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GEOLOGY OF THE CUARENTA MERCURY DISTRICT STATE OF DURANGO, MEXICO

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CONTENTS

ILLUSTRATIONS

GEOLOGY OF THE CUARENTA MERCURY DISTRICT, STATE OF DURANGO, MEXICO

By David Gallagher and Rafael Pérez Siliceo

ABSTRACT

The Cuarenta mercury district is in the semiarid mountain region of the difficultly accessible northern part of the State of Durango, Mexico. The oldest rock in the district is a granite that was injected by diabase dikes along north-trending joints and was then truncated by erosion. A thick series of limestone conglomerates and rhyolite tuffs and flows was deposited upon this unconformity in late Tertiary time under conditions of crustal instability. Some sporadic silicification of all the rocks followed, probably as a late phase of the volcanism. The region was tilted northward about 20° and dislocated by minor east-trending and N. 50° E. faults and by still younger north-trending faults. Cinnabar-depositing solutions rose along the faults and, where retarded and diverted by impermeable diabase dikes, faults, and silicified zones, formed small tabular ore bodies, particularly near the granite-conglomerate unconformity. The largest and richest ore shoots formed where two impermeable structural features intersected, particularly under dikes overlain by conglomerate at the unconformity. In contrast, the few ore shoots that were localized by a single impermeable feature are small and low in grade. The principal cinnabar deposits lie west of the town of Villa Cinabrio in a northwest-trending zone two kilometers long. The cinnabar was discovered in 1932. Peak production of around 300 flasks of mercury per month was attained from 1940 to 1943. The district has produced a total of about 15,000 flasks, but the mines are wrecked beyond any hope of reclamation by gophering and pillar robbing. Mining stopped in the Cuarenta mercury district in August 1943. A large tonnage of low-grade ore is said to remain, but whether this ore is real or imaginary must await proof by extensive, and expensive, sampling.

INTRODUCTION

The productive mercury deposits of the Cuarenta mercury district occur in a narrow zone, about 2 kilometers long, just west of the town commonly called by its old name, Cuarenta, but now officially re-named Villa Cinabrio, in the northern part of the State of Durango, Mexico (fig. 23). Maps of this part of Mexico are poor, and they are at variance with one another. None shows Villa Cinabrio, but its approximate longitude and latitude as measured on the "Million Map" of the American Geographical Society are 105°30' W. by 26°08' N. Villa Cinabrio, about 7 kilometers east of Castañeda, is 38 kilometers by dirt road northwest of Santa María del Oro, 56 kilometers southeast of Rosario, the nearest railhead, and 144 kilometers southeast of the famous silver mines of Parral, Chihuahua. All the roads in the region are bad, and they are impassable during the rainy season.

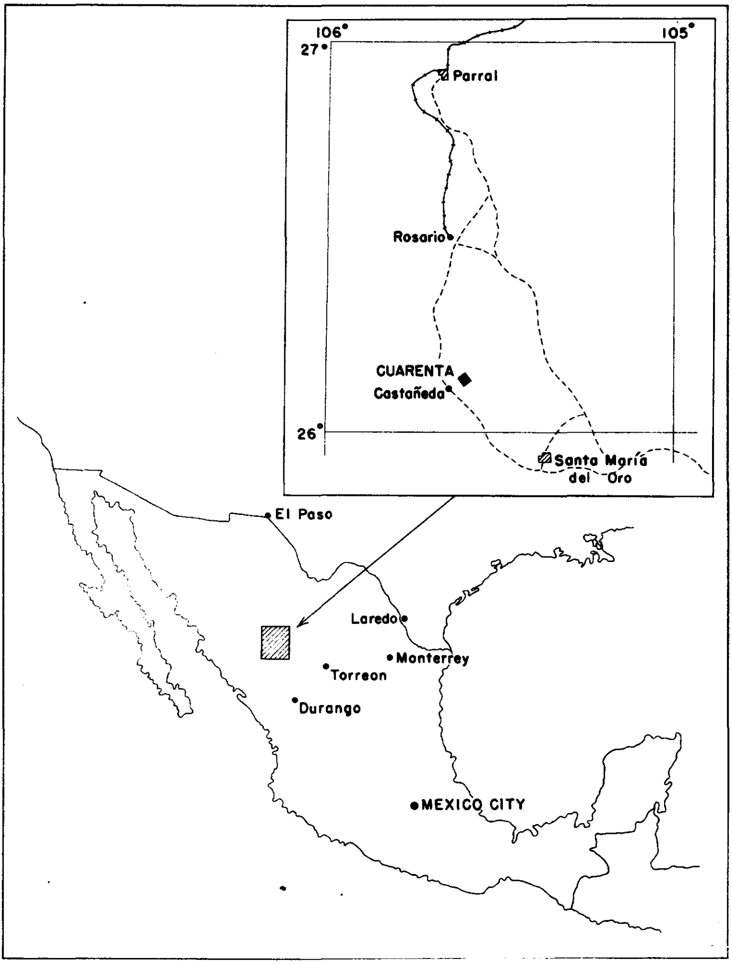

Figure 23. Index map showing location of the Cuarenta mercury district.

The population of Villa Cinabrio was about 3,000 during the boom period of 1941, and consisted mostly of "gambusinos" (as the small, independent mine operators are called in Mexico) and their families. Only about 1,500 people remained in 1943, and in 1944 the town was almost deserted. Conditions in the Cuarenta district are unattractive; water is scarce and bad, there are no sanitary provisions, timber is scarce and poor, wages low, and during the boom there was almost no law enforcement.

Field work and acknowledgments

The work leading to this report was part of a larger cooperative program carried on by the United States Geological Survey, Department of the Interior, the Instituto de Geología of the Universidad Nacional Autónoma de México, and the Dirección General de Minas y Petróleo of the Secretaría de la Economía Nacional. This cooperative program is sponsored by the Interdepartmental Committee on Scientific and Cultural Cooperation under the auspices of the United States Department of State.

Field work was done from May 20 through June 4, 1943. A topographic map of 17 square kilometers was made by plane table, largely by Kenneth Segerstrom, at 1:10,000 scale and 10-meter contour interval. The initial altitude was determined by barometer. The surface geology of this area was mapped, and the accessible mines were visited.

We wish to thank Mr. Claude D. Moll, president of the Compañía Explotadora de Durango, S. A., for his hospitality and friendly cooperation.

PHYSIOGRAPHY

The Cuarenta district lies in the southwesternmost mountains of the Sierra del Oso, which trends northwest from Santa María del Oro to Rosario, and is bounded on the southwest by the valley of the Río Nazas. Where this valley passes the Cuarenta district it has a southeastward trend and is about 10 kilometers wide. The elevation of the river is here about 1,600 meters above sea level, and the low rolling hills and terraces of unconsolidated valley fill rise to about 1,800 meters elevation at the base of the bordering mountains. Within the map area these mountains attain elevations of more than 2,200 meters, and they stretch away beyond it as far as the eye can see, seeming to increase in height away from the Río Nazas.

The mountain region is in the youthful stage of the erosion cycle. The valleys are steeply V-shaped and the slopes of the mountains are precipitous. There are many talus slopes. Cliffs 20 meters high are numerous. Low hills with more gently rounded form occupy some of the broader valley areas within the mountains.

As the upper parts of the mountains are composed of a series of rhyolite lava flows that dip about 20° N., there are many upland surfaces that are inclined planes, locally called "mesas," which slope northward as they coincide approximately with the tops of individual flows. Such "mesas" succeed one another northward, somewhat like a stairway, but as the present drainage flows southward, contrary to their direction of slope, these "mesas" may be remnants of an old surface that was eroded by a different drainage system.

GEOLOGY

The oldest rock in the area is a granite, into which diabase dikes were intruded. The granite and its contained dikes are truncated by an old erosion surface that is an unconformity on which the succeeding rocks were laid down. These younger rocks are a thick series of closely associated conglomerates and rhyolitic volcanic rocks that constitute the most abundant and widespread rocks of the region.

Granite

Granite underlies the lower part of the northern slope of Cerro El Cuarenta, much of the Arroyo del Cuarenta, and all of the Cerro Salitrillo. Most of the granite is medium-grained (1 mm. to 2 mm.), equigranular, and holocrystalline, and consists of quartz and white feldspar with a little biotite, the whole having a nearly white color; but some of it, particularly in the Arroyo del Cuarenta, is dark with hornblende. One small aplite dike was found in the granite on the western slope of Cerro El Cuarenta.

Diabase

Dikes that are tentatively identified as diabase are abundant throughout the granite, particularly near the most productive mercury mines. They strike about N. 10° E., and dip to the west at inclinations between 30° and 70°. Most of the diabase is fine-grained, but in the largest dikes, which attain a thickness of 20 meters, the grain size is as coarse as 1 millimeter. These dikes are peculiar because, unlike normal diabase that consists essentially of labradorite and augite with 2 to 10 percent of magnetite, some of these contain such an abundance of hematite, martite, and limonite that they are locally referred to as "iron dikes."

Conglomerate-rhyolite series

The conglomerate-rhyolite series, which has a thickness in excess of 200 meters, consists of a lower conglomerate and an upper conglomerate overlain by rhyolitic volcanic rocks that include tuffs, rhyolite flows, and rhyolite agglomerates.

Lower conglomerate.—The oldest unit of the conglomerate-rhyolite series is a conglomerate that in places attains a maximum thickness of about 100 meters, but elsewhere pinches out completely. It is composed of limestone pebbles, cobbles, and boulders. Some of the largest boulders are half a meter in diameter. Cobbles that range in size from 10 to 20 centimeters are most common, and those of any one outcrop generally show a restricted range of sizes. The pebbles, cobbles, and boulders are subrounded to well-rounded, and generally equidimensional, but some are flattish or slab-shaped. They are composed of fine-grained, massive, compact, gray limestone, but nearly all are fractured and veined with white calcite, indicating a period of deformation before they were quarried by erosion. The matrix of the limestone conglomerate appears to be sandy, although tuffaceous material may also be present.

A rubble of limestone pebbles litters the surface of much of the area underlain by conglomerate, because under present conditions of weathering the matrix is more readily decomposed than the pebbles. A contrast to this selective disintegration of the groundmass under chemical weathering, which prevails throughout most of the area, is seen at places where mechanical abrasion is intense, as along the outer sides of the curves in streams. There the conglomerate is worn to a smooth surface that truncates the pebbles and matrix alike.

Upper conglomerate.—Above the lower conglomerate there is a finer-grained conglomerate with a striking and diagnostic brilliant green color, due to a powdery green mineral, probably a chlorite, that is abundant in the matrix and that also coats, or partially coats, the pebbles. This conglomerate is a conspicuous feature in the vicinity of the Cuarenta mines, where it is generally about 25 meters thick, but it is not continuous throughout the region.

The upper conglomerate is composed of pebbles, most of which are between half a centimeter and 3 centimeters in diameter, but some are larger. Most of them are flattish ellipsoids. They display a rude parallelism, indicating bedding, and they overlap in such a way as to suggest that they were deposited by currents flowing from the north toward the south. These are features that cannot be seen in the coarser underlying limestone conglomerate. A few lenses of sandy material and a few of sandy limestone also occur in the upper conglomerate, but all of these interbedded lenses are small and are distinctly subordinate in volume to the conglomerates themselves.

Most of the pebbles in the upper conglomerate are limestone, but some are rhyolite showing that the rhyolite volcanic eruptions began before the deposition of the conglomerate was completed. The fact that the volcanic eruptions began during the conglomerate sedimentation is also shown by the small, lenticular masses of tuff that are interbedded here and there in both the lower and upper conglomerates. Furthermore, the lower and upper conglomerates are separated in a few places by a thin layer, about half a meter thick, that is flow rhyolite in some exposures and pyroclastic material in others.

Rhyolitic volcanic rocks.—The rhyolitic volcanic rocks overlying the conglomerates consist of tuffs, rhyolite flows, and rhyolite agglomerates, which are not separately differentiated on the map (pl. 51).

The rhyolitic tuffs interstratified with the conglomerates are commonly red, and some, but not all, show bedding that indicates deposition in water. Throughout the mapped area the upper conglomerate is overlain by a structureless, chalk-white tuff 2 or 3 meters thick that forms a prominent ledge and break in slope all along the hillsides to the north of the mines. Above this is a tuff approximately 70 meters thick which was not seen in place anywhere because it is covered by rhyolite talus from the flows above. The presence of this tuff is inferred from the topographic form of the slopes and from the rhyolitic and tuffaceous character of all float above the chalk-white tuff.

In the valley of the Arroyo de La Sardina some small prospect pits expose a yellowish tuff. The thinness and regularity of its bedding, and the high degree of sorting, indicate that it was deposited in water.

A succession of rhyolite lava flows blankets the summits of the mountains and "mesas." As the flows are not directly associated with the cinnabar deposits, they were not investigated in detail.

In some places, notably on the "mesas" to the east of the Boquilla de La Sardina, the rhyolitic material is agglomerate or breccia instead of typical flow rhyolite, although from a distance it has the same general aspect and topographic form. It is strikingly beautiful in pattern and color, and is composed of angular fragments of rhyolite of a wide variety of sizes and shapes, and many kinds and colors, cemented by a matrix of finer-grained rhyolitic material. These agglomerates are contemporaneous with the rhyolite flows.

In summary, the conglomerate-rhyolite series, comprising a variety of rocks, represents a closely inter-related group that began with water-laid conglomerates and tuffs and ended with terrestrial lava flows as sedimentation diminished and volcanic activity increased.

Patches of identical limestone conglomerates were observed in the region over a distance of nearly 200 kilometers north-south and 50 kilometers east-west. They doubtless have a far greater extent, for such conglomerates are a well-known feature of Mexican geology, particularly in the western Cordillera. They occur beneath the rhyolite, but generally only in places where the pre-rhyolite andesitic eruptives are absent.1/ Evidently during the andesitic volcanic period, which was the first volcanic activity in Mexico following the deformation of the Cretaceous limestones, conditions favorable for the deposition of conglomerates existed at many places where the andesitic eruptives were not forming. Such places were probably inland basins, for it is unthinkable that the highly specialized conditions necessary for the deposition of conglomerates could have existed continuously over so wide an area.

Many features of these rocks suggest the special conditions under which they were formed, and also indicate contemporaneous crustal instability. They formed in basins, and although the component fragments are water-rounded, it is inconclusive whether they were deposited just off shore in lake waters or as terrestrial material, such as fans. Possibly both conditions existed. The water-laid tuffs, occurring as interbedded lenses in the conglomerates, indicate that some deposition occurred under water, but the massive tuff lenses, devoid of bedding, indicate deposition on land.

The granite surface on which the conglomerate was unconformably laid down had considerable relief. There is a particularly noteworthy upward protuberance of this surface south of Loma El Risco. The conglomerates are not continuous, they vary in width, and are absent in some places. The map (pl. 51) shows that in general conglomerate occurs on the lower parts of the granite surface, whereas the higher parts are directly overlain by rhyolite. Possibly the conglomerates never were deposited over the entire area, but were laid down only in depressions in the granite surface. On the other hand, some of the conglomerate may have been removed by erosion prior to the inundation of the region by rhyolitic volcanic rocks.

The conglomerate lies directly upon a clean granite surface devoid of a weathered zone or a soil mantle. The water currents

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1/ Berry, John G., personal communication.

that could have delivered such coarse rock fragments would have simultaneously removed any soil that might have been present, but on the whole the clean granite surface suggests subaqueous deposition.

The thin layer of rhyolitic material that separates the lower and upper conglomerates further attests to the crustal instability at the time, as does also the difference in characters between the two conglomerates. They must have been deposited under very different conditions. The abrupt change from conglomerate sedimentation to the widespread deposition of the massive, chalk-white tuff, indicates a change from littoral to terrestrial conditions, probably brought about either by uplift or by drainage of the basin. Lastly, crustal instability might be expected in a region of violent volcanic activity.

The age of the granite and its included dikes is unknown, but although direct evidence is lacking in the Cuarenta district, the conglomerate-rhyolite series may be assigned to the Tertiary, and the period of vast rhyolite eruptions to late Miocene or to Pliocene time, in conformity with the generally accepted chronology of Mexican geology.

Recent gravel

Most of the mountain slopes are covered with rhyolitic talus and the low hills with limestone pebbles. These contribute to the stream load, and have been discharged upon the Río Nazas Valley flats forming alluvial fans. The entire Nazas Valley contains a thick deposit of recent gravel deposited by the Río Nazas itself and by the many tributaries that flow into it from either side.

SILICIFICATION

Most of the rock exposures show no silicification, but here and there all the rocks have been silicified to various degrees in irregular, small patches and zones that are apparently unrelated to major structures.

The relative ages of the rocks involved suggest that the silicifying solutions may have been genetically related to the rhyolite eruptives, perhaps rising from the magma below as one of the late emanations. Furthermore, the silicification appears to antedate the faulting because the faults cut zones of silicification and are not themselves silicified.

In the Cuarenta district silicification was only one of the several factors that determined the localization of ore shoots, and it was an active factor in the localization of only a few of them. Many of the best ore bodies in the Cuarenta district are not associated with zones of silicification, and many of the silicified zones in the district are not the loci of ore deposition.

STRUCTURE

The conglomerates and rhyolitic volcanic rocks dip 20° to 25° to the north, and strike slightly north of west. This might at first appear to be inconsistent with the distribution of the rocks as shown on the map (pl. 51), but it can be readily understood when the character of the unconformity and the conditions of deposition of the rocks of the conglomerate-rhyolite series are taken into account. A few minor departures from this general northerly dip are attributable to drag on faults. This northward dip is due to post-rhyolite tilting, involving a block of the earth's crust at least as large as the Sierra del Oso, and which occurred long before the erosion that formed the present topographic surface, because the present surface has been carved by a southward-flowing drainage. Its age relative to the faulting is not known.

Joints

Joints are so abundant in the granite that it is difficult to obtain a good hand specimen. Those that strike about N. 10° E. predominate over all others; they dip at diverse inclinations to the west, and evidently controlled the emplacement of the diabase dikes.

Faults

Three sets of post-rhyolite faults are present. The youngest strike generally north, dip nearly vertically, and displace the rocks as much as a few tens of meters. The apparently anomalous offset of the lower conglomerate with respect to the granite between the Porvenir mine and El Puerto is due to rapid, post-fault stripping away of the conglomerate by erosion at this place, baring the granite surface. The valley of the Arroyo de La Sardina may follow one of these faults, as indicated not only by its general form, but also by the offset between the rhyolite and the conglomerate west of Cerro Ventura, and by offset and drag of layers at the Boquilla de la Sardina, but the evidence is not sufficient to warrant drawing this fault on the map.

Several faults of small displacement strike N. 50° E. and dip steeply, some northwestward and some southeastward. They are cut by the north-trending faults. Some nearly east-trending faults are also present. They appear to be older than the north-trending faults, although their age relations are not clearly revealed by the exposures.

Some additional faults are probably present, as suggested by the breaks in the topography (see pl. 51), but as their exact locations are not revealed by positive field evidence they have not been plotted on the map.

The fault shown in cross section A-A' (pl. 51) was observed near the Porvenir mine and doubtless extends at least as far southwestward as the plane of the cross section. It may extend much farther southwest, as indicated by the relative altitude of the conglomerate on the southeast and the upper surface of the granite on the northwest, but it has not been extended on the map because its surface trace in the rhyolite is obscure. Because of the obscuring effects of the rhyolite, and also because of the irregularity of the unconformity at the base of the conglomerate-rhyolite series, it is impractical to try to postulate the exact buried relations at this place in the cross section (pl. 51). The displacement of this fault may be less than is suggested by the section.

ORE DEPOSITS

The cinnabar deposits of the Cuarenta district yielded some small, rich ore shoots, but most of the ore was low in grade. Faults were the feeder channelways, and the ore shoots were localized by impermeable barriers. A single barrier localized some masses of low-grade ore, but the best ore shoots were formed where two such impermeable features intersected.

Distribution

The most productive mercury deposits of the Cuarenta district are in a northwest-trending zone about 2 kilometers long by half a kilometer wide. This zone is west of the town of Villa Cinabrio in the vicinity of the granite-conglomerate unconformity. A few prospects in which only a little low-grade ore was found lie along an approximately east-trending zone near the south base of Cerro El Cuarenta and the west side of the valley of the Arroyo de La Sardina. Although the deposits shown on the map constitute the Cuarenta mercury district, the limits of the district are arbitrary, because many comparatively unproductive mercury prospects are scattered throughout this part of the State of Durango. Deposits of other metals also occur near Villa Cinabrio, for about 3 kilometers east there is a small copper prospect, and in the hills about the same distance north of the town a small gold mine is operated.

Mineralogy and grade of ore

Cinnabar is the only sulfide mineral in the ore. It is associated with various quantities of chalcedonic silica, iron oxide, and soft clay-like material. There are no reliable assay data on the grade of the ore, and the local mining method involves hand-sorting to an unknown degree. In the past some high-grade stringers and ore shoots have been found, but on the whole the available evidence suggests that the average grade of much of the ore is around 3 kilograms of mercury per metric ton (6 pounds per short ton).

Form, structure, and size

The ore bodies are irregular in shape but most of them approximate a tabular form because of their structural environment. Examples are: (1) fracture fillings (Foco mine, in part); (2) ore bodies (see fig. 24) underlying the footwall sides of diabase dikes (Foco mine, and small mines on Loma El Risco); (3) ore bodies in faults (Porvenir mine); (4) bodies of disseminated ore in the lower part of the conglomerate more or less parallel to the surface of the unconformity (Foco mine, in part, and prospects southwest of Porvenir mine); and (5) ore bodies beneath more or less lens-shaped, silicified zones paralleling the bedding of the tuff (Tulises mine).

The rich ore shoots are small, no more than a few meters in length and depth, and a few centimeters to a meter in thickness. However, they may occur in a series within a given mineralized zone, resulting in an individual mine several tens of meters in length.

Localization of the ore

All the most productive mines are near faults. Conversely, prospects remote from faults have not been productive. This

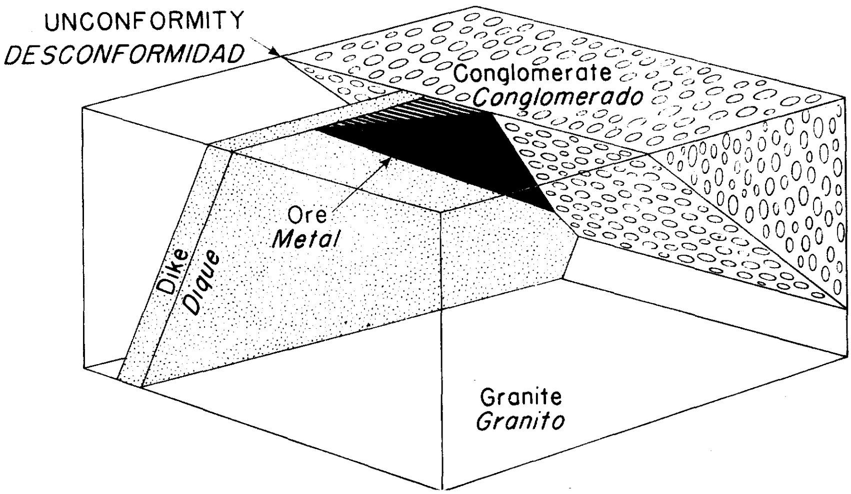

Figure 24. Block diagram showing most favorable structural environment of ore.

suggests that the faults are essential to the occurrence of ore and that they were the main feeder channelways along which the mineralizing solutions moved.

Movement of the mineralizing solutions was further guided by impermeable bodies such as diabase dikes, silicified zones, and fault gouge. These also served as barriers that influenced the localization of the ore shoots.

The best traps that were encountered by the mineralizing solutions were intersections of two of these impermeable features, and at such intersections the largest and richest ore shoots were deposited.

Accordingly, the most productive ore shoots have been found under the footwall sides of the diabase dikes just beneath the unconformity, where they are overlain by the conglomerate. This is best exemplified in the Foco mine. It is also shown by the small mines on Loma El Risco, although less clearly, because there the conglomerate has been stripped away by erosion. Erosion may have also removed the uppermost parts of the ore shoots in these little mines, because the ore shoots in them are small and disappear at a depth of only a few meters.

No valuable ore bodies have been found beneath the diabase dikes in the valley west of the Foco mine, and it will be noted that although these are near the unconformity, and may have been overlain by conglomerate, they are remote from faults. Similarly, no valuable ore bodies have been found under any of the numerous dikes to the south of Cerro Salitrillo, for these are remote both from faults and from the unconformity as well.

Some small ore shoots in the Foco mine are in richly mineralized, but narrow fractures in the granite just beneath the overlying conglomerate, particularly where the conglomerate has been rendered less permeable by pre-ore silicification. The ore in these fractures generally disappears at a depth of only 2 or 3 meters below the unconformity, indicating that the fractures alone were not sufficient to cause the ore localization, but that a second and intersecting feature, namely the unconformity, was necessary as well.

The Porvenir mine could not be entered, but the ore shoot, as described to us by Mr. Moll, the owner, and as indicated by the stopes shown on his map, occurred in a N. 50° E. fault dipping about 50° SE. The chimney-like form of this ore shoot suggests that the intersection of a second structural feature determined its location.

Disseminated ore has been found in some places. Much of the lowest meter or two of the conglomerate in the Foco mine was low-grade ore containing disseminated cinnabar. Somewhat richer portions of this disseminated ore were found beneath silicified zones in the conglomerate, such as lenses of silicified interbedded tuff. Some prospects along the unconformity have yielded a little disseminated ore, but no large ore bodies have been found in them, because neither dikes nor faults were present.

At other places where the ore was localized by only a single impermeable barrier it has proved to be small, low in grade, and of little or no value. Thus, the small amount of ore found in the Tulises mine occurred beneath thin, horizontal, silicified layers in the tuff, unaccompanied by a second intersecting, impermeable feature. Similarly, the small amount of ore, all of which was low in grade, that was found in the Minas El Sol, occurred along the unconformity alone.

Therefore, as a guide to prospectors, valuable cinnabar ore bodies are to be sought in the Cuarenta district only in the vicinity of faults, and at the junction of two impermeable structural features. Conditions are favorable if one of these is the unconformity, and more favorable if the other is a diabase dike.

Age and origin

The cinnabar mineralization was post-rhyolite in age, and although it may have been genetically related to the same magmatic source as the rhyolitic rocks, there is no evidence to substantiate such an interpretation.

SUMMARY OF GEOLOGIC HISTORY

1. Granite intrusion, followed by erosion bringing the granite nearer to the surface, and formation of westward-dipping N. 10° E. joints.

2. Intrusion of diabase dikes along these joints in the granite.

3. Long period of erosion truncating the granite and the diabase dikes.

4. Deposition of conglomerate under conditions of crustal instability and accompanied by the first rhyolite tuff eruptions. (There may have been local uplift and erosion cutting away some of the conglomerate.)

5. Thin tuffs and thin rhyolite flows, of local extent only.

6. Down sinking, or at least changed conditions of sedimentation, permitting the deposition of the finer-grained, green conglomerate.

7. Uplift.

8. Sub-aerial deposition of the chalk-white tuff.

9. Great rhyolite tuff eruptions.

10. Great eruptions of rhyolite lava flows and agglomerates.

11. Silicification.

12. Faults trending east and N. 50° E.

13. Faults trending north.

14. Regional tilting to the north. (This may have preceded or accompanied the faulting.)

15. Cinnabar mineralization.

16. Erosion; deposition of recent gravels; and continued erosion.

MINING

History

Cinnabar was discovered in the Cuarenta district in May 1932 by O. V. Seifert P. The Compañía Explotadora de Durango, S. A., was organized in 1933 with Claude D. Moll as president, and work was commenced at the Porvenir mine. A flotation plant which this company installed at the mine in January 1938 treated 100 tons per month until it was closed down for lack of water in April of the same year. Shortly afterward the Porvenir mine was also closed down because of bad ground and lack of ore, but work continued in the company's nearby Foco and Faro mines.

During the boom years in the Cuarenta district, from 1940 to early 1943, about 2,000 "gambusinos" worked a multitude of small deposits, mostly on land owned by Mr. Moll's Compañía Minera Almadeña, S. A., which had succeeded the previous company.

In June 1942 the upper part of the Faro mine caved, and at the same time water was encountered in the adjoining Foco mine at a depth of 50 meters. Although this part of the Foco mine was in ore, no further work was done except by a few "gambusinos." Company operations were finally suspended altogether in August 1943, and in 1944 even "gambusino" mining had practically ceased.

Production

The flotation plant at the Porvenir mine produced a total of about 100 flasks of mercury. At the peak of the boom about 700 retort tubes were in operation in the district, producing a total of about 300 flasks of mercury per month. Production records are incomplete and unavailable, but Mr. Moll estimates that total production from the Cuarenta district from its discovery to August 1943 was about 15,000 flasks of mercury.

MINES AND PROSPECTS

The three largest mines are the Porvenir, the Foco, and the Faro. All the others are small, and most of them are nameless. Dozens of workings dot the hillsides; they range in size from little shallow pits to irregular gopherings about 30 meters deep and a few tens of meters in lateral extent. At the time of the authors' visit most of them were abandoned and many were caved. Mining was by hand methods. The ground was removed by pick and shovel wherever possible, and dynamite was used only as a last resort. One old hoist operated intermittently, and a few hand windlasses were in use on some of the deepest "gambusino" holes, but most of the ore was carried out in sacks on the backs of the miners. Timber was not used, even where necessary, and this together with pillar-robbing caused frequent cave-ins.

The Porvenir mine is now caved and inaccessible, but an old map by Mr. Moll shows an inclined shaft extending downward toward the southeast at an inclination of about 50°, to a vertical depth of 50 meters. Five levels extend laterally southwest and northeast. The 35-meter level, the longest to the northeast, extends 90 meters from the shaft. The workings toward the southwest were much shorter, except the upper level which, in a last unsuccessful attempt to find ore in this mine, was driven 235 meters southwestward. The only ore shoot extended down the dip of the inclined shaft and had an average strike length of about 10 meters, but it pinched out on the bottom level. It is believed that the mineralization of the Porvenir mine was localized along the footwall side of a N. 50° E. fault dipping about 50° SE., at its junction with a vertical structure, perhaps another fault, but as the mine could not be entered this interpretation could not be verified.

The interconnected Foco and Faro mines are fantastically irregular gopherings that extend down the north-dipping granite-conglomerate unconformity a maximum inclined distance of 110 meters, and laterally about 50 meters. Most of the Faro mine had collapsed, so that the surface entrance has been lost, but some of the lower workings could be reached by rope through stopes from the Foco mine. The Foco mine was in almost as bad condition. These mines were advanced downward from one pod of ore to another. Some of the best ore shoots were under diabase dikes in the footwall granite just beneath the unconformity, but much of the ore occurred in the underlying granite as bodies of highly mineralized, soft, altered material, that a few meters downward, terminated in small mineralized fractures too narrow to mine. Some good ore was found also in the lower part of the conglomerate, but for the most part this conglomerate ore was disseminated and low in grade. The work in progress at the time of our visit consisted of robbing pillars and scratching the walls wherever a trace of cinnabar could be seen by the sharp-eyed "gambusinos."

The northwesternmost mines in the main mineralized zone are a few small, irregular diggings in the lower part of the conglomerate, near the granite, in the east side of the valley of the Arroyo del Tintero. The ore is a dissemination and ranges in grade between 2 and 7 kilograms per metric ton (4 to 15 pounds per short ton).

The small mines near the south base of Cerro El Cuarenta have encountered only low-grade ore and have produced a negligible amount of mercury. Those named El Sol are holes inclined down the dip of the conglomerate following a low-grade mineralized zone, notably stained with iron oxides, and about a meter thick. The largest of these mines extends about 20 meters down the dip. Next to the east is a series of pits and open cuts called El Temblete mines. These are in tuffs that have been dragged to a southward dip in the footwall side of an east-trending fault which here dips 70° S. The mercury content of the ore, after sorting, is said to range between 5 and 10 kilograms per metric ton (10 to 20 pounds per short ton). The easternmost mine of this zone is called the Tulises. It is in nearly horizontal tuff on the west side of the valley of the Arroyo de La Sardina about 20 meters above the stream, and consists of a series of irregular, horizontal chambers, with a maximum over-all extent of about 25 meters long by 25 meters wide. The ore occurs under silicified, horizontal, lenticular layers in the tuff, and is very low in grade.

ORE RESERVES AND FUTURE OF THE DISTRICT

The mercury mines of the Cuarenta district are wrecked by gophering and pillar-robbing beyond any hope of reclamation. Mining stopped in the Cuarenta mercury district in August 1943. Good ore is said to remain under water in the bottom of the Foco mine, and the lower 2 or 3 meters of much of the conglomerate is said to constitute a large tonnage of low-grade ore, but whether this ore is real or imaginary must await proof by someone willing to spend the money necessary to sample it properly.

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