At the locality visited a small pit has been dug and a tunnel face started for a meter or two on a mineralized fracture containing quartz, chalcopyrite, and molybdenite. Both the chalcopyrite and molybdenite impregnate the brecciated quartz diorite porphyry to a slight extent near the fracture. Except for stains of malachite and limonite there are no secondary minerals and no signs of chalcocitization. These mineralized fractures are of no economic value. This is the only place where molybdenite was seen in the copper veins. The presence of this mineral probably indicates that the vein was formed at a relatively high temperature.

Altogether possibly 8 or 10 square kilometers of intrusive porphyries are exposed in this locality. Many of the porphyries are impregnated with pyrite and considerably altered. (See p. 295.) The conditions at this place do not seem to be particularly favorable for the discovery of valuable mineral deposits. The porphyries are overlain unconformably by the upper Eocene limestone, and boulders of the igneous rocks are abundant in the basal conglomerate of this formation.

IRON DEPOSITS AT MORNE BECKLY.

By Wilbur S. Burbank and John S. Brown.

Geography and Geology.

Morne Beckly lies about 5 kilometers east of Limonade, on the main road between Cap-Haïtien and Ouanaminthe. It is a low, dome-shaped swell, roughly 400 or 500 meters in diameter, standing about 35 or 40 meters above sea level, 10 meters higher than the surrounding plain. The hill, which is an outcrop of bed rock that projects above the alluvial deposits of the plain, consists largely of talcose, chloritic, and amphibolitic schists. The schistosity strikes about N. 30°–40° W. and dips steeply. The schist is intruded by small dikes of quartz diorite porphyry and felsite and by a number of small pegmatitic veins of quartz. Some of the quartz pegmatites have a pinch-and-swell structure that is characteristic of intrusion during deformation. Veins of quartz and epidote were seen, some of them containing iron oxides. The schists appear to be considerably deformed and are locally contorted and faulted.

The age of these schists is uncertain, but they show a degree of metamorphism greater than that noted at most other places in the Republic. Undoubtedly some deformation took place during or somewhat before the quartz diorite intrusion in Cretaceous time. The schists and intrusive porphyries are more fully described on pages 296, 308-309.

Character and Occurrence of Ore.

The presence of magnetic iron ore on this hill has been known for some time and is mentioned in a number of accounts published during the colonial period. Some prospecting has been done, principally by Henri

Thomasset,[1] who made numerous surface trenches across the hill, but no ore was shipped. He gives four analyses showing only the amount of metallic iron in the samples, which ranged from 61 to 65 per cent.

The iron is found in boulders consisting of magnetite, hematite, and quartz. These boulders may be as much as 30 centimeters in diameter and are strewn apparently irregularly over the surface of the hill. The ore is only a comparatively thin veneer in the residual soil on the ground, and at no place on the hill or in the prospect trenches was there any indication of the primary ore body from which the boulders were concentrated.

Nearly all the ore contains some quartz, and in some blocks a considerable proportion of quartz cements the iron oxides. Sections of the ore show both magnetite and hematite in varying proportions. Some sections showed plates of specularite entirely replaced by magnetite and in turn partly replaced by a second generation of hematite.

Origin.

The mode of origin of the iron oxides is not clearly evident, but they probably owe their formation to the igneous activity that accompanied the intrusion of quartz diorite during Cretaceous time. Dikes of quartz diorite porphyry and felsite cut the schists in the vicinity of the deposits. The field relations indicate that the iron oxides were segregated in the quartz veins that cut the schists. The association of the iron oxides with quartz seems to be general. Although no large veins carrying iron were found, many small quartz veins, 8 to 10 centimeters wide, carrying abundant specularite and magnetite were seen on Morne Beckly, and these minerals occur as float at other places on the North Plain. One large piece of a vein that was 10 to 12 centimeters wide contained 70 to 80 per cent of specularite and magnetite, the remainder of the vein being milky quartz. Smaller veins contain, besides quartz and iron oxides, some iron-rich epidote.

It seems quite certain that if the iron originated in quartz veins there are no large ore bodies and that the iron found on the surface is a residual concentration effected during a long period of erosion. The southern part of the North Plain has apparently been eroded under relatively stable conditions for a long time, as is indicated by concretionary deposits of iron and manganese found on its surface at other places. (See p. 477.) The drainage on the plain is relatively inactive and does not quickly remove the residual products of weathering.

The iron may have been formed by the contact-metamorphism of limestone bodies in the schists, but most of the evidence seems to be against such a hypothesis. No limestone bodies were found in the metamorphic complex on the North Plain, and no characteristic contact minerals are associated with the magnetite and specularite.

[1] Op. cit., p. 409.

Economic Value.

The quantity of iron ore visible on Morne Beckly is insufficient to give the deposits any commercial value. The hill is only 400 to 500 meters in diameter and the soil, which contains only a relatively small percentage of iron ore, is thin. Whether or not commercial ore bodies are concealed in the metamorphic complex here or elsewhere on the North Plain can be determined only by extensive prospecting and magnetic surveying.

An analysis of a boulder consisting principally of magnetite and hematite and a little quartz gave the following results:

Analysis of iron ore from Morne Beckly.

[By Ledoux & Co., New York.]

	Per cent.
Fe	70.75
SiO_2	4.17
P	.011

DEPOSITS OF MANGANESE.

By Wilbur S. Burbank and John S. Brown.

Manganese Deposits in the Commune of Gros-Morne.

GEOGRAPHY AND GENERAL GEOLOGY.

The manganese deposits here described are about 20 kilometers by road northeast of Gonaïves, in the Commune of Gros-Morne, just west of the Gonaïves-Gros-Morne road. They lie 300 to 350 meters above sea level, on a series of broken ridges that trend about N. 30° W. (See Pl. II, in pocket, prospects Nos. 22 and 23.) The largest deposit seen is on one of the most prominent of these ridges, called Morne Macat, which stands 200 to 300 meters west of the road and rises 140 to 150 meters above the level of the road. The road is easily passable for automobiles as far as the deposits.

The geology of the region is shown on Plate II. The ridge of Morne Macat is a fault scarp marking the contact between the downfaulted upper Oligocene limestone that lies east of the ridge and the basal upper Eocene and the Mesozoic volcanic rocks that form the main mass of the ridge and the country rock for several kilometers to the west. The volcanic rocks are overlain by basal upper Eocene conglomerate and limestone, which form the crest and part of the slope of the hill and dip 30° to 50° E. The upper Oligocene limestone east of the fault is sharply upturned and dips about 65° E.

Along the fault plane between the sedimentary and the igneous rocks considerable jasper, chalcedonic silica, and quartz were deposited, forming lens-like veins from 3 to 5 meters wide. The manganese is concentrated in these veins.

CHARACTER AND EXTENT OF FAULTING.

The fault is apparently normal. The fault plane is at most places nearly vertical but at some places dips steeply eastward. The strike of the plane at this locality is about N. 30°–40° W. The throw of the fault corresponds approximately to the thickness of at least the basal part of the Eocene limestone in this region, which is probably at least 500 meters, possibly much more. Figure 30 gives sections across the mountain at Morne Macat and shows the relation of the deposits to the limestones and the volcanic rocks.

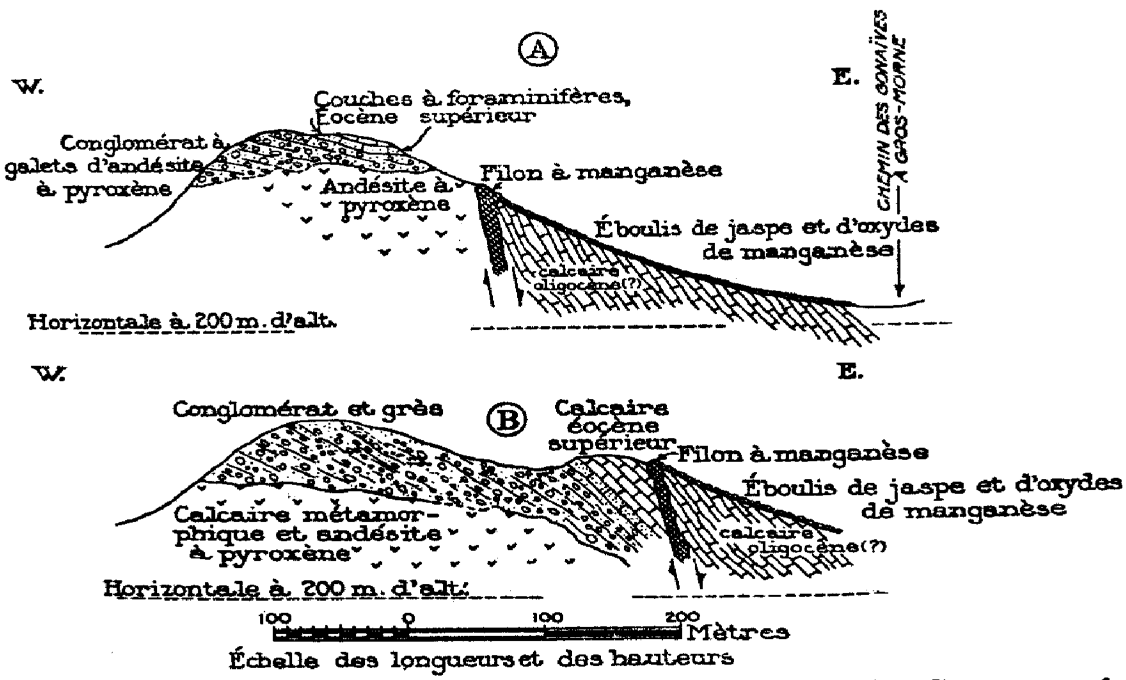

FIGURE 30.—Sections showing the manganese deposits in the Commune of Gros-Morne.

A, outcrop 22; *B*, outcrop 23. For locations see Pl. II (in pocket).

A complete description of the northward and southward extensions of this fault is given on pages 120-121.

MINERALOGY.

The manganese minerals found in these deposits are oxides, generally in intimate mixtures. Judged by their physical properties and by other simple tests the more common minerals are probably manganite ($Mn_2O_3.H_2O$), pyrolusite (MnO_2), and wad, but they can not be accurately identified without chemical analysis. No silicates or carbonates of manganese were found. The mineral aggregates vary from soft masses to hard crystalline or amorphous looking lumps, some of which are in the form of botryoidal and fibrous growths. The deposits may contain psilomelane and other minerals but none were identified, either by their physical character or by chemical tests. Most of the aggregates of manganese minerals are either intimately intergrown or veined with siliceous material that consists of quartz, chalcedony, and jasper.

Thin sections of the ore show that at many places the manganese and silica must have been deposited nearly contemporaneously. In some of the sections the manganese oxides are clearly earlier in origin than the quartz and chalcedony; in others they are in part later. A section of richer ore shows that manganese was deposited with earlier fine-grained quartz and chalcedony. These minerals were followed and usually surrounded by coarser radial or spherulitic growths of chalcedony, and finally by granular and prismatic quartz. Later quartz and chalcedony veinlets cut all the structures and carry some fibrous growths of manganese. The later generations of chalcedony and quartz are clearer and less stained by the iron and manganese oxides.

Sections of ferruginous and manganiferous jasper show that the original jasper has been in part replaced by manganese oxides. Some of the jasper is stained brilliant red, yellow, and dull brown from admixture of iron oxides; some of it is green, but the exact cause of this color is unknown; some of it is stained black by manganese oxides and is veined with small stringers of manganese oxide, usually consisting of pyrolusite. The greater part of this deposit, however, consists of ferruginous jasper, which is reddish or yellowish brown in reflected light and nearly opaque to transmitted light. It appears to have been partly recrystallized, though it may have originally contained some spherulitic growths of quartz that have a zonal staining. The later manganese oxides have usually replaced the jasper between the quartz spherulites. Later veins of quartz and chalcedony cut across both the jasper and the manganese oxides and replace some of the former structures.

At many places the ferruginous jasper evidently replaces the limestone wall rocks, as it contains fossils. At several places the limestone is silicified and shows a fine crystalline intergrowth of quartz and chalcedony, which preserves the bedding laminations. In some thin sections the limestone has evidently been directly replaced by manganese oxides.

The andesites that form the west wall of the fault zone are less extensively silicified than the limestone. In some andesite near the fault zone the augite and the feldspars have been brecciated and replaced by calcite. The alteration of the andesite is generally accompanied by a change of its original greenish color to brown or light gray.

A study of thin sections of the ore shows that the manganese either accompanied silica introduced later into the jasper or was concentrated during a secondary silicification or crystallization from manganese originally disseminated through the jasper. The manganese oxides do not appear to have replaced earlier silicates or carbonates, and their intimate association with the chalcedony and quartz shows that the oxides were deposited with the silica that crystallized later. If the manganese was originally deposited in some other form than as oxide some of the original jasper or silica was taken into solution during the oxidation of the vein and redeposited as quartz and chalcedony with the oxides. It seems more probable, however, that the manganese was originally deposited as oxide disseminated through the jasper, both probably having been in places deposited as colloidal gels, and that later redistribution and recrystallization in the jasper caused the local concentration of the manganese oxides and the formation of later generations of chalcedony and quartz. The crystallization of gelatinous silica to chalcedony and quartz could have been caused by a rise in the temperature of the depositing solutions.[1] Some of the manganese oxides at the surface, however, were undoubtedly redeposited by surface waters, for small seams of pyrolusite associated with later calcite, soft masses of wad, and surface breccias formed by the cementing of jasper fragments by iron and manganese oxides can be positively attributed to the action of surface water.

The mineralogy and the texture of these ores are very similar to those of some of the "bayate" deposits of the Island of Cuba.[2] They differ to some extent, however, in their mode of occurrence, in that the Cuban deposits are not associated with definite fault zones but are replacements of limestones and tuffaceous sediments, usually along bedding planes. The ores of the Haitian and Cuban deposits are probably also similar chemically, although the Haitian ore analyzed (see p. 475) is more siliceous than the better grade Cuban ore. Small amounts of barium and copper were also found in the Cuban ores.[3]

ORIGIN OF THE DEPOSITS.

These deposits were probably formed in one of three ways—(1) by deposition from cold descending meteoric waters, which leached their mineral content from the overlying limestone or igneous rock; (2) by deposition from ascending hot or cold meteoric waters which, after penetrating to considerable depths, escaped upward along the fault plane, deriving their mineral content from the rocks along which they passed; or (3) by deposition from ascending hot waters of magmatic origin, which derived their mineral content largely from the magma.

The large amount of chalcedony, jasper, and quartz in these deposits indicates that they were formed by hot spring waters that rose along the

[1] For a discussion of the formation of certain jasperoids in the Tintic district, Utah, and for further references to the deposition of gelatinous silica, see Lindgren, W., and Loughlin, G. F., Geology and ore deposits of the Tintic mining district, Utah: U. S. Geol. Survey Prof. Paper 107, pp. 154-159, 1919.

[2] Burchard, E. F., Manganese-ore deposits in Cuba: Am. Inst. Min. and Met. Eng. Trans., vol. 63, pp. 51-104, 1920. Hewett, D. F., and Shannon, E. V., Orientite, a new hydrous silicate of manganese and calcium from Cuba: Am. Jour. Sci., 5th ser., vol. 1, pp. 491-506, 1921.

[3] Burchard, E. F., op. cit., pp. 65 and 83.

fault plane, as descending cold meteoric waters would not carry so much silica. There is little or no evidence to show whether the hot waters were derived from deep seated meteoric circulation or from igneous intrusives, and the period of their activity is not known. The structure competent to provide artesian pressure for the upward circulation of meteoric water along the fault has not existed during Recent time and probably did not exist during Pleistocene time. Possibly, however, structure suitable to give artesian pressure existed during Miocene time, before the greater part of the Eocene and Oligocene limestones in the western part of the Massif du Nord had been removed by erosion. If such a structure existed, the area of intake probably lay northeast of the fault, toward the center of the arch in the western part of the Massif du Nord. (See Pls. I and XXVII.) If there were suitable retaining beds in the basal part of the limestone series, part of the water entering at the intake area might have been confined to the contact between the volcanic rocks and the overlying limestones. Upon reaching the fault the waters would escape upward, and at lower temperature and pressure would probably deposit part of the minerals they leached from the volcanic rocks and the basal beds of the limestone.

It is, however, more probable that the deposits were formed by hot spring waters associated with igneous activity of Miocene or later age and could be correlated with the Miocene intrusion of quartz diorite in the Montagnes de Terre-Neuve. (See pp. 428, 433.)

CONCLUSIONS AS TO CHARACTER OF VEINS.

The bodies containing the manganese are probably discontinuous lens-like veins formed at favorable places by hot spring waters that ascended along the fault zone. Probably they replaced the limestone wall rock and filled and widened open spaces, the proportion in which the two processes combined varying from place to place or from time to time. At many places along the fault there is no vein, although some hydrothermal action is indicated by the bleaching and alteration of the andesitic wall rock. If the vein was not formed by surface oxidation but originated as suggested above the oxides of manganese probably continue below the zone of oxidation.

South of Morne Macat deposits of ferruginous jasper were seen on several small ridges along the line of the fault for a distance of 2 or 3 kilometers but no large quantities of manganese accompanied the jasper. The longest continuous vein exposed is the vein on the east slope of Morne Macat, which is 3 to 5 meters wide and at least 160 to 170 meters long. Of this entire exposure only about 20 meters midway on the hill, where the vein is 8 or 9 meters wide, has any appearance of containing sufficient manganese to be of commercial interest. A chip sample taken across the entire width of this ore body was analyzed in the chemical laboratory of the United States Geological Survey by J. G. Fairchild and the analysis gave the following results:

Partial analysis of manganese ore from Morne Macat.

	Per cent.
Mn	25.8
Fe_2O_3	1.52
P	.028

In the course of the analysis the presence of what is probably barium was found. A little copper was identified.

As the gangue of the manganese oxides is almost entirely siliceous, probably 40 to 50 per cent of the ore analyzed is silica. Ore containing so much silica is not commercially valuable. Although the silica content of the ore might be reduced by sorting, much of the manganese oxide is so intimately mixed with the siliceous gangue that even mechanical concentration would be expensive. The lumps of pure manganese oxides are not usually large enough to be successfully hand sorted. A few small veins and masses of pure manganese oxides, 8 to 10 centimeters in width, were seen, but most of the manganese is mixed with the jasper. A large quantity of float is found on the hillside below the jasper reef, out of which lumps of high-grade manganese ore can be picked, but the percentage of lumps of high-grade ore is low. There is not enough manganese at this locality to warrant the exploitation of the deposit at the present price of manganese, but there is enough to suggest that if the price should again rise careful prospecting here as well as along the entire length of this fault zone would be warranted.

No other bodies of manganese ore were found but others may exist along the fault zone. Slight silicification of the limestone, forming limonitic jasper, bearing some stains, probably of manganese, was seen along the same fault line at Rivière Lhormand, about 5 kilometers west of Gros-Morne. (See pp. 120-121.)

Manganese Deposits in the Commune of Jacmel near Coteaux.

Manganese deposits are reported to occur at several places in the mountains north of Jacmel, in the drainage area of the Grande Rivière de Jacmel and its tributaries. One small deposit that was examined during the reconnaissance is about 12 kilometers north of Jacmel, near the habitation called Coteaux. It is along a fault contact between the basal upper Eocene limestone and the basaltic volcanic rocks of late Cretaceous age. The structural conditions here are remarkably similar to those at the Morne Macat deposits, near Gros-Morne. The strike of the fault is nearly parallel to the strike of the limestone, about N. 60° W. The dip of the contact plane between the limestone and the basalt could not be determined but was probably very steep. The