UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary
GEOLOGICAL SURVEY
W. E. Wrather, Director

Bulletin 935-G

GEOLOGY AND MANGANESE DEPOSITS OF GUISA-LOS NEGROS AREA ORIENTE PROVINCE, CUBA

BY
W. P. WOODRING AND S. N. DAVIESS

Geologic Investigations in the American Republics, 1941-43
(Pages 357-386)

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1944

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.
Price 45 cents

CONTENTS

ILLUSTRATIONS

GEOLOGY AND MANGANESE DEPOSITS OF GUISA-LOS NEGROS AREA, ORIENTE PROVINCE, CUBA

By W. P. Woodring and S. N. Daviess

ABSTRACT

The Guisa-Los Negros area—an area covering about 1,000 square kilometers in southwestern Oriente Province—includes most of the producing manganese mines in the part of the Sierra Maestra manganese district west of Santiago de Cuba. Recorded shipments of manganese ore from mines in the area totaled 44,770 long tons in 1942, about 18 percent of the yield from Cuba during that year.

The rocks in the area are of Eocene age and are divided into three formations: these, in ascending order, are the Cobre volcanics, the Charco Redondo limestone, and the San Luis formation.

The Cobre volcanics, though they include minor lava flows, are made up chiefly of waterlaid tuff and agglomerate. Limestone, most of it markedly tuffaceous, forms lenses of varying extent and thickness in the volcanics, and calcareous tuff is a common constituent. The estimated thickness of the part of the formation that is exposed in the area is at least 1,500 meters, but its base is not exposed and its total thickness is probably several thousand meters.

The Charco Redondo limestone, which has a maximum thickness of about 150 meters, conformably overlies the Cobre volcanics. Although in general the contact between the formations is marked by an abrupt change in lithology or by a conglomerate at the base of the Charco Redondo, in places it is gradational. The formation consists mainly of massive open-textured limestone, but it includes some thin-bedded dense limestone and some conglomerate containing rounded and angular pieces of limestone indistinguishable from limestone in the body of the formation. In the Taratana and Charco Redondo districts, conglomerate overlying bedded manganese deposits near the base of the formation contains rounded and angular detritus derived from the ore beds. A zone of interbedded limestone and tuff, about 60 meters thick, lies between Cobre volcanics and Charco Redondo limestone in the eastern part of the area. It is interpreted as the equivalent of the lower part of the Charco Redondo farther west, but it was mapped in places as a separate unit.

The San Luis formation conformably overlies the Charco Redondo limestone. Though made up principally of marl,

calcareous mudstone, thin-bedded limestone, and thin beds of massive limestone, it also includes tuff, calcareous tuff, tuffaceous sandstone, and conglomerate. Its maximum thickness in the mapped area is about 700 meters, but the total thickness is greater, for its top is beyond the limits of the area.

Fossils from the uppermost part of the Cobre volcanics, and from the Charco Redondo limestone and San Luis formation, are of early upper Eocene age. The Cobre volcanics may include deposits of middle Eocene age, but the age of the lower part of the formation is not definitely known.

Dikes and small stocks of andesitic and dioritic rocks are widespread in the Cobre volcanics, and at some places they intrude the Charco Redondo limestone. These intrusives are presumably of Eocene age, and most of those in the Cobre are probably almost contemporaneous with the volcanics.

The principal structural features of the Guisa-Los Negros area have a general northwesterly trend, oblique to the prevailing westerly trend of the Sierra Maestra. Major folds are few and generally broad, and are subordinate to the numerous faults. With the single known exception of a minor steep reverse fault, the faults are normal. Most of them have a displacement of less than 30 meters; along some, however, the displacement ranges from about 150 to 200 meters. Northwestward- and northward-trending faults are most numerous. The deformation that produced the folds and faults is presumably to be correlated with deformation dated elsewhere in Cuba as late Oligocene or about the end of the Oligocene. The faults of different trend are probably of the same general age, but at several places northward-trending faults displace others.

Manganese deposits in the area are divided into seven types on the basis of occurrence and association. The most important types are bedded ore in limestone, bedded ore in tuff not associated with bayate (chert), and nonbedded ore in limestone. They occur mainly in the lower part of the Charco Redondo limestone and in the upper part of the Cobre volcanics.

Prospecting is most likely to be successful if done on contacts between tuff and limestone, at the base of the Charco Redondo limestone and at other horizons. The most favorable area for prospecting by drilling is at the south end of the Cautillo syncline, where bedded manganese deposits have been found near the base of the Charco Redondo limestone.

INTRODUCTION

During the period from October 1940 to the present time (1943), the Geological Survey, United States Department of the Interior, in cooperation with the Dirección de Montes, Minas y Aguas, Ministerio de Agricultura of the Cuban Government, has been carrying on an investigation of Cuban manganese deposits under a project sponsored by the United States Department of State and the Office of Economic Warfare. A preliminary examination of many deposits in various parts of Cuba was made during the winter of 1940-41, and a brief report on that work was published in 1942.1/ A later report, based on more detailed field work done in 1941-42, comprises detailed

1/ Park, C. F., Jr., Manganese deposits of Cuba: U. S. Geological Survey Bull. 935-B, pp. 75-97, pls. 21-24, figs. 7-9, 1942.

descriptions and maps of important mines in southern Oriente Province, together with notes on small mines and prospects in the same area.2/ Another report describing similar investigations during the winter of 1942-43 is now being prepared.

As a result of the field work on mines and prospects from 1940 to 1942, much information was gathered on the geology of small areas scattered through the manganese districts of Oriente Province, and on the general geologic setting of the manganese deposits. This work did not, however, include regional geologic studies; and regional geologic mapping was needed to serve as a basis for tying together isolated detailed geologic maps centering about producing mines, and for giving a comprehensive view of the association of manganese deposits with particular geologic features. Field work designed to meet this need was therefore carried on from December 1942 to April 1943, and the results of that work are given in the present report. The Guisa-Los Negros area was chosen because, at the time when the field work was started, airplane photographs covering that area were available through the liberal cooperation of the United States Navy.

The field work may be regarded as intermediate in character between detailed mapping and reconnaissance. It was not uniform in thoroughness; the time devoted to any given area depended principally on its accessibility and economic importance. Little time was given, for example, to the extensive areas of Cobre volcanics in the southwestern and southeastern parts of the region covered by the geologic map (pl. 68), whereas the areas occupied by the lower part of the Charco Redondo limestone were more thoroughly studied. An advance edition of the geologic map, including a brief text, was distributed to the Cuban Government and to the war agencies of the United States Government in August 1943.

The cooperation and hospitality of mine owners and operators and of residents are gratefully acknowledged. The project was planned and carried out under the general supervision of D. F. Hewett, C. F. Park, Jr., and J. V. N. Dorr, II, of the Geological Survey. Mr. Antonio Calvache, Consulting Engineer of the Dirección de Montes, Minas y Aguas, extended many courtesies on behalf of the Cuban Government. Mr. Guido Calvache served at times as a field assistant. C. F. Park, Jr., M. W. Cox, and J. A. Straczek, of the Geological Survey, placed at our disposal their knowledge of the geology of the Guisa-Los Negros area, resulting from their detailed studies. Mr. Cox had examined many small mines and prospects, and was familiar with the geology of much of the area.

Aside from the reports already mentioned, resulting from the current program of the Geological Survey, little has been published on the geology and manganese deposits of the Sierra Maestra district in and adjoining the Guisa-Los Negros area. Burchard's 3/ publication on Cuban manganese includes descriptions of the Francisco, Cádiz, Llego, Guisa, Charco Redondo, Adriana, and San Antonio mines in the Guisa-Los Negros area, and descriptions of mines in the Bueycito district, southwest

---

2/ Park, C. F., Jr., and Cox, M. W., Manganese deposits in part of the Sierra Maestra, Cuba: U. S. Geol. Survey Bull. 935-F, pp. 307-355, pls. 51-67, figs. 15-18, (in press, 1944).

3/ Burchard, E. F., Manganese ore deposits in Cuba: Am. Inst. Min. Met. Eng. Trans., vol. 63, pp. 84-93, figs. 23-26, 1920.

of that area. Hewett and Shannon,4/ in a mineralogical paper, have outlined briefly the geologic relations and origin of manganese ore in the Bueycito district, and deposits in that district have been described by Calvache.5/ The general geology of the Sierra Maestra has been described by Taber.6/

LOCATION AND GEOGRAPHIC FEATURES

The region shown on the geologic map (pl. 68) embraces an area covering about 1,000 square kilometers in southwestern Oriente Province. (See fig. 19.) It is designated the Guisa-Los Negros area from the towns of Guisa and Los Negros, in the western and eastern parts of the area, respectively. The Central Highway and the Consolidated Railroad of Cuba extend along the northern border of the area. Contramaestre, at its northeastern border, is 80 kilometers by highway, and about the same distance by railroad, northwest of Santiago de Cuba, the shipping port for the manganese ore produced in the area. Bayamo, Santa Rita, Jiguaní, Baire, and Contramaestre are located on the highway and railroad. Horno, Guisa, La Tabla, Los Negros, Matias, File, Bijagual, and Mafo are towns and villages south of the highway and railroad. Other place names on the map designate country stores, or small groups of houses clustered about country stores.

The Guisa-Los Negros area, as shown by the generalized topography on the Santiago de Cuba sheet of the American Geographical Society's 1:1,000,000 map of Hispanic America, lies in the rolling upland between the Cauto Plain and the Sierra Maestra, and extends southward into the rugged foothills of the Sierra Maestra. The flat alluviated Cauto Plain, on which Bayamo is located, reaches into the northwestern part of the area. Between Jiguaní and Contramaestre low undulating hills extend northward beyond the area.

Altitudes in the area range from 52 meters above sea level at Bayamo to about 750 meters above sea level in the highest ridges in the southern part. In the rugged foothills the relief is locally as much as 300 meters. Along the crest of the Sierra Maestra south of the area the highest peaks are reported to have altitudes of 885 to 1,765 meters above sea level. In general there is a southward increase in ruggedness, as well as in altitude. Aside from the extension of the Cauto Plain along Bayamo River, the most extensive lowlands in the area are Cautillo Valley, Jiguaní Valley, Mafo Lowland, Guisa Lowland, which is considerably dissected, and Los Negros Valley.

The northern part of the area is readily accessible from the highway and railroad skirting the north edge. The road from the Central Highway to Guisa and the short road from Contramaestre to Mafo are the only paved roads leading south of the highway, and are therefore the only roads that can be depended on to be passable for automobiles after a heavy rain. The nonsurfaced roads are generally impassable for automobiles

4/ 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, 4 figs., 1921.

5/ Calvache Dorado, Antonio, El manganeso de Bueycito: Cuba Dir. Montes Minas, Bol. Minas 7, pp. 78-84, 1923.

6/ Taber, Stephen, Sierra Maestra of Cuba, part of the northern rim of the Bartlett Trough: Geol. Soc. Am. Bull., vol. 45, pp. 567-620, pls. 57-85, 4 figs., 1934.

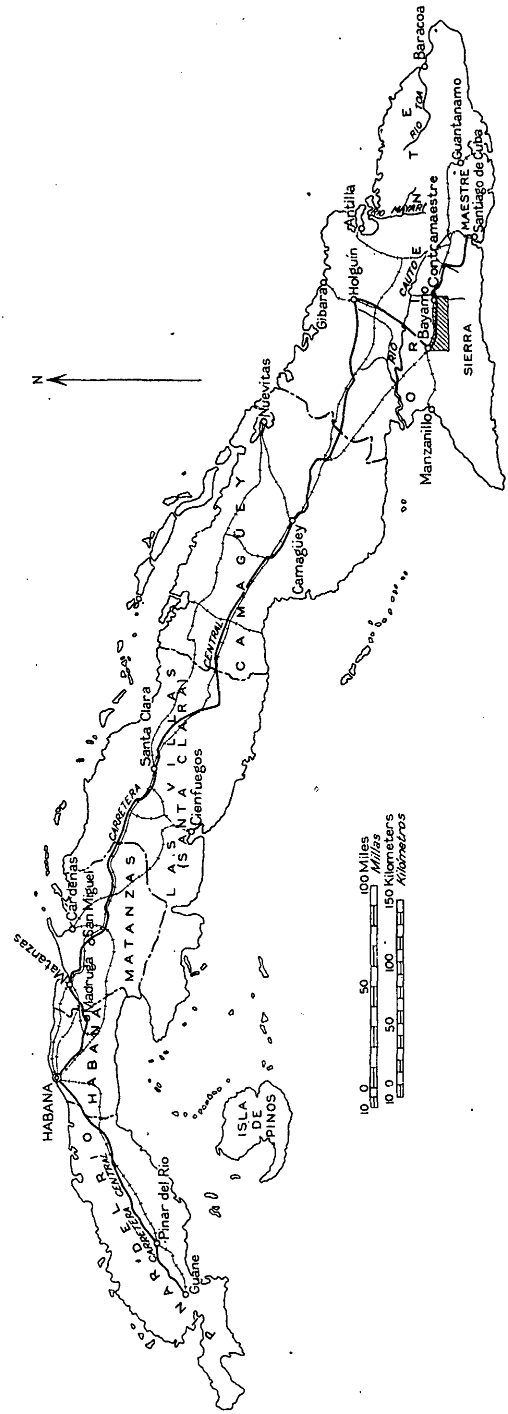


Figure 19.--Map of Cuba showing location of Guisa-Los Negros area.

after a heavy rain. Roads to mines are being slowly improved, however, and after the field work was completed a gravel-surfaced road was put through from Diamante across the Cautillo Valley to the Taratana mines. A few truck roads used for getting out charcoal and lumber are not shown on the map, as they are likely to be ephemeral. Trails in parts of the area that are not too rugged are used locally for oxcarts. Except along the roads that are passable for trucks and oxcarts, products of the country are moved out and imports are brought in by mule pack-trains. Only the principal trails are shown on the map. After a heavy rain, some stretches along the trails are virtually or quite impassable on horseback.

The rainy season lasts from May to October, and is marked by maxima in May or June and in September or October. At Santiago de Cuba, 50 kilometers in a direct line southeast of Contramaestre, the mean annual rainfall is 1,113 millimeters; at Manzanillo, 45 kilometers west of Bayamo, it is 1,354 millimeters.7/ The precipitation in most of the Guisa-Los Negros area, particularly in the southern part, is probably greater than at Manzanillo. In an abnormally dry year, several months may pass during the dry season with virtually no rain; in an exceptionally wet year, on the other hand, the dry season may be almost as wet as a normal rainy season. Even during a normal dry season regional storms may bring heavy rains, and near the mountains local showers, which generally fall during the afternoon, are to be expected.

The Guisa-Los Negros area has numerous streams, the largest of which are the Bayamo with its tributaries the Guisa and Guamá, the Cautillo, and the Contramaestre with its tributary the Mogote. Extensive areas underlain by limestone, such as those between Cautillo River and Mogote River and its tributaries, have, however, no surface drainage, and in such areas water is scarce. During the height of the dry season even the Guisa and Guamá Rivers disappear for short stretches in limestone.

Population is densest in the valleys and lowlands, except in the Cauto Plain, where large dairy farms are located. Flat-lying lands are in general not extensive enough for large-scale agricultural projects. The only sugar settlement (central) is at the northeast border of the area, and its tributary cane fields are for the most part east of Contramaestre River. Crops raised on the small subsistence farms located throughout the area consist principally of corn, plantains, yuca, malanga, sweet potatoes, and tobacco. The only extensive sugar cane fields are in the Mafo Lowland. Except in the most rugged parts of the area, much land is used for grazing. Toward the south, in the foothills of the Sierra Maestra, the proportion of cleared land steadily diminishes. Coffee is the principal crop in these rugged hills, the large coffee plantations (cafetales) being for the most part at altitudes greater than 300 meters. To a visitor from temperate regions, the cultivation of slopes as steep as 45°, and the retention of soil on those slopes without artificial aid, are striking features (pl. 72). Jiguaní Valley evidently has poor soil. The lower part of the valley has groves of jata palm, which is characteristic of deficient soils in Cuba.

Uncleared tracts are covered with dense partly evergreen hardwood forests (pls. 69-72), which supply charcoal and a

7/ Fassig, O. L., Rainfall and temperature of Cuba: Tropical Plant Research Foundation Bull. 1, p. 17, 1925 (43.8 and 53.3 inches, respectively).

little valuable lumber. Abandoned cleared areas revert rapidly to scrubby brushland.

STRATIGRAPHY

Bedrock sedimentary formations in the Guisa-Los Negros area have a total exposed thickness of about 2,400 meters. They are divided into three formations, which are, in ascending order, the Cobre volcanics, the Charco Redondo limestone, and the San Luis formation (pl. 73). These three formations are conformable, and the Charco Redondo limestone is inferred to grade laterally into volcanic sediments of the Cobre and into strata mapped with the San Luis formation, as shown in plate 74. At least the upper part of the Cobre volcanics, all of the Charco Redondo limestone, and the part of the San Luis formation within the mapped area are of upper Eocene age. The Cobre may include deposits of middle Eocene age, but that has not been proved.

Although the three Eocene formations are conformable—that is, there is no indication of structural discordance—the entire Eocene section is characterized by discontinuities, not only between the formations but also within them. Evidence for these discontinuities is afforded by abrupt changes in lithology, particularly at the base of beds or zones of limestone in the Cobre volcanics and the San Luis formation and at the base of the Charco Redondo limestone, and by conglomerates, which are numerous and widespread in all three formations. Many of the conglomerates at the base of limestone units and also within these units consist partly, or even entirely, of limestone like that forming the matrix. Other beds in limestone, made up chiefly of heads of calcareous algae, closely resemble conglomerates, and may in fact be considered conglomerates of an unusual character.

It is difficult to determine the magnitude of these discontinuities, but they evidently are of the minor rank for which the term diastem has been proposed.8/

Eocene series

Cobre volcanics

The Cobre volcanics constitute the oldest formation in the Guisa-Los Negros area. The name, in the form Cobre series and Cobre formation, was proposed by Taber.9/ Although Taber designated no type region, he evidently intended that the name should cover the volcanic rocks of the Sierra Maestra, with its interbedded limestones. The volcanic rocks in the Guisa-Los Negros area are younger than those at and near El Cobre, 15 kilometers west of Santiago de Cuba—the town from which the name of the formation was presumably derived—but until marked discontinuities are recognized in the sequence of volcanic rocks, it seems appropriate to use the name Cobre volcanics for the oldest formation in the Guisa-Los Negros area.

8/ Barrell, Joseph, Rhythms and the measurements of geologic time: Geol. Soc. America Bull., vol. 28, p. 794, 1917.

9/ Taber, Stephen, The structure of the Sierra Maestra near Santiago de Cuba: Jour. Geol., vol. 39, pp. 537-541, 1931. Op. cit., pp. 576-581, 1934.

The base of the formation is not exposed in that area, and the thickness of the exposed part of it is difficult to determine owing to minor folds, failure to recognize key beds, and possibility of displacement along undetected faults. The thickness along and near Bayamo River, where the section is apparently continuous, is estimated to be 1,500 meters. Taber 10/ estimated the thickness of volcanic rocks in the Sierra Maestra near El Cobre and Santiago de Cuba to be at least 4,500 meters, possibly even 6,000 meters, but that part of the range has not been mapped, and the main part of the range, farther west, has not even been examined by geologists.

Areas underlain by the Cobre volcanics are characterized by three types of topography. In the high foothills of the Sierra Maestra, south of the southern boundary of the Charco Redondo limestone, the volcanics form sharp-crested deeply furrowed ridges separated by narrow valleys. Farther north, wherever the Charco Redondo limestone has been removed in small areas, the volcanics form narrow flat-floored valleys; these valleys are generally cultivated, whereas the bordering limestone hills are uncleared or only partly cleared (pl. 69). More extensive areas of volcanics in the upland north of the foothills are characterized by low hills and valleys, which are cultivated or used for grazing (pl. 71).

Stratigraphy and lithology.--The Cobre volcanics include minor lava flows, particularly in the southern part of the area, but they consist chiefly of waterlaid tuff and agglomerate. The formation contains a small proportion of limestone, which forms conspicuous ledges. Well-sorted tuffaceous siltstone and sandstone grade into poorly sorted tuff and agglomerate, and noncalcareous tuff grades into tuffaceous limestone.

Brownish, reddish, and greenish massive to well-bedded tuff, and brownish and reddish agglomerate are the most common pyroclastic rocks. According to published descriptions, 11/ the tuffs range in composition from rhyolitic to basaltic but are mostly andesitic. The agglomerates also are mainly andesitic. Many of the constituents of the tuff and agglomerate are altered, and in some mineralized areas they are highly altered. Some of the blocks in the agglomerates are of limestone like that in the limestone beds, though most of them are of tuff and lava. Some angular to imperfectly rounded blocks in agglomerate have a length of as much as a meter or two, but most of the blocks are less than 30 centimeters in diameter.

Although much of the volcanic material may be classified as tuffaceous sandstone, well-sorted tuffaceous sandstone consisting mostly of well-rounded mineral and rock grains is not common; sandstone of that character crops out, however, on the east side of the tuff valley 4½ kilometers east of Horno. Tuffaceous siltstone, likewise, is not common, but a 10-meter cliff on Guisa River 150 meters southwest of Las Toronjas exposes hard, flaggy, somewhat calcareous, tuffaceous siltstone, and much of the material in a 60-meter cliff section on Contramaestre River 2.4 kilometers northeast of Cruz de los Baños is tuffaceous siltstone.

10/ Taber, Stephen, op. cit., p. 541, 1931. Op. cit., p. 577, 1934.
11/ Park, C. F., Jr., and Cox, M. W., op. cit., p. 312. Taber, Stephen, op. cit., pp. 537-538, 1931; op. cit., pp. 577-578, 1934.

COBRE VOLCANICS AND CHARCO REDONDO LIMESTONE NEAR LA PULLA.

View looking southward toward La Pulla (first group of buildings in upper left). Cultivated valley in Cobre volcanics at the left; forested karstland of Charco Redondo limestone at the right. Photograph by U. S. Navy.

CHARCO REDONDO LIMESTONE SOUTHWEST OF CHARCO REDONDO.

View looking southward. Coffee and plantains are grown in cleared tracts in foreground. Group of buildings at upper left is Palma del Perro. Photograph by U. S. Navy.

SOUTHERN PART OF GUISA LOWLAND.

View looking southward. Cleared tracts in foreground and middle distance are underlain by Cobre volcanics. Forested tracts are underlain chiefly by Charco Redondo limestone. Photograph by U. S. Navy.

SOUTH EDGE OF GUISA LOWLAND.

View looking southward. Base of Charco Redondo limestone is at foot of forested cliff near top of steep scarp in foreground. Photograph by U. S. Navy.

The calcareous tuff in the formation is almost invariably well-bedded in beds a few centimeters to a meter thick, and much of it is flaggy. It is found almost throughout the exposed part of the formation. In the grass-covered hills east of Las Cajitas, calcareous tuff is conspicuous in all the exposures, which represent the uppermost 150 meters of the formation. On the slope leading down to Guisa River 1½ kilometers west-northwest of the Effie mine, three ledges in the uppermost 10 meters of the formation consist of calcareous tuff, some of which is cross-bedded. West of Bayamo River a zone, about 300 meters thick, includes much calcareous tuff. The top of the zone is ill-defined, but is estimated to be 600 meters below the top of the formation.

Limestone, most of it markedly tuffaceous, is found in the pyroclastic rocks as lenses of varying extent and thickness. Some of these lenses are shown on the geologic map. Where there are few, all of them are shown, but in the southeastern part of the area, however, where they are numerous and for the most part poorly exposed, only the most conspicuous are shown. The limestone near Bayamo River 1½ kilometers northeast of El Platano is about 10 meters thick, and the manganese-bearing limestone at the Lorenzo prospects northwest of Filé is 7 to 10 meters thick, but the thickness of most of the limestone beds is between 1 and 5 meters. The thickest beds consist of massive open-textured algal limestone like that characteristic of much of the overlying Charco Redondo limestone; others consist of thin-bedded, dense, flaggy limestone. The tuffaceous material ranges from grains, which are very numerous and give much of the limestone a speckled appearance, to pebbles and fragments several centimeters long. Some of the limestone, also like limestone in the Charco Redondo, has a basal conglomerate that includes pebbles and angular fragments of limestone like that forming the matrix.

Volcanic flows were recognized in the southern part of the area and at scattered localities elsewhere. Others may be present, but the flows are difficult to distinguish, as weathered lava may be confused with weathered tuff and dike rocks. Andesitic and rhyolitic flows are reported from other parts of the Sierra Maestra foothills,12/ and the agglomerate in the Bueycito district, southwest of the mapped area, contains remnants of flows of basaltic and latitic composition.13/

Fossils and age.--The larger Foraminifera listed in the following table were collected from calcareous tuff and tuffaceous limestone in the Cobre volcanics. Loose specimens were collected from weathered calcareous tuff at locality 3.14/ Aside from calcareous algae in the limestone, other fossils are rare, and no fossils whatever were found in coarse-grained tuff and agglomerate. Sections of gastropods, including an ampullinid(?), and of small pelecypods were observed in tuffaceous limestone at locality 1, and the limestone at the San Lorenzo prospect contains poorly preserved corals.

12/ Taber, Stephen, op. cit., pp. 578-579, 1934.
13/ Park, C. F., Jr., and Cox, M. W., op. cit., p. 319.
14/ The localities at which fossils were collected are described after the lists of fossils and are plotted on the geologic map.

Larger Foraminifera from Cobre volcanics

Species	Localities						
	1	2	3	4	5	6	7
Coskinolina? sp.		X					
Dictyoconus cf. americanus (Cushman)			X				
Operculina (Operculinoides) sp. (lenticular)	X	X	X	X			
Discocyclina crassa (Cushman)	X	X	X	X	X	cf.	X
Discocyclina sp. (small, moderately thin)	X	X	X	X	X	X	X
Discocyclina cf. perkinsi Vaughan		X	X				
Discocyclina (Asterocyclina) sp.		X		X	X		?

1 (W 24).15/ Tuffaceous limestone on north side of canyon north of Maria Lola prospects, 1.7 kilometers west of El Platano.

2 (W 23). Trail from Arroyon prospect to Bayamo River, limestone lens 1.6 kilometers northeast of El Platano.

3 (W 18). Weathered calcareous tuff on ridge, 1.3 kilometers northwest of Las Cajitas.

4 (W 27). Tuffaceous limestone on trail to Antonia mine, 100 meters west of mine office.

5 (W 25). Tuffaceous limestone on ridge north of Guisa River, on trail from Josefina prospect to Las Toronjas, 800 meters southeast of Antonia mine.

6 (W 37). Tuffaceous limestone on trail from Filé to San Lorenzo prospects, 300 meters southeast of the prospects.

7 (W 39). Tuffaceous limestone from shaft about 100 meters east-northeast of main open cut at Santa Ana mine.

Discocyclina crassa 16/ is the most abundant fossil from the Cobre volcanics. This species is found practically throughout the three sedimentary formations in the Guisa-Los Negros area, but its range in Cuba, with respect to either stratigraphic position or age, is not yet known. Specimens from the Guisa-Los Negros area closely resemble virtual topotypes from a locality adjoining the Boston manganese mine, 3.2 kilometers east-southeast of El Cristo in eastern Oriente Province. Well-preserved specimens have a narrow peripheral flange, which as a rule is broken away. The thickness of the test is variable, *D. cubensis*,17/ based on material from the type locality of *D. crassa*, being apparently a moderately thick, heavily pillared form. *D. crassa* has been found in formations assigned to the upper Eocene in Jamaica, Haiti, and Trinidad. A closely related, if not identical, form from California has been named *D. californica*.18/

The genus *Lepidocyclina*, which is widespread in the Charco Redondo limestone and the San Luis formation, is not recognized in the collections from the Cobre volcanics; but as the genus occurs elsewhere in America in deposits as old as lower Eocene, it might well be found by making additional collections from the Cobre.

15/ Numbers in parentheses are field designations.

16/ Cushman, J. A., Fossil Foraminifera from the West Indies: Carnegie Inst. Washington, Pub. 291, p. 53, pl. 9, figs. 4, 5; pl. 10, figs. 2, 4, 1919; The American species of *Orthophragmina* and *Lepidocyclina*: U. S. Geol. Survey Prof. Paper 125, p. 42, pl. 8, figs. 1, 2, 1920.

17/ Idem, p. 52, pl. 9, fig. 3; pl. 10, figs. 2-4, 1919; p. 40, pl. 7, figs. 1, 2, 1920.

18/ Schenck, H. G., *Discocyclina* in California: San Diego Soc. Nat. History Trans., vol. 5, no. 14, p. 224, pl. 27, figs. 3, 4, 6; pl. 28, figs. 2-6; pl. 29; pl. 30, figs. 2, 3; text figs. 8-10, 1929.

The part of the Cobre volcanics exposed in the Guisa-Los Negros area is evidently upper Eocene in age, presumably early upper Eocene. Outside the area, however, the formation may include deposits that are of middle Eocene age or even older. Corals found in the Cobre volcanics near El Cobre 19/ have in fact been thought to be of Jurassic or Cretaceous age. It is improbable, however, that any part of the formation is Mesozoic, for crab remains of Eocene and Oligocene affinities were also collected near El Cobre, apparently from the coralliferous strata.20/

Charco Redondo limestone

The dominantly volcanic rocks to which the name Cobre volcanics is here applied are overlain by limestone that, though included by Taber 21/ in his Cobre formation, constitute a well-defined, economically important unit. The type region for this limestone formation is at the south end of the Cautillo syncline, west of Charco Redondo settlement and the Charco Redondo mine, after which it is named. The thickness of the formation is there about 150 meters.

The Charco Redondo limestone overlies the Cobre volcanics conformably. The actual contact between the formations is not exposed at many places on the surface, owing to soil cover and to slumped blocks of limestone, some of which are so large that they may be mistaken for outcrop. It is exposed, however, in a good many mine openings. In places the contact is gradational through a zone of calcareous tuff, but more commonly it is marked by an abrupt change from tuff to limestone, or from tuff to conglomerate with a calcareous matrix. Changes in the character of the contact may take place within a short distance; for example, on Cautillo River 225 meters west of the K6 adit of the Charco Redondo mine the contact is gradational, whereas 600 meters to the east-northeast, on the Casualidad claim, the contact is abrupt and the Charco Redondo limestone has a basal conglomerate. (See section p. 370, and column C, pl. 76.) The abrupt change in lithology at the base of the Charco Redondo, and basal conglomerate, both generally widespread, indicate a general discontinuity between that formation and the Cobre volcanics. Although there is no clear local evidence that this discontinuity is greater than those within both formations, deposition of as much as 150 meters of limestone containing little or no volcanic debris—such debris being characteristic not only of the underlying formation but, to a less extent, of the overlying one—indicates a far greater and longer lasting change in conditions than those recorded by the thin limestone beds of the Cobre volcanics.

The Charco Redondo limestone has a maximum thickness of about 150 meters in the central part of the area. The original thickness was possibly greater than 150 meters in the south-central part, where the top of the formation is not now represented. The formation thins westward, eastward, and northward. West of Bayamo River the thinning is rapid, the formation loses most of its massive cliff-forming limestone, the upper part grades into thin-bedded limestone and marl mapped with the overlying San Luis formation, and the lower part probably grades into the volcanics of the Cobre. The largest interfingering tongues of Charco Redondo limestone and San Luis

---

19/ Vaughan, T. W., in Taber, Stephen, op. cit., p. 540, 1931.
20/ Rathbun, Mary, in Taber, Stephen, idem.
21/ Taber, Stephen, op. cit., pp. 580-581, 1934.

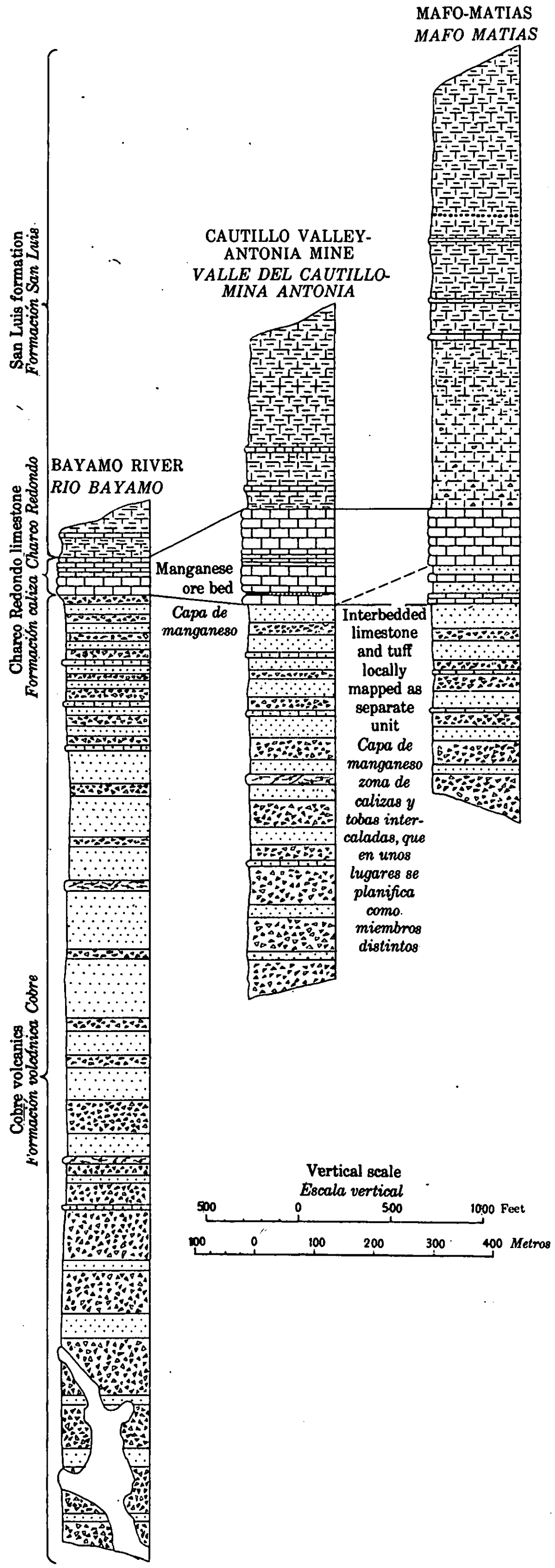
formation in that area are shown on the geologic map, but the representation is generalized, inasmuch as it does not show the numerous minor tongues of both formations. Toward the east the lower part of the Charco Redondo limestone is interpreted as fingering into Cobre volcanics, forming a zone of interbedded limestone and tuff about 60 meters thick, which is mapped in some places as a separate unit. The thinning of the Charco Redondo to the north is probably due to its gradation into the San Luis formation.

The geologic map covers practically the entire known outcrop area of the Charco Redondo limestone on the north flank of the Sierra Maestra. Immediately west of the mapped area an embayment of the Cauto Plain extends southward, and no limestone comparable to the Charco Redondo is known to crop out between the edge of the plain and the Bueycito district.22/ East of Loma La Gloria, the prominent ridge southwest of Mafo, the San Luis formation is faulted against the Cobre volcanics, and still farther east no limestone identified as the Charco Redondo has been found.23/

In areas of considerable relief the Charco Redondo limestone forms steep slopes and high cliffs, which rise above valleys and lowlands underlain by Cobre volcanics. In the rolling upland in the northern part of the Guisa-Los Negros area the limestone forms similar features on a reduced scale or shows little topographic contrast with the Cobre volcanics. A slight rise, for example, marks the base of the Charco Redondo along the Central Highway immediately east of the Santa Rita cemetery. Even in areas of moderate relief some flat lowlands are underlain by limestone. Such lowlands may be seen along the trail from Las Cajitas to Ortega, between Charco Redondo and Rihito, and between Charco Redondo and La Tabla. On the east side of Bayamo River, 4.7 kilometers north-northeast of Santa Barbara, a pedimentlike surface, floored with limestone and grading imperceptibly into the alluviated valley, extends fully 300 meters out from the edge of the hills, which consist of limestone of the same character. The origin of these flat limestone surfaces is not known.

The karstland which almost surrounds Pozo Prieto shows highly picturesque surface features carved from limestone. The karstland is shown on plate 75, and part of it is included in the view on plate 69. Karstland features include sink holes, some of which are as much as 75 meters deep and at many places have practically vertical sides, and long, more or less linear, deep gashes that mark joints or faults enlarged by solution. Sink holes of various sizes and depths are scattered through the outcrop area of the Charco Redondo limestone. The floors of most of them probably coincide with the top of the Cobre volcanics, covered with residual clay derived from the limestone. Though this clay doubtless conceals volcanic rocks in many sink holes, volcanics are not shown on the geologic map except where they were seen in natural exposures or are inferred to underlie the clay on the basis of evidence furnished by mine workings. In no part of the Guisa-Los Negros area has karstland erosion reached the stage represented in the part of Pinar del Río Province, in western Cuba, characterized by isolated, vertical-walled limestone hills and mountains designated mogotes.

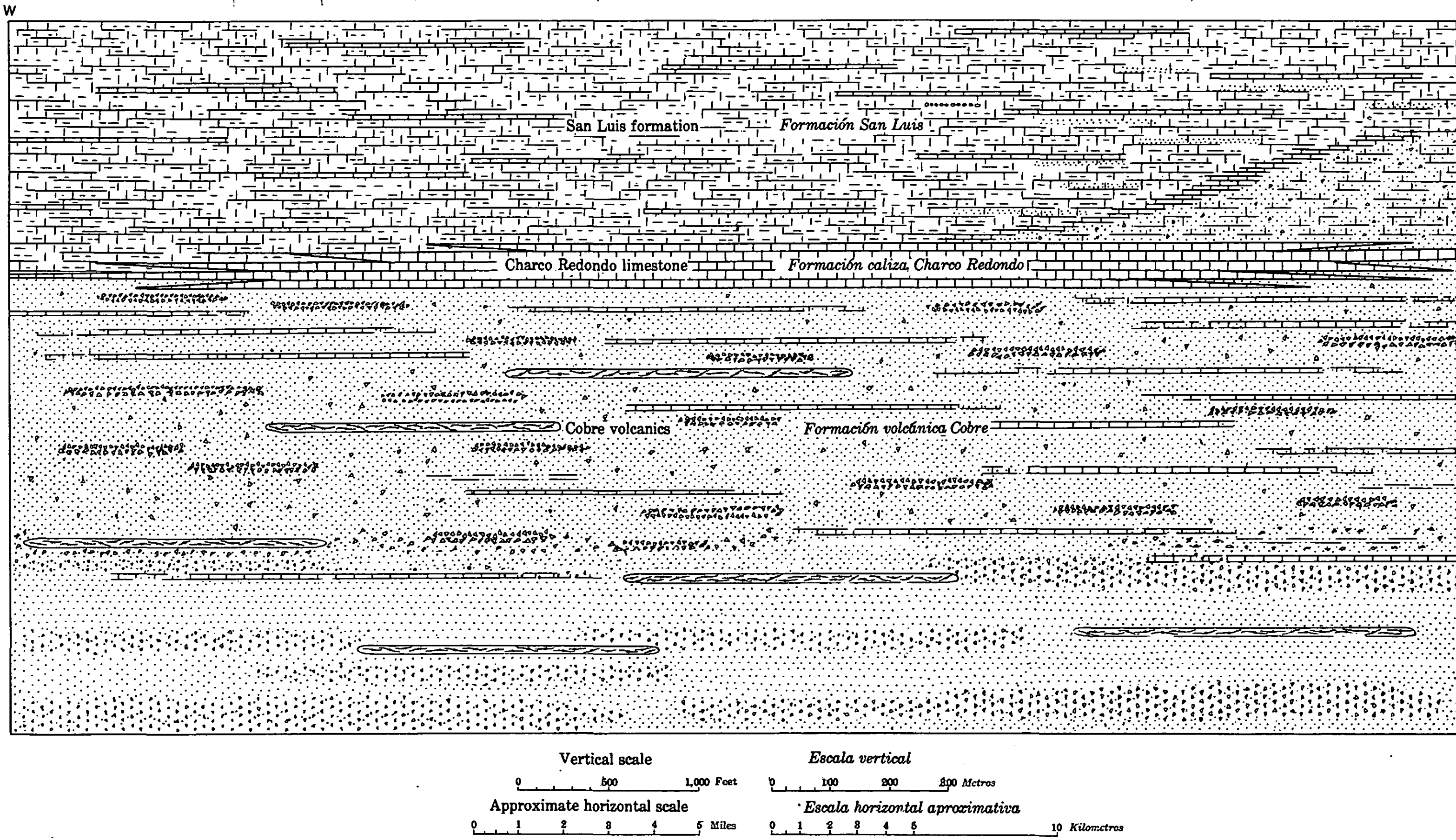
22/ Park, C. F., Jr., and Cox, M. W., personal communication.
23/ Idem.



GENERALIZED STRATIGRAPHIC SECTIONS OF FORMATIONS EXPOSED IN GUISA-LOS NEGROS AREA

CORTES GEOLOGICOS ESQUEMATICOS DE LAS FORMACIONES QUE AFLORAN EN EL AREA GUISA-LOS NEGROS

Face p. 368



INFERRED STRATIGRAPHIC RELATIONS OF COBRE VOLCANICS, CHARCO REDONDO LIMESTONE, AND SAN LUIS FORMATION

RELACIONES ESTRATIGRAFICOS INFERANDOS DE LA FORMACION VOLCANICA COBRE, LA FORMACION CALIZA CHARCO REDONDO, Y LA FORMACION SAN LUIS

Massive limestone is generally fantastically pinnacled and fretted by solution, forming an extremely rough surface aptly called diente del perro (dogtooth). Though much limestone bears only meager pockets of residual clay soil, it supports forests; and the soil is locally cultivated.

Stratigraphy and lithology.--Two main types of limestone are represented in the Charco Redondo: (1) open-textured limestone, which generally contains abundant shreds of calcareous algae and orbitoidal Foraminifera, and is more or less dolomitic; (2) dense, fine-grained limestone. The open-textured limestone, which is much more abundant than the dense limestone, is generally massive, forming beds more than a meter thick, whereas the dense limestone is generally thin-bedded. In the Taratana and Charco Redondo districts—that is, in the type region—the open-textured limestone in the lower 15 meters of the formation is thin-bedded, but thin bedding is not so prevalent as it appears to be at first glance. Well-defined bedding planes are a few centimeters to as much as 6 meters apart. Between the widely spaced bedding planes the weathered limestone has alternating shelves and recesses that simulate bedding but that are somewhat undulatory and are not bounded by bedding planes. Much of the open-textured limestone on the north side of the Guisa Lowland contains discrete rounded calcareous particles, a few millimeters in diameter, that give the appearance of oolitic texture. At many places the limestone is partly or entirely crystalline. In limestone of that character bedding generally cannot be recognized.

Limestone of either the open-textured or the dense type may be white, gray, or cream-colored. Reddish iron stains are common, particularly along faults and near the contact with volcanic rocks. Greenish chloritic limestone is found in the Guisa-Los Negros area but is not common. At localities near Ortega, southeast of the Taratana mines, massive open-textured limestone contains brownish chert nodules. Except in conglomerate at and near the base, the formation contains little tuffaceous material, though scattered grains of tuff are locally widespread even far above the base.

At the south end of the Cautillo syncline—in mines and prospects shown by a distinctive symbol on the geologic map—the lower 25 meters of the limestone contains beds of manganese oxide ranging in thickness from a few centimeters to 2 meters. Bedded manganese oxide is also found near the base of the formation in the Antonio district and at the Luz prospects southwest of Guisa. The bedded manganese deposits in the Taratana and Charco Redondo districts, where they are of greatest economic importance, are shown in plate 76.

The conglomerate at the base of the Charco Redondo limestone ranges in thickness from a fraction of a meter to 10 meters. It invariably contains a mixture of rounded and angular debris, the angular debris being generally the more abundant. The most abundant rocks in the debris are tuff and limestone. The limestone, which forms both pebbles and angular fragments, is indistinguishable lithologically from limestone in the continuous beds higher in the formation and contains the same fossils. Conglomerate of normal character consisting mostly of pebbles and cobbles is rare, but it is found 1½ kilometers northeast of Guisa, where the slope below the base of the limestone is littered with smoothly rounded limestone pebbles, having a maximum length of 10 centimeters, derived from the basal conglomerate. Heads of calcareous algae, ranging in diameter from about 5 to 10 centimeters, are scattered through the basal conglomerate in many places, and at some localities

588177 O - 44 - 3

they are so numerous that they virtually form a basal algal bed that may be considered conglomerate of unusual character.

In the gorge of Cautillo River, 225 meters west of the K6 adit of the Charco Redondo mine, where the contact between Cobre volcanics and Charco Redondo limestone is more or less gradational, the following section is exposed:

Section of basal part of Charco Redondo limestone on Cautillo River, 225 meters west of Charco Redondo K6 adit

	Meters
Charco Redondo limestone:	
Limestone, distinctly bedded, bedding planes a few centimeters to as much as 6 meters apart. Somewhat undulatory "layers" on weathered surface between widely spaced bedding planes. Scattered tuff grains.	10+
Conglomerate with tuff matrix. Pebbles, cobbles, and angular fragments of limestone, tuff, and dike(?) rock. Maximum length 25 centimeters, average about 15 centimeters	0.3
Tuffaceous limestone and calcareous tuff. A 10-centimeter bed of tuff, 23 centimeters above base, contains pebbles and angular fragments of limestone and tuff. Limestone weathers to form somewhat undulatory alternating shelves and recesses, the shelves being $2\frac{1}{2}$ to $7\frac{1}{2}$ centimeters apart	2.4
Cobre volcanics:	
Calcareous tuff and tuffaceous limestone	3+

In many areas, beds of conglomerate are common in the lower 25 to 30 meters of the formation, and some are present at higher horizons. Many of these intraformational conglomerates consist almost entirely of limestone debris, mostly angular fragments, and in some of them heads of calcareous algae predominate. A 3-meter limestone conglomerate, 35 meters above the base of the formation, was used as a guide bed in the detailed mapping of the Taratana district 24/ (pl. 76, column A). A layer of cross-bedded limestone, a third of a meter to $1\frac{1}{2}$ meters thick and consisting of small limestone fragments in a fine-grained calcareous matrix, served the same purpose in the Antonio district.25/ Intraformational conglomerate consisting chiefly of pebbles and cobbles is as rare as basal conglomerate of that character. A 30-centimeter conglomerate exposed along a trail 4.8 kilometers northwest of Guisa is an example of this type of conglomerate. A conglomerate near the base of the limestone on the trail between El Sordo and Las Coloradas is another example.

The most interesting intraformational conglomerates are those overlying bedded manganese oxide in the Taratana and Charco Redondo districts (pl. 76). These conglomerates contain pebbles and angular fragments of manganese oxide, as well as of limestone and tuff. At some places in the Taratana district, there is more manganese oxide in conglomerates than in the underlying bed from which the manganese oxide was presumably derived; at a few places, indeed, the bedded manganese oxide assumed to have been originally present was completely removed when the conglomerate was formed. The manganese-bearing conglomerates of the Taratana-Segunda Gloria-Guisa district immediately overlie bedded manganese oxide (pl. 76, columns A, B), or are thought to represent the debris of such a bed at the few localities where no bedded ore is found immediately below them.

24/ Park, C. F., Jr., and Cox, M. W., op. cit., p. 324.
25/ Idem, p. 335.

The manganiferous conglomerate exposed on Arroyo Caridad, south of the Charco Redondo mine, is separated from the only bed of manganese oxide exposed in the vicinity by 1½ meters of thin-bedded tuffaceous limestone (pl. 76, column D). The conglomerate at that locality contains limestone boulders and fragments as much as a meter long, and tuff boulders and fragments that have a maximum length of half a meter. In both the Taratana and Charco Redondo districts the manganiferous debris is concentrated in the lower part of the conglomerate, which grades upward into ordinary conglomerate that generally consists mainly of limestone.

A zone of interbedded limestone and tuff, cropping out in the eastern part of the Guisa-Los Negros area, east of the Antonio and Pozo Prieto districts, is regarded as equivalent to the lower part of the Charco Redondo limestone farther west. (See pls. 73 and 74.) This zone, which has a maximum thickness of about 60 meters, was mapped as a separate unit wherever it could be differentiated from the main body of the Charco Redondo limestone without undue expenditure of time, which could be done only where exposures are good. The base of the main body of the Charco Redondo was drawn at the horizon where limestone greatly predominates, and, on this interpretation, the stratigraphic position of the base of the main body of the Charco Redondo rises steadily eastward. The distinction, however, between the two units is not sharp; thin beds of tuff are found in the main body of the limestone, not only near the base but even near the top. Meager exposures along the trail leading northward from the Defensa mine show four thin beds of tuff in the limestone on the slope south of Mogote River, and at the Arcádio mine and along the trail from Los Negros to Mafo there is tuff near the top of the Charco Redondo.

Much of the limestone in this intermediate zone is in thin beds and is markedly tuffaceous, like the limestone in the Cobre volcanics, and is locally stained reddish by oxidation of tuffaceous debris. Other beds or zones of limestone are non-tuffaceous, are as much as 15 meters thick, have a basal conglomerate, and are indistinguishable from limestone in the main body of the Charco Redondo. The ore at the Yeya mine is found in a tuff-agglomerate lens, with a maximum thickness of 12 meters, in limestone of the intermediate zone.

In exposures of the lower part of this zone along the Los Negros-Matias road north of Brazo Seço River, beds of limestone 1½ to 3 meters thick alternate with still thicker beds of tuff. A 5- to 6-meter limestone higher in the section has a basal conglomerate consisting of limestone and tuff. In the Negritos area tuffaceous limestone and thick ledges of non-tuffaceous dogtooth limestone are more abundant in this zone than tuff, which is exposed only in road-cuts. Were it not for these exposures, at least the upper part of the section would be mapped with the main part of the Charco Redondo. Tuffaceous limestone forms ledges near Negritos, but farther west, in the Antonio district, it underlies flattish areas like those formed by tuff, whereas the non-tuffaceous limestone mapped with the main part of the Charco Redondo forms ledges and cliffs. In the Los Negros Valley and in the Yeya district the total thickness of tuff is greater than that of limestone. The thickest limestone in the Yeya district is shown on the geologic map. It has a thickness of 7 to 10 meters, and is characterized by a basal conglomerate made up of cobbles, boulders, and angular fragments of tuff and limestone.

Fossils and age.--At many places larger Foraminifera, mostly orbitoids, are abundant in open-textured limestone; in

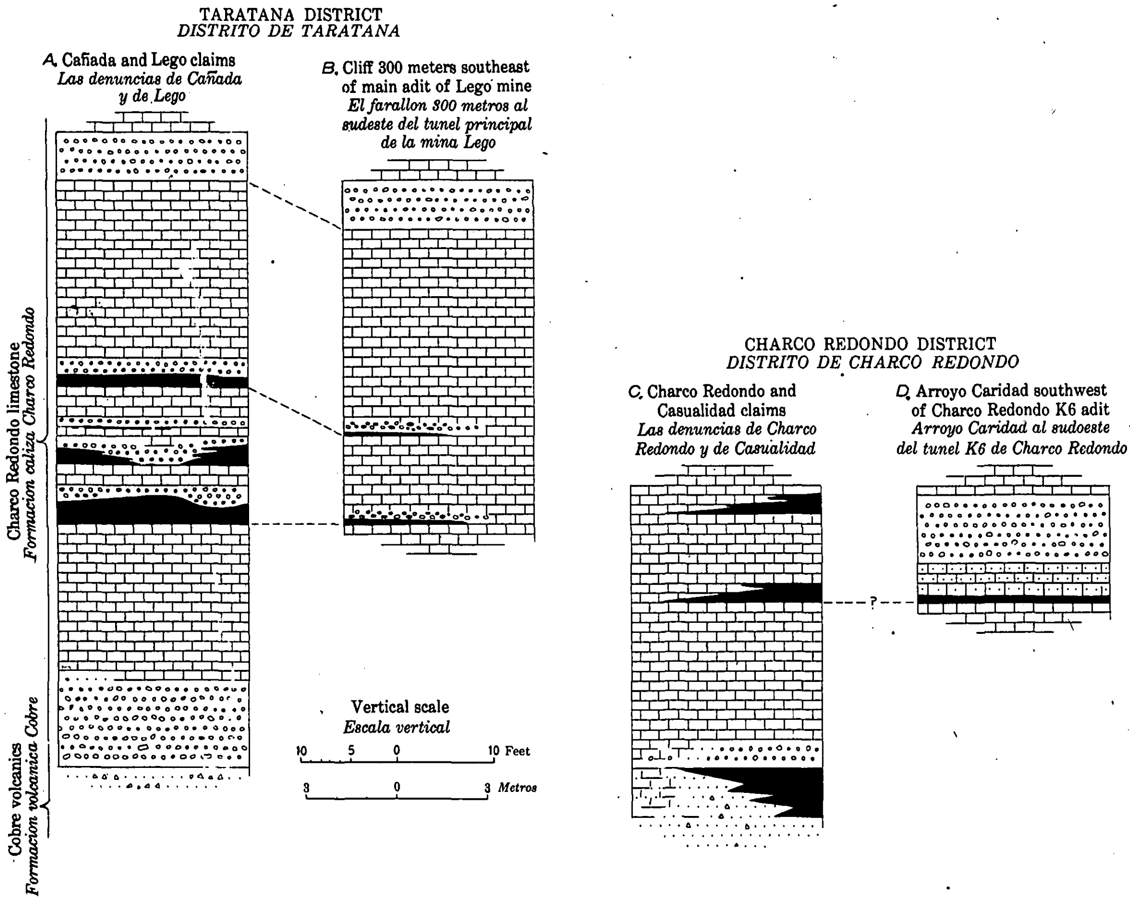
Larger Foraminifera from Charco Redondo limestone

Species	Localities																					
	8	9	10	12	14	15	16	17	18	19	19a	19b	19c	19d	19e	19f	19g	19h	19i	19j	19k	19L	20
Dictyoconus cf. americanus (Cushman).	X	?					X		?		?	X	X	?	X	?	?	?	X	?	X	?	X
Operculina (Operculinoides) sp. (lenticular).				X	X				X		X	X	X	X			X			X	X		
Operculina (Operculinoides) sp. (flat).							X							X	X		X	X					
Genus?, cf. Pellatispira...		X	X																				
Lepidocyclina (Pliolepidina) pustulosa (Douvillé) (pl. 77, B).	cf.						X		X		X	X	X	X	X	X	X	X	X	X	X	X	X
Discocyclina crassa (Cushman) (pl. 77, A).				X	X	X	X	X	X	X	?			X				X			X	X	
Discocyclina sp. (small, moderately thin).				X	X				X	X								X					
Discocyclina cf. perkinsi Vaughan.					X		X			X													
Discocyclina (Asterocyclina) asterisca (Guppy).					X					sp.													

8 (W 31). Trail from El Descanso to La Justa mine, 400 meters south-southwest of El Descanso.
9 (W 13). Trail from Guisa to Santa Barbara, 500 meters east of Santa Barbara.
10 (W 12). Trail from Guisa to Santa Barbara, a kilometer east of Santa Barbara.
12 (W 14). Guisa highway, 2.9 kilometers northwest of Guisa.
14 (W 21). Rotten limestone from water-well dump 3 kilometers north of Guisa, on charcoal road leading off from Guisa highway 3.4 kilometers northwest of Guisa.
15 (W 36). Loose orbitoids in soil in hills southwest of Cautillo Valley, 4.1 kilometers southeast of Horno.
16 (W 32). Trail on limestone dip slope southwest of Cautillo Valley, 5.7 kilometers southeast of Horno.
17 (W 16). Open cut at Effie mine.
18 (W 17). Trail on cliff southeast of Lego mine of Taratana group, 45 meters west of locality where ore beds pinch out and 500 meters southeast of mine office; a foot above conglomerate overlying upper ore bed.
19 (W 28). Gorge of Cautillo River 225 meters west of K6 adit of Charco Redondo mine; a meter above base of Charco Redondo limestone.

KARSTLAND SURROUNDING POZO PRIETO DISTRICT.

View looking southward; Los Negros-Matias road and Mogote River at the left. Note straight deep gashes, marking joints or faults enlarged by solution, and sinkholes. Photograph by U. S. Army.



SECTIONS OF LOWER PART OF CHARCO REDONDO LIMESTONE AND UPPER PART OF COBRE VOLCANICS AT SOUTH END OF CAUTILLO SYNCLINE

CORTES DE LA PARTE INFERIOR DE LA CALIZA CHARCO REDONDO Y DE LA PARTE SUPERIOR DE LAS ROCAS VOLCANICAS LLAMADAS COBRE A LA EXTREMIDAD MERIDIONAL DEL PLIGUE SINCLINAL DE CAUTILLO

BLACK AREAS REPRESENT MANGANESE ORE BEDS; BLACK SPOTS IN CONGLOMERATES REPRESENT DETRITAL FRAGMENTS OF MANGANESE ORE

AREAS NEGRAS REPRESENTAN CAPAS DE MINERAL DE MANGANESO, MANCHAS NEGRAS EN LOS CONGLOMERADOS REPRESENTAN FRAGMENTOS DETRITICOS DE MINERAL DE MANGANESO

Face p. 372

19a to 19L (W 28a to W 28L). Cliff on north side of gorge of Cautillo River and along upper (abandoned) road from river to Charco Redondo mine office, at successively higher horizons in Charco Redondo limestone. Stratigraphic distance above base of formation: 19a, $2\frac{1}{2}$ meters; 19b, 5 meters; 19c, $9\frac{1}{2}$ meters; 19d, $12\frac{1}{2}$ meters; 19e, 23 meters; 19f, 26 meters; 19g, $29\frac{1}{2}$ meters; 19h, $32\frac{1}{2}$ meters; 19i, 40 meters; 19j, $53\frac{1}{2}$ meters; 19k, $69\frac{1}{2}$ meters; 19L, 75 meters.

20 (W 29). Lower road from K6 adit of Charco Redondo mine to mine office, about 100 meters west-southwest of junction with upper road. Highest well-exposed limestone on road, about same horizon as 19L.

fact, they may be found in such limestone almost anywhere except where the limestone is crystalline. They are not found in the dense type of limestone. Globigerinids are the most common fossils in the dense type of limestone. Smaller Foraminifera are scattered through the formation, and at locality 14 loose specimens, replaced by moderately coarse-textured calcite, were collected. Miliolids are locally abundant.

The larger Foraminifera collected are listed in the table on pages 372-373. Lepidocyclina and Discocyclina are the most common genera; Dictyoconus and Operculina are less abundant but widespread. Specimens free from matrix were found at localities 14 and 15. A peculiar genus, evidently related to Pellatispira, is represented at localities along the trail from Guisa to Santa Barbara; it is there associated with miliolids.

Megafossils other than calcareous algae are less abundant than Foraminifera, being represented by corals, bryozoa, mollusks, and echinoid spines and fragments. Aside from calcareous algae, they are for the most part poorly preserved and difficult to extract. The best material consists of specimens weathered out from the matrix, which were collected at localities 11 and 13. Specimens of Pseudomiltha? cf. haitensis with both valves in attached position are relatively abundant near the base of the limestone at localities northwest, north, and northeast of Guisa, including locality 13. Shark teeth were found in limestone at scattered localities, and are known to occur in bedded manganese deposits in both the Taratana and the Charco Redondo districts.

Mollusks from Charco Redondo limestone

Species	Localities	
	11	13
Gastropods		
Nerineid, genus?..................	X	
Terebralia? sp....................	X	
Mitreola? cf. labratula (Lamarck).	X	
Pelecypods		
Pseudomiltha? cf. haitensis Woodring and Mansfield.		X
Corbis cf. clabornensis Dall.....	X	

11 (W 22). Loose specimens on south slope of Guamá River, 2 kilometers southeast of Tienda Nueva at El Corojo.

13 (W 20). Charcoal road leading off from Guisa highway 3.4 kilometers northwest of Guisa; loose specimens collected 2.8 kilometers northwest of Guisa.

The following Foraminifera were found in the zone of interbedded limestone and tuff mapped as the lower part of the Charco Redondo in the eastern part of the area. Locality 21 represents loose specimens collected from soft greenish tuff.

Larger Foraminifera from zone of interbedded limestone and tuff mapped as lower part of Charco Redondo limestone

Species	Localities	
	21	22
Dictyoconus? cf. americana (Cushman)................	X	
Operculina (Operculinoides) sp. (lenticular)........		X
Discocyclina crassa (Cushman).......................	X	X
Discocyclina sp. (small, moderately thin)...........	X	X
Discocyclina? cf. perkinsi Vaughan..................	X	
Discocyclina (Asterocyclina) asterisca (Guppy)......	X	?sp.

21 (W 38). Soft greenish tuff, stream crossing on Baire-Los Negros road 1.2 kilometers northwest of Los Negros.
22 (W 30). Tuffaceous limestone on trail from Negritos to Antonio mine, 100 meters west of Negritos.

Discocyclina crassa (pl. 77, A) is widespread and locally abundant in the Charco Redondo; Lepidocyclina pustulosa (pl. 77, B) is represented at an even greater number of localities. Based originally on material from Trinidad, Lepidocyclina pustulosa has been found in formations assigned to the upper Eocene in Jamaica, Mexico, Panama, Curaçao, Venezuela, and Trinidad. It apparently is absent from the two collections from the zone of interbedded limestone and tuff. Discocyclina asterisca, a minute star-shaped species, is represented by well-preserved specimens from locality 14. It is thought to be characteristic of upper Eocene strata in Trinidad and Venezuela.

A Pseudomiltha similar to P. haitensis, which occurs in the middle Eocene Plaisance limestone of Haiti, is recorded from Eocene deposits near Sagua la Grande in northern Santa Clara Province.26/ The unidentified Campanile-like nerineid from locality 11 is a representative of a Mesozoic family not found heretofore in the Eocene.

The Charco Redondo limestone, like the Cobre volcanics, is assigned to the upper Eocene, and is presumably early upper Eocene. Limestones associated with manganese deposits in the manganese districts of Oriente Province have been assigned to the Eocene—some of them specifically to the upper Eocene—since the early part of the present century.

San Luis formation

The San Luis formation was named by Taber,27/ presumably from the town of San Luis, 40 kilometers east-southeast of Contramaestre. According to a personal communication from M. W. Cox, strata at and near San Luis are probably equivalent to those near Contramaestre. In the Guisa-Los Negros area the San Luis formation crops out in the low hills west of Bayamo River, in the Cautillo Valley, and in the Mafo Lowland. In the last-named region the formation is most completely exposed.

26/ Ortega y Ros, Pablo, Informe sobre el registro petrolero "Carco", denunciado en la Provincia de Santa Clara por la Compañia Petrolera Carco: Cuba Dir. Montes, Minas, y Aguas, Bol. Minas 15, p. 44, 1937.
27/ Taber, Stephen, op. cit., pp. 584-585, 1934.

The San Luis formation overlies the Charco Redondo limestone conformably. As already stated under the heading "Charco Redondo limestone," the formations interfinger west of Bayamo River, and a northward thinning of the Charco Redondo is probably due to gradation into the San Luis.

The top of the San Luis formation does not crop out within the limits of the mapped area. The greatest thickness, about 700 meters, is exposed in the Mafo Lowland.

The San Luis formation forms lowlands or low rolling hills, both of which are characterized by narrow strike ridges of limestone. The marl and calcareous mudstone, which constitute the bulk of the formation, are soil-covered, and are not exposed except in road cuts, trail trenches, and stream banks.

Stratigraphy and lithology.--Though composed principally of marl, calcareous mudstone, and limestone, the San Luis formation includes tuff, calcareous tuff, sandstone, and conglomerate. The marl and calcareous mudstone are cream-colored or light-brown when weathered; fresh rocks, observed only in material dug from wells, are gray. The limestone is partly thin-bedded and partly massive; both types form relatively thin zones—not more than a few meters thick. The thin-bedded limestone, which is the more abundant, is dense and grades through marly limestone into marl. The massive limestone is open-textured and algal or orbitoidal, closely resembling the prevailing type of limestone in the Charco Redondo.

Southwest of Mafo the lower part of the formation—that underlying a zone of limestone shown on the geologic map—consists principally of tuff and calcareous tuff, chiefly greenish. This unit of volcanic rocks has a maximum thickness of about 300 meters, but it thins rapidly westward and is apparently missing west of Baire. In the Mafo Lowland strata overlying the mapped limestone zone include thin beds of fine-grained to medium-grained tuff and marly tuff, as well as fine-grained to medium-grained tuffaceous sandstone. Tuffaceous material in the tuffaceous sandstone consists of rock and mineral grains, derived evidently from pre-existing volcanic rocks. Conglomerate consisting of well-rounded pebbles of indurated tuff, which have a maximum length of 5 centimeters, is exposed at localities lying $2\frac{1}{2}$ to 4 kilometers west-northwest of Mafo. None of the rock types just mentioned was observed in the Cautillo Valley and west of Bayamo River.

Fossils and age.--Smaller Foraminifera were collected from marl and calcareous mudstone of the San Luis formation in Cautillo Valley at localities 24 and 25, and in the Mafo Lowland at localities 27, 29, and 30. This material was examined by Dorothy K. Palmer, of Habana, whose report, made available through the courtesy of officials of the Atlantic Refining Co., is as follows:

Foraminifera from San Luis formation

[Identifications and comments by Dorothy K. Palmer]

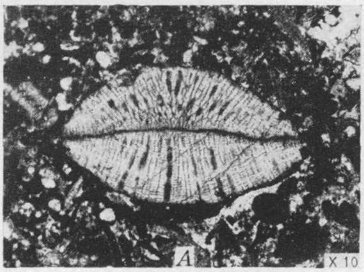
Locality 24 (W 34). Southwest side of Cautillo Valley, trail trench 1.5 kilometers southwest of Calabazar. The assemblage includes the following characteristic species:

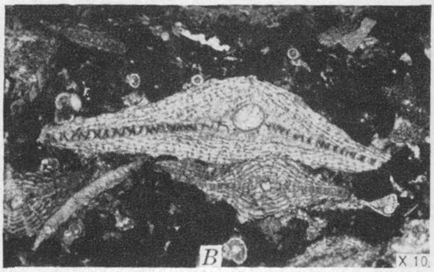
Ammodiscus incertus (d'Orbigny)
Vulvulina cf. colei Cushman
Clavulinoides marielinus Cushman and Bermúdez
Listerella cf. caribaea Cushman and Bermúdez
Karreriella cubensis Cushman and Bermúdez
Gaudryina chapopotensis (Cole)
Chrysalogonium tenuicostatum Cushman and Bermúdez
Robulus pseudocultratus Cole
Vaginulina costifera Cole
Vaginulina legumen (Linné) var. elegans (d'Orbigny)
Glandulina radicula (Linné)
Nonion micrus Cole
Bulimina tuxpamensis Cole
Chrysalidinella cubana Cushman and Bermúdez
Uvigerina aff. blanca-costata Cole
Uvigerina cf. gladysae Cole
Nodosarella subnodosa (Guppy)
Ellipsonodosaria cocoaensis Cushman
Ellipsonodosaria curvatura Cushman
Ellipsonodosaria decurta Bermúdez
Eponides trümpyi Nuttall
Eponides umbonata (Reuss)
Rotalia cf. mexicana Nuttall var. mecatepecensis Nuttall
Pulvinulinella culter (Parker and Jones) var. mexicana Cole
Globigerina cf. bakeri Cole
Globigerina dissimilis Cushman and Bermúdez
Globigerina mexicana Cushman
Hantkenina alabamensis Cushman
Globorotalia centralis Cushman and Bermúdez
Cycloloculina cubensis Cushman and Bermúdez
Cibicides cf. acuta (Plummer)
Cibicides cushmani Nuttall
Cibicides tuxpamensis Cole
Cibicides cf. pseudowuellorstorfi Cole
Anomalina grosserugosa Gümbel
Discocyclina (Asterocyclina) sp.
Lepidocyclina (Lepidocyclina) aff. subglobosa Nuttall

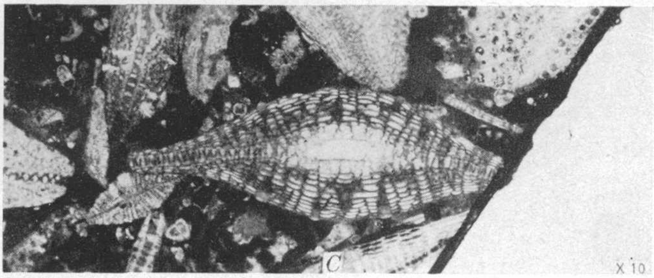
Locality 25 (W 35). Southwest side of Cautillo Valley, water-well dump 2.7 kilometers south of Calabazar. The faunal assemblage is almost identical with that from locality 24. In addition, well-preserved specimens of Textularia cf. eocaenica Gümbel and Pulvinulinella cancellata Cushman and Bermúdez were noted.

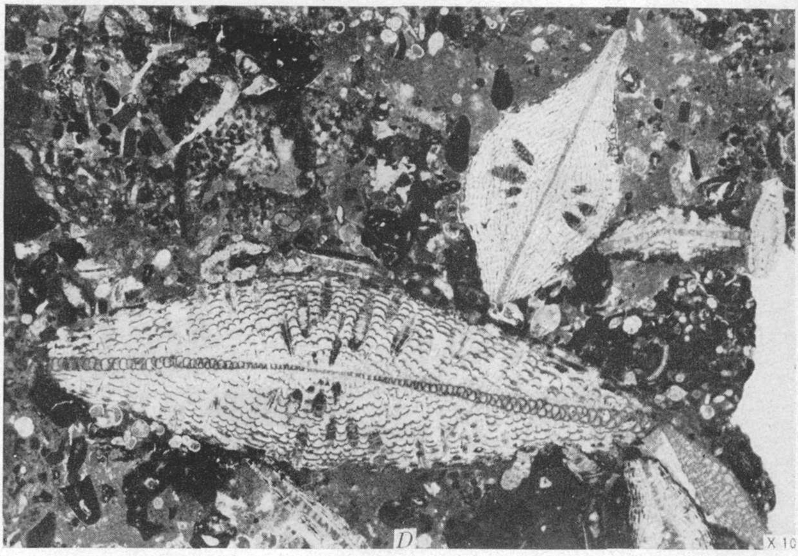
Locality 30 (W 41). Eastern part of Mafo on road to Estrella and Sorpresa mines, 300 meters east of plaza. The assemblage is similar to that at locality 24, but the following additional species are represented:

Allomorphina trigona Reuss
Chilostomelloides oviformis (Sherborn and Chapman)
Ceratobulimina sp.
Bulimina cf. inflata Seguenza
Bulimina cf. pupoides d'Orbigny
Ammobaculites sp.
Pleurostomella rimosa Cushman and Bermúdez
Rotaliatina? mexicana Cushman









FORAMINIFERA FROM CHARCO REDONDO LIMESTONE AND SAN LUIS FORMATION.

A. *Discocyclina crassa* (Cushman), × 10. Charco Redondo limestone, locality 12.
B. *Lepidocyclina* (*Pliolepidina*) *pustulosa* (Douvillé), × 10. Charco Redondo limestone, locality 19–L.
C. *Lepidocyclina* (*Pliolepidina*) *pustulosa tobleri* (Douvillé), × 10. San Luis formation, locality 28.
D. *Lepidocyclina* (*Pliolepidina*) *pustulosa* (Douvillé), × 10 (large specimen). *Discocyclina crassa* (Cushman), × 10 (small specimen at lower left). San Luis formation, locality 31.

Locality 29 (W 43). On trail, 2.8 kilometers west-southwest of Mafo. The assemblage is similar to that at locality 24, with the addition of the following:

Ammobaculites sp.
Ellipsoglandulina multicostata (Galloway and Morrey)
Pleurostomella sp.
Textularia cf. eocaenica (Gümbel)
Textularia marielensis Cushman and Bermúdez
Anomalina dorri Cole
Rotaliatina? mexicana Cushman

Locality 27 (W 45). Trail from Mafo to Baire, 3.2 kilometers southeast of Baire. The foraminiferal assemblage is approximately equivalent to that at locality 24, but comprises fewer species.

Locality 26 (W 46). North side of east approach to underpass on Central Highway, 4.2 kilometers (4.6 kilometers by highway) northwest of Baire. The assemblage includes the following distinctive species:

Robulus gutticostatus (Gümbel) var. cocoaensis (Cushman)
Marginulina cocoaensis Cushman
Nodosaria mexicana Cushman
Chrysalogonium tenuicostatum Cushman and Bermúdez
Amphimorphina cf. crassa Cushman and Bermúdez
Amphimorphina cf. lirata Cushman and Bermúdez
Plectofrondicularia cf. paucicostata Cushman and Jarvis
Bulimina consanguinea Parker and Bermúdez
Bulimina tuxpamensis Cole
Eponides jucundus Bermúdez
Siphonina nuda Cushman and Bermúdez
Planulina suturata Cushman and Bermúdez
Pulvinulinella culter (Parker and Jones) var. mexicana Cole
Chilostomella ovoidea Reuss
Chilostomelloides oviformis (Sherborn and Chapman)
Hantkenina alabamensis Cushman
Hantkenina brevispina Cushman
Globorotalia cerroazulensis (Cole)
Discocyclina (Asterocyclina) sp. (fragments)
Lepidocyclina sp. (fragments)
Pseudorbitolina sp. (fragments)

Massive open-textured limestone in the San Luis formation, like limestone of the same type in the Charco Redondo, contains orbitoids and other larger Foraminifera, and in places—the Sorpresa mine, for example—is crowded with orbitoids. The following species were collected:

Larger Foraminifera from San Luis formation

Species	Localities		
	23	28	31
Dictyoconus cf. americanus (Cushman)...............	X		
Operculina (Operculinoides) sp. (lenticular)........	X		
Operculina (Operculinoides) sp. (flat)..............		X	X
Lepidocyclina (Pliolepidina) pustulosa (Douvillé) (pl. 77, D).	X	X	X
Lepidocyclina (Pliolepidina) pustulosa tobleri (Douvillé) (pl. 77, C).		X	X
Discocyclina crassa (Cushman) (pl. 77, D)...........	X	X	X
Discocyclina cf. perkinsi Vaughan...................		X	X
Discocyclina (Asterocyclina?) sp....................	X	X	

23 (W 33). Trail on northeast side of Cautillo Valley, 4.7 kilometers northwest of Calabazar.

28 (W 44). Immediately northwest of trail from Mafo to Baire, 4.2 kilometers southeast of Baire.

31 (W 42). Massive limestone, 2 meters thick, at Sorpresa mine.

Mrs. Palmer has prepared the following comments on the age and relations of the smaller Foraminifera from the San Luis formation:

> The assemblages from the San Luis formation are assigned to the lower part of the upper Eocene. Most of the species listed have been reported from the Eocene of Mexico and Cuba. Many of the Mexican species are found in both the Tempoal (Guayabal of Cole) and Chapapote formations. The most characteristic species not found in both formations are from the Chapapote. The Tempoal fauna is regarded as of middle Eocene (Claiborne) age and the Chapapote as of upper Eocene (Jackson) age. The most closely related assemblage in western Cuba is that described by Bermúdez 28/ from Jabaco, Pinar del Río Province. The Jabaco fauna, however, represents somewhat shallower water, and this facies difference may account in large measure for the faunal difference. The Jabaco fauna also has some species in common with the Tempoal, but the general concensus of opinion is that it is slightly younger and approximately of lower Chapapote age.
>
> The assemblage from locality 26 differs slightly in characteristic species from the others. Though it includes some Tempoal species, it closely resembles the typical Chapapote fauna, and is almost identical with that from the upper part of the outcrop at Jabaco. On the basis of these relations, the assemblage at locality 26 is thought to be slightly younger than the others.

The San Luis formation, like the Charco Redondo limestone and the Cobre volcanics, contains an orbitoid fauna considered upper Eocene in age. On the basis of the smaller Foraminifera the San Luis is assigned to the early upper Eocene. Massive open-textured limestone in the San Luis is faunally, as well as lithologically, like limestone of that type in the Charco

28/ Bermúdez, P. J., Foraminíferos pequeños de las margas eocénicas de Guanajay, Provincia Pinar del Río, Cuba: Soc. Cubana Hist. Nat. Mem., vol. 11, pp. 325-328, 1937.

Redondo. Lepidocyclina pustulosa tobleri (pl. 77, C)—a form characterized by an enormous initial chamber—is rare in the San Luis and was not found in the Charco Redondo, despite the large number of collections from the Charco Redondo. This variety of L. pustulosa is recorded from upper Eocene formations in Mexico, Panama, Colombia, Curaçao, Venezuela, and Trinidad.

If the strata at locality 26, near the base of the San Luis northwest of Baire, are younger than those at other localities where smaller Foraminifera were collected, the section northwest of Baire is greatly abbreviated as compared with other localities, or is marked by one or more discontinuities.

Quaternary system

Older alluvium

An older and a younger alluvium have been separately mapped. The older alluvium covers areas of considerable extent along Contramaestre River at the eastern border of the mapped area, and small areas along Mogote River, a tributary of the Contramaestre, forming river terrace remnants at one to three levels. This older alluvium consists of brownish silt, sand, and gravel, generally poorly sorted. It is presumably of Quaternary age and may be Recent.

Younger alluvium

The younger alluvium is shown on the geologic map in southward-extending embayments of the Cautillo Plain and along some of the principal streams. Like the older alluvium it consists of silt, sand, and gravel, but it is not so distinctly brownish as the older alluvium.

Much of the Jiguaní Valley, mapped as alluvium, is littered with slabs of travertine, which cements limestone rubble along the northeast border of the valley. The geologic history of this travertine-littered area, part of which has a relief of a few meters, was not worked out.

INTRUSIVE IGNEOUS ROCKS

Dikes and small stocks are widespread in the Cobre volcanics, and at a few places they are intruded into the Charco Redondo limestone. In underground workings at the Yeya mine an andesitic dike cuts and metamorphoses the manganese ore. The largest and most conspicuous areas of intrusive rocks are shown on the geologic map. The intrusives are presumably of Eocene age, and those in the Cobre volcanics are probably almost contemporaneous with the pyroclastics and lavas.

The intrusive rocks are chiefly andesitic and dioritic.29/ Specimens from localities southeast of Guisa, south of the Antonia mine, and northwest of Palma del Perro were examined by

29/ Taber, Stephen, op. cit., pp. 541-544, 1931. Op. cit., pp. 578-579, 1934. Park, C. F., Jr., personal communication.

C. F. Park, Jr., who reports that they represent altered andesite porphyry. Coarse-grained dioritic rocks were observed south of the Yeya mine, where the Rosita prospects show magnetite and specularite in contact-metamorphosed limestone, and southwest of Baire. Quartz-bearing intrusives have not been found in the Guisa-Los Negros area. Quartz-bearing porphyry, tentatively designated dacite porphyry, is present in the Manacas district,30/ 20 kilometers southeast of Contramaestre, but it is not certain whether the porphyry forms a laccolith or a flow. According to Taber,31/ a dike of olivine basalt cuts the San Luis formation under the highway bridge at Contramaestre but no intrusive rocks were found elsewhere in the San Luis.

Most of the intrusive rocks in the Guisa-Los Negros area are dark-colored and dense; in places they are porphyritic. Dikes, such as those in the Guisa Lowland, form narrow ridges strewn with boulderlike masses that are the product of spheroidal weathering. The large intrusive body southeast of Santa Rita forms an area of low relief adjoining Jiguaní Valley. It is not certain that intrusive rocks constitute the bedrock formation throughout this area, but wherever bedrock exposures were observed they show dense or porphyritic igneous rock. Part of the area is covered with caliche, as may be seen in a trail trench leading to a small stream 5.6 kilometers east-southeast of Santa Rita. At that locality soft caliche as much as 2 feet thick overlies the igneous rock, and stringers of caliche extend down into cracks, forming a network in the rock.

STRUCTURE

The principal structural features of the Guisa-Los Negros area have a general northwesterly trend, as is apparent from the formation pattern on the geologic map—a trend that is oblique to the general westerly trend of the Sierra Maestra. The strata have in general a prevailing gentle dip to the north-northeast. Dips greater than 15° or 20° are rare, but locally there are steep dips, for the most part associated with faults. Major folds, generally broad, are few, but there are many abrupt minor folds and warps, particularly in the Cobre volcanics. Faults are very numerous.

Folds

The major folds—the Horno anticline, the Guisa anticline, the Cautillo syncline with the accompanying Lucia anticline, and the Loma La Gloria dome—have an average trend of N. 50° W. These folds are broad and gentle, with the exception of the Lucia anticline, which at least in its southern part, is relatively sharp. The Palma del Perro anticline, a fold of intermediate size, trends westward. Of all these folds, the Cautillo syncline has had the greatest effect on the regional structure, but, owing to a fault of considerable displacement on the northeast limb, this fold does not appear at the surface except at the southeast end.

30/ Park, C. F., Jr., and Cox, M. W., op. cit., p. 347.
31/ Taber, Stephen, op. cit., p. 586, 1934.

Faults

So far as observed the faults of the Guisa-Los Negros area are normal, with the exception of a steep reverse fault, dipping 70°, at the Effie mine in the southwestern part of the area. Most of the faults are, or are assumed to be, practically vertical; but some dip 30° to 70°. The displacement on most of the faults is not greater than 30 meters, but on some of them it is much greater. The fault that downthrows the Charco Redondo limestone against Cobre volcanics south of Las Cajitas has a displacement of about 150 meters; the fault between the San Luis formation and the Charco Redondo limestone on the northeast limb of the Cautillo syncline has an estimated maximum displacement of 200 meters. The displacement along the group of northeastward-trending faults in the eastern part of the area is estimated to be locally as great as 200 meters or more.

Northwestward- and northward-trending faults are most numerous. The downthrow on the majority of these faults is on the east, or northeast, but the greatest faults have their downthrow on the west and southwest, and their aggregate throw is greater than that of the faults whose throw is on the other side. The net result of this condition is that, in passing northeastward, one finds the upper part of the Cobre volcanics and much of the Charco Redondo limestone repeated. At several places northward-trending faults displace others of different trend.

The most conspicuous faults are those that displace the contact between the Cobre volcanics and the Charco Redondo limestone, and these are doubtless much more numerous than shown on the geologic map. Mine workings reveal many small faults between these formations that would hardly be detected on the surface. At many places, in both outcrops and mine workings, faults apparently die out in the Cobre volcanics a short distance from the point where they leave the Charco Redondo limestone. They are difficult to detect, however, in outcrops of Cobre volcanics. Those that are shown on the geologic map in areas of Cobre volcanics are based on observed displacements of Charco Redondo limestone, or of limestone beds in the volcanics. Faults in the Charco Redondo limestone are marked by brecciated zones, locally as much as 30 meters wide. Deep linear gashes and relatively straight lines of sink holes in the heavily forested karstland of Charco Redondo limestone (pl. 75)—shown by a separate pattern on the geologic map—probably mark faults. They were not examined, but some of them are known to lie along the extension of faults.

Structural history

The deformation that produced the folds and faults in the Güisa-Los Negros area cannot be dated in the area itself, further than by saying that in at least the northern part of the area it is obviously later than deposition of the early upper Eocene San Luis formation. In the Santiago de Cuba basin, however, 50 kilometers east-southeast of the Guisa-Los Negros area, the mildly deformed middle Miocene La Cruz marl 32/ rests with marked unconformity on strongly deformed Cobre volcanics,

32/ The designation "marl" is hardly appropriate for the La Cruz formation, which contains very little marl.

at least the upper parts of which are of early upper Eocene age. In the Santiago de Cuba basin, therefore, and presumably also in the Guisa-Los Negros area, the main deformation must have taken place within the interval between upper Eocene and middle Miocene. Closer dating might be made by determining the relations of strata, apparently of Oligocene age, with the underlying San Luis formation in the drainage basin of Guaninicum River north of San Luis, and the relations between the Eocene formations of the Sierra Maestra foothills and Taber's Manzanillo formation. Mansfield 33/ considered the Manzanillo formation lower Miocene—that is, older than the La Cruz marl—and the presence of Orthaulax in the Manzanillo supports that age assignment. Elsewhere in Cuba, deformation of varying intensity took place after deposition of Oligocene strata and before deposition of the transgressive Güines limestone,34/ which is of upper Oligocene or lower Miocene age, or is transitional Oligocene-Miocene—although at some places in Habana Province the Güines limestone conformably overlies, and grades into, the upper Oligocene Cojimar formation.35/ The deformation marked by the unconformity at the base of the Güines limestone is closely dated as late Oligocene or about the end of the Oligocene—depending on the position of the Oligocene-Miocene boundary—and the deformation in the Sierra Maestra is presumably to be correlated with it.

Direct evidence for earlier or later deformation in the Guisa-Los Negros area is not now apparent. Park 36/ and Park and Cox 37/ concluded that the manganese was deposited by warm waters during the last stages of the period of vulcanism, in late Eocene or possibly early Oligocene time. If this conclusion is accepted, and if the manganese deposits that at many places are more or less closely associated with faults are primary deposits, faulting took place in at least the southern part of the area before the main period of deformation, or else the vulcanism persisted later than the early Oligocene. If, on the other hand, the manganese deposits are primarily of sedimentary origin—representing primary concentration during discontinuities in the deposition of tuff and limestone, and at many places later secondary concentration—the association of manganese deposits with faults may have no bearing on the structural history.

MANGANESE DEPOSITS

All the important manganese mines in the part of the Sierra Maestra manganese district west of Santiago de Cuba are located in the Guisa-Los Negros area, with the exception of the mines in the Bueycito district,38/ 25 kilometers southwest of Bayamo, and of those in the Manacas district,39/ 20 kilometers southeast

33/ Mansfield, W. C., in Taber, Stephen, op. cit., p. 587, 1934.

34/ Rutten, M. G., Geology of the northern part of the Province Santa Clara, Cuba: Geog. geol. Mededeel., Phys.-geol. Reeks, no. 11, pp. 5, 6, 28, 1936. Thiadens, A. A., Geology of the southern part of the Province Santa Clara, Cuba: Idem, no. 12, pp. 6, 50, 1937. Vermunt, L. W. J., Geology of the Province of Pinar del Río, Cuba: Idem, no. 13, pp. 6, 30, 33, 1937.

35/ Palmer, R. H., The geology of Havana, Cuba, and vicinity: Jour. Geology, vol. 42, pp. 134-135, 1934.

36/ Park, C. F., Jr., op. cit., p. 28.

37/ Park, C. F., Jr., and Cox, M. W., op. cit., p. 315.

38/ Idem, pp. 318-320.

39/ Idem, pp. 347-349.

of Contramaestre. Recorded shipments of manganese ore from the Guisa-Los Negros area totaled 44,770 long tons in 1942, about 18 percent of the total yield from Cuba during that year and 32 percent of the yield from small mines in Cuba.

The manganese ore minerals of the district are oxides. The mineralogy, physical properties, and origin of the ores have been discussed by Park 40/ and by Park and Cox.41/

Classification of the deposits

On the basis of their occurrence and association, the manganese deposits may be classified as follows:

Classification of manganese deposits of Guisa-Los Negros area

- Lode ore
  - Bedded ore
    - Bedded ore in limestone
    - Bedded ore in tuff
      - Bedded ore in tuff, not associated with bayate 42/
      - Bedded ore in tuff, associated with bayate
  - Nonbedded ore
    - Nonbedded ore in limestone
    - Nonbedded ore in tuff
- Surficial ore
  - Granzon 43/ ore
  - Cave ore

The types of deposits are shown in figure 20. The numbers designating types in figure 20 are used on the geologic map for indicating the location of those types. If more than one type is represented at a mine, the numbers near the symbol for that mine are arranged in order of decreasing importance. Mines and prospects are divided, on the map, into two groups, one including those whose total yield has been less than 1,000 tons, the other those that have yielded more than 1,000 tons. Names of mines described in detail in the report by Park and Cox 44/ are underscored on the map.

The preceding classification differs somewhat from the classification adopted by Park and Cox.45/ In their classification bedded deposits in the Charco Redondo limestone and San Luis formation are classed as limestone ore if they have a calcareous matrix, and as tuff ore if they have a tuff matrix. This distinction has a practical basis, as the two types of ore require different handling and milling. In the present report, on the other hand, the bedded deposits in these two mainly calcareous formations are all classed as bedded deposits in limestone, regardless of their matrix, in order to correlate the bedded deposits with the geology. Even if the distinction based on matrix had been made, there seldom would have been occasion to apply it, since most of the bedded deposits in the Charco Redondo limestone and San Luis formation have a tuff

---

40/ Park, C. F., Jr., op. cit., pp. 80-83, 90-94.

41/ Park, C. F., Jr., and Cox, M. W., op. cit., pp. 313-317.

42/ "Bayate" is a term widely used in Cuba for chert, generally brownish, reddish, or black.

43/ "Granzon" is a local term for surficial ore consisting of pellets of manganese oxide, but it is also used by miners for detrital lode ore.

44/ Park, C. F., Jr., and Cox, M. W., op. cit.

45/ Idem, pp. 313-315.

matrix; in fact, the only bedded deposits in those formations that are characterized by limestone matrix are those at the Guisa and Segunda Gloria mines and those on the borders of the Taratana group of mines. The black calcite matrix in the K6 adit of the Charco Redondo mine is secondary; the original matrix may have been tuff or limestone.

Park and Cox's subdivision of nonbedded deposits, moreover, depending on association or nonassociation with faults, is not adopted because the proper classification of many deposits on that basis is uncertain.

The yield in 1942 of the several types of ore, the symbols used on the map to distinguish those types, and examples of each type are shown in the table on the following page.

The small production of bedded ore associated with bayate in tuff is noteworthy, such ore being relatively abundant in some other parts of Oriente Province.

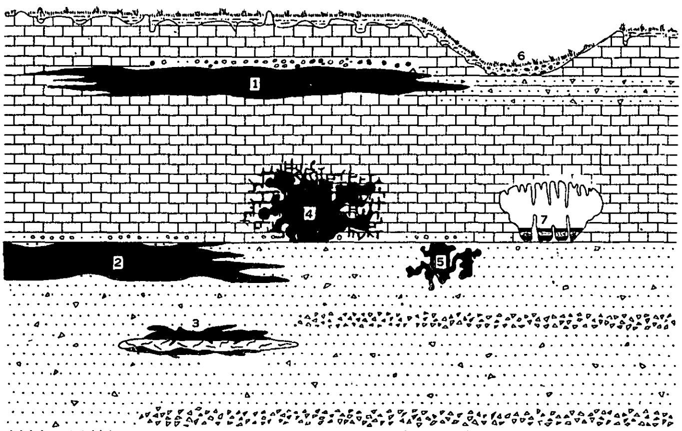


Figure 20.--Types of manganese deposits in Guisa-Los Negros area. 1, Bedded ore in limestone; 2, bedded ore in tuff, not associated with bayate; 3, bedded ore in tuff, associated with bayate; 4, nonbedded ore in limestone; 5, nonbedded ore in tuff; 6, granzon ore; and 7, cave ore.

SUGGESTIONS FOR PROSPECTING

Manganese deposits are found in the three bedrock sedimentary formations. It is apparent from the geologic map, however, that most of the known deposits, including all the important ones, are close to a contact between volcanic rocks (generally tuff) and limestone—a relation that was early recognized by Park.46/ There are fewer exceptions to this rule than one might infer from the map; as to some of these deposits, the map merely shows them to be in a limestone formation (Estrella and Sorpresa mines), in interbedded limestone and tuff (Yeya and Dichosa mines), or in a tuff formation (Santa Ana and Arroyon mines). As a matter of fact, all the deposits just mentioned are close to contacts between tuff and limestone. The mines not close to such contacts have indeed made only a negligible yield. Among them are the Fortuna (southwest of Mafo), Caridad (southwest of Los Negros), Cristina Segunda, Bessie, and La Justa.

46/ Park, C. F., Jr., op. cit., p. 88.

Production of manganese ore in Guisa-Los Negros area in 1942

Type of ore	Recorded production (long tons)	Percentage of total production	Map symbol	Examples
Bedded ore in limestone,	22,292	49.8	1	Charco Redondo, Taratana
Bedded ore in tuff, not associated with bayate.	12,668	28.3	2	Casualidad, Montenegro, Lucia
Bedded ore in tuff, associated with bayate.	170	.4	3	Santa Ana, La Justa
Nonbedded ore in limestone.	7,299	16.3	4	La Unica, Cádiz, Pozo Prieto, Progreso
Nonbedded ore in tuff.	2,341	5.2	5	Yeya, Effie, Arroyon
Granzon ore......	Small	....	6	San Alberto (part), Pozo Prieto (part)
Cave ore.........	Small	....	7	Antonio (part)

The most widespread contact between tuff and limestone is at the base of the Charco Redondo limestone. This contact is generally easy to recognize, being marked by a change in slope that is conspicuous except in areas of low relief. In the Charco Redondo-Casualidad district, the strongest mineralization is found along contacts where the transition from one formation to the other is abrupt,47/ and it may well be generally true that abrupt contacts are better worth prospecting than gradational contacts. Contacts between tuff and limestone in the zone of interbedded limestone and tuff in the eastern part of the Guisa-Los Negros area are likewise promising; the nonbedded ore, in a tuff-agglomerate lens in limestone overlying tuff, at the Yeya mine is in this part of the section. Only the thickest limestone in the Yeya district is shown on the geologic map, but the district contains other beds of limestone that are not shown; and in no other area where the zone of interbedded limestone and tuff is shown as a unit are beds of limestone mapped separately. Ore has been found in the Cobre volcanics in association with thin beds of limestone, but only in small amount.

At many places there are manganese deposits more or less closely associated with faults. These deposits are found not only on fault contacts between limestone and tuff, but also on faults with limestone on both walls. In prospecting the contact between Cobre volcanics and Charco Redondo limestone, and similar contacts at other horizons, faults and brecciated zones that may have served to localize mineralization should be looked for. Faults of later date than the mineralization are common in the Guisa-Los Negros area.

Brecciated zones in limestone, including zones that may have localized mineralization, may possibly represent solution breccia as well as fault breccia, though no unequivocal examples of solution breccia have been recognized. Some minor

47/ Park, C. F., Jr., and Cox, M. W., op. cit., p. 329.

faults along the contact between tuff and limestone may likewise be due to solution of limestone, though they may be due to compaction of tuff.

Limestone close to contacts with tuff is especially deserving of attention from prospectors, as the yield of bedded ore in limestone during 1942 represents half of the total yield of the Guisa-Los Negros area during that year. Most of this ore came from three mines (the Charco Redondo and the two mines in the Taratana group) in which the ore beds are close to the base of the Charco Redondo limestone. Bedded manganese deposits at this horizon crop out at scattered localities in a strongly curved arc at the south end of the Cautillo syncline. So far no deposits of commercial grade have been found at the surface between Charco Redondo and Taratana. Whether deposits of better grade might be found farther north—that is, down the dip—owing to stronger concentration when the ore was first deposited or to secondary enrichment by water moving down dip, can be determined only by drilling. This is the most favorable area for prospecting by drilling.

Discovery of minable pockets of ore in limestone, which constitute the most widespread type of ore body in the Guisa-Los Negros area, requires careful search, and the prospecting of even small pockets and stringers. Although stringers or small pockets may pinch out, past experience has shown that they may open into large pockets or pipelike bodies that yield several thousand tons of ore.

O