil mantle makes surface observations of the area between the Bonanza and Nonpareil mines sketchy and unreliable. Only scattered outcrops of altered rock were seen, indicating that the mineralized zone is thin. Some of the zone between these mines has been prospected by Bonanza Mines, Inc., but results to date are not encouraging.

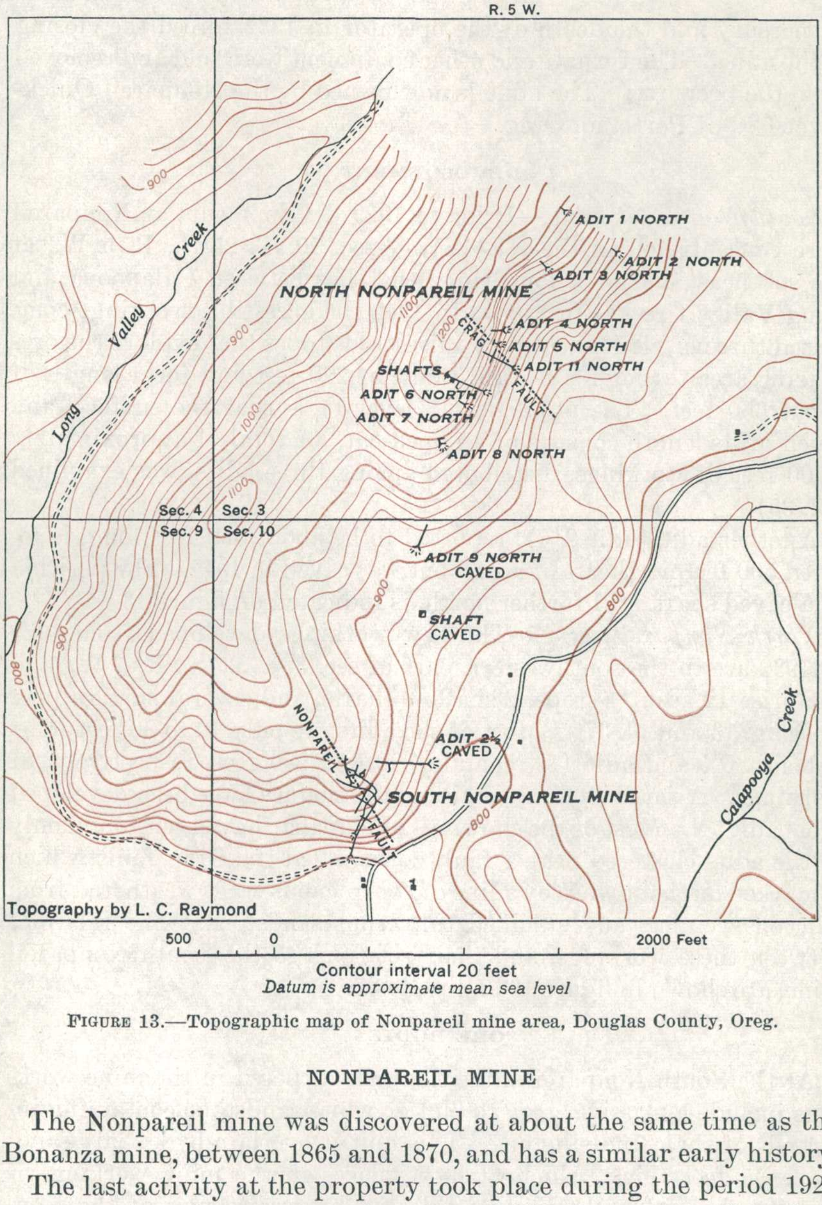

FIGURE 13.—Topographic map of Nonpareil mine area, Douglas County, Oreg.

NONPAREIL MINE

The Nonpareil mine was discovered at about the same time as the Bonanza mine, between 1865 and 1870, and has a similar early history.

The last activity at the property took place during the period 1928 to 1932, when the mine was leased to C. M. Everett. A four-deck Herreshoff furnace was installed in 1931. After an unsuccessful attempt to work the original (South Nonpareil) mine, Everett started development farther north by driving 12 short adits into the east slope of the ridge 1,850 to 3,500 feet northeast of the old mine. This part of the development is now known as the North Nonpareil mine. Good showings of cinnabar were found in a thin ore shoot at adit 5N (see fig. 13), and this body was worked for a while, but the dwindling price of mercury and the death of the operator in 1932 forced the closing of the mine. The furnace and other equipment were sold and removed from the property. The mine is now owned by the Nonpareil Quicksilver Co., of Portland, Oreg.

DEVELOPMENT

South Nonpareil mine.—Prior to 1929 developments at Nonpareil were concentrated in the NE¼SW¼ sec. 10, T. 25 S., R. 5 W., at the southeast end of a long ridge that lies between Calapooya and Long Valley Creeks (fig. 13). In 1942 the accessible workings comprised three levels connected by raises and stopes that explore the ore-bearing area through a vertical range of 220 feet and for a length of about 360 feet. The upper level (level 1) is near the surface, and much of its length consists of an open-cut. A total of approximately 2,700 feet of workings, distributed among three adits, was examined (pl. 35).

Another adit (adit 2½), reported to be about 350 feet long, is located 500 feet northeast of adit 3 but was caved in 1942. The position of a caved shaft, still farther north, is indicated on figure 13.

North Nonpareil mine.—The new workings developed from 1929 to 1932 are in the southwestern part of sec. 3, T. 25 S., R. 5 W., and comprise 12 adits, 1 stope, 2 shallow shafts, and several surface pits. (See fig. 13 and pl. 37.) Most of the adits are only 10 to 30 feet long, but adit 6N and adit 11N contain 290 and 280 feet, respectively, of workings. A small stope and raise to the surface have been developed from adit 5N. Most of the showings of cinnabar have been found only in the adits clustered near a fault zone, called the Crag fault, which is marked on the surface by a line of conspicuous crags weathered from siliceous veinlets and silicified tuffaceous sandstone. The relations between these workings, and their relations to the South Nonpareil mine, are shown in figure 13 and plate 37.

ORE BODIES

At the South Nonpareil mine the rocks exposed in the mine workings include a massive, gray to buff or white sandstone containing interbeds of shale and siltstone. This unit is overlain by a shaly sandstone 35 feet thick, which at most places in the mine workings is heavily charged with limonite released by weathering of the iron-bearing minerals (principally siderite and marcasite) brought in by the mineralizing solutions. Above this shaly sandstone is a lenticular bed of tuffaceous sandstone and tuff about 55 feet thick, which in turn is overlain by massive, dark-gray sandstone (pl. 35). This sandstone unit is about 120 feet thick and is overlain by the shale unit that plays such an important part in ore control at the Bonanza mine.

The ore bodies mined at the Nonpareil mine were nearly all from horizons stratigraphically lower than at the Bonanza mine and therefore some distance below the contact of the shale and tuffaceous sandstone. Only in one adit, indicated as adit 2½ on plate 16 of Bulletin 850 and now caved and inaccessible, has the shale-sandstone contact been exposed. At both the South and North Nonpareil mines mineralization was largely controlled by cross faults. All the ore bodies mined were adjacent to or within a short distance of two northwest-trending cross faults, the Crag fault at the North Nonpareil mine and the Nonpareil fault at the South Nonpareil mine. These two faults, although of small displacement, are each traceable for several hundred feet. They contain considerable sandstone fault breccia and are well mineralized with carbonates, silica, limonite, marcasite, and—locally—cinnabar. Hydrothermally altered zones parallel these faults, as is best shown on level 3 (pl. 35). The hydrothermally altered zones, the minerals encrusted on the fault surfaces, and the occurrence of the ore bodies adjacent to the faults indicate that the ore-bearing solutions rose along these cross faults.

Five stopes have been opened in ore shoots in the sandstone of the South Nonpareil mine. The lowest, stope 3, was localized by three structural controls: (1) the Nonpareil fault, which strikes N. 20° W. and dips 60° to 70° SW. and up which the mineralizing solutions rose; (2) a shear that strikes N. 8° E. and dips 34° E. and caps the stope above level 3; and (3) a bed of tuff and tuffaceous sandstone that was more permeable to the mercury-bearing solutions than the fine-grained massive sandstone.

The stope 3 ore shoot is localized beneath the intersection of the Nonpareil fault and the shear. The shear terminates against the Nonpareil fault and, with the Nonpareil fault, forms an inclined tent structure that strikes N. 13° W. and plunges 18° to 20° SE. (pl. 36). The plunge of the intersection is less than the dip of the bedding; therefore the ore zone migrates continuously higher in the stratigraphic column as the intersection is followed down the plunge to the southeast. Eventually, if the fault and the shear continue to the southeast of level 3, the intersection will meet the shale-sandstone contact, which at the Bonanza mine forms the hanging wall of the ore bodies. From the relations at the Bonanza mine, this intersection appeared to be a favorable locus for ore deposition, but when it was drilled in 1944 no ore was discovered.

Stope 1 is adjacent to the Nonpareil fault, along which level 1 was driven. The fault on this level strikes N. 13° W. but dips 60° to 80° NE., whereas on levels 2 and 3 it dips 53° to 80° SW. As shown on plate 36, cross section *B–B′*, the Nonpareil fault steepens above level 3, becomes vertical between levels 1 and 2, and then inverts to an easterly dip on level 1.

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The stopes that open from level 2 (stopes 2A, 2B, and 2C and sub-stope 1, which is an extension of stope 2B) are different. They are on ore shoots that lie along shear zones within the permeable sandstone and tuffaceous sandstone. These beds of permeable sandstone sheared more easily than the finer-grained massive sandstones. Most of the shear zones were mineralized adjacent to the Nonpareil fault and have been mined. They are small, lens-shaped areas within the sandstone; they strike parallel to the bedding but dip at higher angles than the bedding and are vertical in places. Thus the shear zones cross the beds and pass from the permeable tuffs and tuffaceous sandstones into less permeable, finer-grained massive sandstones, both upward and downward. The individual shear zones are less than 10 feet thick, but locally they merge to form larger shear zones and close to the Nonpareil fault they are commonly wider. The zones die out both laterally and downward and cannot be definitely projected to other levels. The individual tuff beds within the tuffaceous sandstone cannot be traced or correlated over a wide area because they pinch and swell, finger out laterally and vertically, and vary greatly in composition and character even over short distances.

The ore shoots from level 3 upward become of greater lateral extent and greater thickness; thus on level 2 the shear zones are mineralized up to 80 feet from the Nonpareil fault. The divergence of the ore shoots from the Nonpareil fault is well shown in plate 36. The stoped areas near the surface (level 1) are larger than on the lower levels and suggest that as the steeply dipping shear zones approached the overlying, more gently dipping, more impermeable sandstone contact the ore shoots were both larger and more continuous. Thus the Nonpareil ore shoots may represent only the roots of a considerably larger deposit that has been mostly eroded away.

The Crag fault, at the North Nonpareil mine, strikes N. 45° W. and dips 70° SW. to vertical. The only ore shoot mined at the North Nonpareil mine was that in adit 5N, although cinnabar has been found in several other workings. (See pl. 37.) The ore shoot in adit 5N (called adit 2N on p. 40 of Bull. 850) was deposited in a bedding-shear zone in tuffaceous sandstone by mercury-bearing solutions that rose primarily along the premineral Crag fault. Rich, though spotty, showings of cinnabar were found along the sheared bedding near the intersection of the shear zone with this cross fault. The Crag fault, like the Nonpareil fault, served as the main channelway for ascending hydrothermal solutions. The rock adjacent to it is extensively altered and has been impregnated by numerous veinlets of silica and carbonate. Leaching and redeposition of the iron-bearing minerals have stained the rock with limonite, and local hardening of the rock from the introduced silica causes the fault zone to stand out on the surface as a line of cavernous-weathered crags. The ore shoot in adit 5N lies stratigraphically well below the shale-sandstone contact, as do the ore shoots at the South Nonpareil mine. A few poorly exposed outcrops of shale near the base of the hill indicate that prior to erosion the contact lay about 100 feet stratigraphically above the ore shoot in adit 5N. This was later confirmed by diamond drilling.

Other workings at the North Nonpareil mine have failed to disclose deposits of ore, although in adits 6N and 11N, and in the shafts above adit 6N, cinnabar can be panned and is visible as small veinlets in sheared tuffaceous interbeds. A few rich pockets of cinnabar were found in adit 4N (referred to as adit 1 on p. 40 of Bull. 850) in 1930, but no body of milling ore was discovered.

In February 1944 the United States Bureau of Mines began a diamond-drilling project at the Nonpareil mine to test the possible occurrence of mineralized shear zones at or near the shale-sandstone contact at both the North and South Nonpareil mines. Drilling explored the areas at the intersection of the Nonpareil and Crag faults with the shale-sandstone contact. No prospecting had been done previously at the shale-sandstone contact at the North Nonpareil mine, because it is covered by thick landslide and talus debris. Vertical hole 3 (pl. 37) was drilled at the North Nonpareil mine within the acute angle formed by the intersection of the Crag fault and the shale-sandstone contact, which here strikes N. 36° E. and dips 40° to 45° SE. This hole passed through 51 feet of landslide material, intersected the shale-sandstone contact at 61 feet, but cut no shear zones and found no ore. Hole 4 (pl. 38), the second hole drilled, was located 75 feet S. 30° E. of hole 3 and was inclined 45° in a N. 70° W. direction. It passed through 61 feet of landslide material, intersected the shale-sandstone contact at 84 feet and the Crag fault between 110 and 126 feet, and stopped in sandstone at a depth of 219 feet. No shear zones were cut either at the contact or at greater depth. The Crag fault, as revealed in the drill cores, consists of 16 feet of intensely brecciated, fine-grained sandstone, cemented and mineralized with carbonates, silica, marcasite, and some realgar. No cinnabar was seen. The abundance of silica, carbonates, and marcasite indicates that the mineralizing solutions rose along the fault but that conditions were not favorable for the deposition of cinnabar as they were at higher altitudes such as in adit 5N.

Two holes (pl. 37, holes 1 and 2) were drilled from a station 12 feet in front of adit 5N to determine the possible downward extension of the ore shoot, which trends N. 26° W. and pitches 42° SE. The ore shoot was localized along the intersection of the Crag fault and a bedding shear. Holes 3 and 4 (pl. 37), drilled to intersect the projection of this ore shoot down the pitch, passed through the Crag fault zone of intensely brecciated, altered and sheared, fine-grained sandstone, highly mineralized with limonite, into the unaltered sandstone on the south side of the Crag fault. Some cinnabar was found, but no milling ore.

The ore body in adit 5N is apparently an isolated pocket of ore, not connected with a larger ore body at depth. Similarly, evidence indicates that no major ore body will be found at the shale-sandstone contact at the North Nonpareil mine, for no shearing nor mercury mineralization was found either at the contact or at stratigraphically lower horizons in holes 3 and 4.

A series of holes (pl. 36, holes 5, 6, and 7) was next drilled at the South Nonpareil mine to test the extension of stope 3 toward its possible intersection with the shale-sandstone contact. The holes, as drilled, proved the extension of the Nonpareil fault to the shale contact, but no ore was found and no evidence of shearing along or near the contact was noted. Evidence from the drill holes indicates that the Nonpareil fault in all probability dies out toward the shale contact and probably splits into a number of small shears that dissipate themselves into the shale. The total amount of movement on the fault is small, probably less than 20 feet.

Hole 8 (pl. 36) was drilled to explore the hanging wall of the Nonpareil fault and the downward extension of the shear zone in which stope 2A is located. It was also intended to test the possible occurrence of similar shear zones in the area not exposed by the level 3 workings. This hole, drilled to a depth of 185 feet, penetrated several zones of silicified, brecciated sandstone, well mineralized with carbonates and marcasite, but found no ore. The conclusion reached is that, although these or similar shear zones may extend to greater depths than the present mine workings, the possibilities of finding much ore are small.

PROBABLE TOTAL PRODUCTION

No authentic information is available concerning the total production of the Nonpareil mine, for which a yield of as much as 1,000 flasks of quicksilver has been claimed. A fairly reliable estimate, however, can be made. A comparison of the maps published in Bulletin 850, for which the field work was done in 1930, and the maps made in 1944 shows that about 700 tons of rock was mined from the stopes during that period. The production of the Nonpareil mine from 1930 to 1933 was about 64 flasks. Thus the average grade of rock mined, if we assume that all the rock was furnaced, was 7 pounds of mercury to the ton. This figure for the average grade of the ore mined is probably correct, as it is comparable to that of the ore mined at the Bonanza mine from 1937 through 1944, which averaged 7 to 8 pounds of mercury to the ton. A sample of ore from the ore bin at the Nonpareil mine, characteristic of the last ore furnaced, was assayed and found to contain 7.4 pounds of mercury to the ton. Two channel samples taken within the mine assayed 7.3 and 7.0 pounds of mercury to the ton; the locations are indicated on the level map (pl. 35). The total calculated tonnage of rock mined from the stopes is about 3,700 tons. Thus, if we accept the figure of 7 pounds of mercury to the ton as representative of the mine as a whole, the total production of the Nonpareil mine is about 340 flasks.

RESERVES AND RECOMMENDATIONS FOR EXPLORATION

There are no reserves of blocked-out ore at the Nonpareil mine. Ore bodies above level 3 of the South Nonpareil mine are almost completely worked out, but a small amount of low-grade ore still exists on the walls of the stopes and in a few pillars. The ground between the head of stope 2B, along the Nonpareil fault, and substope 1 has not been explored. This area, noted on plates 35 and 36, has a vertical extent of 55 feet and a maximum length of 45 feet. The maximum width probably does not exceed 4 feet. High-grade cinnabar stringers as much as an inch thick in stope 2B along the Nonpareil fault, together with numerous small stringers along the fault northwest of stope 2B, indicate that the area is worth exploring.

The drilling project completed in March 1944 indicates that no large ore bodies are to be expected at the shale-sandstone contact in the localities prospected. Exploration work within the mine should be concentrated along the Nonpareil fault and the Crag fault, for all the ore bodies mined to date have been on or near these two faults.

BUTTE PROSPECTS

The Butte prospects are in sec. 26, T. 24 S., R. 4 W., about 2½ miles northeast of the South Nonpareil mine. They are described briefly in Bulletin 850. No new development work has been done at the property since 1930. The zone of alteration in the sandstone is approximately 200 feet wide. The shale and siltstone member of the Umpqua formation appears either to have become sandier or to have thinned, because the palagonite tuff is closer to the mineralized zone than at other localities. No cinnabar was seen in the accessible workings.

SUTHERLAND PROSPECT

The Sutherland prospect, which lies at the southwest end of the mineralized zone about 1½ miles from the Bonanza mine, was not visited in 1942. It is briefly described in Bulletin 850. No additional work has been done on the property since 1930, and no cinnabar was seen on the property when it was examined at that time.

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