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MANGANESE DEPOSITS IN COSTA RICA

BY

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CONTENTS

	Page
Abstract.....	387
Introduction.....	387
Transportation and accessibility.....	388
History and production.....	388
Geology of the ore deposits.....	389
Reserves.....	390
Costs.....	391
Mines.....	391
Santa Rosa district.....	391
Playa Real.....	392
Other properties near Playa Real.....	392
La Esperanza.....	392
La Bejia.....	393
La Pedregosa.....	393
El Encanto.....	394
La Seba.....	394
El Zapotalillo.....	394
Other prospects near Playa Real and Puerto Viejo.....	394
Playa Blanca.....	395
El Sesteco.....	395
El Mico.....	396
Los Limones.....	396
El Licor.....	397
El Curiol.....	398
Loma Blanca.....	399
El Guastomate.....	399
El Guacalito.....	399
La Catasolapa.....	399
Wolf.....	399
Carbon.....	400
El Jocote.....	400
Other properties near Santa Rosa.....	400
Arenal district.....	400
La Desdichada.....	401
Río Seco-Lagarto district.....	401
El Cuchofino.....	401
Filacho Mula.....	401
Judas.....	402
Pie Paloma.....	402
El Zapote.....	402
El Espavelar.....	402
Los Bolillos.....	403
El Cacao.....	403
La Victoria.....	404
Río Piedra Amarilla-Río Guajiniquil district.....	404
El Pital.....	405
Los Saltos.....	405
Piedra Amarilla.....	406
Los Munecos zone.....	407
El Carrizal.....	408
Los Chanchos.....	408
Other properties in Río Piedra Amarilla-Río Guajiniquil district.....	408

	Page
Mines--Continued.	
Sardinal district.....	408
El Francés.....	409
La Cuestacita.....	410
Other properties near El Francés.....	410
El Panamá.....	410
Other showings near Culebra Bay.....	410
Justo Perez.....	410
La Libertad.....	411
Showings north of Sardinal.....	411
Showings near Belen.....	411
Nicoya-Pavones district.....	411
La Cuesta de Matambú.....	411
Cerro Grande.....	412
Matina.....	413
Pavones.....	413
La Colonia Carmona.....	414
Tambor.....	414

ILLUSTRATIONS

	Page
Plate 78. Map of the Nicoya Peninsula, Costa Rica.....	390
79. Geologic map of El Curiol mine.....	398
80. Sketch map of Los Bolillos workings.....	406
Figure 21. Sketch map of part of workings, Playa Real...	393
22. Sketch map of Playa Blanca workings.....	395
23. Sketch map of El Sesteo workings.....	396
24. Sketch map of El Licor mine workings.....	397
25. Sketch map of El Cacao workings.....	404
26. Sketch map of El Pital workings.....	406
27. Sketch map of Los Saltos workings.....	407
28. Sketch map of El Francés workings.....	409
29. Sketch map of Cerro Grande.....	412
30. Sketch maps of Los Pavones workings.....	414

MANGANESE DEPOSITS IN COSTA RICA

By Ralph J. Roberts

ABSTRACT

The manganese deposits of Costa Rica are on the Nicoya Peninsula, in the Province of Guanacaste, on the Pacific coast. Between 1915 and 1920 nearly 32,000 long tons of high-grade ore was shipped from them to the United States, but since 1920 the mines have been inactive.

The sedimentary rocks of the Nicoya Peninsula are Tertiary sandstone, chert, shale, and limestone. They are interbedded with basalt, and are intruded by diabase and diorite.

The manganese deposits are of three types: hypogene, supergene, and residual. In the hypogene deposits the manganese minerals are the silicates braunite, bementite, and rhodochrosite; these minerals occur in jasper, which replaces sedimentary and igneous rocks along bedding and fault zones. The deposits are tabular, lenticular, or irregular in shape. Some of them are as much as 120 feet long, 20 feet wide, and 100 feet deep, but on the average they are considerably smaller. The supergene and residual deposits are composed of pyrolusite, wad, and psilomelane, formed by weathering of the silicates. All of them are extremely irregular. The greater part of the ore mined and shipped was oxide ore, but braunite predominated in ore mined from the deeper workings at the Curiol mine. The depth of oxidation ranges from a few feet to more than 75 feet.

Since most of the old workings are inaccessible and many of the deposits have not been adequately explored, it is difficult to predict how much ore is available in the district. About 1,000 tons of ore containing between 30 and 50 percent of manganese is estimated to be blocked out or on the dumps. Several thousand tons may remain to be developed in extensions of known ore bodies and in new ore bodies. Some of the ore can be sorted, or concentrated in simple washers, but part of it, possibly 50 percent or more, will have to be crushed and concentrated by more costly methods.

INTRODUCTION

The manganese deposits of Costa Rica are on the Nicoya Peninsula, in the Province of Guanacaste, on the Pacific coast (see pl. 78). Most of them are within 10 miles of the Pacific Ocean, in a belt about 45 miles long extending from San Juanillo to Culebra Bay. One deposit is near Puerto Thiel, on

the Gulf of Nicoya, and others are scattered through the central part of the peninsula.

The Nicoya Peninsula is separated from the central plateau of Costa Rica by the Gulf of Nicoya and the broad lowland of the Río Tempisque. It is largely occupied by mountains. West of the Tempisque and as far south as Nicoya the mountains are but moderately rugged, the highest having altitudes of about 2,000 feet, and here the vegetation consists largely of grasses and shrubs. South of Nicoya some peaks rise above 3,000 feet, and in the parts of this region that are at high altitudes or near the Pacific coast the vegetation is dense and tropical.

Transportation and accessibility

The principal ports of Costa Rica are Port Limon on the Atlantic Ocean and Puntarenas, in the Gulf of Nicoya, on the Pacific Ocean. They are connected by the Northern Railway, which runs from Port Limon to San José, and by the Ferrocarril al Pacífico, which runs from San José to Puntarenas. Many launches with regular schedules ply between Puntarenas and points on the Nicoya Peninsula, which are connected by bus or truck service with the principal towns.

The yearly rainfall on the Nicoya Peninsula is about 70 inches, most of which falls between June and December. During the rainy months heavy hauling is difficult, and at times it is impossible on the dirt roads. Most of the hauling is still done with oxcarts, but the use of trucks is gradually increasing. At present few of the roads are surfaced, but the road from Puerto Jesús to Nicoya is now being macadamized, and it is expected that all-weather roads will be built between other towns in the next few years.

Most of the manganese ore produced in Costa Rica between 1914 and 1920 was shipped from Playa Real, Puerto Viejo, and Lagarto. High tides and shallow water near shore required the use of lighters and long piers for loading the ocean-going steamers. The piers then used have been destroyed, and there are no loading facilities at the present time.

History and production

In the 1915-18 period the Costa Rica Manganese & Mining Co. operated the Playa Real and Curíol mines, and shipped some ore from nearby properties. Later this company was absorbed by the American Manufacturing Co. of Philadelphia, which continued to make shipments, largely from the Curíol mine, until 1920. In 1930, control of most of the properties passed into the hands of Capt. W. R. Scott and Guadalupe Gatgens, but as these men failed to do the required work the denouncements lapsed and were taken up by others. The properties lay idle until 1936, when control of several of them was acquired by Otto Sauter, who did a little exploration work, and shipped 300 tons of ore from El Guacalito in 1938. In 1937, E. W. Creevy bought all of the properties except the Curíol and Guacalito. He carried on an active program of exploration until the end of 1940, but shipped no ore.

The manganese deposits of Costa Rica are now largely held by companies: the Guanacaste Manganese Co. controls the Curíol, Playa Real, and Guacalito properties; La Compañía

Rotheberg controls properties near Santa Rosa, Río Sequito, and Lagarto; and the Rothe Co. controls properties in the Río Guajiniquil area and near Sardinal and Santa Rosa.

The first shipments of manganese ore from Costa Rica were made in 1915 from the Playa Real mine. This mine has been the largest single producer and, together with the Curiol mine, has yielded about 85 percent of the ore shipped. The recorded production is given in the following table:

Production of manganese ore in Costa Rica, 1915-38 1/

<u>Year</u>	<u>Long tons</u>
1915.....	?
1916.....	1,244
1917.....	7,163
1918.....	9,968
1919.....	9,988
1920.....	3,202
1938.....	300
Total.....	31,865

The manganese content of the ore shipped ranged from 40 to 55 percent and averaged about 50 percent. Iron and phosphorus were low. The ore contained as much as 10 percent of silica, in part mechanically mixed with manganese oxides, but in part present in the mineral braunite.

Geology of the ore deposits

The rocks of the Nicoya Peninsula are partly sedimentary, partly igneous, and all of Tertiary age: the sedimentary rocks are predominantly shale, chert, and limestone; the igneous rocks include basalt flows, intercalated with the sediments, and intrusive diorite and diabase. The bedded rocks have been folded into northwestward-trending anticlines and synclines, and in places they have been complexly faulted.

The manganese deposits in bedrock are associated with masses of red and yellow jasper, which replace both sedimentary and igneous rocks. In sedimentary rocks the jasper follows bedding planes, commonly along contacts with igneous rock. In igneous rocks it follows fracture zones. The manganese minerals replace jasper and the adjacent wall rocks.

The deposits are of three types: hypogene, supergene, and residual. These types are closely associated, and all three may be found at a single property. The hypogene deposits, which were formed by ascending hypothermal solutions, contain manganese silicates replacing jasper; the supergene deposits consist of manganese oxides derived from the silicates by weathering in place; and the residual deposits consist of nodules and fragments of oxides in the soil that mantles the slopes below outcrops.

The hypogene manganese minerals are braunite ($3\text{MnMnO}_3 \cdot \text{MnSiO}_3$), bementite ($8\text{MnO} \cdot 5\text{H}_2\text{O} \cdot 7\text{SiO}_2$), and rhodonite (MnSiO_3). Of these, only braunite is rich enough in manganese to be shipped directly as metallurgical ore. Small veins of rhodochrosite have been found in two deposits. The manganese minerals found in the supergene and residual deposits are pyrolusite,

1/ Webber, B. N., Manganese deposits of Costa Rica: Am. Inst. Min. Met. Eng. Tech. Paper 1445, February 1942.

psilomelane, and wad, all of which grade at depth into silicates.

The hypogene ore bodies are tabular, lenticular, or irregular in shape. Some tabular ore bodies follow faults and extend to depths of 75 feet or more; others are nearly flat or pockety, and shallow; still others are thin residual caps. The manganese silicates occur in layers, pockets, and veins within the jasper, which follows bedding planes and fault zones. Ore bodies along bedding planes may have any dip from nearly horizontal to vertical; those along fault zones commonly have steep dips.

As the oxides formed from the oxidation of silicates for the most part remained in place, the supergene ore bodies are mostly similar in form to the hypogene bodies; however, the oxides were in part transported downward by circulating waters and deposited along fractures and bedding planes in the wall rock adjacent to the jasper. The depth of oxidation in the Nicoya Peninsula is variable, extending from a few feet to 75 feet or more below the surface; commonly, however, complete oxidation extends no deeper than 20 feet. At the Curiol mine (pl. 79), where the downward percolation of solutions was aided by fracturing and shearing in the ore zone, oxidation was nearly complete 75 feet or more below the surface; but at El Cacao (fig. 25) manganese silicates occur within 5 feet of the surface.

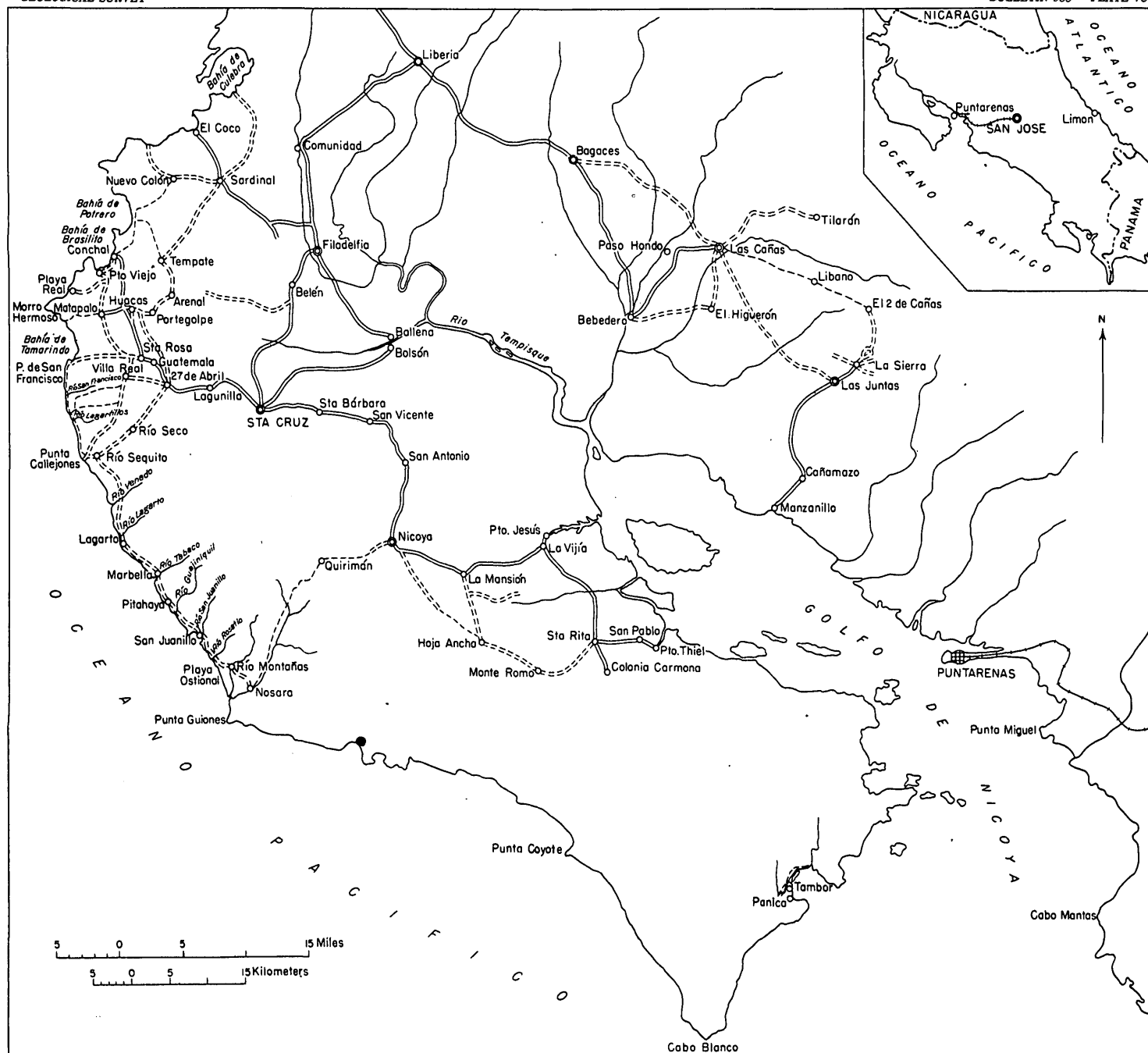
Individual ore bodies contain from a few tons to several thousand tons. One ore body at the Curiol mine was 120 feet long, 20 feet in average width, and in places at least 100 feet deep. Most of them, however, are smaller, and on the average they are less than 50 feet long, 5 feet wide, and 20 feet deep. There is commonly much waste material in the ore bodies, and in the 1915-20 period the ore was selectively mined and sorted before shipment.

Reserves

The principal factors that influence estimates of reserves are (1) mineral composition, (2) depth of oxidation, and (3) form of the ore bodies.

All of the oxide minerals may be high enough in grade to be shipped as metallurgical ore, but braunite is the only hypogene mineral that contains enough manganese to constitute shipping ore; oxidation thus increases the value of the ore, and it is consequently desirable to identify the principal minerals present and determine to what extent the ore is oxidized. As oxidation is influenced by local structures, the depth to which it extends in a given ore body must be determined before an accurate estimate of the reserves in that body can be made.

As not enough exploratory work has been done in most of the Guanacaste manganese deposits to determine these factors, and as many of the old workings are inaccessible, it is difficult to estimate reserves. About 1,000 tons of ore containing 30 to 50 percent of manganese is already blocked out or on the dumps. About half of this could be sorted to give an ore of shipping grade (40 to 45 percent of manganese). Several thousand tons of ore containing about 40 percent of manganese can probably be found in extensions of known ore bodies and in newly discovered ore bodies. In addition, a considerable tonnage of ore containing 20 to 35 percent of manganese may be available on old dumps, in the workings, and in new deposits. This ore would



MAP OF THE NICOYA PENINSULA, COSTA RICA
 MAPA DE LA PENINSULA DE NICOYA, COSTA RICA

have to be concentrated; part of it could be concentrated in simple washers, but most of it would have to be crushed and concentrated by more costly methods.

Costs

Skilled labor is not plentiful in Costa Rica at the present time (1942), because of the demands for such labor in the Canal Zone and on the International Highway. Unskilled labor, however, is reasonably abundant in Guanacaste, and training for most mining operations would not require much time. The pay of unskilled laborers is now \$0.50 to \$1.00 a day.

Hauling is largely done with oxcarts at a cost of about \$0.20 a ton per kilometer in the dry season. Truck hauling over dirt roads in the dry season is estimated to cost about \$0.15 a ton per kilometer.

Mining costs will vary from mine to mine, and an average figure can hardly be given. Men who worked at Playa Real and Curiol between 1917 and 1920 estimated that costs for mining, sorting, transportation to ports, and loading ranged from \$20 to \$30 a ton. Costs will probably be about the same in 1942, and profitable operation may require a price of \$1.00 a unit or more, depending upon the size of the operation, distance from the coast, and other factors. Loading facilities, housing, and administration costs would also have to be considered.

If the low-grade ores that would require concentration are to be used, other problems will arise. The deposits will have to be adequately explored and sampled, then tested to determine the best method of recovery. Portable equipment would be desirable, for it is unlikely that any single property will warrant an expensive installation.

The ore could be shipped by ocean to Pacific coast ports of the United States, or to Atlantic ports via the Panama Canal. In an emergency the ore could be sent overland to Puerto Limon by railroad, but the additional cost would be nearly \$10 a ton and reloading would be required.

MINES

Most of the manganese ore deposits on the Nicoya Peninsula are within 10 miles of the Pacific coast, but some of them are farther inland and one is on the Gulf of Nicoya. For convenience they have been grouped in districts, named after the principal towns nearby.

Santa Rosa district

The Santa Rosa district includes, among others, the Playa Real and Curiol mines, which together have produced about 30,000 tons of high-grade manganese ore. Production from other properties has been small, and few of them have been explored.

The ore from the Playa Real mine was loaded from a pier at Playa Real. The first shipments of ore from the Curiol mine were transported by oxcart to Puerto Viejo, but later a railroad 2 miles long was built to Los Boquerones from Puerto Viejo.

If manganese ore is again shipped from Costa Rica, Puerto Viejo will probably be the best shipping point. The roads from Playa Real and Curiol to Puerto Viejo (via Conchal) can be improved at small cost so that they will be passable by truck even during the rainy season.

Playa Real

The Playa Real mine, 2 miles southwest of Puerto Viejo, on the Pacific coast, produced about 19,000 tons of manganese ore between 1915 and October 1918. The property is now owned by the Guanacaste Manganese Co. of San José. Sears ^{2/} examined the mine when it was in production and published a description of the workings, illustrated by a sketch map showing the general distribution of the ore bodies. Much of the following information is from his report.

The ore bodies are distributed throughout a northerly trending belt about 1,600 feet long and in places several hundred feet wide. The ore is found as a residual capping and in irregular pockets in red shale, chert, or jasper (see fig. 21). It consists for the most part of pyrolusite and wad. A little braunite was seen in the cores of boulders, and it appears probable that the oxides were largely formed from braunite. The ore bodies were shallow, and although some ore was taken from underground workings, most of it was mined from pits less than 15 feet deep. Several tunnels were driven during the 1915-18 period, but only low-grade ore, shale, chert, or jasper were found. The ore mined at Playa Real was of high grade, averaging about 50 percent of manganese; it contained about 10 percent of silica, and iron and phosphorus were low.

The pits are now partly caved, but exposures in them indicate that the bulk of the shipping ore has been mined. Some material high in silica remains in the pits and on the dumps, and there are small ore bodies in the underground workings. The ore remaining will probably have to be concentrated before shipping, but further exploration to determine the available tonnage, ought to be made before operations are started. At present there are no shipping facilities at Playa Real.

Other properties near Playa Real

Several other properties near Playa Real were visited, including La Esperanza, El Encanto, El Zapotalillo, La Pedregosa, and La Seba, all said to be owned by the Guanacaste Manganese Co. Ore was shipped from La Esperanza and El Encanto in 1917 and 1918 by Robert Crespi for the Manganese Mining & Manufacturing Co.

La Esperanza

La Esperanza, a property half a mile south of Playa Real, was worked in 1918. The production is not known, but it is estimated to have been less than 200 tons. The workings, which are at an altitude of 350 feet, may be reached by oxcart road from Playa Real. They consist of shallow trenches in chert and

^{2/} Sears, J. D., Manganese deposits of Costa Rica: U. S. Geol. Survey Bull. 710-C, p. 68, 1919.

shale, which have been locally replaced by jasper and which extend for about 200 feet along a narrow ridge. One trench exposes a layer of low-grade siliceous ore $3\frac{1}{2}$ feet wide, striking N. 40° W. The deposit appears to be virtually worked out, though it still might yield a few tons of low-grade ore.

La Bejia

The workings at La Bejia, three-quarters of a mile south of Playa Real, consist of a trench 50 feet long and an adjoining pit 40 feet long. They explore a pyrolusite-braunite ore body, dipping 75° SW., in chert, shale, and jasper. Although the ore now exposed in the workings is of low grade, about 20 tons of good ore is piled on the dump. This ore was probably mined

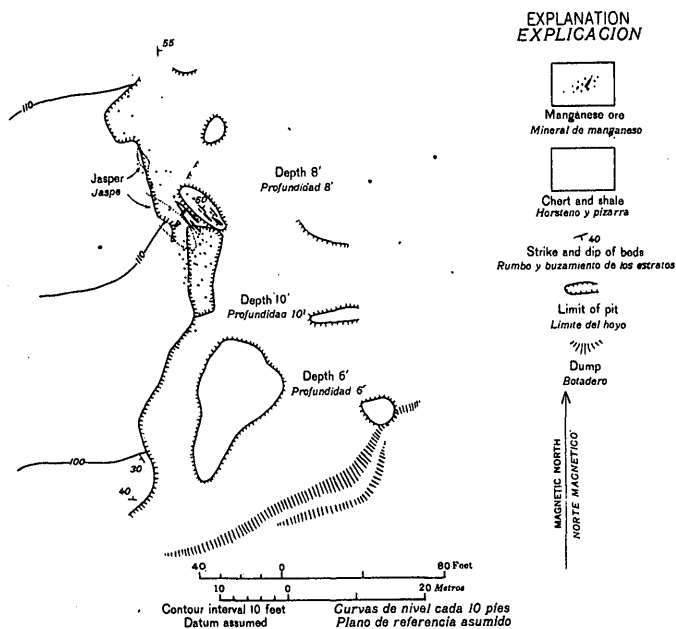


Figure 21.--Sketch map of part of workings, Playa Real

from the pit, but the bottom of the pit is now concealed by debris. To the northwest the ore pinches, and, unless the ore extends to considerable depth or continues southeast of the present workings, the outlook does not appear to be promising. Ore from this property could be hauled to Playa Real by oxcart after road improvements had been made.

La Pedregosa

La Pedregosa is about a mile south of Playa Real. The workings consist of shallow cuts in a jasper zone, trending N. 50° E., which is 3 feet or more in width and can be traced for 100 feet. The ore fills fractures in the jasper and replaces jasper. Although part of it is of fair grade, much of it is siliceous. There is no road to the property at present.

El Encanto

El Encanto, a mile south of Puerto Viejo and a few hundred feet from the Playa Real-Puerto Viejo road, is at an altitude of 150 feet. About 1,000 tons of residual ore is said to have been shipped from here in 1917-18. The ore came from shallow cuts, now overgrown with trees and shrubs, and from an adit 50 feet long. The adit explores a manganese oxide-jasper layer 2 to 4 feet thick, which replaces shale and chert along the bedding and dips gently southeast. A sample of this ore was found to contain 34.23 percent of manganese, 7.06 percent of iron, and 30.91 percent of insoluble material, consisting largely of silica (SiO_2) and alumina (Al_2O_3).

La Seba

La Seba, about a quarter of a mile southwest of El Encanto, is at an altitude of 100 feet. This property is said to have shipped 70 tons of ore in 1918. The workings consist of several shallow cuts, which explore a jasper zone parallel to bedding in chert and shale. The rocks strike N. 10° W. and are vertical. The material exposed in the trenches is of low grade, but about 10 tons of ore estimated to contain about 45 percent of manganese is piled near the workings. This deposit appears to be worked out, but prospecting of nearby slopes for residual ore may be warranted.

El Zapotalillo

El Zapotalillo is a quarter of a mile west of El Encanto, on a narrow ridge a few hundred feet from the Pacific Ocean. Manganese oxide showings follow the bedding in shaly chert, which is vertical and strikes N. 45° W., for a distance of about 400 feet along the ridge. The manganiferous material is in two lenses, one 75 feet and the other 100 feet long and each about 3 to 5 feet wide. The lenses consist of chert cut by discontinuous manganese-oxide veinlets that are commonly less than an inch wide. Thin crusts of manganese oxide cover the outcrops in a few places. There may be some residual ore on the northeast-facing slope below the outcrop, but the available tonnage is probably small.

Other prospects near Playa Real and Puerto Viejo

Mina de Barrante and Mina Cerro Zapote, just southwest of Puerto Viejo, both show a little siliceous manganese ore, but neither showing appears to have promise.

If mining becomes active in this district again, other ore bodies may be discovered. It is unlikely, however, that any of them will prove to be even as large as that of the Playa Real mine, for bedrock exposures are fairly good on the slopes and the region has been thoroughly prospected.

Playa Blanca

The Playa Blanca property is on the Pacific coast, 3 miles northeast of Puerto Viejo. The workings (fig. 22) are in chert and shale on a low ridge trending N. 60° W., parallel to the strike of the rocks. No ore has been shipped, but piled on the dumps is about 100 tons of sorted ore, a sample of which assayed 32.91 percent of manganese, 4.43 percent of iron, and 30.33 percent of insoluble material. The ore body, mined in the course of exploration by E. W. Creevy in 1939, has been traced for 80 feet along the strike. It is as much as 30 inches thick and consists of psilomelane and pyrolusite. For the most part it is siliceous and, as mined, probably does not contain more than 25 percent of manganese. About 100 or 200 tons of this material may be available in the workings.

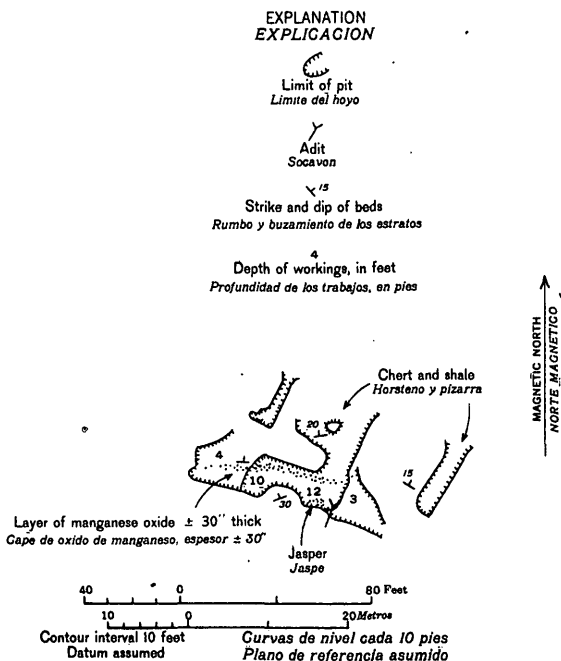


Figure 22.—Sketch map of Playa Blanca workings.

El Sesteco

The Sesteco workings are on the Puerto Viejo-Santa Rosa road, about a mile northwest of Matapalo. About 1,000 tons of ore was shipped from here in 1918 by the Manganese Mining & Manufacturing Co. Chert, shale, and jasper crop out east and west of the workings, but, though they contain small veinlets of manganese oxide, no ore bodies have been found in these rocks. Residual manganese ore, however, is revealed in shallow cuts and pits, distributed over an area of 200 by 100 feet, to a depth of 2 to 4 feet (see fig. 23). It is estimated that the soil in this area contains 5 to 10 percent by weight of manganese-oxide nodules. Possibly 500 tons of good ore could be obtained here by washing and sorting, and further exploration might disclose residual ore in other areas nearby.

El Mico

The Mico workings, on a low hill half a mile southwest of El Sesteo, show a little siliceous manganese ore in chert and shale striking N. 40° E. Several shallow pits and a short adit explore the showings, which do not appear promising.

Los Limones

The Los Limones property, $1\frac{1}{2}$ miles south of Huacas, was explored by E. W. Creevy in 1938. Except for a few tons of ore taken as a sample, no shipments have been made. The workings

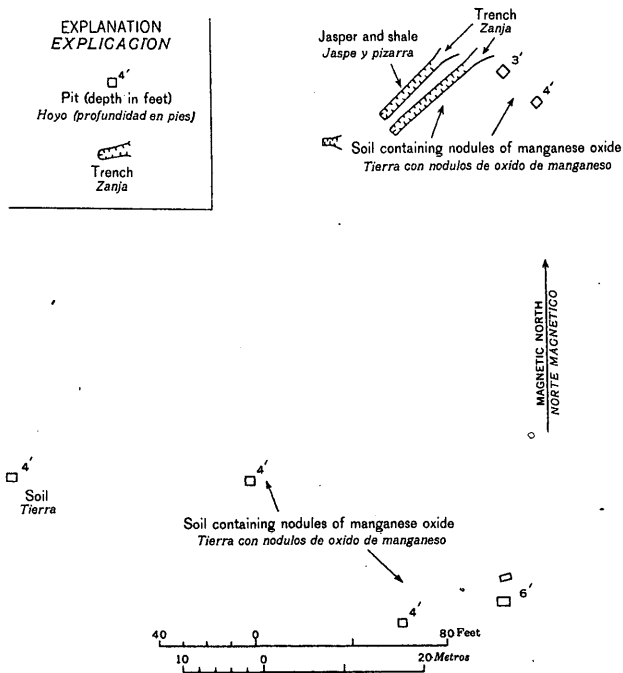


Figure 23.—Sketch map of El Sesteo workings.

explore a manganiferous zone near the top of a narrow ridge in chert and shale striking N. 10° W. and dipping steeply east. The manganiferous zone is as much as 20 feet wide and can be traced by float for about 200 feet. In shallow cuts, manganese oxides are seen to be sparsely distributed in this zone. Pockets of fair-grade ore 1 to 3 feet wide are exposed in places, but they are only a few feet long. A 27-foot shaft which was put down near the top of the ridge connects with an adit driven from the slope below. The dump from the adit shows no ore. The portal, now partly caved, is in altered diorite.

A few tons of high-grade ore and possibly 100 tons or more of low-grade ore may be available at Los Limones. If exploration is undertaken the slopes should be prospected for residual ore.

El Licor

El Licor, 500 feet north of the village of Santa Rosa, was explored by E. W. Creevy in 1938. It is now owned by the Rothe Co. of San José. No ore has been shipped, but 100 tons mined in the course of exploration is piled just west of the workings. Analysis of a sample of this ore showed 34.23 percent of manganese, 1.13 percent of iron, and 32.32 percent of insoluble

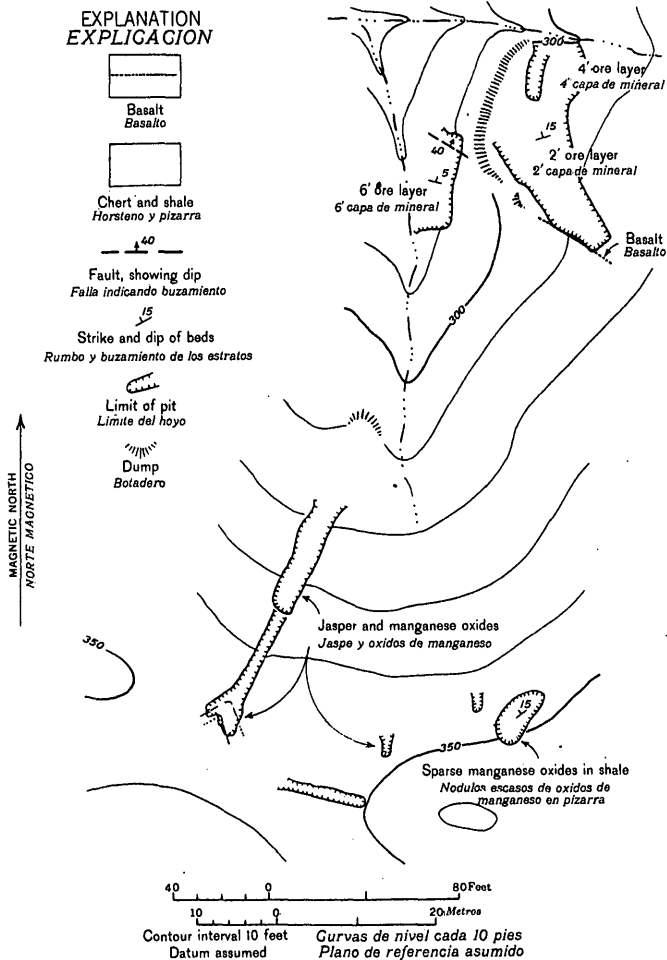


Figure 24.—Sketch map of El Licor mine workings.

matter. Two ore bodies have been mined in the open pits shown in figure 24. One was 80 feet long, 20 feet wide, and 2 to 4 feet thick; the other was 40 feet long, 15 feet wide, and in places as much as 6 feet thick. The ore consists of manganese oxides, probably derived from silicates, which replaced a chert lens along the bedding. The ore is in fault contact with diorite or basalt at the north end of the lower pit, and the two ore bodies may be parts of a single body repeated by faulting.

Workings near the divide to the south show small pods and veins of jasper and manganese oxides in shale and igneous rock.

Most of the ore mined was obtained from the north workings; the material becomes siliceous and thinner toward the borders. Possibly a few more tons of fairly good ore could be selected from the pits.

El Curiol

El Curiol (pl. 79) is 2 miles southeast of Santa Rosa on the road to Santa Cruz. The mine was worked by the Manganese Mining & Manufacturing Co. from 1916 to 1920 and produced about 9,000 tons of ore, said to have averaged 50 percent of manganese and 10 percent of silica. The property is now owned by the Guanacaste Manganese Co. of San José.

Two ore bodies have been mined. The main ore body trends west and the other northwest; both dip steeply. Residual ore that covered the surface northwest and south of the main pit ^{3/} accounted for a considerable part of the total tonnage mined.

The ore bodies extend along fault contacts between diorite and cherty shale and converge at the caved shaft. The ore minerals replace the shale and to a less extent the diorite along the faults. The ore is a mixture of braunite and pyrolusite; pyrolusite predominated in the residual ore and in ore mined near the surface, but braunite was more abundant in ore mined from the bottom of the pit. The ore was said to be solid and to have required little sorting.

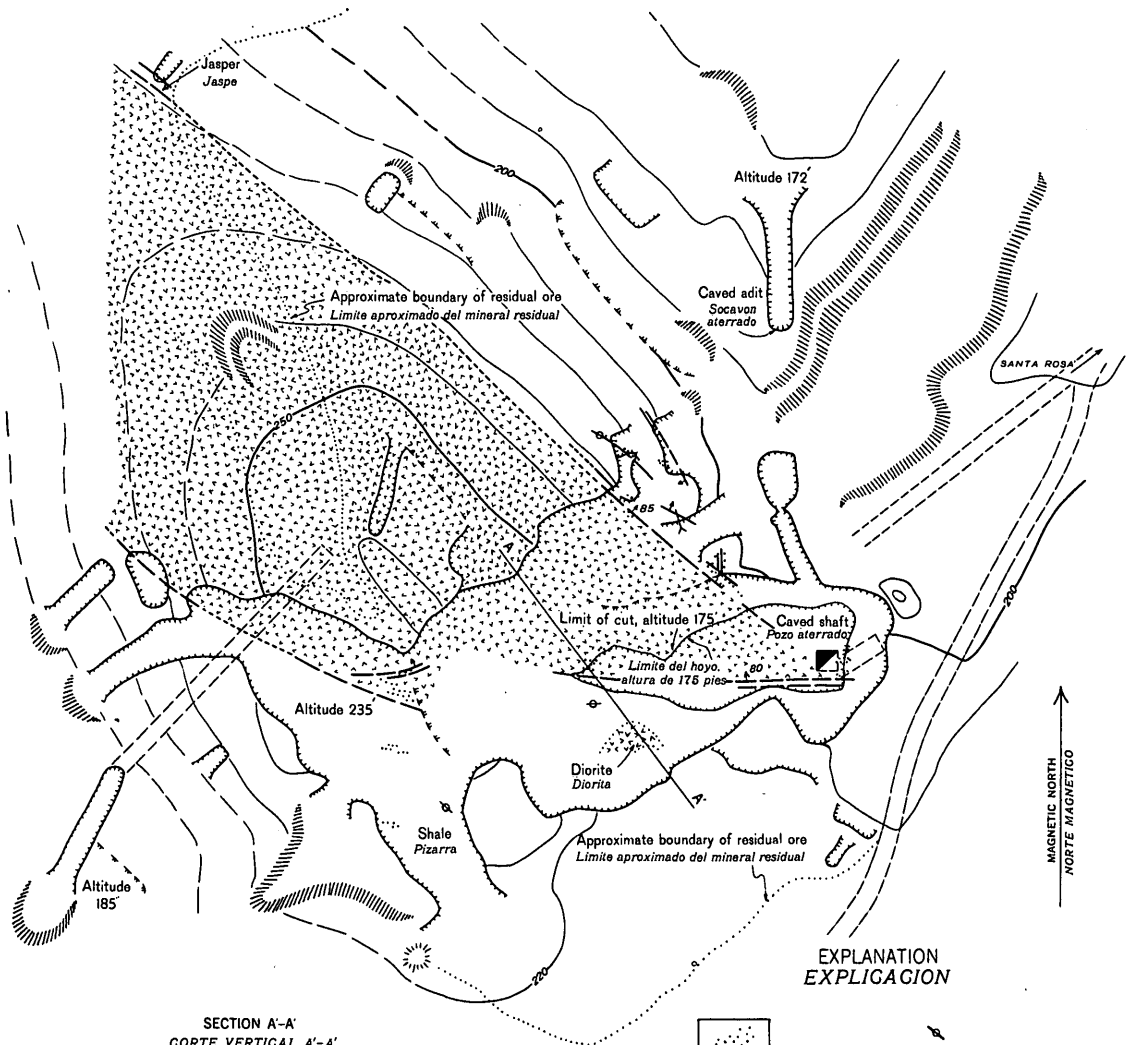
The ore body in the main pit trends east, dips steeply south, and pitches 20° E. It is about 120 feet long and as much as 20 feet wide. The ore is cut off by a shear zone above the 175-foot level in the east face of the pit, but the short drift 10 feet below the level follows ore for a short distance. The ore is reported to widen downward and to be 8 or 10 feet wide in the shaft at a depth of 50 feet below the bottom of the pit, but work ceased before the length of the ore body at this level was determined.

The shallow pits west of the main pit are said to have contained small, discontinuous lenses of ore, but in March 1942 the pits were slumped and no ore was seen in them. An adit driven in beneath these pits at an altitude of 185 feet is entirely in diorite and jasper.

The other of the two principal ore bodies extends northwest from the caved shaft along a nearly vertical fault zone. Pockets of manganese oxides were mined in shallow pits for a distance of about 140 feet from the shaft, but the tonnage was small.

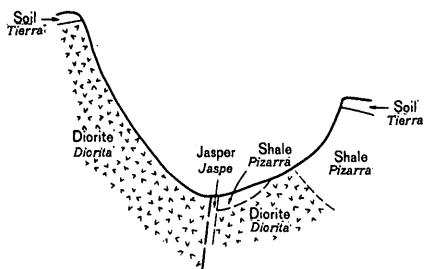
In view of the report that there is an ore body 8 or 10 feet wide below the bottom of the main pit, further exploration appears warranted.

^{3/} Sears, J. D., op. cit., p. 71.



EXPLANATION
EXPLICACION

SECTION A-A'
CORTE VERTICAL A-A'



Manganese ore
Mineral de manganeso

Diorite
Diorita

Chert and shale
Horsteno y pizarra

Fault or fracture, showing dip
Falla o fractura indicado buzamiento

Vertical fault
Falla vertical

Strike and dip of beds
Rumbo y buzamiento de los estratos

Strike of vertical beds
Rumbo de las capas verticales

Adit
Socavon

Limit of pit
Límite del hoyo

Dump
Botadero

40 0 80 Feet
10 0 20 Metros
Contour interval 10 feet
Datum assumed
Curvas de nivel cada 10 pies
Plano de referencia asumido

GEOLOGIC MAP OF EL CURIOL MINE
MAPA GEOLOGICO DE LA MINA EL CURIOL

Loma Blanca

Loma Blanca, about 6 miles southeast of Santa Rosa, is owned by La Compañía Rotheburg of San José. The workings are two shallow cuts in silicified basalt and shale. Small veins and pockets of manganese oxide occur in these rocks, but they are of low grade and locally ferruginous. The few tons of selected ore piled on the dumps does not appear to be worth shipping.

El Guastomate

El Guastomate, owned by Octavio Jimenez and others of San Jose, is about 2 miles northeast of Santa Rosa. Shallow cuts explore a manganese-oxide zone, which follows the bedding of shale and chert striking N. 50° W. and dipping steeply north-east. Two pods, each 30 feet long and as much as 7 feet wide, are exposed; the average manganese content of this material is estimated to be only about 20 percent, but there are small pockets of high-grade ore. Other showings of low-grade and siliceous ore nearby do not appear promising.

El Guacalito

El Guacalito, owned by the Guanacaste Manganese Co., is 4 miles south of Santa Rosa. The ore body crops out on a low ridge trending N. 65° E. and is explored by shallow cuts. The ore consists of manganese-oxide pockets and veins in jasper and shale. The manganiferous zone extends for 200 feet and is as much as 20 feet wide. It is reported that 300 tons of ore was mined from this property in 1917 but was not shipped because of its low grade. About 300 tons of low-grade ore, said to have contained 30 percent of manganese, was shipped to Germany by O. Sauter in 1938. Possibly a few tons of siliceous ore is available in the present workings, but the outlook for future production is not promising.

La Catasolapa

La Catasolapa is 2 miles northwest of Santa Rosa, on the road to Matapalo. The workings, consisting of some cuts and a short adit, explore a manganiferous zone in chert and shale, which strike N. 50° W. and dip 35° SW. The material exposed is of extremely low grade, though a little fair-grade float is found on the surface. This property appears unlikely to become a producer.

Wolf

The Wolf claim is half a mile east of Morro Hermoso, at an altitude of 50 feet, and appears to be the one that was listed by Sears ^{4/} as the Morro Hermoso. La Compañía Rotheburg is the present owner. The workings extend along a low ridge for about 100 feet; they consist of a trench 50 feet long with a 10-foot shaft near the south end, and several small pits. The ore consists of soft wad and hard manganese-oxide nodules in clay

^{4/} Sears, J. D., op. cit., p. 72.

derived from weathered shale, chert, and jasper. The ore zone parallels the bedding, which dips 30° SW. Some ore from this property is said to have been shipped in 1917 from Playa Real. Little ore is exposed in the present workings, but further exploration might reveal small ore bodies, and the slopes nearby might yield a few tons of residual ore.

Carbon

The Carbon claim, on Morro Hermoso, also owned by La Compañía Rotheburg, has showings of low-grade ore a few hundred feet from the Pacific shore. This material is too siliceous to be of commercial importance.

El Jocote

El Jocote, owned by Adan Rodriguez of San José, is a mile east of Point Carbon. Shallow cuts were being dug in March 1942 along a zone of siliceous manganese oxide, which follows the bedding of chert and shale. The zone can be traced by float for 75 feet and is as much as 3 feet wide where exposed in the cuts. It strikes N. 55° E. and is vertical. About 10 tons of manganese-oxide boulders has been piled in the stream below the outcrop, but the material is too low in grade to be shipped. The deposit does not appear to be promising.

Other claims nearby, also owned by Adan Rodriguez—El Congo, La Sopresa, La Conga, and La Quebrada—have showings of low-grade manganese ore. All of it is siliceous, and the tonnage available appears to be too small to warrant further exploration.

Other properties near Santa Rosa

Sears ^{5/} described a number of manganese-oxide showings at the Matapalo, Guayaquil, San Francisco, Hatillo, 27 de Abril, Huacas, and Portegolpe properties. Some assays of the ore are said to have shown high percentages of manganese, but much of the ore is siliceous. About 100 tons of ore was shipped from the Iglesias mine near Huacas, but the other properties have been unproductive. Some of these properties might yield a few tons of high-grade ore from surficial material, and other showings may be discovered in this area.

Arenal district

Near Arenal, La Compañía Rotheburg has denounced several properties. Of these the Cerro Diablo, half a mile southeast of Arenal, La Cuestacita, half a mile southwest of Cerro Diablo, and Canafitola, a prospect 2 miles west of Arenal, show manganese-stained shale. None, however, appear to have promise. At the Carbonal claim, 4 miles east of Arenal, a contact zone between shale and diorite is stained with oxides of copper and iron.

^{5/} Sears, J. D., op. cit., p. 73.

La Desdichada

La Desdichada is 4 miles southwest of Arenal on the Huacas-Arenal road. There are showings of low-grade manganese oxide in red shale, and a little high-grade float has been found. The property does not appear promising.

Río Seco-Lagarto district

Between the Río Seco and Lagarto many properties have been denounced. Only two of them, the Espavelar and La Victoria, have been productive. Some of the others are new discoveries, and the rest were too small or of too low grade to warrant exploitation in the 1914-18 period.

It is unlikely that any of these properties will yield more than a few hundred tons of high-grade ore. For the most part they have not been sufficiently explored to determine their reserves, but it seems unlikely that any of them contain large ore bodies, of either high or low grade. Most of the deposits are difficult of access; they are near roads passable by oxcart, but these roads would have to be improved for heavy hauling. There are, moreover, no shipping facilities, and piers would have to be built or lighters used to load the ore. Lagarto was the shipping point for ore from the Victoria and Espavelar properties between 1914 and 1918, but the piers and loading facilities there have been destroyed.

El Cuchofino

El Cuchofino, 7 miles south of Santa Rosa, near the farm of Gregorio Rodríguez, was explored by E. W. Creevy in 1940. No ore has been shipped, but several sackfuls were taken for laboratory tests, and a few tons is now piled on the dump. An assay of the ore gave 39.11 percent of manganese, 11.07 percent of iron, 18.28 percent of insoluble matter. The workings, which are in jasper and shale, consist of an open cut 40 feet long and 20 feet wide, a pit 10 feet deep, and some shallow trenches. The ore that was mined came largely from the open cut, but only small pockets are now visible in the walls of the cut. In the pit there is a little soft manganese oxide in sheared jasper and shale. The ore zone appears to trend northwest and to dip steeply; it can be traced for 300 feet, but showings in trenches do not appear promising. Further exploration to the northwest might possibly disclose small ore bodies.

Filacho Mula

Filacho Mula, a mile southwest of Cuchofino, is also owned by La Compañía Rotheburg. Shallow pits explore a silicified zone 150 feet long and as much as 25 feet wide in altered igneous rock. Veinlets and small pockets of manganese oxides, chiefly pyrolusite, occur throughout the zone. The zone trends N. 30° W., and the rock is locally sheared. The ore now showing is of good grade, but the tonnage is small and the deposit does not appear to warrant further exploration.

Judas

The Judas property is a mile southwest of Filacho Mula. Three pits explore an outcrop of siliceous jasper in sheared and altered igneous rock. The jasper zone is 10 to 15 feet wide and about 50 feet long; it appears to trend N. 20° E. Small pockets and veins of manganese oxides occur in and adjacent to the jasper, but the deposit does not show much promise.

Pie Paloma

Pie Paloma is at an altitude of 600 feet, half a mile southwest of the Judas and 2 miles from the Pacific Ocean. Two open cuts explore a jasper zone, with thin veinlets of manganese oxides on fracture planes. The zone is 20 to 30 feet wide and about 300 feet long; it trends N. 20° E., following a fault zone in shale, in which the bedding strikes N. 20° W. and dips 35° SW. The material is too low in grade to warrant further exploration.

El Zapote

El Zapote is a mile southwest of Pie Paloma, near the Villa Real-Río Sequito road. A pit 5 feet deep was sunk alongside a jasper zone which crops out for a length of 40 feet and is in places as much as 15 feet wide. The pit shows only low-grade siliceous ore. Manganiferous jasper float is scattered over a wide area surrounding El Zapote, but the relief is low and the outcrops poor, and no ore was seen in place.

El Espavelar

The Espavelar mine, which is 7 miles east of Lagarto, at an altitude of 300 feet, is now owned by the Rothe Co. The workings are at the summits of rolling hills above the Río Espavelar. According to Sears,^{6/} something less than 2,000 tons of ore was shipped from here in 1917-18 via Lagarto; the grade of this ore is not known, but, to judge from material now on the dumps, some of it was of high grade and some was siliceous. In 1917 and 1918, ore was hauled to Lagarto by oxcart over a hilly road, but this road is now in such disrepair that much of it is impassable even for ox carts.

The ore occurs in irregular, shallow pockets in jasper that was formed by replacement of shale along a shale-diorite contact. The mass of jasper appears to be nearly horizontal, and its maximum thickness is only about 30 feet. The ore bodies, for the most part, follow fractures trending northwest and west. The individual ore bodies are said to have contained from a ton or less to 800 tons. The ore consisted largely of pyrolusite, but braunite was found in a few places.

Four areas in a northwest-trending belt 1,500 feet long have been explored. (1) Espavelar No. 1, at the southeast end of the belt, has yielded less than 100 tons of ore; the material showing in the pits is siliceous and of low grade. (2) Espavelar No. 2, about 500 feet northwest of No. 1, is said

^{6/} Sears, J. D., op. cit., p. 72.

to have yielded about 300 tons. Some of the ore was high-grade pyrolusite, but much of it was siliceous. (3) Espavelar No. 3, 1,000 feet west of No. 2, is said to have produced about 500 tons. (4) Espavelar No. 4, 300 feet south of No. 3, is said to have produced 800 tons of ore from an open cut 100 feet long. An adit 50 feet long was driven south into the hill from the open cut, but only jasper and diorite were encountered.

Except for a little ore remaining in the pits and on the dumps, the Espavelar mine appears to be worked out. Further prospecting in the jasper might disclose small ore bodies, but none as large as that on Espavelar No. 3.

Los Bolillos

The Bolillos workings are about 3 miles east of Espavelar by way of a hilly trail. This property may formerly have been called El Pavo or Las Masas. No ore has been shipped from it, but considerable exploration work has been done (see pl. 80). The trenches and shaft on the west side were made by the H. Mann Co. in 1918, and the open cuts on the east side by E. W. Creevy in 1940. These workings explore irregular jasper zones containing pockets and veinlets of manganese oxide. The jasper zones trend north and east and replace basalt. Exploration thus far has disclosed only small ore bodies. One of these, in the cut 200 feet east of Pozo Azul, was 45 feet long and as much as 8 feet wide in places, but it extended only a few feet below the surface. The ore bodies explored to the northeast of this cut were also shallow. The Pozo Azul, Pozo Norte, and other nearby workings are also in jasper, but the pockets and veins of manganese oxide exposed in them are small. Although nearly all of the easily available manganese oxide has been mined from the present workings, a small tonnage might possibly be found by further exploration.

It is estimated that about 75 tons of ore is piled on the dumps. An analysis of a sample of this ore showed 28.03 percent of manganese, 12.45 percent of iron, and 27.10 percent of insoluble matter. A few tons of ore could be selected for shipment, but since there is no road it would have to be transported to Lagarto on pack animals. The present showings do not appear to warrant construction of an oxcart road.

El Cacao

El Cacao (fig. 25) is 4 miles east of Lagarto and 2 miles west of Espavelar. Although considerable trenching was done on the property in 1917, it is said that all the ore found was of such low grade that none of it was shipped. The workings are in jasper, which replaces red shale along bedding planes. In the largest pit, near the center of the area mapped, the bedding strikes N. 80° W. and dips 30° NE. Altered basalt underlies the red shale in the pit. The jasper contains partly oxidized braunite and bementite a few feet below the surface. The ore-bearing layer is as much as 4 feet thick in places but it appears to thin out northeast and southwest of the trench. In the other cuts there are veinlets and pockets of sparsely distributed manganese oxides. The reserves in the property appear to be only a few tons of siliceous ore.

La Victoria

The Victoria mine is 2 miles southeast of Lagarto. Sears 7/ reports that 200 tons of ore was shipped from it in 1918. The workings are shallow cuts in jasper and shale on a small knoll, and the ore consists of small veinlets and pods of manganese oxides in the jasper. A few tons of siliceous ore is piled on the dumps, but further exploration does not appear warranted.

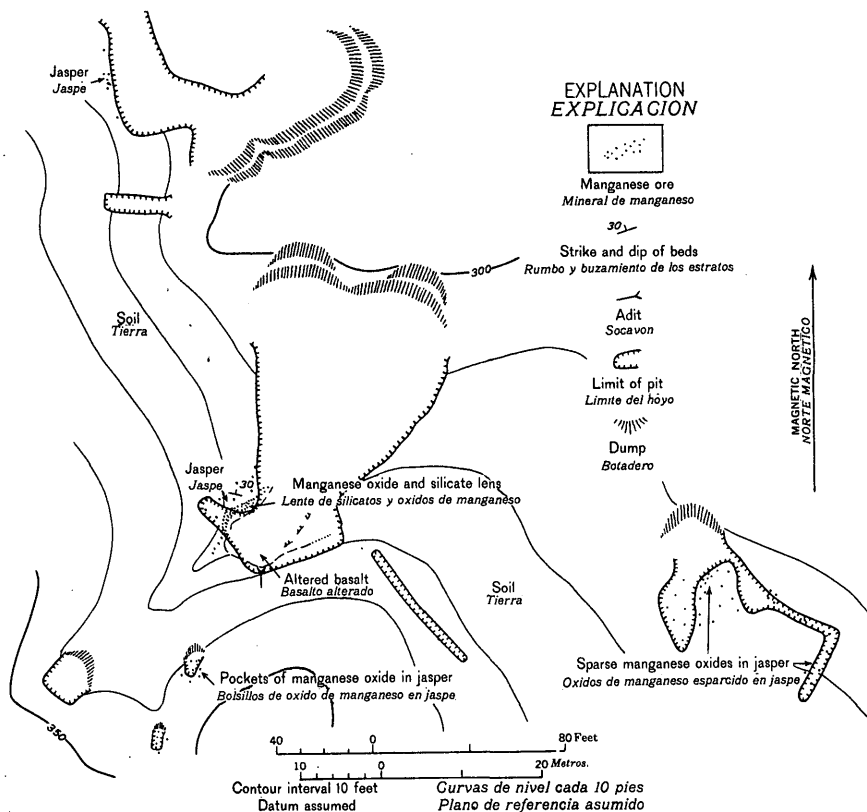


Figure 25.—Sketch map of El Cacao workings.

Río Piedra Amarilla-Río Guajiniquil district

Deposits grouped near the headwaters of Río Piedra Amarilla and Río Guajiniquil have been known for many years, but because of their remoteness they have not been explored. They can now be reached by trail from San Juanillo or Los Bolillos. As the country is hilly and much of it is covered with dense tropical vegetation (the rainfall here is heavier than in other parts of the Nicoya Peninsula), road construction and maintenance would be difficult and expensive.

7/ Sears, J. D., op. cit., p. 72.

There are no loading facilities near the mouth of Río Guajiniquil, and, as along the coast to the north, the water is shallow, so that lighters or long piers would be required for loading ocean vessels.

The manganese oxides are in jasper, which appears to replace igneous rock along steeply dipping fault zones. Although few individual bodies of jasper are more than a few hundred feet long, the fault zones can be traced for several miles. Only a few of the deposits have been explored. The ore bodies thus far discovered are small and irregular or of low grade, but further exploration might possibly disclose ore bodies of minable size.

El Pital

The Pital zone (fig. 26) is 6 miles from the Pacific Ocean, on the Río Pital, a tributary of the Río Piedra Amarilla. The workings made by E. W. Creevy in 1938 consist of shallow trenches, which explore a north-trending zone of manganoiferous jasper, about 100 feet wide and 350 feet long, in igneous rock. The contacts between jasper and igneous rock are commonly sheared, but the jasper appears to have been formed by replacement of basalt along steeply dipping or vertical fault zones. No primary minerals were seen, but the manganese oxides were presumably derived from silicates.

The ore bodies exposed in the trenches are small and irregular; they commonly cannot be traced from one trench to the next. The manganese oxide mostly occurs in pockets and small veinlets, but it is also disseminated throughout the jasper. Some outcrops of the jasper are thinly coated with nearly pure pyrolusite, giving an exaggerated idea of the tonnage available. One body of ore is 40 feet long and 20 feet or more in width, but apparently too siliceous to be shipped. Locally the ore contains considerable iron oxide. An assay of a grab sample gave 11.15 percent manganese, 16.94 percent iron, and 50.31 percent insoluble matter.

At El Perro, 350 feet east of El Pital, manganese oxides form a thin crust on jasper. The showing is not promising. E. W. Creevy is said to have core-drilled El Pital and El Perro, but with what result is not known. Careful mining and sorting might produce a few tons of shipping ore from El Pital and El Perro together, but there appears to be no hope of finding large high-grade ore bodies. Further exploration, however, might disclose small bodies of primary or oxidized ore of shipping grade.

Los Saltos

The Saltos workings (fig. 27), a mile north of Pital, explore a northwest-trending jasper zone 800 feet long. Several shallow pits have been dug along the zone, and they reveal small pockets and veins of manganese-oxide ore, part of it ferruginous. Not enough work has been done to determine whether the ore is continuous from one pit to another, but the outlook is not promising. Assay of a picked sample of the ore gave 34.23 percent manganese, 9.94 percent iron, and 28.02 percent insoluble matter.

Piedra Amarilla

The Piedra Amarilla zone is a mile southwest of the Pital zone. It has not been explored, but a layer of jasper trending northeast is exposed in a stream bed. The jasper locally

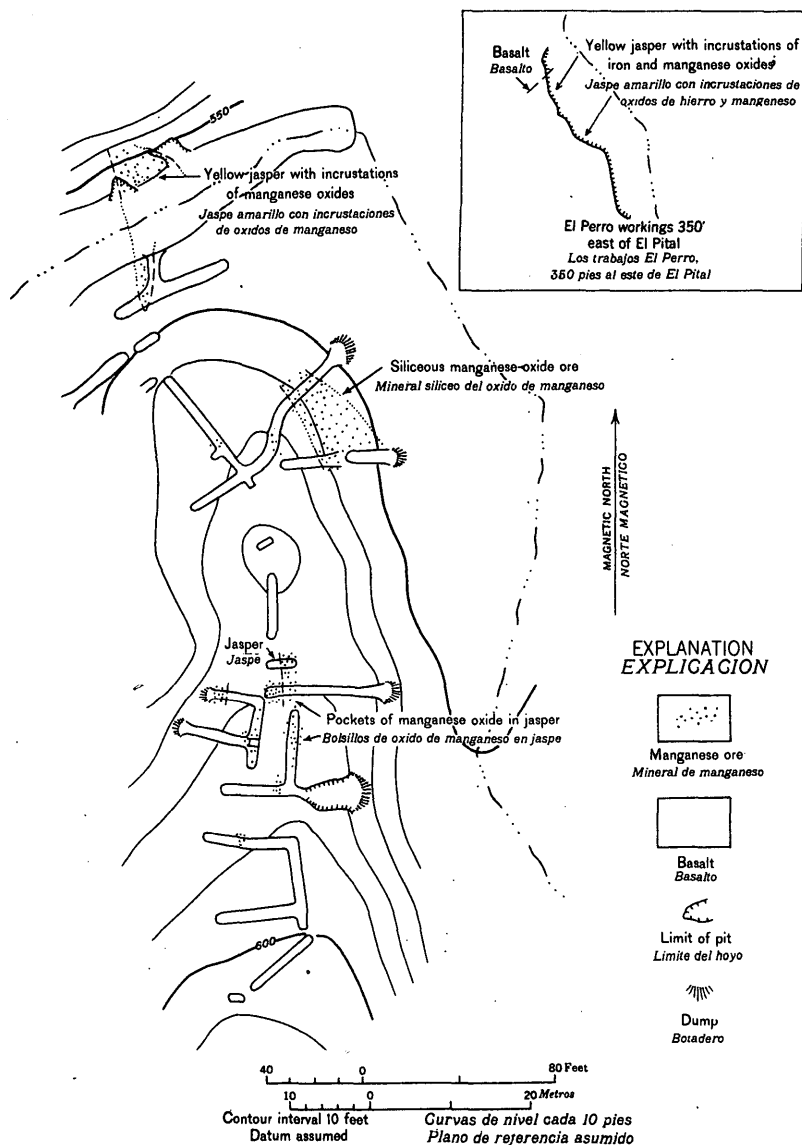
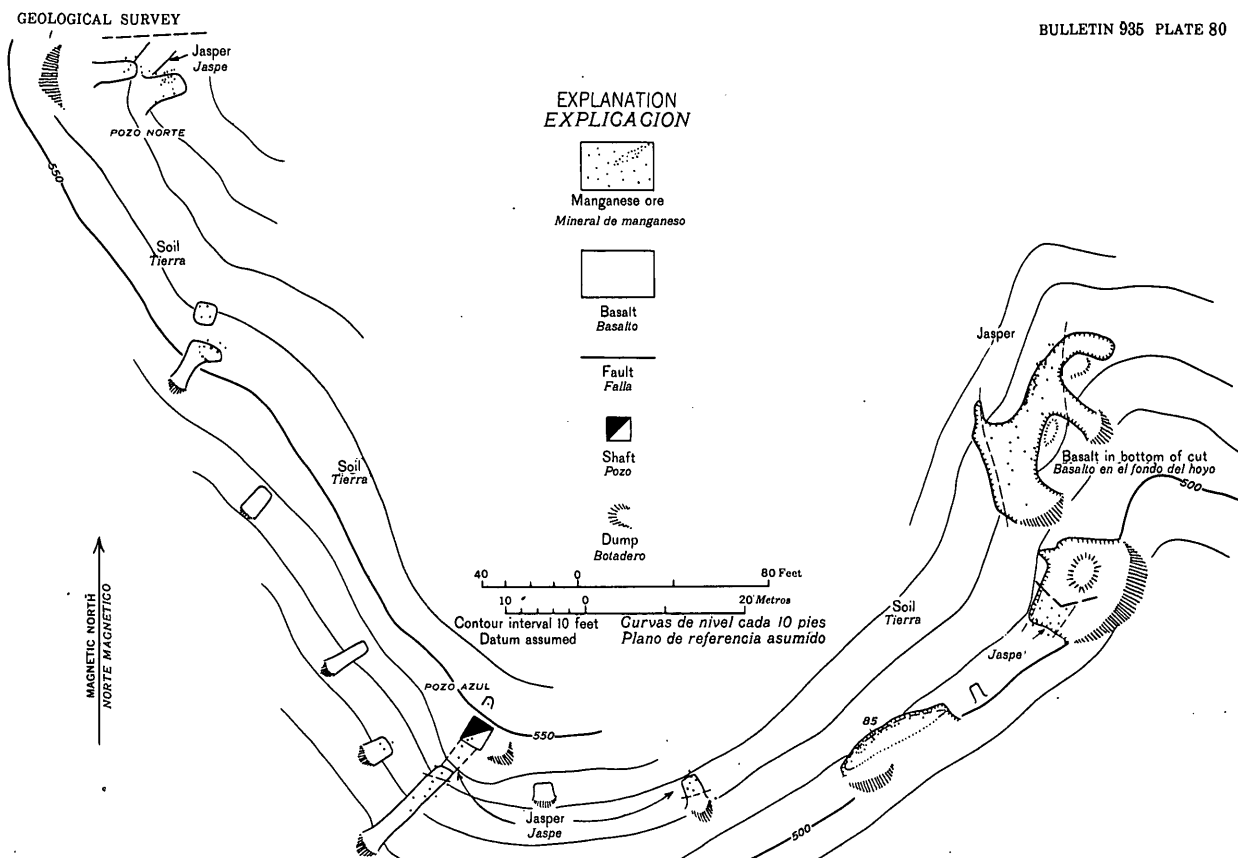


Figure 26.—Sketch map of El Pital workings.

contains considerable hematite. A streak of low-grade manganese oxide extends for at least 20 feet along the stream channel, but exploratory work would be needed to determine its full extent.



SKETCH MAP OF LOS BOLILLOS WORKINGS
CROQUIS DE LOS TRABAJOS LOS BOLILLOS

Los Munecos zone

The Munecos, Sahinos, and Foco showings, about a mile east of El Pital and at an altitude of 900 feet, are in a jasper zone trending N. 60° W. The zone is from 30 to 80 feet wide

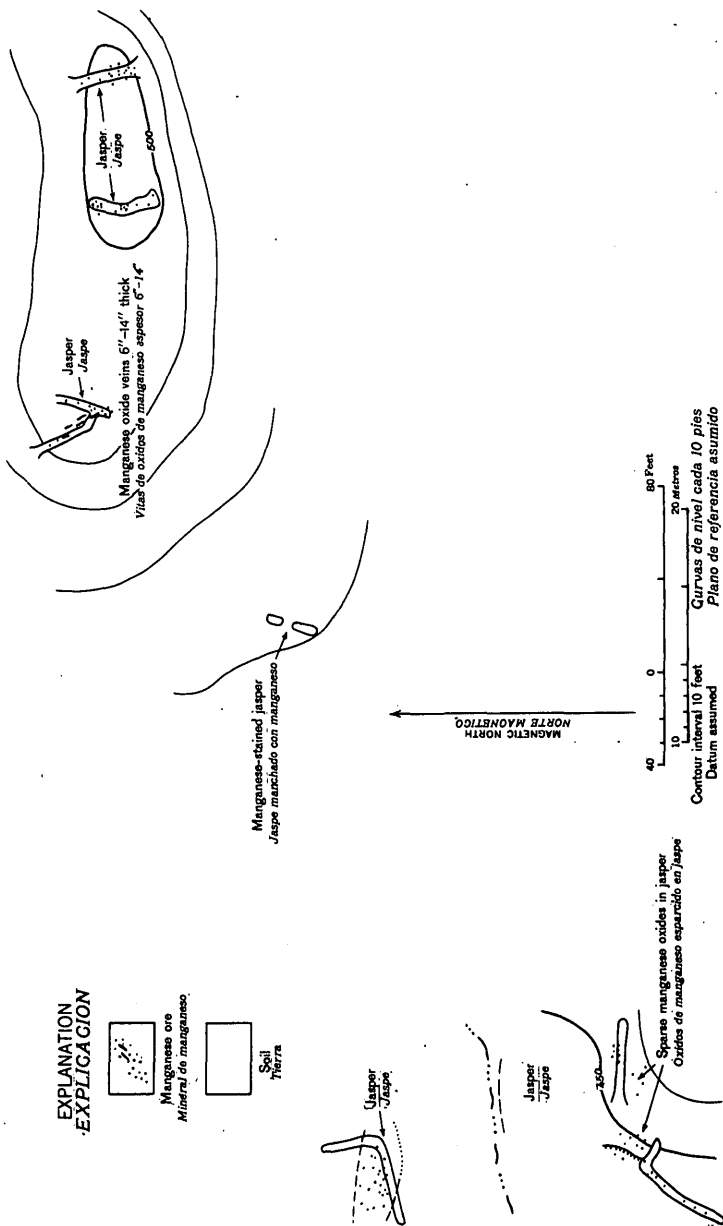


Figure 27.—Sketch map of Los Salto workings.

and is traceable for several hundred feet. Shallow pits in the jasper show small pockets and veins containing manganese oxides, but the material is too low in grade to be promising.

El Carrizal

El Carrizal is a quarter of a mile east of El Foco, at an altitude of 950 feet. A shallow cut shows manganese oxide sparsely distributed in jasper.

Los Chanchos

The Chanchos workings are 3 miles from the Pacific Ocean, on the ridge between Río Los Chanchos and Río Guajiniquil. It is reported that 50 tons of ore was shipped from here in 1937 but that the grade was low.

The ore was mined from two pits along a jasper zone trending northwest; one pit is 100 feet long, 10 to 20 feet wide, and 4 to 7 feet deep; the other, 175 feet to the southeast, is 20 feet long, 15 feet wide, and 15 feet deep. The ore minerals are pyrolusite, braunite, and wad. At least a hundred tons of siliceous ore remains in the pits, and possibly other ore bodies may be found along the strike of the zone. A grab sample taken in the pits and from the dumps assayed 31.60 percent manganese, 13.10 percent iron, and 30.46 percent insoluble material.

Other properties in the Río Piedra Amarilla-
Río Guajiniquil district

Just north of the mouth of the Río Guajiniquil, a red and yellow jasper zone about 20 feet wide crops out on the beach. The jasper strikes northwest and dips steeply southwest; along the strike it grades into unaltered shale bounded on either side by basalt. Locally the jasper contains manganese oxides, but except for a lens of psilomelane 3 feet long and in places a foot wide the material is of low grade. The showing has no commercial importance.

Manganese deposits are also said to occur near San Juanillo and Nosara, but they were not visited, because no guides familiar with these deposits were available.

Sardinal district

Many denouncements have been made near Sardinal. Two of these, El Frances and La Libertad, were explored by E. W. Creevy in 1939; some of the others were trenched in 1918, and the rest have no workings. These properties are owned by the Rothe Co. No large ore bodies of either high- or low-grade ore have been discovered in the area.

There are no ship-loading facilities on the Pacific beaches west of Sardinal. A road passable by car runs from Sardinal to Coco Bay, and loading facilities could be constructed at the beach if it were desirable.

El Francés

El Francés is $3\frac{1}{2}$ miles west of Sardinal and half a mile south of the Sardinal-Nuevo Colon road. No ore has been shipped, but considerable work has been done (fig. 28) and about 350 tons of ore is piled near the workings. An assay of a grab sample of the dumps gave 31.60 percent manganese, 13.10 percent iron, and 39.75 percent insoluble material. The workings, made by E. W. Creevy in 1938, are shallow open cuts and trenches.

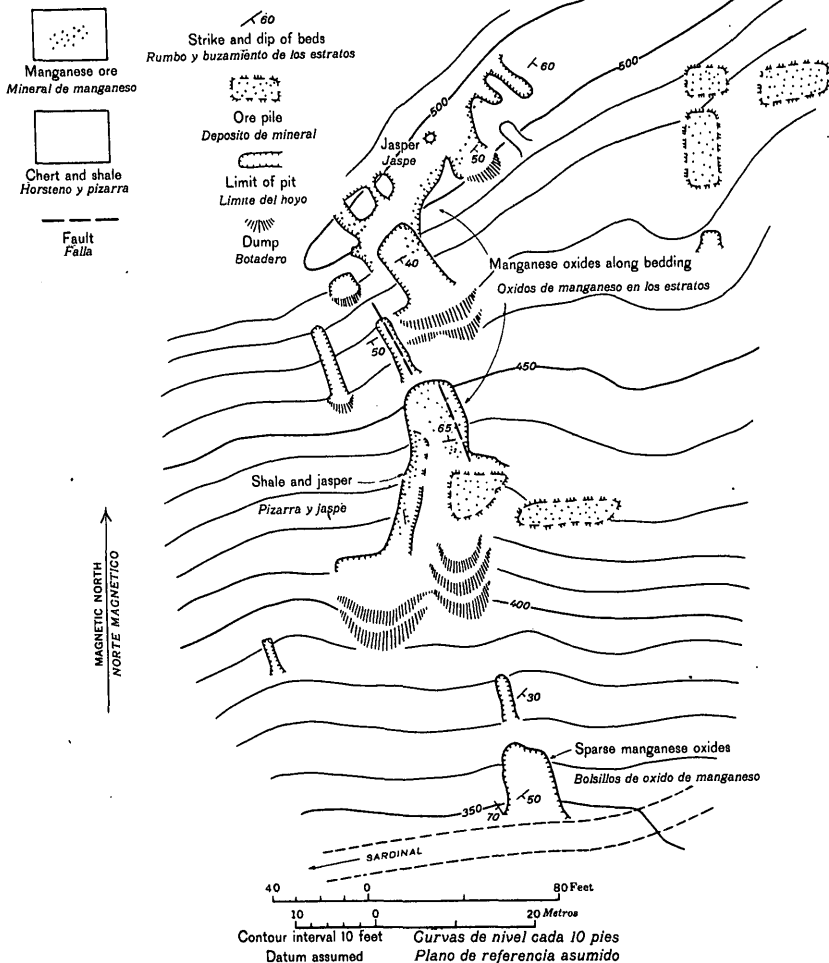
EXPLANATION
EXPLICACION

Figure 28.—Sketch map of El Francés workings.

The ore bodies are lenticular or irregular in shape; the ore minerals are wad, pyrolusite, and psilomelane, which have replaced shale, chert, and jasper. At the top of the ridge a lenticular ore body extending along bedding planes was mined for a length of 80 feet and a maximum width of 20 feet. The cut at an altitude of 430 feet explored an ore body 60 feet

long and 20 feet wide along a fault and bedding planes. The other pits reveal only sparse manganese oxides.

Along the ridge to the northeast and southwest there is shale stained with manganese oxide, but no promising showings have been found there. Although a little ore remains in the pits, it is unlikely that oxide ore will persist much below the present workings.

Samples of El Francés ore were concentrated by R. W. Hunt Co., but because of the intimate admixture of silica it was found necessary to crush to 150 mesh. The recovery ranged from 40 to 60 percent, and a concentrate containing 50 to 55 percent of manganese was made from 30-percent ore.

La Cuestacita

La Cuestacita is about 1,500 feet northeast of El Francés. Two shallow cuts explore manganese oxide-stained shaly chert striking N. 70° W. and standing vertical, and a few boulders nearby are thinly encrusted with manganese oxides. The property does not appear promising.

Other properties near El Francés

Cerro Grande and Nancite, a mile north of El Francés on the other side of the valley, and Chapernal, 3 miles west of Nuevo Colon, were reported to be manganese prospects. When examined, however, they proved to be in pyrite deposits along contacts of diorite and shale, with nothing more than stains of manganese oxide.

El Panamá

The Panamá deposit, on the south side of Culebra Bay, is in altered diorite. Glassy material along fractures in this rock contains a little manganese, but the deposit is too low in grade and too small to be of commercial importance.

Other showings near Culebra Bay

Deposits of manganese ore are reported at Monte de Barco and Playa Hermosa, but only a slight staining of diorite along fractures was seen.

Justo Perez

The Justo Perez (also known as El Boquete del Ramo) is a mile south of Sardinal, near the San Blas road. The deposit consists of two lenticular ore bodies, which lie about 500 feet apart on a line trending N. 10° W. The ore is manganiferous iron oxide, of light to dark brown color; it replaces altered igneous rock and may have been formed by oxidation of pyrite. One of the ore bodies, which is 25 feet long and as much as 10 feet wide in places, is explored by shallow cuts. The other, 35 feet long and as much as 15 feet wide, is explored by a pit 10 feet deep and an open cut. Both ore bodies are considerably sheared along their walls. Analyses of the ore made by E. W.

Creevy are reported to average 1.5 to 4 percent of manganese and 30 percent each of iron and silica. The material has no commercial value.

La Libertad

La Libertad (also known as Cerro Colorado) is $1\frac{1}{2}$ miles south of Sardinal on the San Blas road. In 1939 E. W. Creevy cleaned out the old trenches and extended two of them. A siliceous manganese-oxide zone 3 feet wide striking N. 40° W. and dipping vertically is cut in one trench, and at several places there is rock stained with manganese. The property does not appear promising.

Showings north of Sardinal

At Tabor and at Piedras Pintades, 1 mile and 3 miles, respectively, north of Sardinal, there are showings of manganese-stained sandy shale locally cut by small veinlets of manganese oxide. The material is too low in grade to be of commercial importance.

Showings near Belen

About $1\frac{1}{2}$ miles north of Belen are poorly exposed croppings of iron oxide, locally stained with manganese oxide. The material has no value as an ore of manganese.

Manganese-oxide deposits are also reported about 4 miles north of Belen, near Ojochal, but this locality was not visited.

Nicoya-Pavones district

South and southeast of Nicoya are a number of ferruginous manganese-oxide deposits, from which no ore has been shipped. At Pavones there has been a small production of high-grade ore.

The Nicoya-Pavones area is favorably situated as regards transportation. An all-weather road runs from Nicoya to Puerto Jesús, and freight can be shipped on shallow-draft launches to deep-water anchorage in the Gulf of Nicoya. Ore from Pavones can be shipped from Puerto Thiel, another port on the Gulf.

La Cuesta de Matambú

The property called La Cuesta de Matambú is 2 miles southeast of Nicoya. Several showings of siliceous iron-manganese oxide may be seen near the road, halfway up the slope, at the farm of Vincente Fajardo, and there are others a short distance north of Matambú. The iron-manganese oxide occurs in small lenses replacing shale and chert, which are intercalated with basalt; in places the shale and chert have been converted to jasper. The ore bodies are poorly exposed, but one on the road is 6 inches to 3 feet wide and is exposed for a length of 10 feet; another, also on the road, is a foot wide and 5 feet long. Discontinuous outcrops of iron-manganese oxide may be found in the stream below the Fajardo house and on the slope to

the east, and considerable float occurs on the slopes and in the stream beds.

As the ore bodies appear to be small and of low grade, they are probably not of commercial importance.

Cerro Grande

The Cerro Grande property, a mile and a half south-south-east of Nicoya, is on the road to Dulce Nombre (see fig. 29).

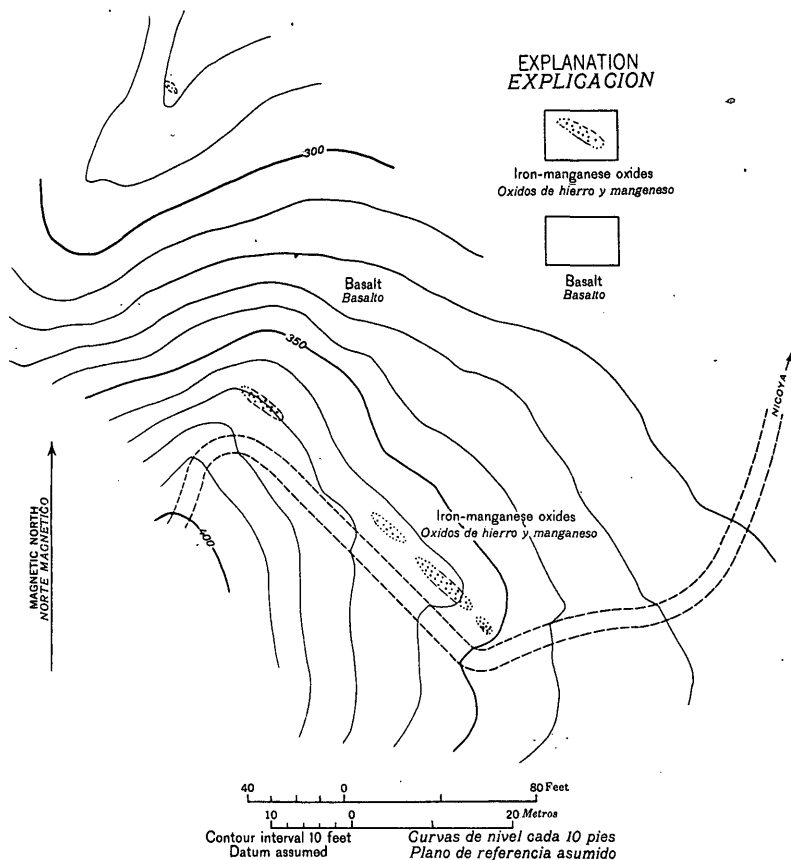


Figure 29.—Sketch map of Cerro Grande.

Four lenses of siliceous iron-manganese oxide striking N. 50° W. are exposed near the road, and a fifth in the stream to the northwest. The oxide, which contains approximately equal percentages of iron and manganese, replaces shale intercalated with pillow basalt. The largest lens is 30 feet long and as much as 6 feet wide. Locally the ore contains veinlets and pockets of pyrolusite. Because of the small size and low grade of the ore bodies, the deposit does not appear to warrant exploration.

Matina

On the slope east of the village of Matina, on the road to Hoja Ancha, iron-manganese oxide crops out at several places. There is one lens 50 feet long and in places as much as 8 feet wide; the other showings are small and discontinuous and do not appear to be of commercial importance.

Manganese deposits are said to occur north of La Mansion, but that locality was not visited. Prospects near Quiriman were visited, but since they are of the same unpromising character as those at Matina, La Cuesta de Matambú, and Cerro Grande they need not be described. None of them appear to warrant exploration.

Pavones

The Pavones mine (also known as Buena Vista) is 2 miles southwest of the village of San Pablo. Sears ^{8/} reports that 80 tons of ore containing 51 percent of manganese was shipped from this property in 1918. In 1939 E. W. Creevy did some exploratory work and piled about 40 tons of high-grade ore on the dumps. The property is now owned by Dario Zuniga of San José.

The workings (fig. 30) explore a manganese-oxide zone trending northeast and are in two groups about 800 feet apart.

The northeast workings consist of three open cuts. The ore in the lowest cut is siliceous and ferruginous; the upper two cuts expose ore bodies that replace jasperized shale along the bedding, which has a strike of N. 70° E. and a dip of 55° NW. The shale lies between altered igneous breccia on the footwall and massive igneous rock on the hanging wall. The ore mineral is pyrolusite, which in places has been brecciated by shearing parallel to the strike of the ore bodies and contains fragments of jasper and igneous rock. In both pits the ore zone is as much as 10 feet thick, but only about a third of it is shipping ore; the remainder is low-grade ore and waste. The similarity of both the ore and the wall rock in the two upper pits suggests that they are part of the same zone, offset a few feet by a fault trending north or northwest, rather than separate ore bodies.

The southwest workings explore three jasper lenses, which are on strike with the northeast workings. The jasper is locally faulted but not strongly sheared. The ore occurs in the jasper, in veins and pockets that are so small as to require careful mining and sorting.

Although the easily available material at this property has been mined, neither the southwest nor northeast ore bodies are worked out; a few hundred tons of high-grade ore may still be obtainable by selective mining and sorting. It is also possible that additional ore bodies may be found along the strike of the ore zone.

^{8/} Sears, J. D., op. cit., p. 82.

La Colonia Carmona

Two deposits, reported to be of manganese ore, near the village of Colonia Carmona, were visited but they proved to be carbonaceous shale.

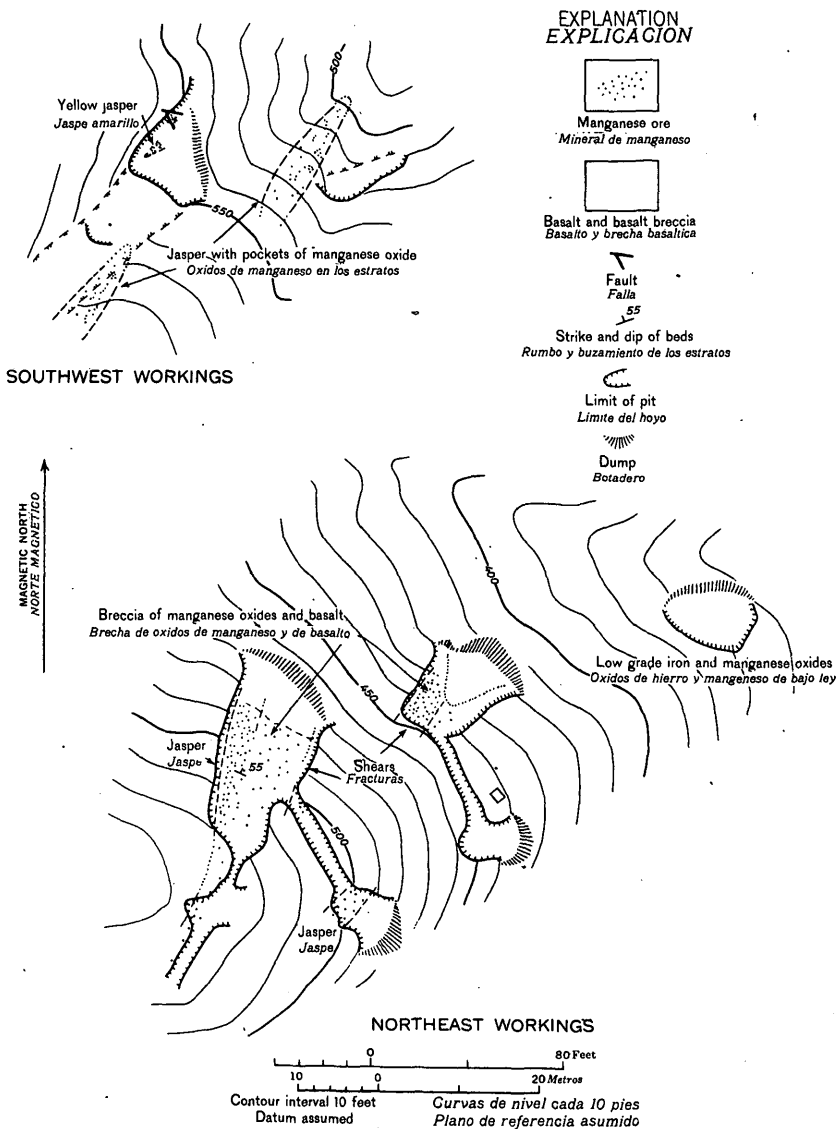


Figure 30.—Sketch maps of Los Pavones workings.

Tambor

Manganese deposits are also said to occur at Tambor Bay. At the one locality that was visited, a little manganese stain was found. The other deposits were not examined, because no guides were available who knew where they were.