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PRELIMINARY REPORT ON THE SERRA DE NAVIO MANGANESE DISTRICT, TERRITORY OF AMAPA, BRAZIL

by

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SERRA DE NAVIO MANGANESE DISTRICT, TERRITORY OF AMAPA, BRAZIL

INTRODUCTION

Manganese deposits recently discovered in the Territory of Amapá, approximately at latitude 1°02'N. and longitude 52°02'W., have attracted attention in recent months. They are situated in and near the Serra de Navio, a boat-shaped hill on the bank of the Amaparí River (see Map 1),[1/] for which they have been named.

The deposits are being explored and developed by a Brazilian company, Indústria e Comércio de Minérios, Ltda., of Belo Horizonte (hereinafter referred to as ICOMI,) who have exclusive rights to both known and as yet undiscovered manganese deposits in the district, under a concession granted by the Brazilian government.[2/]

The most practical method of reaching the deposits is by the Cruzeiro do Sul plane from Belem to Macapá, by car to Porto Grande, and by small boat to the Serra de Navio. Macapá, the capitol of the Territory, is a town of about 4,500 people situated on the north bank of the Amazon River about 300 kilometers west-northwest of Belem. A road is now under construction from Macapá to Porto Grande, on the Araguarí River, 120 kilometers away. Depending on the condition of the road, which is passable with difficulty in wet weather, the trip can be made by car or truck in two to eight hours. The distance from Porto Grande to the deposits is about 120 kilometers, following the course of the Araguarí and its tributary, the Amaparí, and requires about 16 hours in a moderately loaded canoe with a nine-horsepower outboard motor.

1/ This map shows the Amaparí River far south of its probable position. No good general maps are available.

2/ The text of this concession can be found in the Diario Official of December 6, 1947, Rio de Janeiro.

GEOLOGY

General Features

The region between Macapá and Porto Grande is savannah country of low relief, underlain by lateritized river clays of Tertiary or Quaternary age. At Porto Grande a very coarse phacoidal gneiss crops out which is quite similar to that forming many of the hills of Rio de Janeiro. Near the town a few outcrops of the gneiss occur in the Araguarí River and along its banks. From Porto Grande to the junction of the Amapari and Araguari Rivers the country is also quite flat and is covered by rain forest. Up the Amaparí River the terrain gradually becomes more rugged, having a maximum relief in the vicinity of the manganese deposits of about 200 meters. The river elevation is reported to be about 72 meters at Porto Grande and 90 meters at the Serra de Navio. From the Amaparí River the region appears to be heavily forested, but the local woodsmen report that there are grassy plateaus in some places. Although only one outcrop of a deeply weathered, unidentified rock was seen along the Amaparí, it is probable that other outcrops were covered by the high water prevalent at the time of the visit.

No information is available on the geology or rocks in the area close to the Serra de Navio other than the inference that both acid pegmatites and basic intrusive rocks must be present. Evidence for the former is the abundance of cassiterite and tantalite in placers, and for the latter the reported presence of ilmenite concentrations in some streams.

In the district itself no rocks were seen except manganese ore. Quartzite and diorite have been reported in the bed of the Amaparí River, but at flood stage these rocks evidently are under water. Granite has also been reported in the area, but this rock likewise was not seen. Except for the ore outcrops, the region is covered by a mantle of very clayey yellow soil from which it was impossible to infer anything about the underlying rocks.

Occurrence of the ore

The manganese occurs as outcrops and boulders of hard, black to steel-gray oxides which are probably psilomelane-type oxides mixed with some pyrolusite. The ore varies from dense to porous; it is vuggy in most places and usually shows mammillary and botryoidal structures. Ore in the outcrops ordinarily contains no visible gangue minerals other than occasional quartz grains or pockets of quartz, limonite, clay, and a mineral said to be hydroargillite. A small but fairly constant arsenic content is shown by the analyses, but the arsenical mineral is not visible on megascopic examination.

The outcrops have a distinct topographic expression, as they are much more resistant to erosion than the country rocks, and in many places form vertical walls in the forest. The main lines of deposits crop out along the crest or the edge of long ridges which are cut by a few transverse streams, and at the Chumbo deposits (Map 2), by the river. The outcrops usually occur on the steep side of the ridge toward the main drainage, whereas the back slopes are more gentle.

Specimens of mixed gondite (spessartite rock) and manganese oxide have been collected by other geologists from the bed of a stream (not shown correctly on Map 2) cutting the Chumbo deposit, but at the time of

the writers' visit the outcrop was covered by water and could not be seen.

Large quantities of pebbles and boulders of manganese oxide, ranging up to 20 or 30 tons, mantle the slopes below the outcrops and cover the ridges themselves in many places. Some of these are fragments broken from the outcrops, others are secondary concentrations of manganese presumably leached from the manganiferous zones and precipitated in the soil as concretions. The latter are often impure and contain much limonite, silica, and probably clay. The ratio of the two types was not established and undoubtedly differs from deposit to deposit, perhaps in accordance with the local topographic conditions.

Structure

Inferences as to the structure can be gained only from a faint layering, which may be relict bedding or foliation, revealed in a few outcrops, and from the general distribution of the deposits. As some of the deposits are not yet located on the map, and as no topographic map is available, even the distribution affords little basis for anything but speculation. However, it appears probable that there are two manganiferous horizons or zones which strike approximately northwest and dip steeply northeast in the area east of the river. To the west, in the Navio group, the strike appears to have swung to the southwest, still with an almost vertical dip. The pattern of the deposits as shown on Map 2 suggests offsets by faulting, but when all the ore bodies have been located it may be found that the flexures in the linear pattern are more gentle and that folding is responsible for the deviations.

It is probable, judging from the outcrop pattern, that the deposits are individual lenses. No evidence was seen to indicate their general shape except that some (Baixio, for example) appear to be short and thick and others, such as Fritz are long and relatively thinner. It is not known whether these lenses have a pitch.

Origin of the ore

On the basis of present incomplete information, the oxide deposits seem to have been derived by weathering processes from manganese-rich gondite (spessartite rock) or other rocks, as yet unknown, containing manganiferous minerals. This type of deposit is common in Minas Gerais, where it is most notably represented by the Morro da Mina deposit, which has produced about 6,000,000 tons of ore, and by the Saude deposit, as yet undeveloped. Prof. Victor Leniz, of the University of São Paulo, has a paper in press describing the derivation of the oxides of the Navio district from gondite.3/ 4/

If the ore is derived from the weathering of manganese-rich silicates, the possibility of continuation in depth is as much a physiographic as a structural problem. Without maps, in a heavily forested area such as this, definite assertions about the physiographic history are difficult to make. The writers received the general impression, however, that the ridge tops are essentially concordant over a considerable area and that rejuvenation of the river in relatively recent time resulted in rapid removal of the softer rocks. The area is one of continued heavy rainfall. Before development of the present relief, the water table must have been high and oxidation could hardly have proceeded to any great depth. With

3/ Also see Mineraçao e Metallurgia, Vol. XII, No. 72 March-Arpil, 1948 Rio de Janeiro.

4/ Also see Leins paper "Estudo Genetico de Minerio Manganese da Serra do Navio, Territorio de Amapa anais da Academia Brazileira de Ciencias, June 30, 1938;" pp. 211-221.

the present steep slopes, however, the water table must be considerably lower under the ridges, and oxidation and weathering promoted by the luxuriant cover of vegetation will have proceeded to a greater depth.

The savannah area between Macapá and Porto Grande, now at elevations from a few meters at Macapá to about 100 meters near Porto Grande, is underlain by lateritized river deposits of Tertiary or Quaternary age. Near Porto Grande there appear to be a couple of old beach-sand deposits on the laterite. The uplift demonstrated by the present elevations probably explains the rejuvenation of the Araguarí-Amaparí river system.

If this uplift was relatively recent, there may not have been sufficient time available for really deep weathering and oxidation of the manganiferous zones, even under the accelerated natural chemical processes obtaining under tropical conditions. This seems to be borne out by the presence of unaltered gondite in the stream bed cited above. Similarly, many of the outcrops show overhangs, indicating a harder cap on the surface and softer material below. Further mine development should soon supply evidence to indicate the depth of oxidation. It is not impossible that the ore will be found to be merely a shell on unaltered manganese-silicate rock; on the other hand, there may be pockets in which oxidation has proceeded to a considerable depth. It is quite possible that some of the boulder deposits are remnants of ore bodies in their last stages of erosion.

ORE DEPOSITS

Description

The known deposits are scattered along a zone some seven kilometers long trending approximately northwest. (See Map 2). The writers saw 18 of the 23 deposits shown on the map which was made by the surveyor for ICOMI.

Several newly discovered deposits were also seen. The boundaries of the individual deposits are shown quite arbitrarily; they usually include both outcrop and boulder areas. Development work on all but three deposits, the Chumbo, Navio, and Baixio, has been confined to the building of access trails, and on the basis of present exposures it is practically or quite impossible to determine where the outcrops end and the boulders begin. Many boulders and pebbles of manganese oxide occur in the soil between the deposits shown on the map. In the Santa Terezinha group, for example, float ore is almost continuous from Macaco to Sentinela, a distance of three kilometers except for 500 meters between Fritz and Cordovil. No attempt will be made to describe all the outcrops-instead, only the outstanding ones will be noted.

Chumbo, the deposit cut by the river, has an outcrop width of about 13 meters at the river bank. The outcrop rises some 25 meters above the present water stage and has a minimum length of 75 meters. The river bed here is said to be in ore visible at low water. A narrow platform just above water level has been started on which ore is being temporarily stockpiled. Boulders of impure siliceous manganiferous rock, interpreted as cemented alluvium, occur on each side of the outcrop, and on the south flank there is also a very impure soft manganiferous rock containing abundant spherical nodules one to two millimeters across of a gray clay (?) mineral. A broken mass of large boulders continues along the crest of the ridge for some 1,100 meters to the southeast of the river outcrop. Trees have been felled along a strip several hundred meters long, but only a small area near the river has been thoroughly exposed. Good ore

crops out in small cliffs for about 30 meters on both sides of the stream where the gondite was found (p. 3), possibly some 900 meters southeast of the river outcrop. The stream is 30 to 40 meters below the ridge line.

The Navio deposit consists of an outcrop 75 to 100 meters long and 4 to 6 meters wide on the edge of a broad ridge. The ridge side of the outcrop is soil-covered and the ore body may well be wider. The slope side is marked by a cliff 2 to 8 meters high, below which is a cleared area containing abundant large boulders as well as the usual profusion of pebbles. Three trenches have been started, two of them about 45 meters below the outcrop. The faces of these trenches were 3 meters or more high on June 1 and were still in soil and boulders. One trench may be carried forward as an exploration adit to cut the ore at depth.

The most impressive outcrop is that of Fritz, which has a length of 300 meters and a height of 1 to 5 meters. Difference in elevation from one end to the other is 40 meters. The Padeiro is still more extensive, but much of the surface zone consists of large boulders. The area of outcrops and abundant boulders is 340 meters long. The De Paiva deposit affords the greatest vertical exposures of ore. At this deposit there is a sheer wall of ore 30 meters high. The total outcrop length is about 150 meters.

It should be emphasized that the areas along the trend of the ore zone have not been prospected either to the southeast or to the northwest, so other deposits may well be discovered in the future. Manganese ore has been reported from the east bank of the Araguarí River supposedly on the continuation of the strike of the Santa Terezinha group. This river is reported variously as being 8 to 30 kilometers away to the southeast. The region to the north and northeast is unexplored.

Grade of the deposits

Surface outcrops of manganese ore in tropical areas are in some cases enriched to such an extent that they may furnish little clue to the tenor of the ore at depth. All sampling so far done on the deposits has been of the surface material, with one exception. Dr. Fritz Ackermann, territorial geologist of the Territory of Amapá, in his publication "Recursos Minerais do Território Federal do Amapá" (Imprensa Nacional, Rio de Janeiro, 1948), cites 26 analyses of samples all of which are between 53.36 percent and 58.24 percent manganese. He also gives seven complete analyses of ore; these average 49.99 percent manganese, 5.23 percent iron, .093 percent phosphorous, 1.48 percent silica, 3.95 percent alumina, 0.08 percent calcium oxide, 0.043 percent magnesium oxide, 0.19 percent titanium oxide, 0.101 percent arsenic, 0.010 percent sulfur, 0.123 percent vanadium, 10.60 percent loss on ignition.

The true grade of the deposits probably will not be established until they have been explored to some depth, as manganese deposits are often enriched at the surface under tropical conditions of weathering. The writers believe that the ore will be softer and somewhat lower in grade at a depth of 5 to 10 meters, but much of the ore at the surface appears to be of high chemical and physical quality.

Reserves

From the foregoing, it is evident that no estimate of reserves made at this time can be more than a conjecture based on fragmentary evidence. The Chumbo outcrop, if projected to stream level, would have over 50,000 tons. If the whole area of massive boulders along the line of the Chumbo deposit as shown on the map is underlain by ore to a depth of 10 meters,

and has an average width of 10 meters, that deposit would contain about 540,000 tons. Similar calculations can be made for the other deposits, but they are based on abstractions and, at this stage, are idle. If the ore is found to continue to a depth of at least 30 meters, it is not improbable that the area as a whole may have at least 10,000,000 tons.

Five deposits were mapped by Dorr and C. F. Park, Jr. in September 1948. These included Fritz, de Paiva, Chumbo, Navio, and Clemente. Relatively speaking, two are large deposits, two average, and one small. The total definite outcrop length of these deposits was about 1,200 meters; possible outcrop (boulder trains with definite trends across slopes and sharp boundaries) included 1,200 meters more. The average width of outcrop is about 15 meters. Some 80,000 tons per meter of depth should be found in the outcrops of these five deposits, and an additional 80,000 tons might be established per meter of depth in area of possible outcrop.

Because of the large number of individual lenses and because the manganiferous area is still without boundaries, the area cannot be condemned without much more prospecting even if one or more of the lenses proves to have a shallow depth of ore.

Chumbo outcrop from Amapari River
Note men standing on outcrop (arrows)

Base of Chumbo Outcrop

Platform - Navio deposit

Typical ore surface - Navio deposit

Vuggy outcrop - Chumbo deposit

Boulders and soil - Navio deposit

Amapari River

A large tree - Fritz deposit

Road from Macapa to Porto Grande after rainstorm. Flat horizon typical.