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GEOLOGY OF THE HUAHUAXTLA MERCURY DISTRICT STATE OF GUERRERO, MEXICO

BY

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By David Gallagher and Rafael Perez Siliceo

ABSTRACT

The Huahuaxtla mercury district is in the State of Guerrero in southern Mexico, 188 kilometers by road south of Mexico City. Since the discovery of cinnabar in the district about 1923 it has produced a total of approximately 300,000 kilograms of mercury, or 8,700 flasks, nearly half of which was produced during 1940–44, inclusive. Topographically the region is one of rugged limestone hills, rounded shale hills of more subdued form, and steep narrow valleys. The drainage is not adjusted to the structure of the rocks, for it has recently been superposed from a cover of Tertiary (?) conglomerate that formerly overlaid the region. Only two rock formations are present, both of unknown thickness. Both are of Upper Cretaceous age. They comprise a series of thick-bedded gray limestones more than 260 meters thick overlain by a series of shales containing subordinate thin-bedded limestone layers, which is probably several hundred meters thick. These sedimentary rocks have a general northwesterly regional strike and dip about 25° NE. The rocks have been deformed little, if any, by compression, but gentle flexures that may be the result of torsion are numerous, and the rocks are locally much disturbed by drag folding along faults. The region contains many faults, 28 of which are plotted on the map. Probably all are normal faults, some with considerable strike-slip movement. One may be a reverse fault. The Huahuaxtla fault, which is the oldest in the map area, has a shale hanging wall and limestone footwall. It strikes northwest and dips southwest at a moderate inclination and contains gouge and breccia about 10 meters thick, which is the locus of deposition of the principal mercury ore bodies. The limestone footwall surface is irregular and is characterized by great ribs of limestone that trend almost due west diagonally down the footwall surface, and to these ribs the disposition of the ore shoots is related. The breccia is thickest on the south, or down-dip sides of these ribs, and here the largest ore shoots are localized, so that individual ore shoots can be followed down along the individual ribs from one level of the mine to another. The average tenor of the ore is a few kilograms of mercury to the ton. The metallic minerals are cinnabar, which is the chief ore mineral, some metacinnabar, and a little marcasite, pyrite, and native mercury. Huahuaxtla was once famous for fine specimens of rare mercury minerals, but now they are hard to find. The gangue is chiefly the clay of the fault gouge, but much calcite and some gypsum are also present. Iron oxides are widely distributed, and there is a correspondence between their nature and the nature of the mercury sulfide. These deposits were thought to be metacinnabar deposits because most of the ore mineral is black. However, the mineral is actually cinnabar that inverted without change of color from metacinnabar, only a trace of which now remains, so it is best designated by the Mexican miner's term "cinabrio negro," black cinnabar. This cinabrio negro has been found only in the principal deposits in the old Huahuaxtla fault. Some primary red cinnabar is also present, occurring in numerous small unprofitable prospects in all the faults from the oldest to the youngest. It is particularly abundant in some stopes on the 45-meter level of the main mine where a young fault cuts through the old Huahuaxtla fault bearing cinabrio negro. The hypothesis is advanced that the Huahuaxtla district was subjected to two mercury mineralizations, namely, an old metacinnabar mineralization that took place when only the old Huahuaxtla fault was available as a locus of ore deposition, and a young cinnabar mineralization that occurred later than the youngest faults. The many small prospects in the district are of little value, and there is little likelihood of discovering another large deposit, but the future of the principal deposit looks promising. Downward persistence of the ore seems reasonably well assured, and lateral extension of the ore northwestward is a possibility.

INTRODUCTION

The Huahuaxtla mercury district is in the north-central part of the State of Guerrero in southern Mexico, approximately at longitude 99°36′ W. and latitude 18°24′ N. It is reached by a dirt road extending westward from the main Mexico City-Acapulco highway at Puente Campuzano, which is 180 kilometers[1] south of Mexico City, or 20 kilometers south of Taxco. The dirt road follows the valley of the Río Campuzano in a direction generally S. 40° W. most of the way to the mines, a distance of 8.5 kilometers from Puente Campuzano (fig. 12). It is passable throughout the year.

The region is one of rugged limestone hills, rounded shale hills of more subdued form, and steep, narrow valleys. The mines are 1,120 meters above sea level, or about 130 meters above the Río Campuzano, and about 200 meters below the tops of the neighboring hills.

The climate is semitropical and fairly dry. There is no rain from September to June, but torrential rains fall during the rainy season, from June to September, totaling about 100 centimeters annually. Runoff is rapid, and the few shallow wells yield barely enough water for household use. The temperature is equable except in the spring, when it becomes uncomfortably hot before the summer rains begin.

The region is sparsely populated. A few hundred people live in the scattered "jacales," as the little farms are called, that constitute the Pueblo de Huahuaxtla and the smaller Pueblo de San Juan, 1.5 kilometers to the north. Similar small settlements are scattered throughut the region at intervals of a few kilometers. Local labor is sufficiently abundant but not highly skilled. Employment in the mines has raised local standards of living. This formerly agricultural community was unable to grow sufficient food upon the poor soil of the region and was forced to seek money for outside purchases by manufacturing baskets, known as "chiquihuites," which brought

[1] See chart of metric equivalents, p. 173.

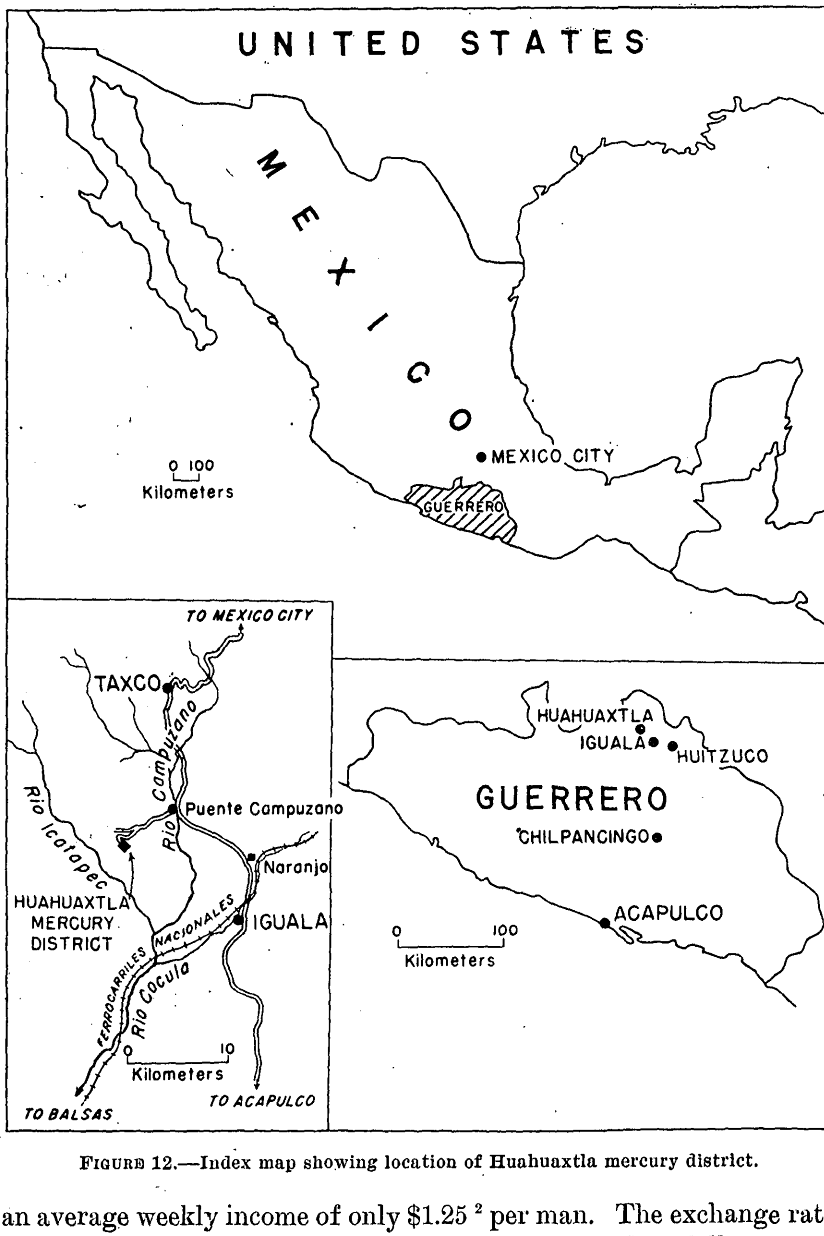

FIGURE 12.—Index map showing location of Huahuaxtla mercury district.

an average weekly income of only $1.25 [2] per man. The exchange rate, Mexican pesos per United States dollar, has ranged as follows:[3]

[2] Throughout this report money is expressed in Mexican pesos, for which the customary sign is the same as the American dollar sign.

[3] Moore, J. R., Handbook of foreign currency and exchange: U. S. Dept. Commerce, Bur. Foreign and Dom. Com., Trade Prom. Ser. No. 102, p. 114, 1930. Asoc. Banqueros México, Anuar. Financ, México, vol. 1, p. 605, 1941. Personal inquiry at the Banco Internacional, S. A., in Mexico City.

1923	$2.060	1934	$3.605
1924	2.061	1935	3.600
1925	2.025	1936	3.602
1926	2.070	1937	3.604
1927	2.118	1938	4.521
1928	2.079	1939	5.181
1929	2.076	1940	5.391
1930	2.122	1941	4.868
1931	2.818	1942	4.861
1932	3.140	1943	4.850
1933	3.559		

A few supplies are obtainable in Iguala, 24 kilometers by road to the south. Heavy supplies are received by rail at Naranjo station, 230.4 kilometers south of Mexico City and 16 kilometers by road from the mines. Firewood is fairly plentiful, but none of the local timber is suitable for mine or structural use. The mine is served by an electric power line of the Compañía Mexicana de Luz y Fuerza Motriz, S. A.

FIELD WORK AND ACKNOWLEDGMENTS

This study is part of the geologic investigations conducted in Mexico by the Geological Survey, United States Department of the Interior, in cooperation with the Dirección General de Minas y Petróleo, Secretaría de la Economía Nacional de México, and the Instituto de Geología, Universidad Nacional Autónoma de México, as part of the program of geologic investigations in the American Republics 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 February 26 through March 13, 1942, and from March 14 through June 11, 1944. An area of 7 square kilometers was mapped by plane table on a scale of 1:5,000, with 10-meter contour intervals; mine maps were compiled from company maps, with additions and corrections, on a scale of 1:500; and the geology of the surface and of all accessible mine openings was recorded on them. To obtain an elevation datum for the mapping, a series of barometric readings was made over 48 hours, and, after being corrected for temperature, was plotted on a graph from which hourly figures were read, and averaged.

We wish to thank the mine staff and the owners, Manuel and Antonio Dodero, for their hospitality and friendly cooperation and Santiago Soto for supplying information on the early history of the mines. Valuable assistance has also been given by many colleagues. The work has come under the general supervision of J. V. N. Dorr, 2d, in Washington, and W. F. Foshag in Mexico. Ralph W. Imlay identified the fossils; J. M. Axelrod confirmed the identification of the "cinabrio negro" and metacinnabar by means of X-ray; and general advice and encouragement was received from E. B. Eckel and J. J. Fahey. The manuscript was read critically and suggestions for improvement made by W. S. Smith, E. H. Bailey, D. L. Everhart, and others. We wish also to thank Ing. Teodoro Flores, Acting Director of the Instituto de Geología of the Universidad Nacional Autónoma de México, and F. D. Ransome, J. F. Magee, and W. G. Kane for their many kindnesses.

HISTORY

Juan M. de Castro of Iguala discovered the mercury ore at Huahuaxtla about 1923.[4] He denounced [5] some ground and, together with a Sr. Alcocer, began to mine in November 1925 by two open-cuts, called the Aurora and the Esperanza. Up to July 1927 work was intermittent because of difficulties of access and scarcity of firewood.[6]

This operation became Castro Hernández y Cía., and was succeeded by Negociación Minera Aurora y Anexas, which operated the Aurora and Esperanza mines in 1928 and 1929 and then sold them to the Cía. Minera Mercurio, S. A., which operated them until midyear, 1932.[7]

In 1928 the Cía. Minera de Huahuaxtla, S. A., owned by Raúl Bailleres, bought the nearby San Antonio and Providencia claims and began to operate them under the management of T. B. Rice. In the fall of 1930 this company also bought the nearby San Luis property, operated by Henri Jacot. In 1931, the year the electric power line reached Huahuaxtla, Bailleres bought and began to unwater the livingstonite mine at Huitzuco, Guerrero, where Rice took charge, leaving Santiago Soto to manage the Huahuaxtla properties. On July 25, 1932, the Cía. Minera de Hauhuaxtla, S. A., suspended operations because of the low market price of mercury and diminution in the grade of the ore and sold out to the Cía. Minera Mercurio, S. A.[8]

The Cía. Minera Mercurio, S. A., then undertook to work all the mines but almost immediately asked the Mexican Government for authority to suspend operations temporarily because of the adverse economic conditions.[9]

The property was then idle for several years, except for the intermittent activity of "gambusinos," as the small independent mine operators are called in Mexico.

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[4] Soto, Santiago, personal conversation.

[5] "Denounced" is a Mexican mining law meaning "staked claim to."

[6] Anonymous, El mineral de Huahuaxtla, Guerrero: México Dept. Minas, Bol. Minero, vol. 24, pp. 10–16, 1927. (Contains a claim map.)

[7] Anuarios de Estadística Minera for the years 1929 through 1933: México Dept. Minas.

[8] Soto, Santiago, personal conversation.

[9] Mining Jour., vol. 16, no. 6, p. 25, Aug. 15, 1932, Phoenix, Ariz.

In 1938 the property was sold to Minas de Huahuaxtla, S. A., which bought the present Herreschoff furnace, but in July 1940, before the erection of the furnace was completed, the property was acquired by Manuel Dodero and his brother Antonio Dodero. They were still operating it as the Compañía Explotadora de Mercuria Huahuaxtla, S. A., in 1945.[10]

PRODUCTION

Castro had six small wood-fired retorts of six to eight tubes each, treating 6 to 8 tons of ore a day said to average 8 percent of mercury.[11] He thought his recovery was about 50 percent, but it was probably much lower. If he was shipping 350 kilograms of mercury a week, as indicated in the anonymous report cited, his recovery may have been as low as 11 to 15 percent, but if F. W. Pabst of Mexico City purchased 28,159 kilograms of mercury from Castro Hernández y Cía., in 1929, as stated in the Anuario de Estadistíca Minera,[12] the recovery may have been 17 to 23 percent.

The Cía. Mercurio de Huahuaxtla, S. A., had a 2-foot Gould rotary furnace capable of treating 10 to 12 tons a day, and it also treated an additional 20 tons per day in home-made retorts. Recovery in 1931 was 82 percent but in 1932 increased to 86 percent. Cía. Minera de Mercurio, S. A., recovered 94 percent in 1931 and 91 percent in 1932.[13]

Data are lacking by which to determine the recovery efficiency of the Herreschoff furnace operated by the Compañía Explotadora de Mercurio Huahuaxtla, S. A., but a single test showed that it was recovering 86 percent of the mercury.

The following tables show the amount of mercury produced at Huahuaxtla from 1927 to 1939 and the mercury produced by Cía. Explotadora de Mercurio Huahuaxtla, S. A., from 1940 to 1944.

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[10] Dodero, Antonio, personal conversation.

[11] Anonymous, El mineral de Huahuaxtla, Guerrero: México Dept. Minas, Bol. Minero, vol. 24, pp. 10–16, 1927.

[12] Anuario de Estadística Minera, 1927; México Dept. Minas, p. 378, 1929.

[13] Calculated from figures given in Anuarios de Estadística Minera, 1931, p. 158, and 1932, pp. 152–153.

Mercury produced at Huahuaxtla, Guerrero, 1927 to 1939 [1]

Operator	Mines	Mercury produced (kilograms)	Ore treated (tons)	Grade (kilograms per ton)
1927				
Castro Hernández y Cía	Aurora, Esperanza	28,159		
1928				
Negociación Minera Aurora y Anexas	do	19,559		
1929				
Negociación Minera Aurora y Anexas	do	4,328	382	
Cía. Minera de Huahuaxtla, S. A	San Antonio, Providencia	533	161	
1930				
Cía. Minera de Huahuaxtla, S. A	do	390	97	
Cía. Minera de Mercurio, S. A	Aurora, Esperanza	18,576	2,294	8.8
Cía. Minera de Huahuaxtla, S. A	San Luis	4,754	636	11.0
Francisco de P. Herrera	Buena Suerte	67	15	9.5
Alfredo Slim	do	340		
Cía. de Inversiones de Minas, S. A	Navidad	240	22	6.0
	Número 13		20	5.4
1931				
Cía. Minera de Huahauxtla, S. A	San Antonio, Providencia	12,322	121	5.3
	San Luis		2,186	5.9
Cía. Minera de Mercurio, S. A	Aurora, Esperanza	53,801	9,198	6.2
1932				
Cía. Minera de Huahuaxtla, S. A	San Antonio, Providencia	4,664	62	11.0
	San Luis		668	7.1
Cía. Minera de Mercurio, S. A	Aurora, Esperanza	41,355	5,450	5.3
	Other mines		4,646	3.5
1927–32, inclusive		189,088		
1933–39, estimated production		100,000		
Total		289,088		

[1] Anuarios de Estadística Minera for the years 1927 through 1933; Mexico Dept. Minas.

Mercury produced by Cía. Explotadora de Mercurio Huahuaxtla, S. A., 1940 to 1944 [1]

	1940		1941		1942		1943		1944	
	Kilograms	Flasks	Kilograms	Flasks	Kilograms	Flasks	Kilograms	Flasks	Kilograms	s
January			1,936.50	56.2	1,459.50	42.3	1,480.30	42.9	1,668.00	48.4
February			1,303.90	37.8	1,725.10	50.0	1,351.80	39.2	3,247.74	94.2
March			1,634.00	47.4	2,704.20	78.4	3,294.70	95.6	2,446.50	71.0
April			1,160.58	33.8	2,297.80	66.6	2,339.20	67.8	1,664.10	48.3
May			1,000.69	29.0	2,924.00	84.8	2,103.20	61.0	7,490.30	217.3
June			1,269.50	36.8	2,446.30	71.0	2,196.30	63.7	6,798.60	197.2
July	162.30	4.7	1,033.50	30.0	1,649.50	47.8	2,406.70	69.8	6,773.30	196.5
August	1,538.30	44.6	407.30	11.8	2,843.50	82.5	1,287.60	37.4	6,795.20	197.1
September	679.93	19.7	683.20	19.8	2,417.80	70.1	1,441.82	41.8	7,654.80	222.0
October	1,627.60	47.2	1,298.00	37.6	2,281.18	66.2	1,486.20	43.1	6,222.60	180.5
November	1,408.40	40.8	1,505.20	43.7	2,080.28	60.3	2,302.10	66.8	3,864.38	112.1
December	1,950.60	56.6	2,083.40	60.4	1,462.00	42.4	1,775.20	51.5		
Total	7,367.13	213.6	15,315.77	444.3	26,291.16	762.4	23,465.12	680.6	54,625.52	1,584.6
Total 1940–44									127,064.60	3,685.6

[1] Published by permission of Sr. Manuel Dodero.

The operating costs of Castro Hernández y Cía. were estimated[14] as $6 for mining and $8 for furnacing, or a total of $14 per ton, or $1.71 per kilogram of mercury delivered to the station in Iguala. The following table gives the operating costs of the Cía. Minera de Huahuaxtla, S. A., from January 1 to July 25, 1932.

Operating costs, in pesos, of the Cía. Minera de Huahuaxtla, S. A., from Jan. 1 to July 25, 1932 [1]

	Per ton	Per kilogram of mercury
Mining:		
Wages	$4. 795	$1. 164
Supplies	1. 254	. 304
	6. 049	1. 468
Treatment:		
Wages	1. 627	. 395
Supplies	3. 177	. 771
	4. 804	1. 166
General overhead	4. 127	1. 002
Total	14. 980	3. 636

[1] Compiled from figures supplied by Santiago Soto.

GEOLOGY

GENERAL

Huahuaxtla is in the transition zone between the great high plateau of central Mexico and the Pacific coastal lowland. It is a region of steep, narrow, V-shaped valleys between rugged limestone hills that range in height through several hundred meters and lower shale hills of more subdued form. The shale hills have smooth rounded and gentle slopes. They support little vegetation except a few large widely scattered trees and a thin cover of yellow grass. The ground underlain by shale is covered with soil and, as there are almost no outcrops, little shale can be seen except in artificial exposures.

Within the map area the limestone hills attain altitudes of about 1,300 meters, or about 300 meters above the valleys, but in the surrounding region there are much higher mountains of limestone. The slopes of the limestone hills are steep and rugged. Cliffs 10 to 20 meters high are common, and even higher cliffs occur on the southwest side of Cerro del Encinal and on the southeast side of Cerro del Chilero. (See pl. 34.)

[14] Anonymous, El mineral de Huahuaxtla, Guerrero: México Dept. Minas, Bol. Minero, vol. 24, p. 14, 1947.

The surface of the limestone areas is an almost continuous outcrop, with large boulders and blocks of limestone, among which there is a little black soil that supports a thin forest. From a distance these limestone slopes show the bedding well, but seen close up the bedding is obscured by the bouldery character of the outcrops and by the vegetation.

The exposed limestone is intricately etched by little solution rills. The absence of large solution caverns and underground drainage indicates that solution has not progressed beyond earliest youth in the erosion cycle.

All the streams are intermittent and, with the exception of two in the west corner of the map area, are tributary to the Río Campuzano, which flows to the Río Balsas and the Pacific. The Río Campuzano flows through alternate valleys of soft shale and high ridges of resistant limestone, indicating that it is antecedent, or superposed. Its tributaries are nongraded, showing rejuvenation.

The general direction of the streams within the map area is approximately parallel to the regional strike of the rocks, and faults and contacts exert only a local influence on the stream courses in a few places. On the whole there is not a delicate adjustment of the streams to the structure of the rocks. It is striking that most of the faults and contacts are not the loci of streams at all. This lack of adjustment indicates that the drainage was developed upon a higher surface of different character, that it was superposed upon the present surface, and that the streams have not been working upon the present surface long enough for the drainage to become adjusted.

Rhyolite pebbles and cobbles, well rounded by stream abrasion, are numerous among the rubble of the shale areas and are occasionally found also on the limestone. They occur in places remote from present streams that could have brought them from rhyolite areas. One rhyolite pebble was found on the summit of Cerro del Chilero. The nearest rhyolite is far to the north and west, but Tertiary (?) conglomerate filled with similar rhyolite cobbles outcrops in many places in this part of Mexico. It is likely that the rhyolite cobbles of the Huahuaxtla district are residuals of such a conglomerate that formerly overlaid the area and from which the superposed drainage was let down.

STRATIGRAPHY

The rocks of the district belong to two sedimentary formations that in general strike in a northwesterly direction and in general dip about 25° NE. The exposed strata comprise the upper part of a limestone formation and the lower part of a shale formation that overlies the limestone.

Fossils are rare and poorly preserved, but both formations contain the gastropod *Trochactaeon*,[15] similar to Coniacian species described by Böse [16] from the Zumpango del Río area of Guerrero. Both formations are of Upper Cretaceous age.

They are apparently conformable and have the same regional strike and dip. Their parallelism can be well seen at any of the good exposures of the sedimentary contact as, for example, on Loma de Apatlaco or near the road south of the Guillermina mine.

The limestone formation consists solely of limestone beds. These beds range in thickness from a few centimeters to several meters but are in general about three-quarters of a meter thick. Most of them are pure, compact, fine-grained gray limestone, but some are lighter in color, even approaching white, and some are nearly black. All of them weather to a uniformly light-gray color on the surface. A few are slightly sandy, and some contain irregular and lenticular pieces of black chert.

The thickness of the limestone formation is unknown because the bottom of the formation has not been found. On the southeast slope of Cerro del Chilero 260 meters of uninterrupted beds can be seen, but elsewhere measurement is hindered by the numerous faults. It seems probable that this formation is at least several hundred meters thick, for the high Cerro del Tecampanario a few kilometers to the west appears from a distance to exhibit hundreds of meters of this same limestone. However, no detailed stratigraphic work has ever been attempted in this part of Mexico.

The overlying formation consists of thin-bedded shale and interbedded thin limestone layers. The weathered shale is brown, but in fresh exposures it is black, as much of it is carbonaceous.

The thin-bedded limestone layers interbedded with the shale are dark gray to black and appear to be more argillaceous and more carbonaceous than the underlying limestone. They range in thickness from about 5 to 30 centimeters but are commonly about 10 centimeters thick. On weathering they yield cubic or tabular blocks that litter the surface. Most of the areas underlain by shale have been cultivated for corn by piling the limestone rubble from these intercalated beds into long rows, at about half-meter intervals, parallel to the contours, and planting the corn in the poor soil between. The interbedded limestone layers are spaced at about half-meter intervals throughout much of the shale, although high in the formation they are less abundant.

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[15] Fossils collected by the authors were identified by R. W. Imlay.

[16] Böse, Emil, Algunas *faunas cretácicas* de Zacatecas, Durango y Guerrero: Inst. Geol. México Bol. No. 42, pls. 14–17, 1923.

The thickness of the shale formation also is known, in this case because the top of the formation has not been found. The shale is so poorly exposed that its thickness is difficult even to estimate, but its widespread areal distribution throughout the region suggests that it may be at least several hundred meters thick.

A limestone member consisting of several limestone beds 30 to 50 centimeters thick, aggregating about 10 meters in thickness, lies near the bottom of the shale formation. It is separated from the sedimentary contact by about 5 meters of shale, except in the western part of Loma del Palo Dulce, where it rests directly upon the underlying limestone formation. This limestone member is not continuous, for it lenses out on Loma del Palo Dulce and is absent along the western part of Cerro del Encinal and south of the Pueblo de San Juan.

What is thought to be the same member, despite its different aspect due to alteration, appears above the sedimentary contact along the crest of Cerro del Encinal west of the Guillermina mine and along the northern rim of Barranca de la Cruz Verde west of the Huahuaxtla church. Instead of the typical limestone member as found elsewhere, there is at these places a shattered and brecciated member composed of limestone beds of similar thickness that have been silicified and ferruginized.

The siliceous and ferruginous character is not an original depositional feature but an alteration that progressed along fractures. These altered portions of what is thought to be the limestone member lie directly upon the underlying limestone formation, whereas the unaltered portions are separated from the underlying limestone formation by about 5 meters of shale, except for the exposure in the western part of Loma del Palo Dulce.

Evidently at some time during the deformation of the region there was movement, at least locally, along the zone of weakness afforded by the sedimentary contact. The movement shattered this limestone member of the shale formation where it was in direct contact with the hard underlying limestone, but where it was protected by an underlying cushion of soft shale it escaped shattering. Later, solutions were able to silicify and ferruginize these fractured portions but could not enter the cushioned portions that had escaped shattering.

STRUCTURE

The rocks have a regional inclination to the northeast and have been deformed little, if any, by compression, although gentle flexures that may be the result of torsion are numerous, and the rocks are locally much disturbed by drag folding along faults. The faulting itself is the dominant structural feature of the region.

The principal mercury deposits are in the oldest fault, the Huahuaxtla, which is described in some detail in the section on ore deposits; small quantities of cinnabar have been found in many of the younger faults.

In some places the sandy limestone beds have been brecciated because of their relative brittleness, and a few brecciated fracture zones trend in a northerly direction through the limestone.

All the faults are probably normal faults, some with considerable strike-slip displacement, but the northeastward-trending fault 400 meters west-northwest of the Huahuaxtla church may be a reverse fault. On most of the faults the displacement appears to be several tens of meters, but evidence is inconclusive, because no horizon markers are available, except at the contact between the shale and limestone formations, and in addition the faults are poorly exposed where they are within one of the individual formations.

The 28 faults plotted on plate 34 are adequately revealed by field evidence; many more may be present. The available evidence does not permit a conclusive determination of the age relations of all the faults but shows that the Huahuaxtla fault is the oldest within the map area.

ORE DEPOSITS

The cinnabar deposits of the Huahuaxtla district include the main Huahuaxtla deposit, the Guillermina deposit, and several small unprofitable prospects, one of which contains a little stibnite.

HUAHUAXTLA DEPOSIT

The Huahuaxtla deposit is situated in the Huahuaxtla fault and has the same attitude. It has been mined along the strike of the fault for 500 meters and to a maximum vertical depth of 45 meters. Plate 35 shows the mine workings, and plate 36 shows the underground geology. These maps were compiled from company maps, with additions and corrections.

HUAHUAXTLA FAULT

The Huahuaxtla fault has a slightly curved northwesterly strike and an average dip of about 30° SW. In the western part of the map area it trends about N. 67° W. and dips 22° SW.; near the mines it strikes generally N. 40° W. and dips 35° SW., although in some parts of the mines it dips more steeply. The outcrop of the fault is not the locus of erosional features, such as streams, or even a topographic break in slope. It can be clearly seen crossing the hills as a sharp line dividing the shale country covered with yellow grass from the gray blocky limestone country with its tangled forest vegetation.

Underground in the mines the fault is seen to be a zone several meters thick, although the hanging-wall margin is not sharply defined because of the softness of the overlying shale.

The fault movement has deformed the hanging-wall shale both by drag folding and by brecciation. Where unbrecciated shale of the hanging wall can be seen, its bedding dips southwestward parallel to the fault plane, but as the regional dip of the shale beds is to the northeast this dip is clearly due to drag on the fault. However, this drag of the shale, together with the difficulty of seeing the bedding in the massive footwall limestone, misled the early operators into believing that the ore deposit was in a sedimentary contact between limestone and overlying shale. Detailed mapping reveals the fault relationship clearly.

The footwall consists of massive limestone beds, each of them commonly 1 to 2 meters thick. Strikes and dips are not quite uniform, but the general strike is in a west-northwesterly direction and therefore differs by only a small angle from the northwesterly strike of the fault. Moreover, the beds dip toward the northeast, opposite to the dip of the fault. Because of their massive character the limestone beds have not been affected by drag folding.

The limestone beds are not cleanly cut by the fault, as there is both brecciation and pronounced irregularity of the footwall surface. The footwall surface exhibits a series of parallel ribs, rolls, or corrugations, of large size, that trend in an almost due westerly direction diagonally down the northwestward-trending fault surface. The relationships are shown in the idealized block diagram (fig. 13).

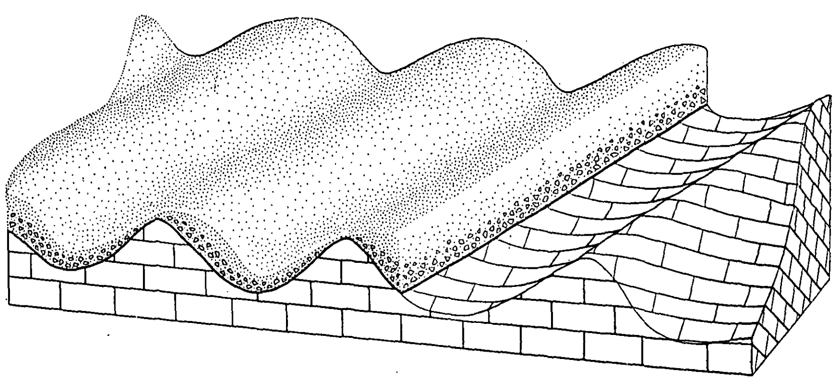


FIGURE 13.—Idealized block diagram, showing the footwall ribs of the Huahuaxtla fault and the thickness of the breccia relative to the ribs at different places. In this diagram the hanging-wall shale has been removed, and the breccia has been in part stripped away revealing some of the footwall surface.

These ribs are generally about 10 meters wide, although some are as much as a few tens of meters across. Their crests rise from about 1 to as much as 5 meters above the intervening troughs, measured normal to the dip. They are roughly parallel to one another, fairly straight in trend, and are spaced at various intervals, commonly about 10 meters, but in some places are much farther apart.

These ribs are unrelated to the bedding of the limestone, for they cut indiscriminately across it. They are believed to be due to scouring by diagonal downward movement of the hanging wall with respect to the footwall in the direction of their elongation and may therefore be likened to gigantic fluting marks, sometimes called mullions.

The fault zone consists of breccia and gouge ranging in thickness from a minimum of 1 meter to a maximum of about 10 meters, measured normal to the dip of the fault. Three kinds of breccia are recognized, all of which grade into one another; limestone breccia; mixed breccia, consisting of shale breccia containing abundant limestone breccia fragments; and shale breccia. The limestone breccia is in the lower part of the fault zone near the limestone footwall. The shale breccia is in the upper part of the fault zone adjacent to the shale hanging wall. The mixed breccia is most commonly in the middle part of the fault zone and is evidently the result of mingling of the broken fragments of the two rocks by movement of the gouge during faulting.

The footwall limestone brecciation can be traced from crackling of the limestone, through limestone breccia consisting of angular fragments as large as 1 meter across but commonly about 3 to 10 centimeters, into mixed breccia where the limestone fragments have become dispersed in gouge.

Much of the mixed breccia consists of a soft mass of minute shale fragments in which limestone fragments, commonly 10 centimeters in diameter, are dispersed, but in some of the mixed breccia the limestone fragments are very tiny, measurable in a few millimeters or even in fractions of a millimeter. The shale breccia is merely the same material without any limestone fragments. Much of it is dirty, highly carbonaceous, black, and very fine grained, resembling pulverulent coal or soft manganese ore.

The breccia, then, overlies the limestone footwall in all its irregularities and underlies the contorted hanging-wall shale, into which it grades almost imperceptibly. It is nonuniform in thickness, but the variations bear a definite relationship to the limestone ribs on the footwall surface. Along the tops of the ribs the breccia is thinnest, decreasing in thickness to as little as 1 meter; on the south or down-dip sides of the ribs it is thickest, attaining a maximum of 10 meters; and on the north or up-dip sides of the ribs it is of intermediate thickness. These relationships are of primary importance in understanding the distribution of the ore shoots.

ORE SHOOTS

Accurate data on the size, shape, persistence, and tenor of individual ore shoots are lacking, because no records were kept by the various owners, but some idea of them can be gained from the dimensions of stopes, from the reminiscences of miners, and from ore exposed during our field work.

The distribution of the ore shows clearly that its deposition was controlled by the fault. The ore minerals occur throughout the fault zone only, and the large ore shoots occur on the south or down-dip sides of the limestone footwall ribs, where the breccia is thickest. Ore shoots of moderate size occur on the north or up-dip sides of the ribs, and a small amount of ore occurs on the tops of the ribs, where the breccia is thinnest. Accordingly the ore persists along the limestone ribs from the surface to the deepest workings; individual ore shoots can be followed down along any one limestone footwall rib from one level to another, but with variations of cross section and tenor.

Although good ore occurs in all three kinds of breccia, the tenor is not uniform. Only part of the fault-zone material is ore in the commercial sense. Differences in the character of the breccia from place to place influenced the grade of the ore. The highest-grade ore occurs in the limestone breccia near the footwall, which offered maximum permeability, and in the shale breccia of finest-grain size, which offered maximum specific surface. It is evident, therefore, that the largest and richest ore shoots occur in the limestone breccia or in the finest-grained shale breccia on the south or down-dip sides of the limestone footwall ribs.

Shoots of rich ore in the limestone breccia next to the footwall, particularly on the south or down-dip sides of the ribs, conform both in dip and in plunge to the attitude of the ribs, but they pinch and swell, so the mineralized zone along any one rib presents a series of podlike ore shoots. These individual rich pods are commonly 5 centimeters to half a meter thick, measured normal to the limestone surface on which they lie, and may persist for as much as a few tens of meters in the direction of the plunge of the rib. Their dimensions down the sides of the ribs are limited by the magnitude of the individual ribs and may be from 1 to 15 meters.

Lower-grade but minable bodies of disseminated ore are present also. These bodies show great irregularity of shape and size. The tenor of the disseminated ore was determined largely by the permeability and specific surface of the breccia from place to place, and these in turn were determined by the fault movement and the configuration of the footwall surface. The distribution, shape, and size of the shoots of disseminated ore can be judged chiefly from the distribution, shape, and size of the stopes. They appear to have been from 5 to 30 or 40, or rarely as much as 80, meters in horizontal length; as much as 20 meters in horizontal width; and a maximum of 10 meters in height normal to the dip, according to the thickness of the fault gouge.

The lack of assay data and the unknown degree of hand sorting used in selecting the ore underground make it difficult to determine the true tenor of the ore. It is said that in the early years of the mine the ore was very rich, but mining at that time was highly selective, and the available data assembled in the production table (p. 155) belies this statement. In recent years attempts to deliver large tonnages to the Herreschoff furnace, coupled with the difficulty of distinguishing good ore from bad by visual inspection underground, have resulted in ore of disappointingly low grade at times. For example, the tonnage supposedly furnaced and the mercury recovered during 1942 indicate a recovered tenor of less than a kilogram per ton, although the furnace was working at an efficiency of 86 percent. Since then the effective tenor has been increased by more efficient mining and closer control over the grade of ore selected. It is said to average at times as high as 5 or 6 kilograms to the metric ton, but on the whole the tenor of the ore delivered to the furnace is probably between 2 and 3 kilograms to the ton.

MINERALOGY

The chief ore mineral is cinnabar. Native mercury is fairly common, and there is some metacinnabar. The rare nonmetallic mercury minerals, such as calomel, terlinguaite, montroydite, and eglestonite, were once fairly abundant in the near-surface parts of the deposit, and indeed Huahuaxtla was famous for fine specimens of these minerals, but they are now hard to find. Marcasite has been found in a few places and a little pyrite.

The principal gangue mineral is the clay of the fault gouge. Calcite is abundant, particularly in the lower part of the fault zone, as fillings in the footwall limestone breccia, and also as a late interstitial mineral among the grains of cinnabar. Some fibrous satin-spar gypsum forms fracture fillings in the breccia. Brown or yellow iron-oxide staining is widespread throughout much of the deposit, and red coatings and fracture fillings of powdery "hematite" are common in the brecciated limestone portions. Some of the breccia fragments are silicified, but silicification is not common and had no important relation to the formation of the ore deposit.

Most of the cinnabar is black, and although it has a dark-red streak it has been mistakenly called "metacinnabar." This metacinnabar occurs in grains of easily visible size, but red cinnabar is also present, although it occurs chiefly as minute specks that are difficult to see. For this reason the ore gives the misleading impression of being a metacinnabar ore with little or no cinnabar, whereas actually the red and black cinnabar are present in about equal amounts.

A little of the so-called metacinnabar actually is metacinnabar, but most of it is cinnabar that has formed by the inversion of metacinnabar, and peculiarly enough it has retained its black color despite the inversion. Indeed the Mexican miner's term for it, "cinabrio negro," is a more accurate appellation than any of our scientific terms.

Polished sections of the ore examined under the microscope reveal that most of the cinabrio negro is anisotropic and is therefore cinnabar, not metacinnabar, which is isometric and hence isotropic. A few uninverted remnants of isotropic metacinnabar remain. The identification of these minerals was confirmed by X-ray.

The cinabrio negro is found as grains of irregular shape, generally 0.5 to 1 millimeter in diameter. It occurs chiefly in the limestone breccia and in places persists into the footwall for a few meters along fractured zones. Although fracture filling was undoubtedly important, much of the cinabrio negro appears to have replaced the limestone. The cinabrio negro occurs also in the shale gouge, but only in the black, carbonaceous parts. Some is found in the black gouge as round nuggetlike pieces about 1 to 3 centimeters in diameter, which appear to have been torn from the footwall and rolled in the fault during postore fault movements. These "nuggets" apparently could withstand such treatment because of a network of pyrite coating the individual grains of cinabrio negro. All the cinabrio negro is believed to have formed by the inversion of primary metacinnabar.

The specks of red cinnabar are commonly no more than 0.1 millimeter across. Such material is disseminated in the gouge, and some occurs also in the limestone breccia. Some of the specks are minute crystals. In a few places rich coarse-grained red cinnabar is found; it generally has a dark purplish-red color. This red cinnabar, together with the minutely crystallized cinnabar, is believed to be primary cinnabar, but much of the red cinnabar is dusty material marginal to grains of cinabrio negro or penetrating minute fractures in it and is believed to be secondary cinnabar.

There is a clear relationship between the occurrence of these minerals and the distribution of ferric iron oxide. Much of the ore of the footwall limestone breccia is devoid of iron oxide and contains cinabrio negro alone. Red cinnabar is present with the cinabrio negro in such ore only if ferric iron oxide is also present. In the black shale gouge, in which such iron as may be present is probably in the ferrous state, red cinnabar is distinctly subordinate to cinabrio negro in amount. On the other hand, in the parts of the shale gouge or mixed breccia that are yellow or brown from ferric iron-oxide coloration, cinabrio negro is absent, and only red cinnabar is found.

One noteworthy concentration of red cinnabar is found in black gouge on the 45-meter level of the San Luis mine, where there were several rich stopes. Most of the ore in these stopes was cinabrio negro, but nearly at right angles to the principal elongation of the stopes that followed the Huahuaxtla fault there was a zone of high-grade red cinnabar ore that evidently followed the San Luis fault. According to surface evidence, the San Luis fault cuts across the Huahuaxtla fault, although it cannot be seen underground because of mine timber.

Marcasite, distinguishable from pyrite by its form, has been found only in the black shale gouge near the hanging wall on the 45-meter level. When dug out, the soft shale gouge containing it is hot, evidently from oxidation. Where the marcasite appears the grade of the ore is low.

Native mercury is common in the ore of the 15-meter and 23-meter levels, which suggests that it was formed by supergene processes, but it seems to be more abundant in proximity to the black carbonaceous gouge than elsewhere. Some has also been found in the black shale gouge ore of the 45-meter level where no minerals that are certainly of supergene origin have been found. It is therefore possible that the native mercury formed during the primary mineralization by the reducing action of the carbon in the shale gouge. No evidence has been found to suggest that the carbon content of such shale gouge at Huahuaxtla is due to any hydrocarbon or bitumen similar to that found in some mercury deposits of California. The carbonaceous material at Huahuaxtla is believed to be simply pulverized carbonaceous black shale.

The rare mercury minerals are now hard to find at Huahuaxtla, although terlinguaite, montroydite, eglestonite, and calomel were recognized, and several other minerals of doubtful identity were found. It is said that the early operators shoveled montroydite crystals an inch long into their retorts by the sackful. These rare mercury minerals were once abundant in the old shallow workings, but only traces were found on the 30-meter level, and none of them have been found on the lower levels of the mine.

Large masses of the shale breccia and mixed breccia in the upper levels of the mine have been bleached from their former black color to a brownish buff, evidently by the oxidation of the contained ferrous iron to ferric iron. The extent of this alteration diminishes in the lower levels of the mine, suggesting that it was accomplished by supergene processes. Although supergene processes have apparently been active, there is no convincing evidence that the tenor of the ore has been noticeably changed by them.

MINE WORKINGS

The mine workings, less than half of which were accessible in 1944, were originally parts of three mines. The nomenclature of the various workings reflects their early history, but in 1944 they were one connected mine under one ownership and management. Accordingly the three major portions are named, from southeast to northwest, the Aurora mine, the Esperanza mine, and the San Luis mine (pl. 35).

The Aurora mine, which consists chiefly of the so-called 15-meter level, is entered through the Aurora adit. Numerous old workings above it, inclined upward toward the northeast within the Huahuaxtla fault, connect it with the Aurora open-cut. Nearly all these upper workings are caved, being in fault gouge and thoroughly gutted by mining. The open-cut itself is largely in limestone and owes its irregular shape in part to fruitless exploration and in part to mining along fracture zones in the footwall limestone into which ore-depositing solutions had penetrated.

Below the 15-meter level, and to the west of it, is the 30-meter level, accessible from the 15-meter level by a manway. The southeastern part of the 30-meter level was originally part of the Aurora mine, but it has been connected with the 30-meter level of the Esperanza mine, and all ore from the 30-meter level is hoisted through the Esperanza shaft.

Stopes and old workings, long since caved and inaccessible, lie between the 15-meter level and the 30-meter level of the Aurora. One part, called the 26-meter level, was accessible until 1944.

Although the Aurora "cata" was apparently connected with the Aurora mine workings, which caved prior to 1942, the nearby Esperanza shaft and its workings were not connected with the Aurora mine until 1943. Until the Cía. Explotadora de Mercurio Huahuaxtla, S. A., had accomplished improvements in 1942 and 1943, the Esperanza and San Luis workings could be entered only through the old manway, a narrow timbered corkscrew incline in black slime, which descends from the southern end of the Esperanza open-cut. Subsequently this manway was used only as an emergency exit.

The Esperanza shaft is in the footwall limestone and was probably intended to tap the deposit at greater depth than the workings of the Aurora mine. Numerous shallow workings in the Esperanza mine are shown on some of the old mine maps, but these workings caved long ago, and none of the workings above the 30-meter level of the Esperanza have been accessible for years.

The parts of the 30-meter and 40-meter levels of the Esperanza near the shaft are in the footwall limestone and were driven southward to the fault-gouge ore zone where the level workings spread out laterally. Ore from the 40-meter level is dumped down to the

45-meter level of the San Luis mine for tramming to the Esperanza shaft.

None of the extensive workings of the San Luis mine above the 45-meter level are accessible and probably no longer exist, although they are shown on some of the old maps in the files of the owners.

Since 1942 the San Luis shaft has been used only for ventilation, and access to the 45-meter level of the San Luis mine is through the long drift in the footwall limestone from the Esperanza shaft. Much of the mineralized part of the 45-meter level of the San Luis was inaccessible in 1944 because it had been mined out, and being in soft black-shale fault gouge it had caved. The main drift south on the 45-meter level encountered the same ore bodies that were found above on the 30-meter and 40-meter levels.

GUILLERMINA DEPOSIT

The Guillermina mine is in the eastern part of the ridge of Cerro del Encinal, about a kilometer north of the Huahuaxtla mine, at coordinates 175 E. and 1,100 N., at an altitude of 1,180 meters.

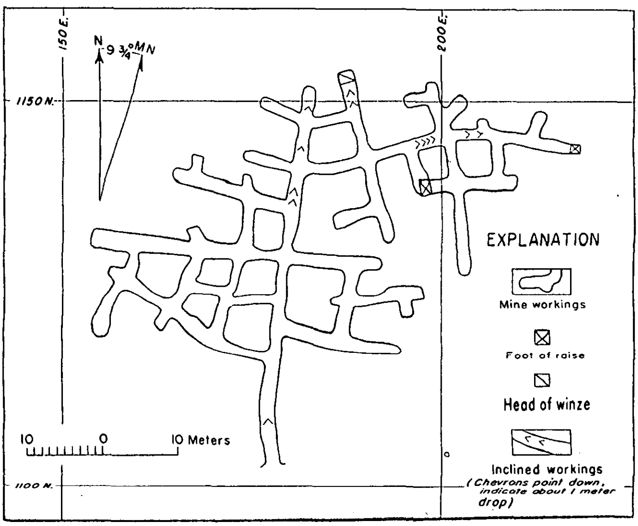


FIGURE 14.—Map of the Guillermina mine workings.

It consists (see fig. 14) of an adit 50 meters long, inclined downward to the north, with horizontal workings ramifying westward as much as 25 meters and eastward as much as 35 meters. These eastern workings have some downward slope both eastward and northward.

Red cinnabar is the only ore mineral present. Traces of some of the rare mercury minerals have been found but no metacinnabar or cinabrio negro. A little ore occurs in limestone gangue, but the principal gangue is clayey material colored by ferric iron oxide. Some calcite and gypsum are present, both as fracture fillings and as minute crystals in voids. Traces of silicification in the limestone fragments have been seen in places.

The mine is in oxidized gougy shale lying on limestone, which may be seen in many places in the floor. The ore is chiefly clayey gouge in which red cinnabar is disseminated, but some red cinnabar is found also in the footwall limestone. The tenor of the ore is not accurately known, but the mercury content of individual samples ranges from a trace to more than a hundred kilograms to the ton. Furnace recovery for a typical week in the spring of 1944 averaged slightly more than 11 kilograms to the ton.

The mine workings and the ore lie in and follow the contact between the limestone formation and the overlying shale. The western part of the mine follows the sedimentary contact between the two formations, but in the eastern part of the mine most of the mine workings and ore are in the gouge of the Alicia fault between the limestone formation and the overlying shale.

The deposit is, therefore, a mineralized fault gouge with shale hanging wall and limestone footwall. It lies at the junction of the southeastward-dipping Alicia fault and the less steep northeastward-dipping sedimentary contact. As a result, the workings plunge downward in a northeasterly direction following the ore, and any ore that may be found by deeper exploration will probably be found in that direction.

Some prospect pits just south and below the Guillermina were called the Amates mine and were worked from time to time by local prospectors, but as only traces of ore were found the prospects were abandoned. Late in 1943 further exploration higher up the hill led to the discovery of the Guillermina ore body. Development muck was retorted, and when enough ore had been blocked out in pillars to feed the Herreschoff furnace for several months a contract was arranged with the Dodero brothers to mine and furnace it. As many miners from Huahuaxtla were moved over to the Guillermina to do this work, there was an opportunity to emphasize development rather than extraction at the main Huahuaxtla mine, and the high figures in the table of Huahuaxtla mercury production (see p. 155) from May through October of 1944 represent the yield from the Guillermina deposit. The Guillermina was then closed down because the blocked-out ore had been extracted.

OTHER CINNABAR PROSPECTS

Twenty-four cinnabar prospects are shown on plate 35. They range in size from single shallow pits to groups of shallow shafts and short adits. Traces of mercury were detected by assay in grab samples from every one of them. None have been commercially successful.

Many of the prospects are in faults; some are at the intersections of faults with other faults or of faults with the sedimentary contact; and others are in breccia zones in the limestone. Brief descriptions of the principal prospects will serve to show their general character.

Limón mine.—The Limón mine, in the western corner of the map area, was owned by Pedro Bustos of Iguala and was operated for a short time in 1941. A trench in limestone extends S. 80° E. for 14 meters, following the Limón fault, which here dips 75° S., and at its eastern end a stope 1.5 meters wide is inclined downward at 35° for 20 meters in a S. 70° E. direction. These workings explore brecciated limestone, veined with white calcite and "hematite" at the junction of the Huahuaxtla and Limón faults. The ruins of a 5-tube retort suggest that mercury was produced, but probably the total output did not exceed a few kilograms.

Perla mine.—The Perla mine, owned by Juan Frausto and Oscar Oscura of Iguala, is in Barranca de Tenancingo, half a kilometer south of the San Juan church. There are several small pits and an adit, which extends S. 12° E. for 11 meters, and S. 10° W. for 5 meters and then enters a drift. The drift runs S. 80° W. for 5 meters, following a calcite-filled breccia zone in limestone that strikes east and dips 68° S. The Perla is said to have produced about 7 kilograms of mercury a week for a short time.

Porvenir mine.—The Porvenir mine, just east of the Huahuaxtla furnace, consists of two shafts 33 meters apart, connected by a surface trench 3 meters wide and 2 meters deep. Each shaft is 17 meters deep and inclined 77° N. These workings all lie along a limestone breccia zone trending N. 75° E., and the shafts are located where poorly defined northward-trending breccia zones intersect it.

Vaca mine.—The Vaca mine, 130 meters southeast of the Porvenir, is a stope inclined downward 45° NW. to a depth of 15 meters. It is in a breccia zone 1 meter thick trending N. 35° W. and dipping 75° NE. It is said to have produced one-tenth of a flask of mercury per week for 7 weeks in the spring of 1940.

The prospect just north of the road, where it crosses Arroyo de San Juan, differs from all the others in containing stibnite (Sb_2S_3). It is an open-cut, 20 by 10 meters, with a maximum depth of 15 meters. It was worked intermittently and unsuccessfully as an antimony mine in the spring of 1942, and then, also unsuccessfully, as a mercury mine for a short time before being abandoned.

AGE AND ORIGIN OF THE ORE

According to current theory, primary red cinnabar can be deposited only in an alkaline environment. The conditions under which metacinnabar can form are not as yet completely known, but apparently it forms most readily in a neutral or acid environment.[17] It can at least be said with considerable assurance that primary red cinnabar cannot form under the conditions that allow the formation of metacinnabar. Red cinnabar that is believed to be primary is found in the main Huahuaxtla mines in a deposit that formed in the oldest fault in the map area. It is found also in the numerous prospects that are in faults of diverse ages down to the youngest in the map area. The red cinnabar mineralization, therefore, must be at least as recent as the youngest faults.

Metacinnabar, and cinabrio negro formed by inversion of metacinnabar, have been found only in the oldest fault, the Huahuaxtla. They have not been found in any of the prospects in the younger faults.

These facts suggest two periods of mercury mineralization: (1) an old mineralization under conditions that allowed the formation of metacinnabar, at a time when the old Huahuaxtla fault was the only one available to the mineralizing solutions, and (2) a young mineralization under conditions that must have been different because they allowed the formation of primary red cinnabar, at a time when all the faults younger than the Huahuaxtla were also available to the mineralizing solutions as channelways of movement and as receptacles in which to deposit the ore.

The absence of metacinnabar from the deposits in the young faults is negative evidence that is inherently weak. Furthermore, these prospects are shallow and entirely within the near-surface zone of oxidation, so that the associated iron oxides are ferric and consequently only the red cinnabar might be expected in them anyway (see pp. 165–166). The criteria available at present for distinguishing cinabrio negro from primary red cinnabar are inconclusive. The chief distinction at present is the surficial color as determined megascopically and the streak. Lastly, there is still much to be learned about the physical chemistry of mercury sulfide deposition.

Despite these serious weaknesses, the field facts favor the two-mineralization hypothesis. Particularly significant is the occurrence of abundant red cinnabar in the stopes on the 45-meter level along the

[17] Dreyer, R. M., The geochemistry of quicksilver mineralization: Econ. Geology, vol. 35, pp. 17–48, 1940. Fahey, J. J., Fleischer, Michael, and Ross, C. P., The geochemistry of quicksilver mineralization: Econ. Geology, vol. 35, pp. 465–470, 1940. Allen, C. A., Crenshaw, J. L., and Merwin, H. E., The sulphides of zinc, cadmium, and mercury; their crystal form and genetic conditions: Am. Jour. Sci., 4th ser., vol. 34, pp. 341–396, 1912.

San Luis fault where it cuts across the Huahuaxtla fault that contains chiefly cinabrio negro.

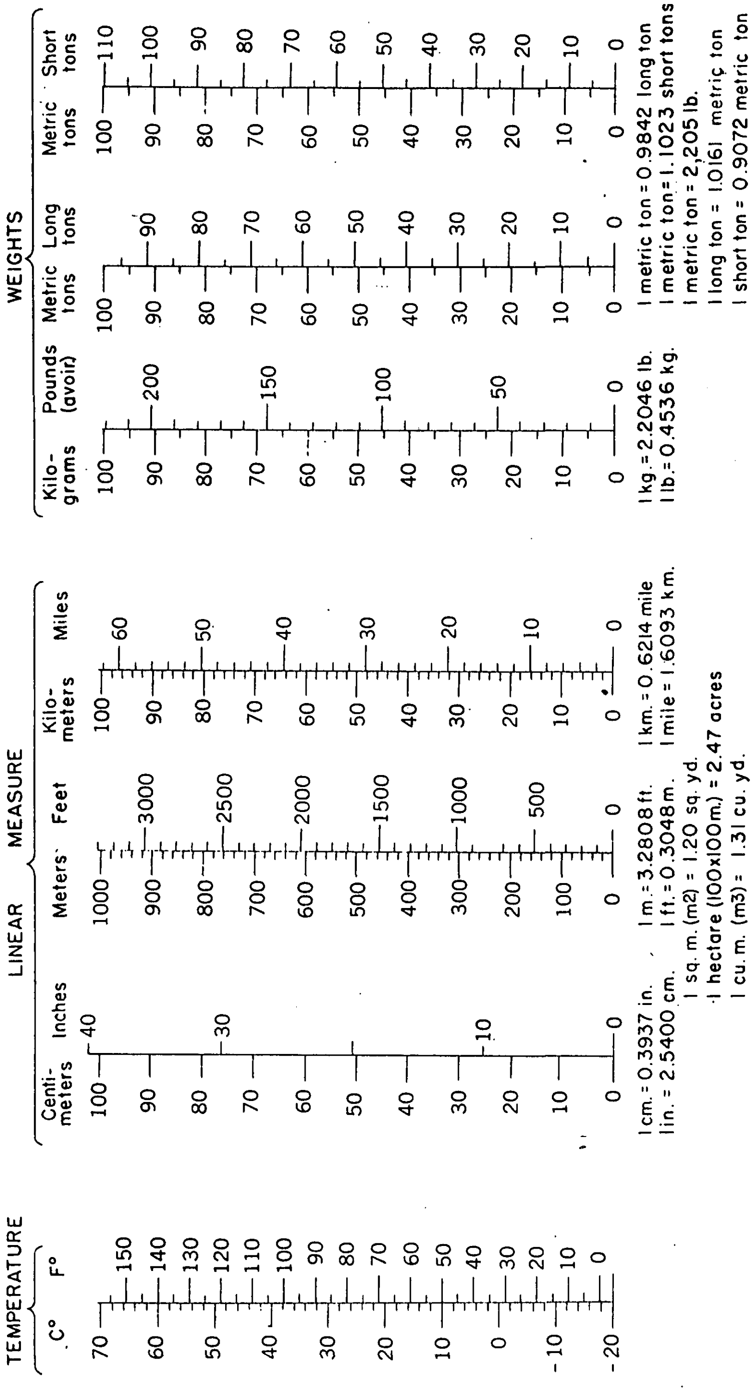
RESERVES AND FUTURE OF THE DISTRICT

Regarding the reserves and future of the district it is concluded that the many small prospects appear to be of little value and that there is little likelihood of discovering another large deposit in the district, but the principal deposit looks promising. No formal statement of ore reserves can be made because little ore is developed ahead of extraction. At the time of writing almost no recoverable ore remains above the 30-meter level, and about half the ore between the 30-meter and 45-meter levels has been mined. So far the deposit has produced about 300,000 kilograms of mercury, or about 10,000 kilograms per meter of vertical depth.

The Huahuaxtla fault is a geologic structure of large magnitude and may reasonably be expected to continue downward for at least many tens of meters more. No downward change in mineralogy or other feature has been observed that might indicate a change in the character or grade of the ore.

Knowledge of the structure of the deposit and of the controls that influenced the localization of the ore can be used as a guide in following the ore both downward and laterally. Downward persistence of the ore seems reasonably well assured. Lateral extension of the deposit southeastward appears to be limited by the Cruz Verde fault, but the ore may persist northwestward along the Huahuaxtla fault into ground as yet unexplored.

Because of the southwestward dip of the deposit, the present shafts and the location of the furnace will become increasingly disadvantageous as the depth of the mine increases. Large-scale reorganization of the mine, although necessitating a large capital expenditure, might be an advisable economy.


METRIC EQUIVALENTS
LINEAR MEASURE
WEIGHTS
TEMPERATURE
Centi-meters
Inches
Meters
Feet
Kilo-meters
Miles
Kilo-grams
Pounds (avoir.)
Metric tons
Long tons
Metric tons
Short tons
C°
F°
1 cm. = 0.3937 in.
1 in. = 2.5400 cm.
1 m. = 3.2808 ft.
1 ft. = 0.3048 m.
1 km. = 0.6214 mile
1 mile = 1.6093 km.
1 sq. m. (m2) = 1.20 sq. yd.
1 hectare (100x100m.) = 2.47 acres
1 cu. m. (m3) = 1.31 cu. yd.
1 kg. = 2.2046 lb.
1 lb. = 0.4536 kg.
1 metric ton = 0.9842 long ton
1 metric ton = 1.1023 short tons
1 metric ton = 2,205 lb.
1 long ton = 1.0161 metric ton
1 short ton = 0.9072 metric ton

INDEX