DEPOSITS OF MANGANESE ORE IN COSTA RICA.

By Julian D. Sears.

INTRODUCTION.

LOCATION OF DEPOSITS AND EXTENT OF DEVELOPMENT.

The manganese deposits thus far discovered in Costa Rica are all on the Nicoya Peninsula, in the Province of Guanacaste, on the Pacific coast. The location of the mines and prospects described in this report is shown on Plate II. The deposits are widespread, but most of them are either of low grade or of small extent. The only deposits from which ore was being shipped in October, 1918, were the Playa Real, Curiol, and Lagarto; of these, the first two are the only important producers.

FIELD WORK.

The following report is the result of an examination made by the writer in October, 1918, to determine the location, character, and extent of the manganese resources of Costa Rica, and especially their availability during the special needs of the war period. The work was essentially reconnaissance, and owing to the nature of the heavily wooded country, with dense underbrush and few outcrops, no complete understanding of the geologic relations could be gained, except where development work had been done.

The localities visited by the writer were Playa Real (five mines and one prospect), Curiol, Lagarto (three mines and four prospects), La Cuesta de Mâtambu (near Nicoya), La Colonia-Carmona and Pavones (near San Pablo, on the Gulf side), and several prospects near Sardinal, at the head of the peninsula. Information on the other mines and prospects described was procured from Mr. Robert A. Crespi, jr., general superintendent of the Costa Rica Manganese & Mining Co., who placed at the disposal of the writer all the data and maps obtained on a four-months' prospecting trip by William Norris, geologist of the company, together with assays of his samples.

ACKNOWLEDGMENTS.

The writer wishes to express his appreciation to Mr. Crespi, who gave full information concerning all features of the mines under

his charge, including maps, reports, and assays; and to Dr. Noble, manager of the Lagarto mines, for his cordial assistance. Hearty thanks are due to D. F. MacDonald, chief geologist of the Sinclair Central American Oil Corporation, for the loan of instruments and equipment and permission to use the base map herein reproduced.

ACCESSIBILITY.

The only port and chief town on the Pacific coast of Costa Rica is Puntarenas, on the Gulf of Nicoya. It is a port of call for many steamers that run between the Canal Zone and the other countries of Central and North America and is the western terminus of the Ferrocarril al Pacífico, which connects at San Jose with the Northern Railway to Port Limon on the Atlantic side.

Puntarenas forms the chief base of supplies for the gold and manganese mines of Guanacaste, as well as for the general population. From it many launches run on regular schedule to the villages around the Gulf; the line to Puerto Util affords ready access to the manganese deposits at Pavones and La Colonia-Carmona, and the other mines and prospects may be reached overland from the lines at Puerto Jesus, Puerto Humo, and Bolson. The companies operating at Playa Real and Lagarto have large launches that make frequent trips to Puntarenas for mail and supplies.

The dirt roads of Guanacaste, connecting the many villages and farms, afford easy travel in the dry season, but during the periods of heavy rains the mud is very bad, and hauling is difficult and expensive. Most of the hauling is done by ox carts, though at Curiol several motor trucks have been used to advantage in the dry season.

At Playa Real and Lagarto long piers have been constructed, but lighters are necessary, for the shallow water near shore and the high tides make it impossible to bring vessels to the piers. During storms the transfer of ore from lighters to vessels is a difficult process. In the Gulf of Nicoya, near the islands of Bejuco and Venado, good anchorage is found for ocean-going vessels, but any ore from deposits near the head of the gulf would have to be brought to them by lighter.

CLIMATE.

The west coast is characterized by a warm, fairly even temperature throughout the year. The rainfall is distinctly seasonal. December, January, and February are the driest months; from then on the precipitation gradually increases until in September and October there are frequent torrential rains that quickly flood the rivers and convert great stretches of lowland into lakes. During the stormy period travel through the Province comes almost to a standstill.

TOPOGRAPHY.

RELIEF.

The greater part of the Nicoya Peninsula is very hilly. Extending northwest and southeast through the center of the peninsula is a mountainous "backbone," which in the southern part, with its foothills that reach almost to the water's edge, forms a trackless wilderness. Toward the north end this ridge approaches the coast and becomes lower, finally merging with the upland plateau north of Sardinal. Along the head of the gulf on the west side the narrow strip of lowland increases to a belt several miles wide fringed by dense mangrove swamps. Across these swamps run long winding estuaries, dry at low tide but forming deep channels at flood tide. On the Pacific side beaches are narrow and are found only in the bays; most of the coast is marked by high cliffs and headlands, and there are many rocky islands near the shore.

The only towns of importance on the Nicoya Peninsula lie in valleys that drain directly into the gulf or into Tempisque River, which forms a great lowland plain through the center of the Province.

DRAINAGE.

During the heavy rains of the wet season the run-off is very rapid; the hill and mountain streams quickly become swollen, and many of the larger rivers are subject to dangerous floods. In the dry season the rivers shrink to small proportions and most of the smaller streams disappear entirely, so that among the poorer class of natives a supply of drinking water often becomes a serious problem.

GEOLOGY.

SEDIMENTARY ROCKS.

Unaltered sedimentary beds form a very small part of the rocks exposed on the Nicoya Peninsula. They include sandstone, shale, conglomerate, and white and gray limestone, lying in a narrow band around the Gulf of Nicoya and in the hills around the lower Tempisque Valley. On the south end of the peninsula these beds have been twisted into complex folds.

Most of the sedimentary rocks of the region have undergone extensive alteration through pressure and the action of circulating waters. The rocks associated with the ore bodies are predominantly of two types. At many places is found a highly metamorphosed rock, prevailingly deep red but varying to chocolate-brown and other shades, which shows quartz veinlets in intricate patterns. Under the microscope the color is seen to be due to a reddish, opaque mineral, probably hematite. The translucent portion is composed of microcrystalline interlocking quartz grains, larger quartz crystals, and fibrous radiating aggregates of chalcedony. Siliceous waters have replaced the primary rock to so great an extent that its original nature could not be determined. At most of the localities observed this rock forms the footwall of the ore deposits.

Above this red rock lie the remnants of light-colored sediments, which form thin caps for some of the hills. At some places they are well bedded; at others no trace of bedding could be found. Their appearance in hand specimens varies considerably, but in thin sections their character is seen to be fairly uniform. There has evidently been an almost complete replacement by siliceous waters. The rock consists in part of amorphous material, probably siliceous, and in part of numerous roughly circular aggregates of microcrystalline quartz with interlocking grains. Stringers of much larger quartz crystals crossing the section probably represent later vein filling. A small amount of opaque material shows red in reflected light and is probably hematite. The original nature of the rock is so obscured by replacement that it can not be determined with certainty, but the appearance of the rock where bedded suggests a thin-bedded limestone.

At a few localities are found shales and more rarely breccia.

IGNEOUS ROCKS.

In the cliffs of the coast and in many of the hills throughout the peninsula are good exposures of igneous rocks. Many of these are dark, fine grained, and basic, including andesite, diorite, basalt, and similar types. One specimen, taken from the footwall at Curiol, was examined under the microscope; it is considerably altered, consisting principally of augite with a little secondary hornblende. Veinlets filled with quartz and chalcedony are prominent. The rock was probably originally a pyroxenite.

Most of the igneous rocks of this area formed the floor upon which were laid down the sediments described above. However, from former studies made to the northeast, around Ballena, where blocks of white limestone are caught in the neighboring intrusive rocks, and from certain features of the deposits visited, the writer believes that probably there was a considerable intrusion of igneous material in this region, with consequent metamorphism by heat and pressure.

STRUCTURE.

No detailed picture of the structure of the region could be obtained from the reconnaissance visits to isolated prospects. However, it seems clear that upon an irregular surface of older igneous rocks were laid down the several sedimentary beds, the remnants of which to-day cap the hills. These beds now show complicated and intricate folds and many faults of varying size, brought about by the igneous intrusion and by regional pressure. At several places the sediments are turned up steeply against igneous rocks; for example, northeast of Sardinal the beds stand almost vertical against the igneous mass to the west and form a high escarpment looking eastward over the great Tempisque Valley lowlands.

MANGANESE-ORE DEPOSITS.

MINERALS.

The ore bodies are intimate mixtures of various oxides of manganese, which in most specimens can not be distinguished except by chemical analysis. Some of the ore is amorphous and moderately soft, with enough pyrolusite to leave a black "smut" on the fingers; some is very hard and distinctly crystalline. The iron content is generally negligible, though at some places reaching a high percentage. The silica is usually not in chemical combination with the ore but is mechanically mixed and occurs in grains and fine stringers, suggesting deposition from the same circulating waters that so greatly altered the country rock.

The manganese oxides are found mostly in pockets or troughs along the contact between the red metamorphic rocks and the light-colored sediments described above. At Curiol the ore body is in direct contact with the igneous rock. Mr. Norris reports that analyses of some of the sedimentary rock near Playa Real show a small amount of manganese, and this fact has led those in charge of the mines to believe that the mineral was leached out of the overlying rocks by descending waters and concentrated at lower levels.

EXTENT.

Most of the pockets or troughs in which the ore is segregated are small and irregular in shape. Within short distances the ore bodies vary widely in thickness and in quality; in cuts already worked the deposits have been found to pinch out sharply and also to range from an ore rich enough (rarely) to ship as mined to one which even with the most painstaking sorting would only pay the cost of continuation to reach a better grade. At a few places the troughs are of sufficient extent to be classed as sheets; at Playa Real, on the "70-meter hill," the deposit is about 500 feet long and from 10 to 100 feet wide and averages about 5 feet in thickness. At Curiol the ore body is of different shape; it stands almost vertical and has a thickness of about 20 feet and a depth so far as explored of more than 100 feet.

ORE RESERVES.

The irregularity of the troughs, the variations in thickness and quality of the deposits, and the numerous faults make it difficult or impossible to determine the available tonnage of mineral zones in uncovered ground, or even where much cutting has been done. For this reason estimates made by several mining engineers for certain of the properties have been shown by later development to be much too large. At Playa Real and Curiol sufficient development work has been done to block out in a comprehensive manner the ore remaining, but where only surface indications can be found estimates are far from certain. However, from the best evidence that could be gathered the writer feels little hope that large reserves of high-grade ore will be found to exist in most of the localities described. A number of the deposits show moderate quantities of low-grade ore, but on account of the heavy cost of hauling to tidewater, they are at present of little value. The operators have found that ore running less than 40 to 45 per cent of metallic manganese does not pay for mining, even at the high prices current during war times. Moreover, even in the ore of better grade, usually only the most careful sorting and cobbing keep the silica content low enough to make the ore acceptable at the smelters.

ALTITUDE.

The deposits of manganese minerals were observed on hillsides ranging in altitudes from 30 to 40 feet to approximately 1,000 feet above sea level. In places much float has been carried down by the streams; in most of the valleys the soil is too deep for outcrops to occur, and if ore is present in the valleys it could be discovered only by tracing it downward through a series of pits from outcrops on the steep hillsides.

RELATION TO FAULTS.

The disturbance of the region has given rise to many faults, mostly small. These faults do not seem to follow any definite system but cross one another at all angles, showing that movement must have occurred in several directions. In the many cuts at Playa Real the structure is well exposed; here some of the faults cut across the ore bodies and are consequently later than the mineralization. Other faults, however, have a different relation to the ore bodies; one observed on the south side of the "60-meter hill" may be taken as an example. (See fig. 2.) On the west side of the fault is the red metamorphic rock. On the east side is the light-colored sedimentary rock, with some traces of bedding, upturned against the fault; below this, and following the plane of bedding, is the ore body, several feet thick; and below this is more of the red metamorphic rock. The noteworthy feature is the downward extension of the ore along the fault line, inclosing the red metamorphic material in a way that could scarcely have been accomplished by faulting alone.

ORIGIN.

All the indications seem to show that the manganese oxide was not deposited at the time of formation of the inclosing rocks but is epigenetic. Messrs. Crespi and Walsh, at Playa Real, believe that the mineral was leached out from some overlying rock and deposited at the contact between the red and lighter-colored rocks, either because of the impermeability of the red metamorphic rock or because of some condition favorable to precipitation. This conception is based on the observed occurrence of the ore along this plane of contact and on the disseminated manganese found in some of the light-colored sediments. They also believe that the faults were later than the mineralization. Under this hypothesis it is difficult to explain the relations in such a fault as that described above; if the ore body was in place before the fault, the red rock should extend to the line of break below the manganese on the east side. Though the evidence is not sufficient at the present stage of development to be conclusive, the writer believes rather that a possible explanation may be found in hydrothermal action. Hot ascending waters could pass easily upward along faults such as those observed and spread laterally along planes of contact between certain rocks. Such waters may have brought in manganese in solution, as the carbonate or possibly the silicate, and deposited it in the fissures and along the contact plane. The manganese would later be subject to oxidizing agents and would pass over to the present form.

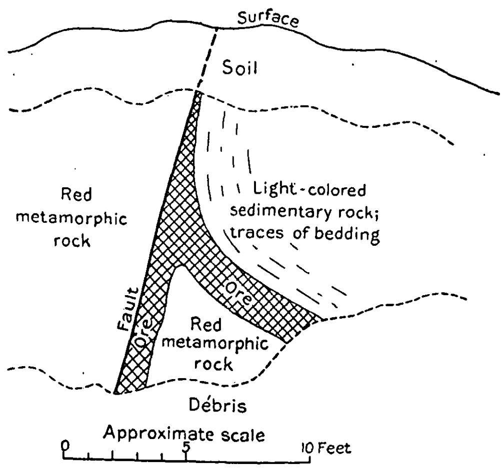


FIGURE 2.—Relation of ore body to faulting at "60-meter hill," Playa Real, Costa Rica.

Although this is an unusual mode of origin for manganese ore, it does not seem impossible. The writer offers this suggestion because of the observed position of the ore bodies, their relation to the faults, and the extensive hydrothermal action that almost surely occurred, as shown by the intense silicification of the country rock.

One evident objection to this hypothesis is that thus far no manganese carbonate or silicate has been discovered in the deposits, but this apparent absence may be due to the incompleteness of the development work. At Playa Real the flat ore body lies so near the surface that all the original material could easily have undergone complete oxidation. If the writer's suggestion proves to be the correct explanation, the vertical deposit at Curiol would represent deposition and replacement in the contact plane between igneous and sedimentary rocks; the base of the oxide ore body has not yet been reached at more than 100 feet below the surface. In this locality further development may show that the ore body passes down below the zone of oxidation into a mass of manganese carbonate or silicate.

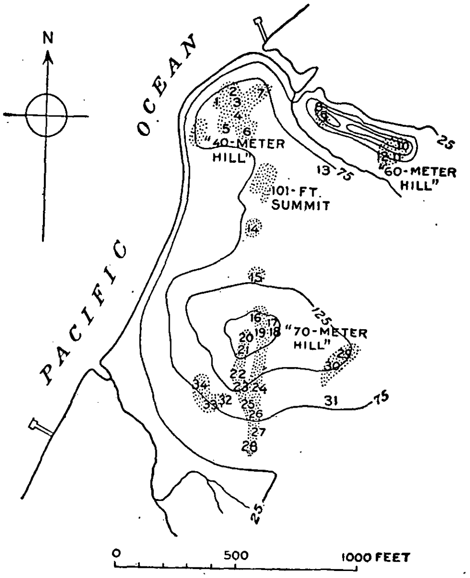


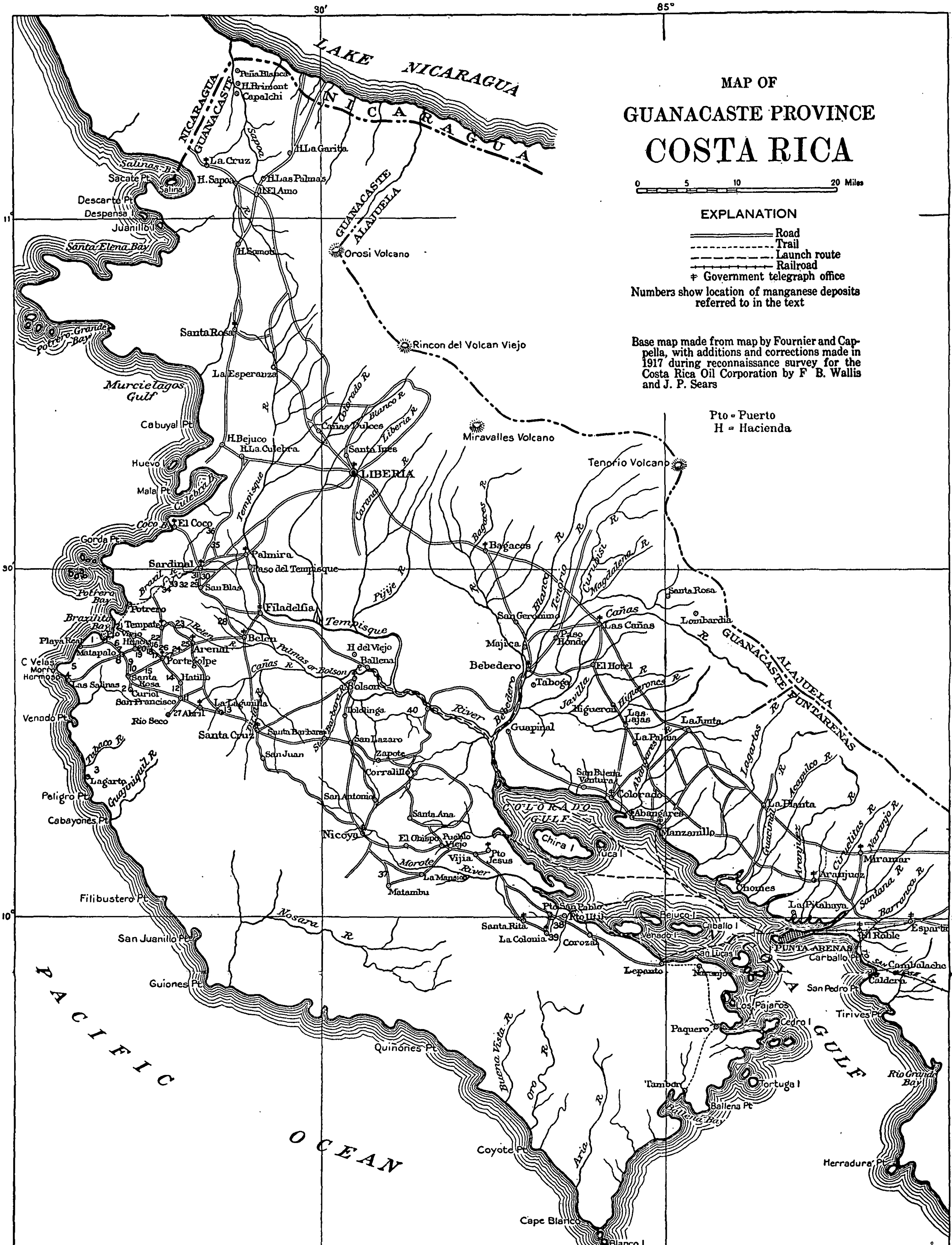
FIGURE 3.—Sketch map showing location of mines at Playa Real, Costa Rica.

MINES AND PROSPECTS.

Playa Real.—The Playa Real mines (1)[1] are the property of the Costa Rica Manganese & Mining Co., now absorbed by the American Manganese Manufacturing Co., of Philadelphia. The deposits are at Playa Real, on the Pacific coast, 2 miles northeast of Morro Hermoso. The property consists of five mines—the "70-meter," "60-meter," and "40-meter" hills, El Encanto, and Esperanza—and one prospect—the Puerto Viejo. The first three mines named are shown on the detailed map (fig. 3); the Esperanza is half a mile southwest of "70-meter hill"; the Puerto Viejo overlooks the harbor of that name; and El Encanto is halfway between it and "70-meter hill."

The general geology has been described in foregoing paragraphs. The sedimentary capping of the hills is only a few feet thick, and this can be stripped and the ore removed by open cuts. The largest ore body was found on "70-meter hill," where the sediments cap the summit and extend down the south slope, which follows the dip. An elongated ore body, trending roughly north and south, lies between the sedimentary rock and the red metamorphic rock below; at the

[1] Numbers in parentheses refer to corresponding numbers showing location on base map, Plate II.


MAP OF
GUANACASTE PROVINCE
COSTA RICA
0 5 10 20 Miles
EXPLANATION
Road
Trail
Launch route
Railroad
Government telegraph office
Numbers show location of manganese deposits referred to in the text
Base map made from map by Fournier and Cappella, with additions and corrections made in 1917 during reconnaissance survey for the Costa Rica Oil Corporation by F B. Wallis and J. P. Sears
Pto = Puerto
H = Hacienda
LAKE NICARAGUA
NICARAGUA
GUANACASTE
ALAJUELA
PUNTARENAS
PACIFIC OCEAN
NICOYA GULF
COLORADO GULF
LIBERIA
Orosi Volcano
Rincon del Volcan Viejo
Miravalles Volcano
Tenorio Volcano
Santa Elena Bay
Murcielagos Gulf
Potrero Grande Bay
Santa Rosa
La Cruz
Bagaces
Filadelfia
Santa Cruz
Nicoya
Las Cañas
Bebedero
Tempisque
Chira I
PUNTA ARENAS
Cape Blanco
Blanco I
30'
85°
11°
10°

sides the ore was pinched out and the sediments and metamorphic rock come together. This ore body has been almost entirely removed in mining. The other bodies are much smaller and occur in irregular pockets in faulted zones near the surface. The Esperanza has been worked out, and possibly half the ore has been removed from each of the others. The ore consists of oxides of manganese. Assays show that the proportion of manganese to oxygen is too high for a large percentage of pyrolusite. Most of the ore is hard. Iron is low, and phosphorus is practically absent. The silica is mixed mechanically, and the ore is sorted by hand to obtain a shipping product that now averages 50 per cent of manganese and 10 per cent of silica. Assays show that the ore as sorted for shipment from the localities indicated by numbers in figure 3 contained the following amounts of metallic manganese:

1	48.17	10	34.62	19	60.53	28	51.06
2	51.07	11	46.05	20	52.09	29	33.07
3	42.09	12	44.05	21	59.68	30	41.05
4	53.04	13	23.92	22	44.08	31	31.42
5	42.36	14	53.87	23	47.06	32	51.66
6	54.69	15	51.03	24	51.37	33	40.08
7	46.05	16	56.37	25	56.65	34	43.67
8	49.04	17	42.38	26	51.69		
9	36.42	18	46.06	27	38.15		

The early development work was done rather at haphazard, tunnels being driven into the hills below outcrops or float, and as most of these tunnels penetrated only the red metamorphic rocks, the efforts were unfruitful. Later development work has been done along the contact, and though it is impossible to determine beforehand where the ore will pinch out or be cut off by a fault, the miners find this the only practical guide and have obtained fair results.

The buildings and equipment are adequate for full development and include camp houses, commissary, chemical laboratory, machine and blacksmith shops, loading bins and chutes, much 18-inch track with cars, and two long piers with loading aprons. The ore is carried out by lighters to the vessels, which can anchor several hundred yards offshore. The fleet at present consists of the *Diria*, with a capacity of 2,500 tons; *Tempate* and *Guanacaste*, 1,200 tons each; *Ethel*, 1,100 tons; *Chiquimula*, 1,000 tons; *Ysabel*, 200 tons; *Tulia*, 35 tons; seven 40-ton lighters; and two 25-ton lighters.

The output from the beginning of 1915 to October, 1918, was 13,000 long tons. The superintendent estimated that the future output, including the ore derived from working over old dumps, would reach 10,000 tons, and that the maximum output from the present workings, with the labor of sorting necessary, would be 1,000 to 1,500 tons monthly.

The laborers at Playa Real and Curiol combined number about 600.

Curiol.—The Curiol mine (2), also the property of the Costa Rica Manganese & Mining Co., is about 8 miles southeast of Playa Real and is reached by a fairly good though winding cart road.

The geology of the deposit varies somewhat from that seen at Playa Real. The ore body is not a nearly flat sheet but is almost vertical, cutting through the hill and suggesting a vein filling. The rocks on the two sides of the ore body are quite different. In a view from the face of the hill into the cut (see fig. 4) the right side or footwall is seen to be an igneous rock, much weathered at the surface but of fresh appearance where observed below in the tunnels. A specimen of this rock was examined under the microscope and is described on page 64 under the heading "Igneous rocks." The hanging wall is of a different type; although it is of a deeper pink or brownish shade than the light-colored sediments at Playa Real, it is seen under the microscope to be of essentially the same character. Its appearance at depth is practically the same as at the surface.

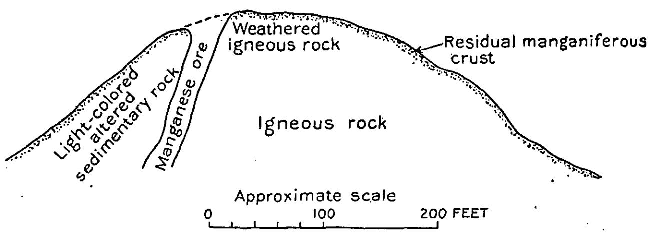


FIGURE 4.—Cross section of hill at Curiol mine, southeast of Playa Real, Costa Rica, showing relation of ore body and wall rock.

As seen by the observer at the entrance to the cut, the surface of the footwall slopes steeply from upper right to lower left, in the middle of the cut; and at the rear it slopes from the top forward. This means that, as viewed, the ore body trends downward, forward, and toward the left. Toward the front of the cut the mass splits and a tongue or wedge of the metamorphic rock appears between the two portions of ore. By open cuts, shafts, and tunnels the ore has been observed for a vertical range of more than 100 feet and an average thickness of 20 feet. Its longest dimension from front to rear is on the crest of the hill, this being shortened below by the forward trend of the rear wall, though at depth the body may continue outward into the valley.

The ore is notably pure from wall to wall, averaging without sorting over 50 per cent of manganese with 10 per cent of silica, and large blocks can be taken out which show only 1 or 2 per cent of silica and over 55 per cent of manganese. The ore is made up of a mixture of the oxides and is fairly hard.

The top and sides of the hill are covered with an almost solid crust of high-grade ore fragments, ranging from some the size of peas to small boulders. This crust will yield much good ore, but cuts show that it is superficial and ceases abruptly within a few feet of the surface.

The deposit has been worked thus far by an open cut, and over 6,000 tons of ore has been removed and shipped. Several shafts and tunnels have now been dug, and further work is to be done by stoping. Owing to the bad condition of the roads in the rainy season, no ore was being shipped from this mine during the writer's visit, but previously ore was hauled by motor truck to Playa Real. Work was under way on a new shipping plant at Puerto Viejo, with a 470-foot pier and a railroad consisting of 2 miles of track, cars, and small

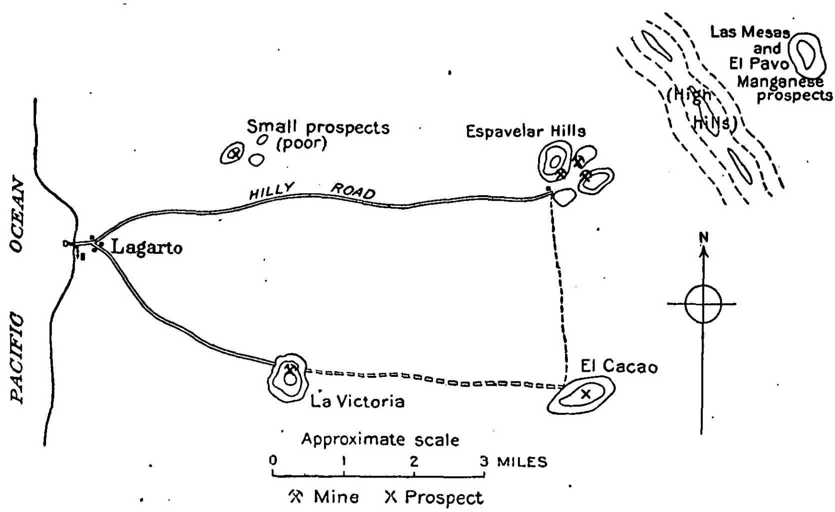


FIGURE 5.—Sketch map showing location of mines and prospects near Lagarto, Costa Rica.

locomotives. This railroad will eliminate the haul over the troublesome hills near the coast, and the hauling to its terminus by the trucks will be easy. After the new plant and railroad are completed, high-grade ore can be shipped at the rate of 2,000 tons a month.

Lagarto.—The several mines and prospects known under the general name of Lagarto (3) are the property of the Compañía Nacional de Manganeso, San Jose, Costa Rica. The shipping port is Lagarto, on the Pacific coast 20 miles south of Morro Hermoso and about 200 miles from Puntarenas. The location of the mines and prospects is shown on the sketch map (fig. 5).

There are three mines, the Espavelar Hills, La Victoria, and El Cacao, and several prospects, of which El Pavo and Las Mesas are the most important.

The general geology of the deposits is the same as that seen at Playa Real. The ore occurs in irregular pockets or troughs on the red metamorphic rocks. Faulting is complicated, and the details of geologic relations are not easy to follow. Failure to recognize the irregularities has led to great overestimates of available tonnage.

Installation at Lagarto was made on a scale comparable to that at Playa Real, in preparation for the large tonnage anticipated, but the operators' hopes have unfortunately not been realized. Numerous houses were constructed at the port, and the equipment includes a large storage bin with chutes, track and cars, and a 550-foot pier.

The mines are in the interior and are reached by poor roads over hilly country; all the ore has been moved by oxcarts.

La Victoria mine has been abandoned because of the low manganese (25 per cent) and high silica content of its ore. El Cacao proved to be of no consequence. The Espavelar Hills mine has proved to be the only real producer; however, the scattered deposits at that locality have now been exhausted, with a total yield of less than 2,000 tons. El Pavo and Las Mesas are said to be good prospects, but the indications are only those afforded by float, no cuts having been made, and the superintendent would not hazard any guess as to their possible tonnage. Owing to the floods in Rio Tabaco and the impassable condition of the mountain roads, the writer was unable to reach these prospects, which lie beyond a very high range of hills east of Espavelar.

Only 200 tons of ore (from La Victoria) have been shipped; the ore from Espavelar is in the bins at the port and is to be bought and shipped by the owners of Playa Real. For the future of Lagarto, the company is depending on the prospects of El Pavo and Las Mesas. Their possible tonnage is problematic, and transportation by oxcart over the 10 miles of hill country to the coast will be tedious and costly.

Playa Honda district.—In the region around Playa Honda (4), just south of Morro Hermoso, the surface indications were good, but prospecting showed that the deposit is only superficial and not valuable.

Morro Hermoso district.—In the vicinity of Giron's farm, near Morro Hermoso (5), a little ore has been extracted. Most of the mineral seen in this vicinity is of very poor quality, but at one place there was a very small patch of good grade.

Playa Real to Matapalo.—Just east of the road between Playa Real and Matapalo (6) there are some small, unimportant showings of manganese oxide in scattered boulders. (See fig. 6.)

Between Playa Real and Matapalo, in the vicinity of Sisteo (7), is a patch of good-quality boulders and residual deposit which is expected to yield about 1,000 tons of ore. This will be shipped from Playa Real.

Matapalo.—In the high ground west of Matapalo (8) much manganiferous material is seen, but most of it is of poor grade. There is a fair quantity of better material, but the deposit is not of sufficient promise to warrant further work. (See fig. 7.)

At two places south of Matapalo (9), east of the old road to Santa Rosa, a little manganese oxide float was observed; this is all of very low grade. (See fig. 8.)

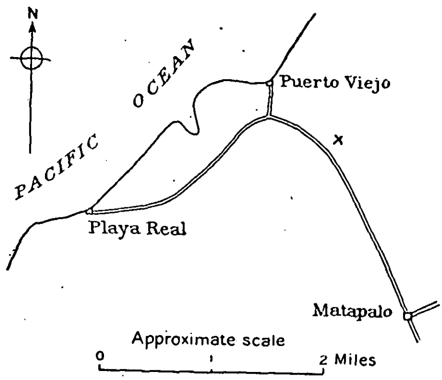


FIGURE 6.—Sketch map showing location of prospect between Playa Real and Matapalo, Costa Rica.

Guayaquil.—Near Guayaquil (10), on the road between Matapalo and Santa Rosa, is a little manganese-bearing material of extremely poor grade, not worthy of consideration.

San Francisco.—Northeast of the road between Santa Rosa and 27 Abril, near San Francisco (11), is a very small prospect of fair-grade boulders of manganese oxide. The quantity is too small to be worthy of development.

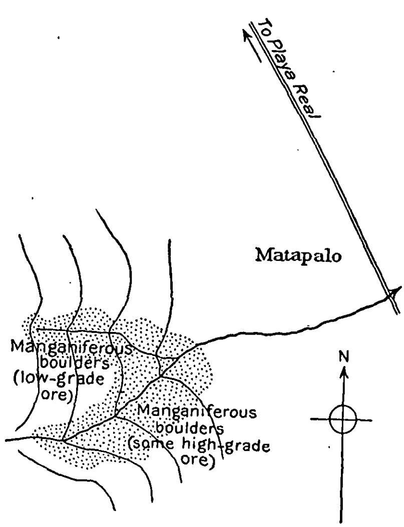


FIGURE 7.—Sketch map showing zone of manganese ore in hill west of Matapalo, Costa Rica.

Hatillo to San Francisco.—In the position indicated in figure 9, on the side of a hill known as Loma Larga (12), between Hatillo and San Francisco, there are residual boulders of ore of very good grade, which assay shows to run 52 per cent of manganese. It is estimated that this locality will yield about 400 tons.

27 Abril to Santa Cruz.—Along the road between 27 Abril and Santa Cruz (13) the showings were largely iron oxide, with very low grade manganese-bearing material. Nothing noteworthy was seen here.

Hatillo to Portegolpe.—A short distance west of the road between Hatillo and Portegolpe (14), in several hills, there are a few small showings, mostly of poor grade. One locality shows some medium-grade manganese ore, but the area has little promise. (See fig. 10.)

Portegolpe to Santa Rosa.—East of the Santa Rosa-Portegolpe road (15) were seen a number of boulders of manganese oxide.

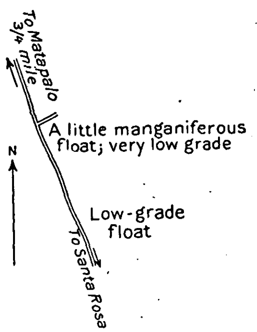


FIGURE 8.—Sketch map showing location of manganiferous float south of Matapalo, Costa Rica.

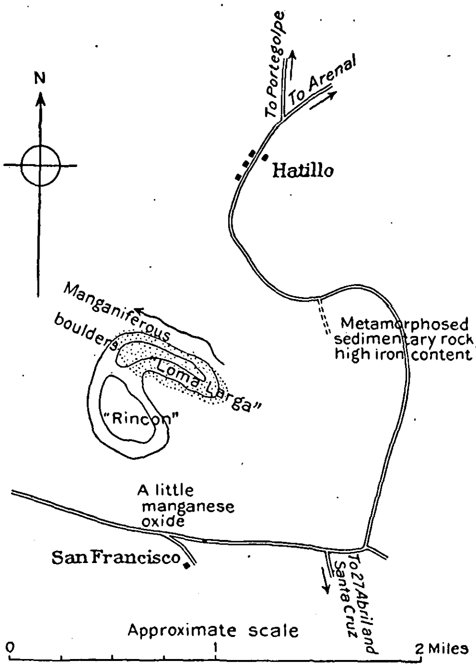


FIGURE 9.—Sketch map showing zone of manganese boulders on Loma Larga, between San Francisco and Hatillo, Costa Rica.

There are no outcrops, and no manganese-bearing material was seen in place. A few of the boulders are of good grade, but most of them are very poor. (See fig. 11.)

Portegolpe to Huacas.—Just north of the road from Portegolpe to Huacas, 1 mile from Portegolpe (16), a manganiferous zone crosses a low hill. A little outcrop and numerous boulders were seen, but the material is too siliceous to have much promise. (See fig. 12.)

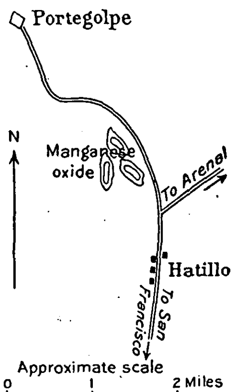


FIGURE 10.—Sketch map showing location of manganese prospect in hills west of road between Hatillo and Portegolpe, Costa Rica.

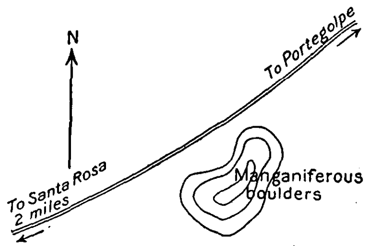


FIGURE 11.—Sketch map showing location of manganese boulders east of road between Santa Rosa and Portegolpe, Costa Rica.

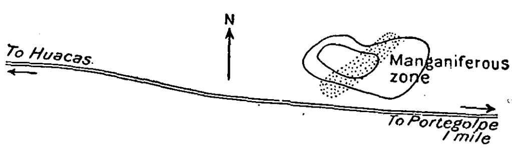


FIGURE 12.—Sketch map showing zone of manganiferous material crossing low hill north of road between Huacas and Portegolpe, Costa Rica.

South of the road from Portegolpe to Huacas, at Marchena (17), are a number of manganese prospects, as shown on figure 13. Prospects numbered 2, 3, 4, and 5 are not promising; No. 1 is good, having yielded samples assaying from 46 to 55 per cent of manganese, but the deposit is small and of little value.

The Panama deposit (18), to the north of Marchena, was promising on top, but it has been prospected and the lower manganiferous material was found to be too siliceous to be commercially valuable. This is one of a number of deposits reported where the surface material is of much higher grade than that at depth.

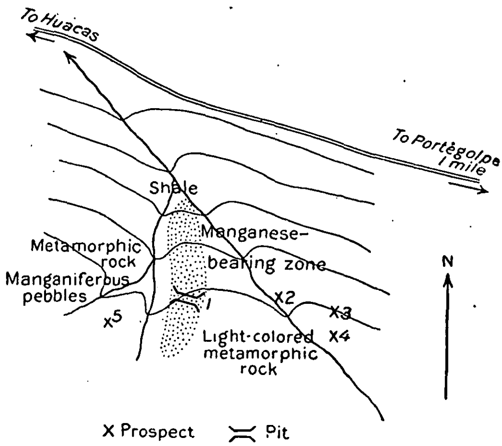


FIGURE 13.—Sketch map showing prospects and manganese-bearing zone south of road from Portegolpe to Huacas, Costa Rica.

From the Iglesias mine (19), south of the village of Huacas, 100 tons of commercial ore has been shipped, and this seems to have exhausted the deposit.

In the vicinity of Huacas (20), manganese-bearing rock has been seen at five localities, as indicated on figure 14. Of these localities, No. 1 shows a small quantity of good-grade ore, averaging 51 per cent

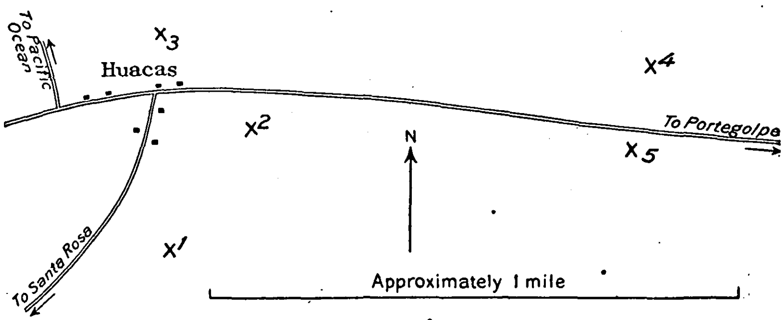


FIGURE 14.—Sketch map showing location of five manganese prospects near Huacas, Costa Rica.

of manganese and 11 per cent of silica; No. 2 shows a large quantity of very low grade material in the old Iglesias workings; at No. 3 is a small quantity of low-grade material, carrying about 11 per cent of manganese; at No. 4 is a fair-sized body of medium to poor grade material, carrying 30 per cent and less of manganese; and the material at No. 5 is all of poor grade.

Brazilito Bay.—The manganese-bearing material seen in the vicinity of Brazilito Bay (21) is of too low grade to have any commercial value.

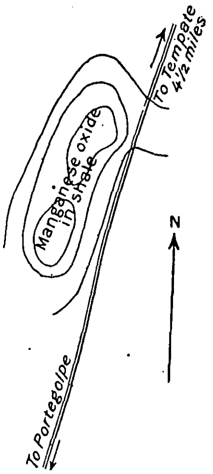


FIGURE 15.—Sketch map of hill showing manganese oxide in shale west of road between Tempate and Portegolpe, Costa Rica.

Piedras Grandes.—The deposit at Piedras Grandes (22), on a hillside west of the road between Tempate and Portegolpe, is manganese oxide in shale. The material is of very poor grade and is not worth development. (See fig. 15.)

Arenal to Tempate.—Just north of the road between Arenal and Tempate (23) a little manganese oxide was observed, but it is so siliceous and of so low a grade as to be valueless. (See fig. 16.)

Granidillos.—At locality 24, indicated on figure 17, there are a few boulders of very high-grade manganese oxide; the other boulders in this vicinity are only fair or poor.

Las Posas.—At Las Posas (25), west of the road between Arenal and Portegolpe, there are several manganese prospects, but the grade of the material is so poor and its iron content so high that it is not worthy of consideration. (See fig. 18.)

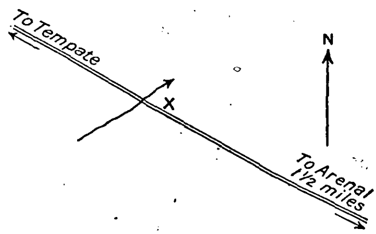


FIGURE 16.—Sketch map showing location of manganese prospect north of road between Arenal and Tempate, Costa Rica.

Vicinity of Portegolpe.—In a hill known as Loma Larga (26), just north of Portegolpe, there is a little manganese oxide of very poor grade.

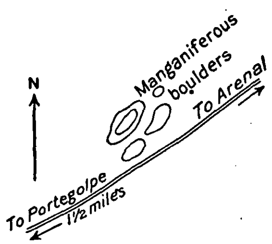


FIGURE 17.—Sketch map showing location of small hills with manganese boulders west of road between Portegolpe and Arenal, Costa Rica.

Most of the manganese-bearing material seen northeast of Portegolpe (27) is of poor grade, but at Portegolpe No. 2 prospect there is some good-grade material. Float is abundant, but the outcrops are very small. No estimate is available as to quantity.

Vicinity of Belen.—West of the road from Belen to San Blas, near Los Planes and Tierra Colorada (28), there is a large showing of very low grade manganese oxide. North of this locality, near Cerro Colorado, is a small deposit of better grade, but the quantity is not sufficient to make it important. (See fig. 19.)

La Libertad.—The property known as La Libertad (29), the claim of L. Rodríguez, is about 2 miles south of Sardinal, west of the road to San Blas. As shown in figure 20, the manganese oxide is exposed up the slope and along the crest of a narrow, elongated hill. The slope shows a fair quantity of boulders, and the mineral is in place in one of the two small cuts on the south slope, as a layer about 2 feet thick, standing on edge. The material is very siliceous and of too low a grade to be of commercial importance.

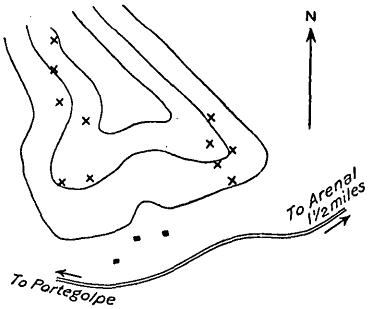


FIGURE 18.—Sketch map showing location of Las Posas manganese prospect west of road between Portegolpe and Arenal, Costa Rica.

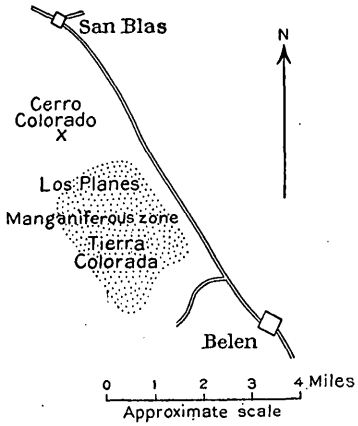


FIGURE 19.—Sketch map showing location of manganese prospects at Los Planes, Tierra Colorada, and Cerro Colorado west of road between Belen and San Blas, Costa Rica.

El Boquete del Ramo.—About a mile south of Sardinal, west of the road to San Blas and near the house of Justo Perri (30), are two prospects for manganese, about 500 feet apart, on the side of an eastward-sloping hill. The locality is known as El Boquete del Ramo. The deposit nearer to the house is shown in a small cut at the base of the hill, on the north bank of a dry gully; this material seems to be in a small pocket, which would furnish very little ore, but the exposure is so poor that little idea of its geologic relations could be obtained. The material at the other prospect is better, but no exposures of ore or rock could be found, either on the slope or in the gullies near by. The slope for a width of 40 or 50 feet and a height of about

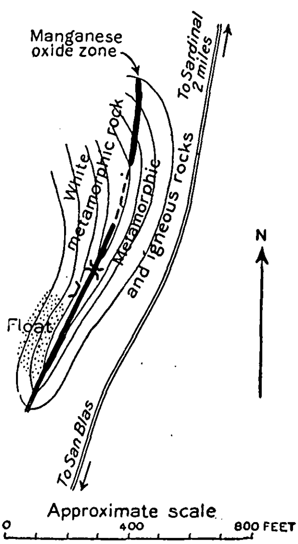


FIGURE 20.—Sketch of manganese-oxide zone and pits at La Libertad, 2 miles south of Sardinal, Costa Rica.

150 feet shows much good float, including some boulders of manganese oxide weighing over half a ton. There are probably several hundred tons of ore in sight in these boulders, but extensive clearing and digging would have to be done to determine whether much more is available from their source. (See fig. 21.)

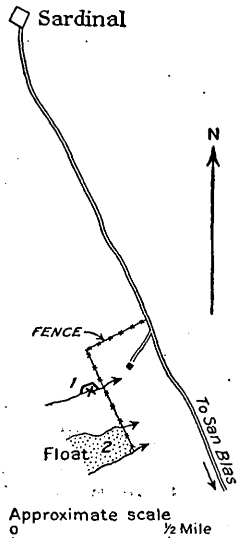


FIGURE 21.—Sketch map showing location of manganese prospects at El Boquete del Ramo, 1 mile south of Sardinal, Costa Rica.

Santísimo.—The Santísimo prospect (31), the claim of Juan Casas, of Sardinal, is about half a mile southwest of Sardinal. It shows only a few scattered boulders of manganese oxide of very poor grade.

Guatemati.—About 4 miles southwest of Sardinal is another claim of L. Rodríguez, known as Guatemati (32). The material exposed here was reported by Mr. Norris as being of extremely poor grade and of no value.

Las Pilas.—About 3½ miles west of Sardinal, south of the road to Potrero, is a claim of L. Rodríguez called Las Pilas (33). In the shale of the hillside were seen stringers of excellent manganese oxide; the quantity, however, is very small, the stringers averaging only a few inches in thickness. Up the slope a little poor float was seen. (See fig. 22.)

El Francés.—About 1,500 feet west of Las Pilas, south of the road to Potrero, is the claim of A. Salazar and F. Castro C., known as El Francés (34). Along the slope of a very steep and narrow "nose" between two gullies are seen numerous fragments of manganese oxide, some of which seem of very good quality but most of which are mixed with rock. On the crest several pits have been dug, exposing the ore in place. The manganese is in pockets in a much weathered rock, which resembles the red metamorphic material at Playa Real. The lower part of the slope shows a gray igneous rock. Probably 40 to 50 tons is exposed at the surface, and there is some promise for more or in depth, but little chance for a deposit of commercial value. (See fig. 23.)

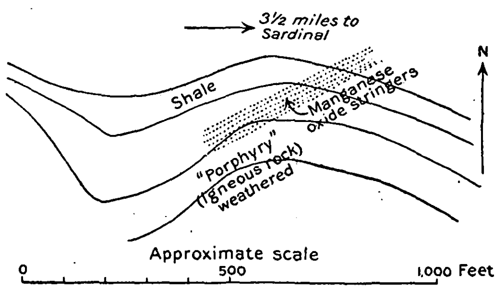


FIGURE 22.—Sketch map of zone of manganiferous material at Las Pilas, 3½ miles west of Sardinal, Costa Rica.

Tulé.—The Tulé prospect (35) is about 2 miles north of Sardinal, east of the road toward Culebra. It was reported by Mr. Norris but could not be found by the writer in four hours spent searching the area. It is described as a "vein of low-grade manganese crossing a small hill; on each side slope is some float of varying quality." It is not regarded as of value.

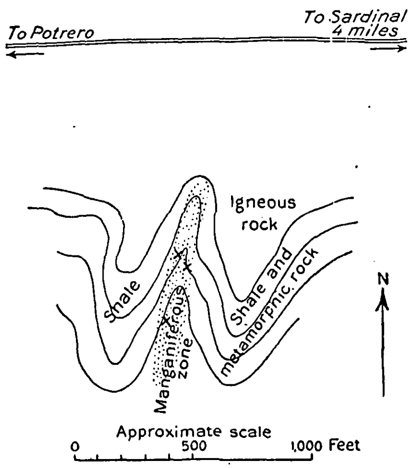


FIGURE 23.—Sketch map of manganese zone and pits at El Francés claim, 4 miles west of Sardinal, Costa Rica.

Piedras Pintadas.—Near Piedras Pintadas (36), about 3 miles north of Sardinal, a large zone of manganese oxide of very poor quality crosses a saddle between two low hills. This material is of too low grade to be considered of any value. (See fig. 24.)

La Cuesta de Mátamba.—The prospect known as La Cuesta de Mátambu (37) is about 2 miles southeast of Nicoya, on the road to Mátambu. The deposit is halfway up the north slope of a hill rising between 700 and 800 feet above the Rio Potrero valley, the first high hill south of the river. The steep and winding hill road shows almost continuous exposures of the country rock in its ruts and banks. The rock is igneous throughout and in most places much weathered. The exposure of manganese oxide crossing the road is a deposit 2 to 3 feet wide, having every appearance of being a vein filling in the igneous rock. This mode of occurrence is not comparable to any other noted in the region. In the stream near by igneous rock is seen in the lower part in gorges and small falls; farther upstream the banks are low and exposures poor, but in the banks and the stream bed there are many boulders of manganese oxide and metamorphosed sediments, both light colored and red, among which slickensided faces are common. The lower part of the stream and the road below the outcrop show many pieces of manganese float, some of good quality. (See fig. 25.)

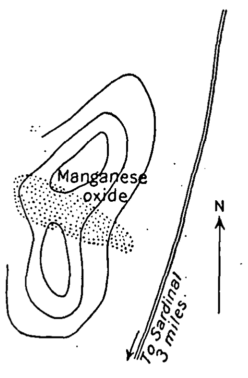


FIGURE 24.—Sketch map showing location of zone of manganese oxide near Piedras Pintadas, 3 miles north of Sardinal, Costa Rica.

Pavones.—The three prospects at Pavones (38) are the property of Dr. Antonio Giustiniani, whose San Jose agent is Señor José Rodo. The property is near the head of the Gulf of Nicoya, about a mile southwest of San Pablo, in the hills west of the road to Corozal. Near the road is the house of José Arraya Méndez, and the mine is about 200 yards uphill from this house. The hills rise steeply from the plains that extend eastward to the gulf. Two of the prospects are about 800 feet apart, with a possible connection indicated; the third prospect is 800 or 1,000 feet to the south of the house. (See fig. 26.)

Prospect 1 is 325 feet above the level of the house, on a very steep hillside, in a cut about 60 feet high and of varying width, in which a deposit of manganese oxide can be well seen. The north wall (hanging wall) is composed of a metamorphosed yellowish shale. The south wall (footwall) shows a deeply weathered rock of mottled reds and greens, possibly a very coarse grained igneous rock but more probably a breccia. Between these two walls is a zone of ore, varying in width but averaging 20 feet. This layer appears to follow the contact between the shale and the mottled rock, in a plane striking roughly northeast and dipping about 70° NW. This attitude would indicate the possibility that the deposit continues to some depth, like the deposit at Curiol, in contrast to the flat-lying body at Playa Real. However, unlike the Curiol deposit, the zone is by no means composed completely of ore; the manganese oxide is separated into many stringers and lenses by layers of the shale and the mottled rock. The ore makes up not more than half of the zone. Some of the ore appears fairly pure, but some is much mixed with fragments of rock, either formed by fracture or deposited with the ore. There seems to be no definite system to this distribution of qualities, and considerable careful sorting would be necessary.

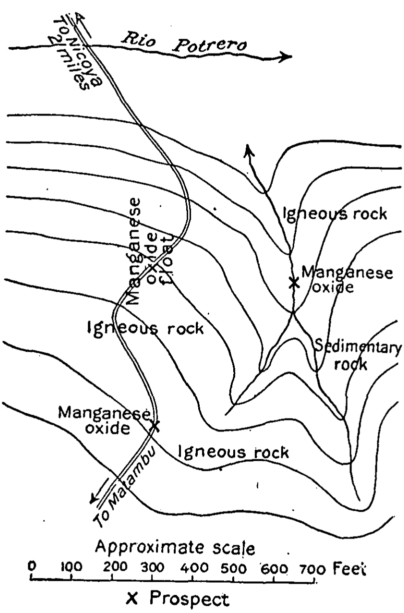


FIGURE 25.—Sketch map showing location of manganese outcrops at La Cuesta de Mátambu, 2 miles southeast of Nicoya, Costa Rica.

At about 350 feet above the level of the house and 30 feet south of the main cut there is a small opening which shows a little low-grade ore. Apparently there is no connection between this deposit and the main zone, from which it is separated by rock. The main zone can be seen on top of the hill above the large cut, where it appears narrower, although the lower part may be concealed by the débris from excavations. Float was traced for some distance down the hill toward the southwest. Many slickensides were seen in both the country rock and the ore, so that while there is no absolute indication of a large fault, there is considerable evidence of movement in various directions.

Prospect 2 lies S. 30° W. from No. 1, in the steep gorge near the head of a stream. Some work has been done here on a zone of ore 8 to 10 feet wide, which by faulting appears wider at some places. The geologic features are comparable to those seen at No. 1. Much of the ore is of good quality, but sorting would be necessary. Float from this deposit was traced for some distance toward prospect 1. An effort was made to determine the continuity or otherwise of this deposit with that at prospect 1 and also uphill to the southwest. This

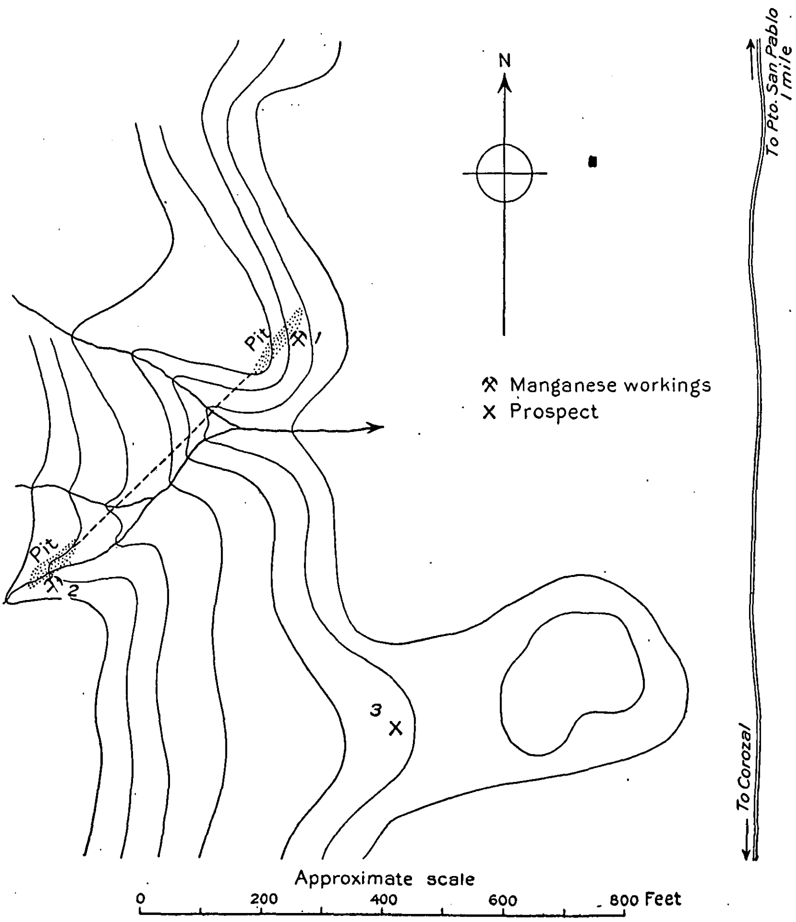


FIGURE 26.—Sketch map showing location of manganese prospects at Pavones, 1 mile southwest of San Pablo, Costa Rica. The dash line indicates possible connection between prospects 1 and 2.

continuity is suggested by the apparent shape of the deposits—that is, the strike of the bedding plane—and the lines of float. The attempt was unsuccessful because of the steep slope of the hills, causing quick washing of float, the lack of true outcrops, and the almost impassable underbrush.

Prospect 3 is about 800 to 1,000 feet south of the house, on top of a small rounded hill, where two shallow pits show a little fair-grade ore. There are no outcrops or exposures, and the geologic relations could not be determined, but there is no probable connection between this deposit and those at prospects 1 and 2.

About 80 tons of ore has been taken from prospects 1 and 2 and is now at the landing at Puerto Util. Assays of the ore from these deposits by Booth, Garrett & Blair, of Philadelphia, and the Berkshill Iron Works (Ltd.), of Sheridan, Pa., show metallic iron, 1.22 per cent; silica, 1.70 per cent; manganese, 51.38 per cent. Each of these tests was made on 12 tons of ore.

If more assays show that the ore of better appearance is really of good quality, the mine warrants sufficient outlay to determine its value for further development. The features now visible, as described above, show the possibility of a deposit hundreds of feet in length, extending to considerable depth along the line of contact; though it seems more probable that the ore occurs in pockets or lenses along such a line. Preliminary work would consist of clearing the underbrush and digging pits along the possible line of connection between prospects 1 and 2, to determine the question of continuity. This work would not be expensive, and if good ore is found along this line, enough to cover the cost could be easily and quickly taken out at the surface by open cuts. Until continuity in length and depth could be proved, any development work should be done on a small scale, without expensive installation.

From the foot of the hill below the deposit a fair cart road extends over the plain to Puerto Util, about 2 miles to the east. This would be an easy haul in the dry seasons, and the road would not be impassable in the rainy months. The port is at the end of a long tidal estuary which extends through mangrove swamps to the gulf; for a few hours of flood tide this estuary forms a winding channel for boats of medium draft. The ore would have to be carried in lighters from the port to vessels anchored near the islands of Bejuco, Venado, and Caballo, some 8 or 9 miles down the gulf.

La Colonia-Carmona.—A prospect was reported near the village of La Colonia-Carmona (39). The locality was visited, and a guide who said he knew the deposit was obtained. He pointed out a little manganese in a small pocket, in a gully southwest of the village. This was the only manganese that could be found in the vicinity and has no apparent value.

Puerto Humo.—A little manganese has been seen in the hills back of Puerto Humo (40), but its content of iron is so high that it has no commercial value.

CONCLUSIONS.

Labor is cheap in Costa Rica but at present is rather scarce. The pay of laborers ranges from 2 to 3½ colones (50 to 80 cents) a day. An abundance of hard wood can be found for development work; this can be sawed and hewn by hand or sawed in one of the several mills scattered through the region. With these low costs as factors, deposits of any reasonable size can be developed at comparatively little expense. However, besides the deposits now producing and a few small bodies near them which will be exploited by the same companies, only the Pavones prospects seem to offer any real hope of being worth development. Extensive prospecting at some of the other localities might disclose greater possibilities than are apparent on the surface, but they do not have much promise. Detailed prospecting work can be done only by careful and intensive study of the areas, and the party should include several laborers to clear underbrush and dig trenches and pits.

DEPOSITS OF MANGANESE ORE NEAR BOQUERON RIVER, PANAMA.

By Julian D. Sears.

INTRODUCTION.

The two manganese-bearing deposits described in this report are on the west side of Boqueron River, in the Republic of Panama, about 20 miles northeast of Colon. (See fig. 27.) The mineral was

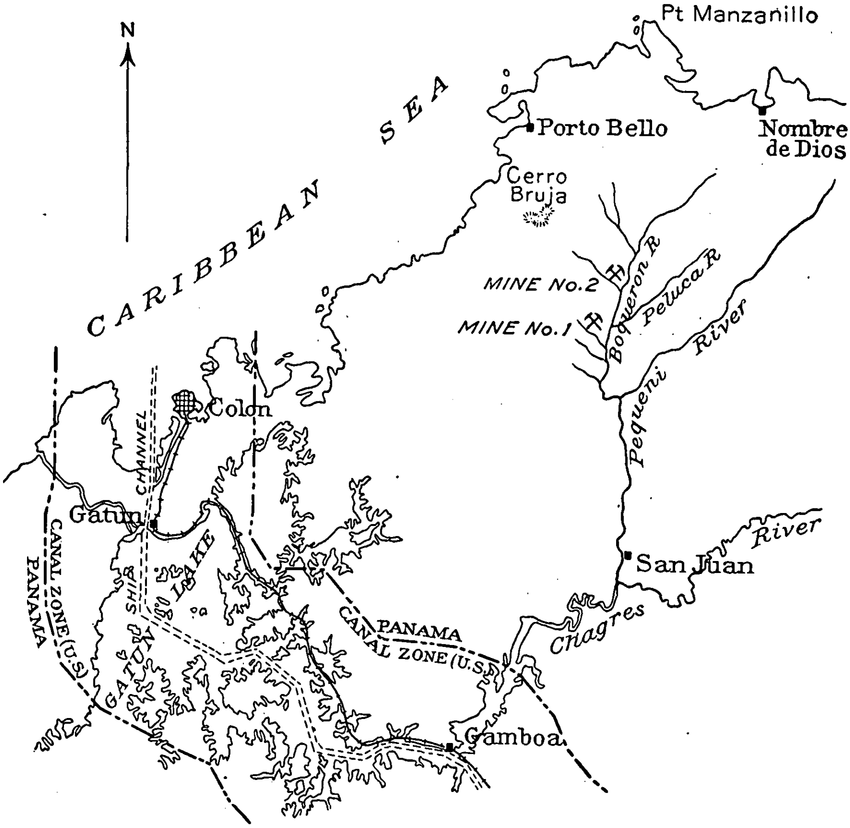


Figure 27.—Map showing location of manganese deposits near Boqueron River, Panama.

first observed by an Indian rubber cutter and pointed out to Mr. Jesse M. Hyatt, of Colon, who has claimed 800 hectares as a mineral zone. The southern deposit, known as mine No. 1, lies on and near a creek about three-quarters of a mile from the river; the other deposit, known as mine No. 2, is about 4 miles distant, on a small branch of Diablo River about 800 feet from the Boqueron.

In November, 1918, the writer visited these deposits in the company of Mr. Hyatt, to whom he wishes to express his sincere thanks for many courtesies. The trip was made by train to Gamboa, by launch to Gatuncillo, and by cayuca two days up Chagres, Pequeni, and Boqueron rivers to the first mine.

GEOGRAPHY.

The country near the mines is very hilly, with highest altitudes of about 1,000 feet. The hills are heavily wooded and carry also dense underbrush. There are no traces of man except an occasional rubber cutter's trail and the remains of the centuries-old paved Spanish highway, or Camino del Rey, which once extended from Porto Bello to Old Panama. Between the mines and the Caribbean coast is a range of mountains, the highest point in which is La Bruja (about 3,300 feet), but in this range there is one gap with an altitude of less than 900 feet.

The Boqueron has an altitude of about 300 feet at the mouth of the Peluca and about 500 feet at the Diablo. Downstream from mine No. 1 there are many rapids; and above the Peluca there are several high falls, which prevent cayucas from passing between the two mines. In the short dry season these rivers diminish notably and the smaller streams disappear; in the long wet season, during which the total precipitation is about 120 inches, the run-off is rapid and the rivers are full, often in heavy flood.

The passage on the river in small cayucas is too slow and difficult to make feasible the shipping of large quantities of ore to the railroad by that method. An engineer who has made a survey for a tram line from the mines to the coast at either Porto Bello or Nombre de Dios reports that a practicable route 11 miles long can be established, but that, with the grading necessary in the broken country, the line would cost over a quarter of a million dollars.

GEOLOGY.

West of the Chagres, in the Canal Zone, there is an area of the "igneous complex" which doubtless constitutes the backbone of the mountain ridge that forms the divide between the Chagres River system and the Caribbean Sea.

Along the Chagres, almost as far upstream as the mouth of the Pequeni, the country rock is excellently exposed in many cliffs. The rock thus exposed has been mapped[1] wholly as the Emperador limestone, but although the writer made only casual observations during

[1] MacDonald, D. F., Bur. Mines Bull. 86, pl. 4, 1915.

the cayuca trip, he is inclined to question the accuracy of this mapping. The beds dip 5° to 10° to the south and southwest, so that the traveler upstream is passing downward in the section. For several miles along the Chagres the rocks appear to be a sandstone, at some places shaly, at other places coarse grained and much cross-bedded. Near the base of this series is a zone of conglomerate. Farther upstream and undoubtedly below the sandy formation there are beds of white and gray limestone, containing many shells and corals. Near the mouth of the Pequeni there are no cliffs; the river is flanked by a wide valley, presumably of shale, although only two small exposures were seen. The writer believes that these three formations represent the Caimito formation (sandstone and limy conglomerate), the Emperador limestone (marine limestone, many corals), and the Cucaracha formation (land-formed clay rocks, lava flows, etc.), all of Oligocene age.

In Boqueron River, below mine No. 1, a hard fine-grained gray rock, with no trace of bedding, forms many shoals and rapids. This is the prevailing rock in the vicinity of the mine, though it is not seen in contact with the ore. Its character could not be determined with certainty under a hand lens, but it is apparently a sediment containing much siliceous cement. Near the head of the stream west of the camp is a dark fine-grained igneous rock, probably basalt.

For a mile below the mouth of Diablo River the rock exposed along the Boqueron is a thin-bedded hard gray siliceous limestone, very unlike the Emperador limestone of the Chagres. At most places where they were observed the beds of this rock stand almost on edge, and at one place in the bed of the river a fault was seen. This formation is found also on Diablo River near the manganese deposit. Associated with the ore bodies, though not in direct contact with them, are shales and breccia, which are described more fully under the heading "Mine No. 2."

ORE DEPOSITS.

Mine No. 1.—The ore at mine No. 1 is a mixture of oxides of manganese. It is hard, black, and for the most part very pure. Where exposed in place it is seen to be segregated in lenses and sheets in clays of various colors but is not in contact with any hard rock.

Much of the manganese oxide seen at mine No. 1 is in boulders. At the point marked 1 on figure 28, in the stream near the camp, are several boulders, each containing over 100 tons of extremely pure, hard ore. In November and December, 1918, these boulders were being broken up, and 100 tons of the material was being bagged and shipped by cayuca down the river to Colon, for careful assays. Several branches of the stream are lined with small and medium-sized boulders. Another branch of this stream (not shown on the map), about a quarter of a mile northeast of the camp, is lined with large and small boulders of good ore that will yield not less than 3,000 tons. All of this material, together with the thick float seen on the hill between locality 2 and the camp, is readily available with practically no sorting. At numerous places, close

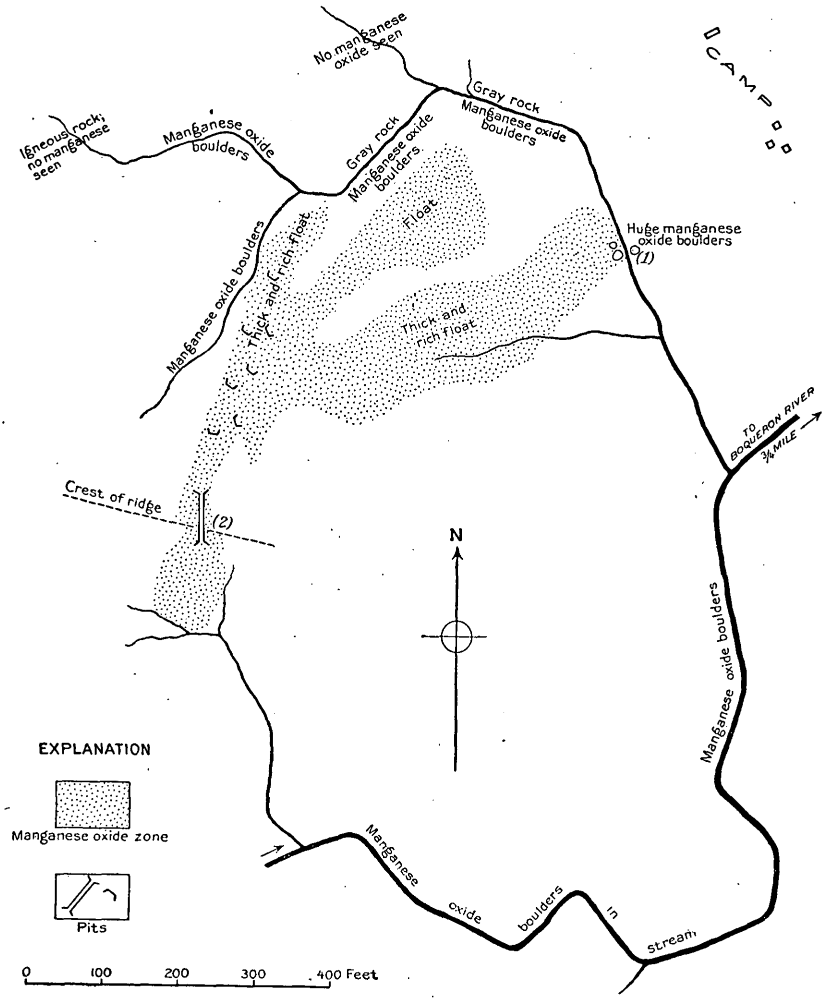


FIGURE 28.—Sketch map of mine No. 1, near Boqueron River, Panama, showing zone of manganese ore (outcrop and float).

to the surface boulders, shallow pits show more manganese oxide in the banks, surrounded by clay.

On the north slope of the hill below locality 2 a number of pits and trenches show ore in place, in contact with red and brown clays, but no hard rock. In these pits the ore has merely been exposed but not yet removed, so that it is not known how deep the mineral extends; however, at one place a drill passed through 8 feet of ore into clay, which may be only a stringer or parting. On top of the hill a north-south cut 60 feet long shows a continuous floor of manganese, and on the south slope, where extensive stripping has been done, the ore is exposed in a zone 100 feet wide, extending down the hill to the first small stream. In several of the cuts the contact of the manganese oxide and the clays has a dip of about 30° W., and the distribution and appearance of the manganiferous rock suggest a sheet or zone of ore inclined in that direction. No evidence of faulting was seen except that a few small pieces of ore showed slickensides.

The manganese oxide is evidently of secondary origin, being the result of concentration and segregation in the residual clays that have been formed by the weathering of the older rocks. This mode of origin is one commonly observed in manganese ore deposits.

Because of the absence of good exposures near by and the lack of bedding in the streams, it is thought unwise to do more than suggest the possibility that the manganese may extend farther underground in this zone, which should be tested by deeper pits. However, the great quantity of boulders and float and the extent of the zones exposed by cuts indicate that 10,000 to 15,000 tons is without doubt easily available.

Mine No. 2.—The ore at mine No. 2 is in boulders in a zone along a branch of Diablo River and up the slope of a steep hill between two of its forks. (See fig. 29.) Near the river the zone of boulders is only 30 to 40 feet wide; some of them lie on the surface and some are buried in the clay banks. Farther upstream the zone widens and the nose between the two branches shows rich heavy float. Several pits expose good manganese oxide in clay. The south slope of the hill has been extensively stripped and good ore is found in a sheet roughly following the surface of the slope. This sheet ranges in thickness from 1 to 15 feet and seems to average about 8 feet. It is in contact with much stained clays, but so far as seen not with hard rock. This sheet extends within 150 feet of the crest of the ridge, which is capped by clays showing no manganese float. At the same elevation on the north slope the top of the sheet is again seen, and numerous cuts on the hillside have revealed a body of manganese oxide 8 to 10 feet thick extending down the slope with an apparent easterly dip. This distribution suggests that the manganese oxide passes as a connected sheet through the hill. The stream to the north shows some manganese oxide boulders but no ore in place. The rock along this stream, which should lie below the manganese zone if that is bedded, is a somewhat metamorphosed sandy shale, with poor bedding. The stream runs down the dip, and so gives practically no idea of the stratigraphic section.

In Diablo River, within 200 feet of the mouth of the creek, is exposed the same thin-bedded siliceous limestone seen on the

Boqueron. The beds here strike about N. 70° E. and are almost vertical. In the gullies and on the hillside south of the creek shale is

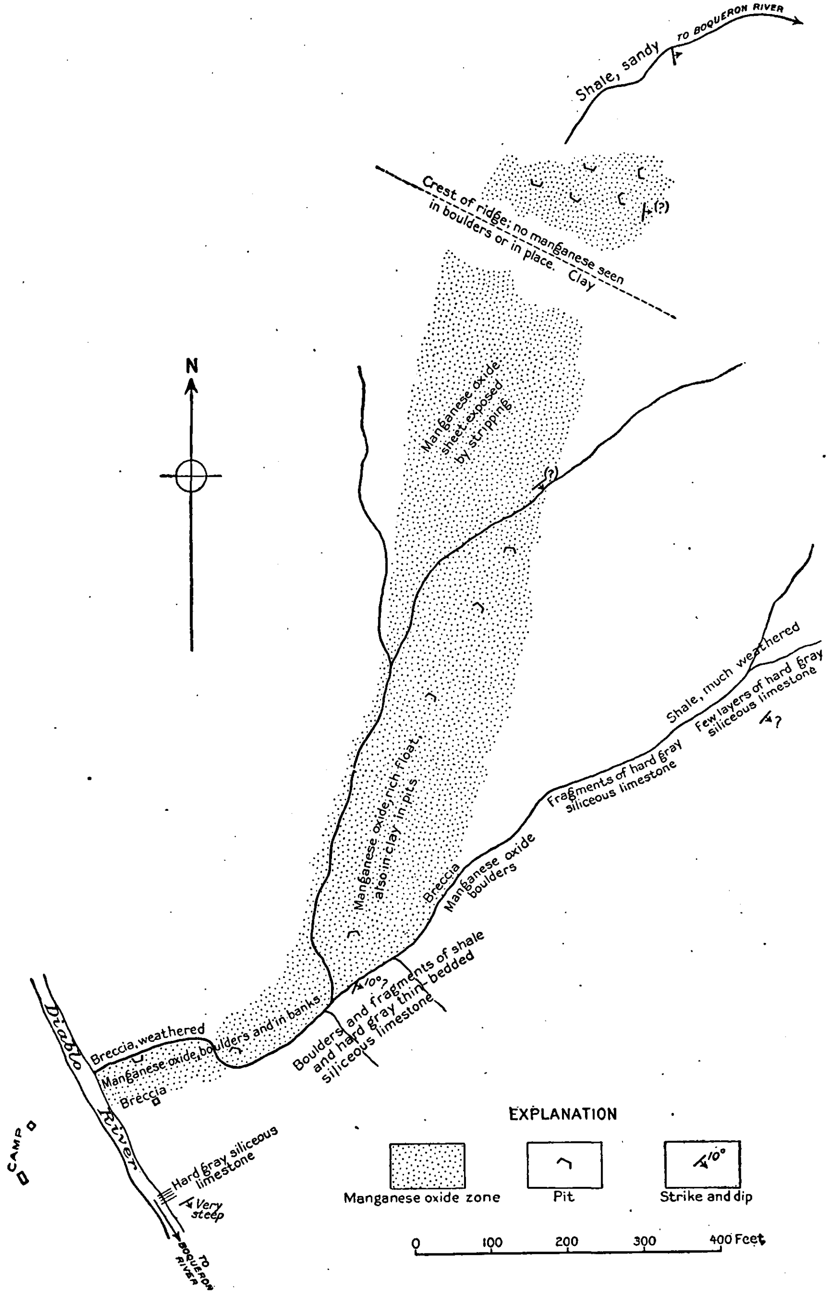


FIGURE 29.—Sketch map of mine No. 2, near Boqueron River, Panama, showing zone of manganese ore (outcrop and float).

seen, with boulders and fragments of this siliceous limestone, which also occurs in boulders up the east fork. None of this material was seen on the north and west sides of the manganese zone. On Diablo

River, just below the mouth of the creek and on the north side of the creek near the mouth, are exposures of a much weathered rock, seemingly a breccia, in which no trace of bedding was observed.

The exposures of rock and manganese are poor and good bedding is lacking, so that it is impossible to make a definite statement as to the underground relations. The upward and eastward succession suggested by the available data consists of sandy shale, breccia, shale with thin bands of siliceous limestone, and finally the main body of hard gray thin bedded siliceous limestone. The manganese is segregated in a zone in the breccia, which near the mouth of the creek stands on edge and farther upstream dips southeast and east. The ore is a secondary deposit formed by concentration in the residual clays weathered from the breccia, possibly being carried in from its original position because the breccia furnished a channel for the ready circulation of waters. This explanation is suggested by the distribution of the rock fragments and exposures in relation to the few dips seen, and by the shape of the ore zone, which is narrow near the area of vertical dip in the siliceous limestone and wider where the dips would indicate a flatter deposit. These features suggest the possibility that the ore body continues to some depth at the mouth of the creek, but the question could be determined only by further excavation.

The ore now in sight, in boulders and in cuts on the two sides of the hill, can reasonably be estimated at 15,000 tons. Most of the ore is good, clean material and would need little sorting. It differs somewhat from that at mine No. 1; it is a little softer and has more of a bluish tint. An assay of some of the ore has given the following result:

Assay of ore from mine No. 2 near Boqueron River, Panama.

[Made by Panama Canal mechanical division testing laboratory. Hygroscopic moisture, 0.71 per cent. Analysis dry.]

	Per cent.
Total manganese	55.3
Sulphur	.01
Phosphorus	.07
Manganese dioxide	84.00
Manganese monoxide	2.86
Ferric oxide	.47
Aluminum oxide	.51
Calcium oxide	.54
Magnesium oxide	.12
Silica	7.58
Sulphur trioxide	.03
Phosphorus pentoxide	.16
Copper oxide	.88