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GEOLOGICAL SURVEY OF THE DOMINICAN REPUBLIC
THOMAS WAYLAND VAUGHAN, Geologist in Charge

MEMOIRS, VOL. I

A GEOLOGICAL RECONNAISSANCE OF THE DOMINICAN REPUBLIC

BY

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A GEOLOGICAL RECONNAISSANCE OF THE DOMINICAN REPUBLIC.

CHAPTER I.

INTRODUCTION.

By THOMAS WAYLAND VAUGHAN.

PRELIMINARY ARRANGEMENTS FOR THE GEOLOGIC SURVEY.

On April 1, 1917, Rear Admiral H. S. Knapp, Military Governor of the Dominican Republic, addressed to the Director of the United States Geological Survey a request for an estimate of the cost of a complete mensuration survey of the Republic and of supplemental mineralogical and botanical investigations. The estimates requested were furnished to Admiral Knapp, and after further correspondence it was agreed that the direction of a topographic and geologic survey of the Republic should be undertaken by the United States Geological Survey, the expense of the work, except that of certain office and laboratory investigations, to be borne by the Dominican Government.

There is no adequate base map of the Dominican Republic, and as a detailed geologic survey must be based upon detailed topographic maps more thorough geologic studies must await the completion of the topographic mapping; but as so little reliable information concerning the geology was available it appeared necessary to make preliminary geologic examinations before beginning more detailed work. Accordingly, on December 4, 1918, the Director of the United States Geological Survey wrote to Admiral Knapp a letter which contained the following paragraph:

> At present the geologic formations in Santo Domingo are not sufficiently well known for purposes of geologic mapping, and not enough information is available on the mineral resources of the island to make practicable the formulation of plans for careful study. It therefore seems to me advisable to make a preliminary inspection of the Republic, and to collect fossils, rocks, minerals, etc., for shipment to Washington, where the material can be studied in connection with other investigations that are in progress. The proper study of such collections and the comparison of them with material from other parts of the West Indies, Central America, and the United States, would probably consume more than a year. The office work on these collections could be prosecuted in Washington without any expense to the Santo Domingo Government, if you are willing to have the material become a part of the United States National Museum collections. However, should a museum ever be established in Santo Domingo, the first set of duplicate specimens could be sent as a beginning toward a local museum. The office studies above outlined could be profitably done while the topographic survey is in progress

and then, by the time the topographic maps are available, more reliable geologic mapping will be possible than would be the case without a preliminary examination of the area and office study of collections made during such an examination.

About the time the letter containing this paragraph was dispatched Rear Admiral Knapp was succeeded as Military Governor by Rear Admiral Thomas Snowden, who acted favorably upon the recommendation of the Director of the United States Geological Survey.

The preliminary arrangements having been made, the Geological Survey party—Messrs. D. D. Condit, Wythe Cooke, C. P. Ross, and I—left New York for Santo Domingo City on March 24, 1919, and arrived there on the morning of April 5, after making reconnaissance examinations around Puerto Plata, Sânchez, and San Pedro de Macorís. On reaching the city I reported to Admiral Snowden and he referred me to Lieutenant Commander Baughman, who helped to complete the preparations for the geologic field work.

FIELD WORK.

The original plan comprised reconnaissance examinations of the Province of Seibo, the Samaná Peninsula, the Cordillera Septentrional, the Cibao Valley, the main Cordillera Central along at least three different routes, and the provinces of Azua and Barahona, including the Enriquillo basin. This plan was carried out, except that the Province of Seibo was not visited at all and that the Samaná Peninsula was examined only along its south shore and at its west end.

The itinerary of the party was as follows: On April 11, Messrs. Condit, Cooke, Ross, and I, in company with Lieutenant Colonel Glenn S. Smith, who has charge of the topographic surveys of the Republic, left Santo Domingo City by automobile for Hatillo, which is about 28.5 kilometers from the city, on the Carretera Durate. At Hatillo we took a pack train by way of El Madrigal, Sabana Grande, and Bonao to El Pino, at the northern foot of Loma Miranda, whence we went to La Vega, arriving there on April 15. At La Vega the party divided, Messrs. Cooke and Ross going to Cotui, Hatillo, Maimón, Cevicos, and Villa Rivas, whence Doctor Cooke went to Sânchez by train to do several days' work at the west end of Samaná Peninsula, while Mr. Ross worked westward along the southern foot of the Cordillera Septentrional toward Santiago de los Caballeros. Colonel Smith, Mr. Condit, and I went to Santiago, and the next day Colonel Smith and I started by automobile for Port-au-Prince, Haiti, while Mr. Condit made geologic studies from Tabera, at the northern foot of the Cordillera Central, across the Cibao Valley and as far north in the Cordillera Septentrional as Bajabónico, where his work connected with that carried southward from Puerto Plata.

Colonel Smith and I separated in Port-au-Prince, and I returned to Santiago by automobile, arriving there April 26. Messrs. Condit, Cooke, and Ross soon joined me at Santiago, and on May 1, after some examinations had been made near Santiago, Mr. Ross went by stage to Monte Cristi to study the western part of the valley of Rio Yaque del Norte, and Messrs. Condit and Cooke and I moved by pack train westward along the south side of the valley of Rio Yaque del Norte. Studies were made from the foothills of the Cordillera Central along Rio Amina as far downstream as Potrero, along Rio Mao as far downstream as Valverde (Mao), along Rio Gurabo as far downstream as a few kilometers below Gurabo Adentro, and Rio Cana was examined at Caimito. On May 10 Mr. Ross joined Messrs. Condit and Cooke and me at Gurabo Adentro and the next day the party again divided.

Doctor Cooke and I started for Santiago with our collections and reached there on May 12. On May 13 I left Santiago for Santo Domingo City by way of Moca and Sánchez and arrived there on May 17. On May 19 I left Santo Domingo City for Porto Rico and the Virgin Islands.

On May 11 Messrs. Condit and Ross started from Gurabo Adentro by way of Sabaneta for Restauración, whence they went across the Cordillera Central to Joca, and thence by Las Matas, to San Juan, reaching there on May 18. The remainder of May and a part of June were devoted to studies in the provinces of Azua and Barahona.

Doctor Cooke was detained several days in Santiago attending to the shipment of collections and did not leave there until May 18, when he started southward across the Cordillera Central. He went by Jarabacoa and Constanza, thence down Rio del Medio to Cañitas, and from there to Túbano and Azua, where he arrived on May 27. He spent the last days of May and part of June in work around Azua, San José de Ocoa, and Baní.

After concluding their work in Azua and Barahona provinces Messrs. Condit, Cooke, and Ross returned to Santo Domingo City. From Santo Domingo City as a base Mr. Condit examined the Perseverancia nickel prospect, Mr. Ross examined the San Cristóbal mining district, and Doctor Cooke made a trip to San Pedro de Macorís. Messrs. Condit and Cooke returned to Washington at the end of June, but Mr. Ross remained several weeks longer to make additional studies around Samaná Bay.

OFFICE WORK.

The original plan for the preliminary reconnaissance included office study of the field observations and the collections, with the intention of utilizing the information thus obtained in planning more careful investigations, but the preparation of a formal volume setting forth the results of the work was not contemplated. Two conditions of later development, however, seem to make it highly desirable that the information obtained be published as soon as practicable. The first of these conditions is the demand for a reliable account of the general geologic features of the Republic by those who are interested in the development of its natural resources. Although our work was only a preliminary inspection, we obtained far more information than has hitherto been available, and we may reasonably hope that its publication will be of some service. The other condition is the uncertainty regarding the continuity of personnel in the investigations. Mr. Condit resigned from the United States Geological Survey in October, 1919, to enter upon private commercial work, and later Messrs. Cooke and Ross both applied for furloughs for similar work. Under such conditions it is obvious that the information obtained through the preliminary studies should be put into such form as to make it available for geologists, whether working for the Government or privately, and as a consequence of these conditions this volume is issued.

Several members of the Geological Survey and others have assisted in the office study of the field data and collections. The chemical analyses of samples of water were made in the water-resources laboratory of the United States Geological Survey under the direction of Mr. C. H. Kidwell, formerly chief of the division of quality of water, and analyses of samples of other kinds were made in the chemical laboratory of the Geological Survey under the direction of Mr. George Steiger, chief chemist. The specimens of igneous and metamorphic rocks were determined by Mr. F. C. Calkins, geologist of the Geological Survey, and the chapter on economic geology was reviewed by Mr. H. G. Ferguson, also geologist of the Geological Survey. Specimens of rock and clay-sand were tested by the Bureau of Public Roads, United States Department of Agriculture. The very large paleontologic collections were sorted into groups and distributed to specialists for study and report. A list of the names of those who cooperated in the study of this material is given on page 89.

Although the chapters of this volume bear authors' names, it is not possible, in a product which is the result of the cooperative efforts of a group of workers, to designate exactly the share done by any one, and such a designation is probably of no great importance. The authors' names indicate those who devoted most attention to the preparation of the several chapters, but Dr. W. P. Woodring and I have reviewed the entire volume and have endeavored to see that the different parts of the report are accordant with one another. This has been a considerable task, as it had to be done in the absence of Messrs. Condit, Cooke, and Ross.

The preparation of the Spanish text has been a task of no small difficulty, because of the great number of technical terms employed. The book was rendered into Spanish by Señor E. M. Amores, chief translator of the Pan American Union, and the translation was carefully compared with the English original by Doctor Cooke. The quality of the result can best be judged by the reader. In justice to both these gentlemen it should be stated that the legends for the maps were written and draughted during Doctor Cooke's absence from the United States and before Señor Amores' services were engaged. The numerous errors in the Spanish legends were not detected until it was too late to correct them.

OUTLINE OF RESULTS.

PHYSIOGRAPHY.

The major physiographic subdivisions of the Republic were ascertained, and they are systematically described in Chapter III and are mapped on Plate I (opposite p. 26). This work has never been done before. Gabb's description of the topography of Santo Domingo [1] contains much information, but it is not presented in a way to bring out clearly the relations between the different features.

STRATIGRAPHY AND GEOLOGIC CORRELATION.

Prior to the reconnaissance of 1919 the only geologic formations in the Dominican Republic that had been recorded consisted of beds of Cretaceous, Miocene, and post-Pliocene age. Doctor Carlotta J. Maury, as a result of her investigations in the valley of Rio Yaque del Norte, discriminated there two Miocene formations, the Cercado and Guarabo formations, and proposed for them the only two definite names that had been applied to Dominican geologic formations. Our examinations have probably yielded knowledge of at least most of the major stratigraphic units, but the basal complex must be more closely studied before it can be clearly understood. It certainly includes rocks of Cretaceous age and probably rocks of pre-Cretaceous age. We obtained additional data on the Cretaceous system and are able to correlate the formation exposed near Sabaneta with the Upper Cretaceous of Cuba, Jamaica, and other islands of the West Indies.

Among the important additions to knowledge made through the reconnaissance are the recognition of a great thickness of upper Eocene deposits, mostly limestones, the discovery of deposits of both middle and later Oligocene age, and the discovery of an unconformity between the Miocene Baitoa formation and the underlying middle Oligocene Tabera formation. Four additional Miocene formations were recognized in the Cibao Valley, and a late Miocene formation, the Cerros de Sal formation, was discriminated on the north side of Sierra de Bahoruco. Some other additions were also made to the knowledge of the stratigraphy.

The geologic correlation of the formations in one part of the Republic with those in other parts and with those in other regions must depend principally upon a knowledge of the remains of the organisms they contain. The preliminary lists of fossils given in Chapter VI show what was accomplished in acquiring knowledge of this kind, which is not only needed for geologic correlation, but is of great value in solving some problems of economic geology. More detailed investigations of the fossils than has yet been practicable will undoubtedly yield a larger amount of valuable information than that contained in this volume.

[1] See Bibliography, p. 18.

IGNEOUS ACTIVITY AND GEOLOGIC STRUCTURE.

Although the igneous rocks and their relations to the sedimentary deposits were only superficially investigated some information was obtained concerning the different kinds of rocks they include, their modes of occurrence, their areal distribution, and their geologic ages. There was igneous activity in the Republic prior to Upper Cretaceous time, and it was recurrent, if not persistent, in parts of the territory until almost Recent time. The igneous rocks of the Republic offer a promising field for investigation and enough was discovered concerning them to guide future work.

The most important result of the study of the geologic structure was the recognition of the highly significant part—in places the dominant part—played by faulting in the deformation of the rocks, and we who were engaged in the field felt keen regret that the lack of good maps and the shortness of the time at our disposal prevented us from studying the faults in detail. In future investigations of the mineral resources of the Republic the contacts of the igneous rocks and the fault systems will be among the phenomena that most need attention. The faults are worthy of study also because of the causal relation they may bear to the severe earthquakes that afflict the Republic from time to time, as it is highly probable that recurrent movement takes place along certain definite zones of fracture.

ECONOMIC GEOLOGY.

The object of the preliminary examination was to procure reliable information on which to base plans for a careful study of the economic geology of the Republic rather than to prepare a special report for publication, but the need of such reliable information as can be given is so obvious that it is now published. Chapter IX gives the results of a reconnaissance of the provinces of Azua and Barahona with particular reference to oil and salt and discusses the probabilities of obtaining supplies of ground water in the western part of the valley of Rio Yaque del Norte. The results of several special examinations of mineral properties are given in Chapter X, on the economic geology, and other information on the mineral resources is there summarized. There is in the Dominican Republic no established mining industry of more than local importance, and none may be developed, but the evidence now at hand appears to indicate that certain tracts are worthy of careful prospecting, and it is reasonable to suppose that still other tracts that may deserve attention will be discovered. One of the great handicaps of the Republic is its inadequate means of transportation, both within its own confines and with the outside world. The means of internal communication are steadily being improved, however, and as the resources of the Republic gain economic importance communication with the outside world may be bettered. Without cheap transportation, it scarcely need be said, low-grade mineral properties cannot be operated profitably.

CHAPTER II.

BIBLIOGRAPHY.

By WENDELL P. WOODRING.

The following list contains the titles of the principal publications on the geology and geography of the Dominican Republic, and the titles of some of the principal publications on the geology and geography of the Republic of Haiti, which are included in the list because of the close relations of the two Republics. The writer has examined all the publications listed. Publications that merely describe itineraries in either Republic are omitted, although some of them contain valuable geographic information. Notices of the occurrence of minerals, such as have appeared in consular reports, are likewise omitted, for they are usually based on unconfirmed rumors. Much of the reliable information contained in these papers is incorporated in the present report with proper acknowledgment, except that West Indies Pilot, vol. 1, and the charts of the Dominican shore issued by the Hydrographic Office of the United States Navy have been freely used in the description of the shore line without special credit other than that expressed here.

ABAD, JOSÉ RAMÓN, La República Dominicana; 400 pp., Santo Domingo, 1888. (Chapters 1-3, geography and topography; chapter 4, geology.)

AGAMENNONE, G., Il terremoto di Haiti (Antille) nella mattina del 29 diciembre, 1897: Soc. seismol. ital. Bull., vol. 4, pp. 177-191, 1898.

ALBERTI Y BOSCH, N., Apuntes para la prehistoria de Quisqueya, tomo 1, geológica y partes descriptivas; 148 pp., 14 pls., 67 figs., 4 maps, La Vega, 1912.

ARNOLD, RALPH, Conservation of the oil and gas resources of the Americas (Haiti and Santo Domingo): Second Pan Am. Sci. Congr. Proc., Sec. III, Conservation of Natural Resources, vol. 3, p. 224, 1917.)

BERGT, W., Zur Geologie von San Domingo: Naturwiss. Gesell. Isis in Dresden, Sitzungs. und Abband., Jahrgang 1897, pp. 61-64, 1897.

BERRY, E. W., Tertiary fossil plants from the Dominican Republic: U. S. Nat. Mus. Proc., vol. 59, No. 2363, pp. 117-127, pl. 21, 1921.

BRINSMADE, R. B., Iron in Santo Domingo: Min. and Sci. Press, vol. 117, pp. 356-358, sketch map, 1918.

BROWN, A. P. and PILSBRY, H. A., Fauna of the Gatun formation, Isthmus of Panama: Acad. Nat. Sci. Philadelphia Proc., vol. 63, pp. 336-373, 3 pls., 3 figs., 1911; vol. 64, pp. 500-519, 5 pls., 5 figs., 1912. (Includes descriptions of a few species of Mollusca from the Miocene of the Dominican Republic.)

CABON, A., Contribution à l'étude de la géographie d'Haïti; notes historique sur la détermination de la position géographique d'Haïti: Bull. semest. de l'observ. météorol. du Séminaire-Collège St. Martial, Jan.-June, 1916, pp. 51-67, 1916.

———— Contribution à l 'étude de la géographie d'Haïti; notes bibliographiques sur la géographie d'Haïti: Bull. semest. de l'observ. météorol. du Séminaire-Collège St. Martial, July-Dec., 1916, pp. 149-174, 1917; idem, Bull. ann. 1917, pp. 93-128, 1918.

CANU, FERDINAND, and BASSLER, R. S., Fossil Bryozoa from the West Indies: Carnegie Inst. Washington Pub. 291, pp. 75–102, 7 pls., 1919. (Describes and lists, on pages 75–76, the Maury collection of Bryozoa from the Miocene of the Dominican Republic.)

CONRAD, T. A., Remarks on the Tertiary strata of St. Domingo and Vicksburg (Miss.): Acad. Nat. Sci. Philadelphia Proc., pp. 198–199, 1852.

COOKE, C. W., A geologic reconnaisance in Santo Domingo (abstract): Geol. Soc. America Bull., vol. 31, pp. 217-219, 1920.

——— The stratigraphic significance of *Orthaulax* (abstract): Geol. Soc. America Bull., vol. 31, p. 206, 1920. (Contains discussion of species of *Orthaulax* from the Oligocene and Miocene of the Dominican Republic.)

COSSMANN, M., Étude comparative de fossiles miocéniques recueillis à la Martinique et à l'isthme de Panama: Jour. Conch., vol. 61, pp. 1–64, 5 pls., 1913. (Describes and figures several species of Mollusca from the Miocene of the Dominican Republic.)

COURTNEY, W. S., The gold fields of St. Domingo; 144 pp., New York, 1860.

CUSHMAN, J. A., Fossil Foraminifera from the West Indies: Carnegie Inst. Washington Pub. 291, pp. 23-71, 15 pls., 1919. (Describes and lists the Foraminifera collected by Miss Maury and her associates in 1917 and gives notes on the correlation and the physical conditions indicated by the fauna. Pages 25–27 refer particularly to the Dominican Republic.

DALL, W. H., Diagnoses of new Tertiary fossils from the southern United States: U. S. Nat. Mus. Proc., vol. 18, pp. 21–46, 1895. (Includes descriptions of mollusks from the Miocene of the Dominican Republic.)

——— Tertiary fauna of Florida: Wagner Free Inst. Sci. Philadelphia, vol. 3, pts. 1–6, pp. 1–1654, 60 pls., 1890–1903. (Contains figures of the species of mollusks described in the preceding paper and discussions of other species from the Miocene of the Dominican Republic.)

DE GARSTON, E. M., Mineral resources of the Dominican Republic: The Mining Journal, vol. 83, p. 682, 1908. [Iron ore in the Dominican Republic (abstract): Iron and Steel Inst. Jour., No. 3, 1908, pp. 495–496; Petroleum in the Dominican Republic (abstract): idem, p. 542; Coal in Dominican Republic (abstract): idem, p. 527.]

——— Mineral resources of the Dominican Republic: Board of Trade Journal, vol. 61, no. 600, pp. 450–452, 1908. [Manganese in Dominican Republic (abstract), Iron and Steel Inst. Jour., no. 3, p. 497, 1908.]

DE MOYA, C. N., Mapa de la Isla de Santo Domingo y Haïti: Published by Rand, McNally & Co., 1906. (Scale 1:400,000.)

DONNELLY, T. F., The copper deposits of San Cristobal, Santo Domingo: Am. Inst. Min. Eng. Bull. No. 104, pp. 1759–1768, 7 figs., 1915; Am. Inst. Min. Eng, Trans., vol. 52, pp. 645-656, 7 figs., 1916; Abstract: Mexican Min. Jour., vol. 21, pp. 8–10, 1916.

DUNCAN, P. M., On the fossil corals of the West Indian Islands: Part I, Geol. Soc. London Quart. Jour., vol. 19, pp. 406–458, 4 pls., 1863; Part II, vol. 20, 20–44 4 pls., 1864; Part III, vol. 20, pp. 358–374, 1864; Part IV, vol. 24, pp. 9–33, 2 pls. 1867.

——— On the correlation of the Miocene beds of the West Indian Islands: Geol. Mag., decade 1, vol. 3, pp. 97–102, 1864.

——— On the genera *Heterophyllia*, *Battersbya*, *Palaeocyclus*, and *Asterosmilia:* The anatomy of their species, and their position in the classification of the Sclerodermic Zoantharia: Roy. Soc. Phil. Trans., vol. 157, pp. 643–656, 2 pls., 1867. (Genus *Asterosmilia*, pp. 652–654, pl. 32, figs. 3a-3d, 4 and 5.)

——— A revision of the families and genera of the Sclerodermic Zoantharia, Ed. and H., or Madreporaria (*M. rugosa* excepted): Linn. Soc. Jour. (Zool.), vol. 18, pp. 1–204, 1884. (Contains notes on Dominican fossil corals.)

EGGERS, BARON H., Reise in das Innere von Santo Domingo: Petermanns Mitt., Band 34, II, pp. 35–41, map, 1888. (Account of a journey from Jarabacoa to Constanza and Pico del Valle.)

FABENS, J. W., Facts about Santo Domingo, 32 pp., map, New York, 1862. (Condensed and published under the title "Resources of Santo Domingo," 22 pp., map, Washington, 1869. The first publication was slightly revised and republished as "Resources of Santo Domingo," 30 pp., map, New York, 1871.

FALCONER, J. D., The evolution of the Antilles: Scottish Geog. Mag., vol. 18, pp. 369–376, 1902. (Discusses the tectonic features and geologic history of the West Indies and Central America.)

FERGUSON, E. G. W., The mineral resources of Haiti, West Indies: Mining World, vol. 31, pp. 133–135, 1909.

FORTUNAT, DANTES, Île d'Haïti [map]; Paris, 1888. (Scale, 1:400,000).

FRAZER, P., Archean characters of the nucleal ranges of the Antilles: British Assoc. Adv. Sci. Rept. 58th meeting, 1888, pp. 654–655, 1889.

GABB, W. M., Informes presentados al gobierno Dominicano por el professor William M. Gabb acerca del examen jeolójico del territorio de la República Dominicana en los años 1869–1871: Revista de Agricultura, Año V, Num. 11 (following p. 314) pp. 1–64; Año V, Num. 12 (following p. 330); pp. 65–92, Santo Domingo, 1910. (In Spanish and English.)

———— Notes on the geology of Santo Domingo: Am. Jour. Sci., 3d series, vol. 1, pp. 252–255, 1871.

———— On the occurrence of petroleum in the island of Santo Domingo: Am. Jour. Sci., 3d series, vol. 3, p. 481, 1872.

———— Description of some new genera of Mollusca: Acad. Nat. Sci. Philadelphia Proc., pp. 270–274, 2 pls. 1872. (Describes new genera from the Tertiary system of the Dominican Republic.)

———— On the Santo Domingo Miocene and its fossils: Am. Philos. Soc. Proc., vol. 12, pp. 371–373, 1873.

———— On the topography and geology of Santo Domingo: Am. Philos. Soc. Trans. new series, vol. 15, pp. 49–260, 2 maps, 1873.

———— Notes on West Indian fossils: Geol. Mag., decade 2, vol. 2, p. 544, 1875.

GARRISON, F. L., Gold in Santo Domingo: Eng. and Min. Jour., vol. 79, pp. 1128–1130 5 figs., 1905.

———— The Island of Santo Domingo; its natural resources and their prospective development: Cassier's Magazine, vol. 30, no. 5, pp. 395–412, 14 figs., map, 1906.

———— Gold mining in Santo Domingo: Eng. and Min. Jour., vol. 84, pp. 490–492, 5 figs., 1907.

———— Metallic sulphides in the tuffs of Santo Domingo: Mining and Sci. Press, vol. 95, pp. 305–310, 6 figs., 1907.

———— The minerals of Santo Domingo: Eng. and Min. Jour., vol. 99, pp. 641–644, 3 figs., 1915.

———— The copper deposits of San Cristobal, Santo Domingo: Am. Inst. Min. Eng. Bull. 108, pp. 2473–2474, 1915.

GARRISON, F. L., and CHALAS, A., Mining laws and legislation in Santo Domingo: Eng. and Min. Jour., vol. 84, pp. 588, 589, 1907.

GENTIL, R., and CHAUVET, H., Grande géographie de l'île d'Haïti, 384 pp., Paris, 1896.

GREGORY, J. W., Contributions to the palaeontology and geology of the West Indies: Geol. Soc. London Quart. Jour., vol. 51, pp. 255–310, 1 pl., 1895. (Contains notes on a number of species of fossil corals from the Dominican Republic.)

GUPPY, R. J. L., On the relations of the Tertiary formations of the West Indies: Geol. Soc. London Quart. Jour., vol. 22, pp. 570–593, 1 pl., 1866. (Contains a short account of the fauna of the Miocene of the Dominican Republic on pp. 574, 575.)

GUPPY, R. J. L., On the West Indian Tertiary fossils: Geol. Mag., decade 2, vol. 1, pp. 404–411, 433–446, 3 pls., 1874. (Contains a check-list of Tertiary fossils from the Island of Haiti.)

——— On the Miocene fossils of Haiti: Geol. Soc. London Quart. Jour., vol. 32, pp. 516–532, 2 pls., 1876.

——— The geological connexions of the Carribean region: Canadian Inst. Trans., vol. 8, pp. 373–391, map, 1909.

GUPPY, R. J. L., and DALL, W. H., Descriptions of Tertiary fossils from the Antillean region: U. S. Nat. Mus. Proc., vol. 19, pp. 303–331, 4 pls., 1896. (Includes descriptions of Mollusca from the Miocene of the Dominican Republic.)

HATCH, D., On a saliferous deposit in St. Domingo: Geol. Soc. London Quart. Jour., vol. 24, p. 335, 1868.

HENEKEN, T. S., On some Tertiary deposits in Santo Domingo, with notes on the fossil shells by J. C. Moore and on the fossil corals by W. Lonsdale: Geol. Soc. London Quart. Jour., vol. 9, pp. 115–134, 7 figs., 1853.

HILL, R. T., Fundamental geographic relation of the three Americas: Nat. Geog. Mag., vol. 7, pp. 175–181, map, 1896.

——— Cuba and Porto Rico, with other islands of the West Indies: 408 pp, 79 pls., 2 maps, New York, 1898. (Contains discussion of Haiti on pp. 236–295.)

——— The geology and physical geography of Jamaica: Mus. Comp. Zool. Harvard Coll. Bull., vol. 34, pp. 256, 41 pls., 40 figs., 1899. (Contains discussion of Dominican Republic on pp. 168–198.)

JONES, WILLIAM F., A geological reconnaissance in Haiti: Jour. Geology, vol. 26, No. 8, pp. 728–752, 1 pl., 10 figs., 1918.

KEMPTON, C. W., Some investigations of Santo Domingo minerals: Mining World, vol. 30, pp. 637-639, 8 figs., 1909.

KNAPP, I. N., Santo Domingo petroleum resources: Oil and Gas Jour., vol. 17, no. 5, p. 50, 1918.

KOFFMAHN, O. *See* Petermann, A.

LEDOUX, J. W., Placer salting in Santo Domingo: Eng. and Min. Jour., vol. 97, pp. 384–386, 1914.

LEWIS, HENRY P., Mining laws of Santo Domingo: Mining World, vol. 33, p. 804, 1910.

——— New mining law of the Dominican Republic: Mining Science, vol. 62, p. 473, 1910.

LÜTGENS, RUDOLF, Geographische und geologische Beobachtungen in Nordwest-Haïti: Geog. Gesell. in Hamburg Mitt., Band 32, pp. 41–90, 1 map, 3 pls., 10 figs., 1919.

MACHADO, MANUEL A., Datos sobre la estratificacion geológica de la República Dominicana: Gaceta Oficial, 2–5, Santo Domingo, July 10, 1912.

MAGNIN, J., Les gisements petrolifères de la République dominicaine: Jour. de Pétrole, vol. 7, pp. 99–101, 1907.

MAURY, CARLOTTA J., Santo Domingo type sections and fossils: Bull. Am. Paleont., pp. 165–459, pls. 27-68, 1917.

——— Santo Domingo paleontological explorations: Jour. Geology, vol. 26, no. 3, pp. 224–228, 1918.

——— A proposal of two new Miocene formational names: Science, new series, vol. 50, p. 591, 1919. (Proposes names Gurabo formation and Cercado formation for certain Miocene deposits in the valley of Rio Yaque del Norte.)

——— On the correlation of Porto Rican Tertiary formations with other Antillean and mainland horizons: Am. Jour. Sci., vol. 48, pp. 209-215, 1919. (Includes a correlation table showing the position of some of the Tertiary formations of the Dominican Republic.)

MAURY, CARLOTTA J., Tertiary Mollusca from Porto Rico: New York Acad. Sci., Scientific Survey of Porto Rico and the Virgin Islands, vol. 3, pt. 1, 77 pp., 9 pls. 1920. (Correlation table opposite p. 4 includes some of the Miocene deposits of the Dominican Republic.)

MILLER, GERRIT S., Jr., Bones cf mammals from Indian sites in Cuba and Santo Domingo: Smithsonian Misc. Coll., vol. 66, no. 12, 10 pp., 1 pl., 1916.

MOREAU DE SAINT-MÉRY, M. L. E., A topographical and political description of the Spanish part of Saint Domingo, translated from the French by William Cobbett: 2 vols.; vol. 1, 314 pp., vol. 2, 318 pp., Philadelphia, 1796. (Original French edition not available.)

——— Description topographique, physique, civile, politique et historique de la partie française de l'isle Saint-Domingue: 2 vols., vol. 1, 788 pp., 2 maps, 1797; vol. 2, 856 pp., Philadelphia, 1798.

MOORE, J. C., On some Tertiary beds in the Island of Santo Domingo, from notes by J. S. Heniker [sic], with remarks on the fossils: Geol. Soc. London Quart. Jour., vol. 6, pp. 39–44, 1850.

PETERMANN, A., Karte der Insel Haiti: Petermanns Mitt., Band 20, pl. 17, 1874. (Scale 1:1,100,000.) Koffmahn, O., Begleitworte zur Karte der Insel Haiti: Idem, pp. 321–323.

PILSBRY, H. A., A new Haitian Oligocene horizon: Acad. Nat. Sci. Philadelphia, Proc. vol. 62, pt. 2, pp. 487–489, 2 figs., 1910. (Describes a few species of mollusks from the Miocene of the Republic of Haiti.)

PILSBRY, H. A., and BROWN, A. P., Oligocene fossils from the neighborhood of Cartagena, Colombia, with notes on Haitian species: Acad. Nat. Sci. Philadelphia Proc., vol. 69, pp. 32–41, 2 pls., 1917. (Includes descriptions of a few species of mollusks from the Miocene of the Dominican Republic and the Republic of Haiti.)

PILSBRY, H. A., and JOHNSON, C. W., New Mollusca of the Santo Domingan Oligocene: Acad. Nat. Sci. Philadelphia Proc., vol. 69, pp. 150–202, 1917.

PILSBRY, H. A. and SHARP, BENJAMIN, Scaphopoda of the San Domingo Tertiary: Acad. Nat. Sci. Philadelphia Proc. pp. 465–475, 2 pls., 1897.

POEY Y AGUIRRE, ANDRÉS, Catalogue chronologique des tremblements de terre ressentis dans les Indes Occidentals de 1530 a 1858; suivi d'une bibliographie séismique concernant les travaux relatifs au tremblements de terre des Antilles: (Extrait de l'annuaire de la Société météorologique de France, tome 5, p. 75, séance du 12 mai, 1857) 76 pp., Versailles, 1858.

POURTALÈS, L. F., List of fossil corals collected by W. M. Gabb, Esq., in Santo Domingo: Geol. Mag., dec. 2, vol. 2, pp. 544–545, 1875.

RATHBUN, M. J., West Indian Tertiary decapod crustaceans: Carnegie Inst. Washington Pub. 291, pp. 159–184, 9 pls. 1919. (Includes descriptions of fossil Crustacea in the Gabb and Maury collections from the Dominican Republic.)

——— Additions to West Indian Tertiary decapod crustaceans: U. S. Nat. Mus. Proc., vol. 58, pp. 381–384, pl. 25, 1920. (Describes additional crustaceans collected by the expedition of 1919.)

RECLUS, ÉLISÉE, The earth and its inhabitants: edited by A. H. Keane, 19 vols., New York, 1886–1895. (Describes the Island of Haiti in vol. 2, pp. 396–422, 1891.)

RITTER, KARL, Naturhistorische Reise nach der westindlichen Insel Hayti: 206 pp, 6 maps, 3 pls., Stuttgart, 1836.

ROTH, H. L., Bibliography and cartography of Hispaniola: Royal Geog. Soc. Supp. Papers, vol. 2, pp. 43–97, 1889.

ROTHWELL, R. P., The gold fields of the southern portion of the Island of Santo Domingo: Am. Inst. Min. Eng. Trans., vol. 10, pp. 345–354, 1882; Eng. and Min. Jour., vol. 34, pp. 31–32, 1882.

Rouzier, S., Dictionnaire géographique et administratif universal d'Haïti: tome 1, 393 pp., 12 maps, 1 pl., 1892; tome 2, 402 pp., 3 maps, 6 pls., 16 figs., Paris, 1893. (Third volume not published.)

Ruschhaupt, F., On the salt mines of St. Domingo: Geol. Soc. London Quart. Jour., vol. 25, pp. 256–257, 1869. (Discussion pp. 257–258).

Sample, C. C., Amber in Santo Domingo: Eng. and Min. Jour., vol. 80, pp. 250–251, 1905).

Scherer, J., Earthquakes in Haiti, April 12–October 10, 1911: Seism. Soc. America Bull., vol. 1, no. 4, p. 171, 1911.

——— Great earthquakes in the Island of Haiti: Seism. Soc. America Bull., vol. 2, no. 3, pp. 161–180, map, 1912.

——— Notes on remarkable earthquake sounds in Haiti: Seism. Soc. America Bull., vol. 2, no. 4, pp. 230–232, 1912.

——— Les grands tremblements de terre dans l'île d'Haïti: Bull. semest. de l'observ. météorol. du Séminaire-Collège St. Martial, July-Dec., 1911, pp. 153–162, 1912.

——— Les tremblements de terre de l'île d'Haïti dans leur rapports avec le relief du sol et les fosses maritimes que l'entourent: Bull. semest. de l'observ. météorol. du Séminaire-Collège St. Martial, July-Dec., 1912, pp. 132-139, 1913.

[Scherer, J.] Catalogue chronologique des tremblements de terre ressentis dans l'île d'Haïti de 1551 a 1900: Bull. semest. de l'observ. météorol. du Séminaire-Collège St. Martial, July–Dec., 1913, pp. 147–151, 1914.

——— L'île d'Haïti et le tremblement de terre de Porto-Rico (du 11 octobre 1918): Bull. ann. de l'observ. météorol. du Seminaire-Collège St. Martial, 1918, p. 93, 1919.

Schoenrich, Otto, Santo Domingo, a country with a future: 418 pp., 30 pls., 1 map, New York, 1918. (Contains short discussion of geology and minerals on pp. 132–143.)

Schomburgk, Sir R. H., Visit to the valley of Constanza: The Athenaeum, No. 1291, pp. 797–799, 1852.

——— The peninsula and bay of Samaná in the Dominican Republic: Royal Geog. Soc. Jour., vol. 23, pp. 264–284, 1853.

——— Mapa de la Isla de Santo Domingo: Paris, 1858. (Scale 1: 400,000.)

Sievers, Wilhelm, Richard Ludwig's Reisen auf Santo Domingo 1888–1889: Gesell. für Erdkunde zu Berlin Zeitschr., Band 33, pp. 302-354, map, 1898.

Sowerby, G. B., Desciiptions of new species of fossil shells found by J. S. Heniker [sic], Esq.: Geol. Soc. London Quart. Jour., vol. 6, pp. 44–53, 2 pls., 1849.

Stuart, R., Haïti, or Hispaniola: Royal Geog. Soc. Jour., vol. 48, pp. 234–274, 1878.

Suess, E., Das Antilitz der Erde (French translation by E. de Margerie, entitled La face de la terre); 3 vols. and index, 3695 pp., 5 pl., 10 maps, 551 figs., 1905–1918. (Discusses tectonic features of the West Indies in vol. 1, pp. 113–124; 362–369; 724–737; vol. 3, pp. 1285–1292; 1628.)

Thomasset, H., Carte physique et politique de l'île d'Haïti: 1908, Port-au-Prince. (Scale 1:400,000.)

Tippenhauer, L. G., Die Insel Haïti, 693 pp., 21 pls., 23 figs., Leipzig, 1892.

——— Geologische Studien in Haïti; I, Aus der sudwestlichen Halbinsel: Petermanns Mitt., Band 45, II, pp. 25–29, map, 1899.

——— Beiträge zur Geologie Haïtis; II, Aus der nordwestlichen Halbinsel: Petermann's Mitt., Band 45, VII, pp. 153–155, map, 1899.

——— Beiträge zur Geologie Haïtis; III, Geologische studien zwischen Port-au-Prince, Jacmel, Bainet, und Grand-Goave: Petermann's Mitt., Band 45, IX, pp. 201–204, map, 1899.

TIPPENHAUER, L. G., Beiträge zur Geologie Haïtis; IV, Die Erzfundstätten von Terre-Neuve und Gonaïves: Petermann's Mitt., Band 47, VI, pp. 121–127, map, 2 figs., 1901.

———— Beiträge zur Geologie Haïtis; V, Das La Selle-Gebirge, die Cul-de-Sac-Ebene, und das Salzseengebiet: Petermanns Mitt., Band 47, VIII, pp. 169–178, map, 1901.

———— Beiträge zur Geologie Haïtis; VI, Das Lingnitlager von Maïssade, und der Aufstieg zum Zentralplateau von Gonaïves und von Norden aus: Petermanns Mitt., Band 47, IX, pp. 193–199, 3 maps, profiles, 3 figs., 1901.

———— Neuer Beiträge zur Topographie, Bevolkerungskunde, und Geologie Haïtis: Petermanns Mitt., Band 55, III, pp. 49–57, map, 1909.

TOULA, FRANZ, Eine jungtertiäre Fauna von Gatun am Panama Kanal: K. K. geolog. Reichsanst. Wien, Teil I, Band 58, pp. 673–760, 4 pls., 15 figs., 1908. Teil II, Band 61, pp. 487–530, 2 pls., 1911. (Refers to fossil Mollusca from Dominican Republic.)

VAUGHAN, T. W., Some fossil corals from the elevated reefs of Curaçao, Arube, and Bonaire: Geolog. Reichs. Mus. Leiden, ser. 2, Band. 2, pp. 1–91, 1901. (Discusses species of West Indian fossil corals and contains "A list of papers on the Recent and fossil stony corals and coral reefs of the West Indies, Florida, the Bermudas, the western shores of the Gulf of Mexico, and northeastern South America," pp. 78–91.)

———— [Correlation of the Cretaceous and Tertiary formations of the Antilles]: Washington Acad. Sci. Jour., vol. 5, no. 13, pp. 489–490, 1915.

———— Correlation of the Tertiary geologic formations of the southeastern United States, Central America, and the West Indies: Washington Acad. Sci. Jour., vol. 8, no. 9, pp. 268–276, 1918.

———— Geologic history of Central America and the West Indies during Cenozoic time: Geol. Soc. America Bull., vol. 29, pp. 615-630, 1918.

———— Fossil corals from Central America, Cuba, and Porto Rico, with an account of the American Tertiary, Pleistocene, and Recent coral reefs: U. S. Nat. Mus. Bull. 103, pp. 189–524, 1919. (Pages 213-218 deal particularly with the Dominican Republic.)

———— The biologic character and geologic correlation of the sedimentary formations of Panama in their relation to the geologic history of Central America and the West Indies: U. S. Nat. Mus. Bull. 103, pp. 547–612, 1919. (Contains, opposite p. 585, a correlation table showing the position of the known Tertiary formations of the Dominican Republic; discusses tectonic relations on pp. 601–603.

———— Stratigraphy of the Virgin Islands of the United States and of Culebra and Vieques Island (Abstract): Geol. Soc. America Bull., vol. 31, pp. 216–217, 1920. (Contains discussion of the correlation of the rocks of the Virgin Islands with those of the Dominican Republic.)

WADE, B. F., WHITE, A. D., and HOWE, S. G., Report of the commission of inquiry to Santo Domingo: Senate Document No. 9, 42d Cong., 1st sess., 297 pp, map, 1871. (Includes brief reports by W. P. Blake, J. S. Adams, and A. R. Marvine on the geology of parts of the Dominican Republic.)

WELLS, JAMES W., A survey journey in Santo Domingo, West Indies: Royal Geog. Soc. Supp. Papers, vol. 3, pp. 589-604, map, 1893. (An account of a trip through Enriquillo Basin.)

ANONYMOUS, Tremblement de terre à Saint-Domingue (Antilles): Cosmos, 47e année, nouvelle série no. 688, pp. 420, 421, 1898.

———— The Dominican Republic; published by direction of the Department of Promotion and Public Works for the Jamestown Ter-Centennial Exposition, 98 pp., 1907. (Chapter 1, geography and topography; Chapter 5, economic geology.)

———— Bermuda Islands, the Bahama Islands and the Greater Antilles: West Indies Pilot, vol. 1, 577 pp. Hydrographic Office, Washington, D. C., 1913.

CHAPTER III.

GEOGRAPHY.

By Wythe Cooke.

GENERAL FEATURES.

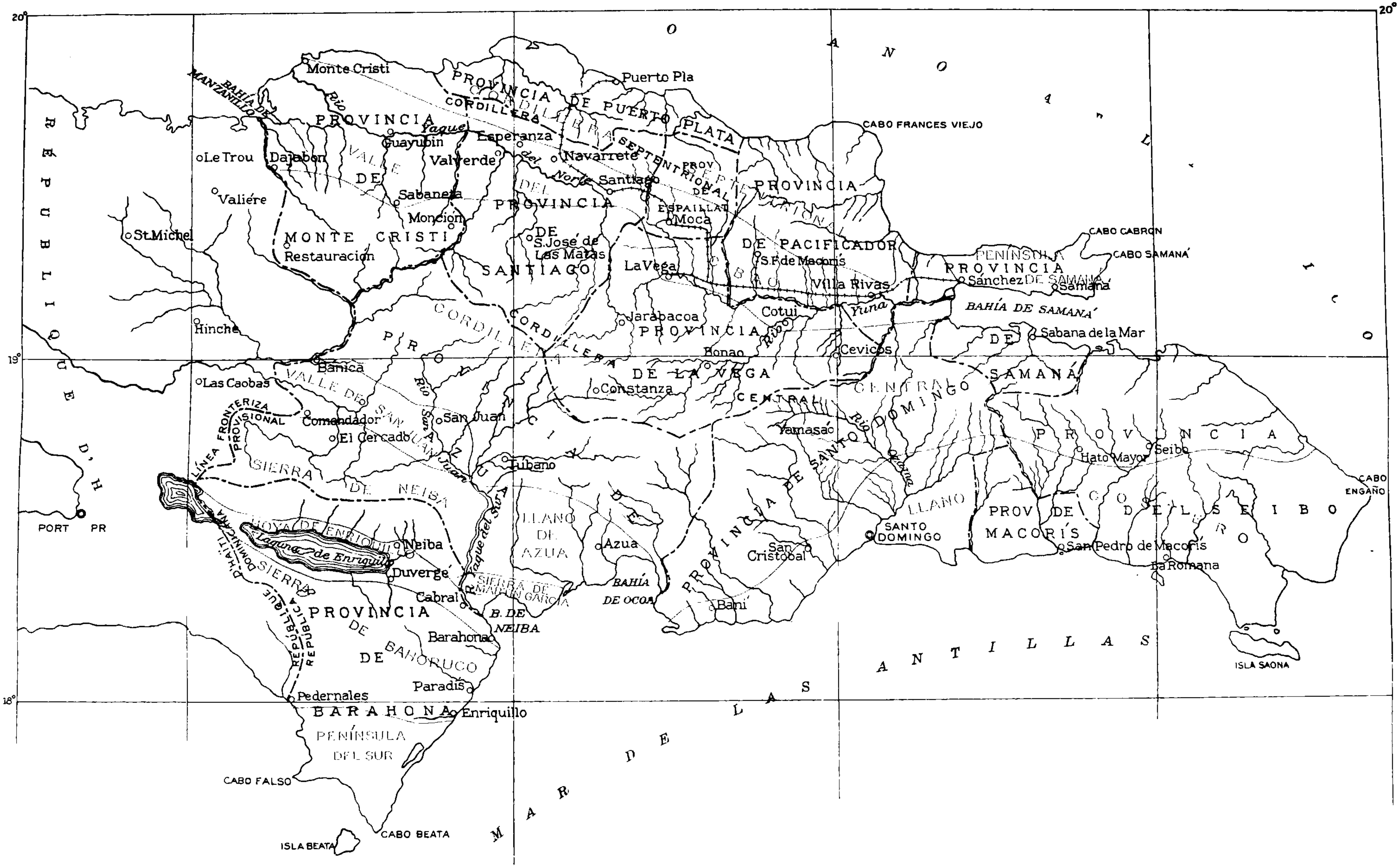
Haiti, which next to Cuba is the largest West Indian island, lies nearly midway between Cuba and Porto Rico. It is separated from Porto Rico, on the east, by the Mona Passage, and from Cuba, on the west, by the Windward Passage. As the maximum depth of water between Haiti and Porto Rico is about 318 fathoms (580 meters) these islands rise from a common, not greatly submerged bank, but the depth between Haiti and Cuba exceeds 1,000 fathoms (1,830 meters). The northern shore of Haiti is washed by the waters of the Atlantic Ocean; the southern shore forms part of the perimeter of the Caribbean Sea. The island lies wholly within the Torrid Zone, between parallels 17° 36′ 40″ and 19° 58′ 20″ north latitude. Its longitude ranges from about 68° 20′ to nearly 74° 30′ west of Greenwich. The area of the island is said to be 73,150 square kilometers, of which the Dominican Republic occupies the eastern two-thirds and the Republic of Haiti the western third, but until detailed accurate surveys are made and the boundary disputes between the republics are settled the true area of the island and that of its two political divisions will not be known.

Lying as it does at the intersection of two of the major tectonic trends of the Caribbean area,[1] the island of Haiti may be divided into two principal parts, a northern, including the greater part of the island, and a southern, including the southwestern peninsula and the area south of the Enriquillo Basin. The axes of the mountain ranges and principal valleys in the northern part trend about N. 60° W., are parallel, and are evidently genetically related to the physical features of central and eastern Cuba. The southern part extends nearly east and west, and its major tectonic axis is in line with the major axis of Jamaica. These two parts can be subdivided into several topographically distinct areas, which will be described separately. A third part, which is structurally distinct from the others, is the broad coastal plain—the plains of Seibo and Baní—in the southeastern part of the island.

The topographic divisions in the part of the island that is included in the Dominican Republic are the Cordillera Septentrional, Samanâ Peninsula, Cibao Valley, Cordillera Central, Valley of San Juan, Azua Plain, Sierra de Neiba, Sierra de Martín García, Enriquillo Basin, Sierra de Bahoruco, southern peninsula, and the coastal plain. The boundaries between these topographic areas are shown approximately on Plate I.

[1] Vaughan, T. W., U. S. Nat. Mus. Bull. 103, pp. 599–603, 1919.

REPÚBLICA DOMINICANA
SERVICIO GEOLÓGICO



CORDILLERA SEPTENTRIONAL.

The Cordillera Septentrional (Northern mountain system), sometimes called the Monte Cristi Range, starts as low, rounded rocky hills near Monte Cristi, extends southeastward for about 200 kilometers parallel to the northern coast, and terminates near the shore of Bahía Escocesa. It is made up of several more or less parallel ranges and a few isolated mountain masses.

The highest mountains in the Cordillera Septentrional are in its west-central part, north of Santiago, where some of the peaks are said to attain altitudes of 1,000 to 1,400 meters above sea level. The range near Santiago as seen from the south presents a fairly even sky line, broken by few serrated peaks such as characterize the Cordillera Central. (See Pl. II, *A*.) The parts of the range that project above the generally even profile have flat or rounded tops. The south front of this range is a fault scarp, which has been considerably modified by erosion.

The western part of the Cordillera Septentrional, to which the name "Monte Cristi Range" might appropriately be restricted, is very irregular. The hills and low mountains composing it are steep and in some places rough, but they do not rise to great heights. The part adjacent to Monte Cristi consists of isolated, rounded rocky hills, 60 meters or more high, rising abruptly from a rolling but, on the whole, level plain, which averages little more than 10 meters in height above sea level. El Morro de Monte Cristi, also called La Granja, shown in Plate II, *B*, is a narrow, wedge-shaped outlier about 225 meters high, composed of nearly horizontal sediments of Miocene age. It is separated from the mainland by salt marshes.[1]

At the arid west end of the Cordillera Septentrional there are few continuous water channels. A little farther to the southeast, where the hills are somewhat higher, the waterways are more continuous and better defined.

At the east end of the Cordillera Septentrional there is no steep southward-facing escarpment like the mountain front near Santiago. The ascent to the mountains proper from the Vega Real is over low foothills or spurs, which rise gradually to altitudes of 100 meters or more above the valley. The hills are composed of buff impure limestones which soften on exposure and afford few bare outcrops. The flat-topped mountains that form the summit of the Cordillera Septentrional between Altamira and El Aguacate suggest a peneplained surface at an altitude of about 650 meters. (See Pl. II, *C*.)

Monte Isabel de Torres (see Pl. III, *A*) rises steeply almost from the water's edge at Puerto Plata to an altitude of 815 meters above sea level and is a conspicuous landmark. As seen from the harbor it is wedge-shaped, and it culminates in a flat-topped peak, which is usually swathed in clouds. In

[1] For further description of the Monte Cristi region see Chapter VII of this volume.

the areas east and west of Puerto Plata the mountains lie back from the shore, and the area between them and the sea is hilly or rolling.

The upland west of Puerto Plata and north of Bajabónico consists of rather evenly sloping ridges whose summits reach altitudes of about 250 meters. Above these summits rise sharp little peaks composed of steeply dipping bedded rock. The surface represented by the summits of these ridges appears to extend around the south, the east, and the west sides of Monte Isabel de Torres, but the details of its features and their significance cannot be ascertained without careful study aided by adequate topographic maps. A low coastal apron extends around Puerto Plata and an alluvial flat along Rio San Marcos. Alluvial or detrital benches appear to reach as high as about 60 meters above sea level, but during the very hasty examination of Rio San Marcos valley no definite system of terraces could be recognized.

SAMANÁ PENINSULA.

Samaná Peninsula consists of a mass of fairly rugged but not very high mountains and at some places of a fringe of flat to rolling lowlands. It projects about 50 kilometers eastward from the northeast corner of the main island mass. Its average width from north to south is 11 or 12 kilometers. The west end of the peninsula is separated from the Cordillera Septentrional on the mainland by a flat, swampy area, the Gran Estero, which in the not very remote past was an open strait, but which has now become nearly closed, partly by uplift of the land and partly by filling in by silt brought down by the Rio Yuna. Water connection between Samaná Bay and the Atlantic Ocean through the Gran Estero is said to be still maintained by several distributaries of the Yuna.

The main mountain mass is divided into three parallel ridges. On the north coast, the mountains come down close to the sea but are interrupted by several stretches of broad, sandy beach. The southern ridge rises steeply from the water between Punta Balandra, at the southeastern extremity of the peninsula, and Los Cocos (see Pl. III, *B*), but west of Los Cocos it is bordered by a narrow fringe of rolling land, probably the dissected remnants of a series of terraces, which range in altitude from sea level to about 30 meters above it. (See Pl. III, *C*.) The mountains in the central part of the peninsula rise to about 500 meters above sea level, and a few are probably somewhat higher. Among the more prominent peaks whose altitudes are shown on the charts of the Hydrographic Office of the United States Navy are El Pilón de Azúcar (Sugar-loaf), 491 meters, 6 or 8 kilometers inland from Santa Barbara de Samaná; a neighboring peak, perhaps Monte la Mesa (Table Mountain), 558 meters; Monte Diablo, rising from the water at Punta Balandra to a height of 400 meters; and Loma Las Cañitas, at Sánchez, the highest point of which is said to be 514 meters above sea level.

At the east end of the peninsula, between Punta Balandra and the head of Rincón Bay, at an altitude of perhaps a hundred meters above sea level, there is a limestone plateau, which merges into the hills on the west side. This area is drained through sinks by subterranean streams, some of which are said to emerge on the beach as springs. Between Punta Balandra and Cabo Samaná several terraced flats, probably of marine origin, are plainly visible from the decks of passing steamers.

The rainfall is very heavy in Samaná Peninsula and it is more evenly distributed throughout the year than in some other parts of the island. As the climate is moist and the soil is fertile, the peninsula is clothed with a dense cover of vegetation which, except on the beaten trails, is in many places impassable.[1]

CIBAO VALLEY.

The Cibao Valley extends from Monte Cristi and Manzanillo Bay eastward to Samaná Bay, a distance of about 225 kilometers, and it ranges in width from about 15 to about 45 kilometers. It is bordered on the north by the Cordillera Septentrional, which is nearly straight, and on the south by the Cordillera Central, which has an irregular front and many reentrant valleys. In the vicinity of Santiago it is divided by a low, hilly watershed into two nearly equal parts.

The western half of the Cibao Valley is drained by Rio Yaque del Norte, which flows northwestward into Manzanillo Bay. Most of the country here is rolling and open, and the streams in it are deeply entrenched below the general level. The gently tilted limestone ledges of the Yaque group (Miocene) form ridges or hogbacks, some of which are 100 or 200 meters high. Among the more prominent hills on the south side of the Yaque are the Loma de Caracol and the Sierra Zamba.

The greater part of the west end of the Cibao Valley is occupied by the broad delta and flood plain of Rio Yaque, but between this low country and the foothills of the mountains lies a strip of higher land dotted with gravelly knolls, which appear to be remnants of a formerly continuous sheet of gravel. Farther upstream the flood plain narrows and finally disappears

The eastern half of the Cibao Valley is drained by Rio Yuna, which flows eastward into Samaná Bay, and its principal tributary, Rio Camú. These streams, as well as the smaller ones, are sharply incised. Between San Francisco de Macorís and Santiago the valleys are 15 to 25 meters deep and little more than 100 meters wide at the surface. The eastern part of the Cibao Valley includes the fertile Vega Real (Royal Meadow), which extends from the swamp lands at the head of Samaná Bay nearly to Santiago. The Vega Real is among the most impressively fertile districts in the world. Its nearly level plains yield large crops of cacao, tobacco, and bananas, and its grassy savannas afford excellent pasturage. It is traversed by the Ferrocarril de Santiago y Samaná.

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[1]For a more detailed description of Samaná Peninsula see pp. 181-185 of this volume.

South of the Vega Real, extending from Loma de los Palos eastward nearly to Sabana de la Mar, there is a plateau that stands 100 meters or more above the surrounding land. From a distance this plateau appears to be nearly flat, but closer inspection shows that it is deeply pitted with large cavities. It rises somewhat toward the east, and near Sabana de la Mar it attains an altitude of about 200 meters above sea level. This plateau is underlain by massive coralliferous limestone, probably of Miocene age, and is drained through underground passages. A trail from Cevicos to Villa Rivas, by far the most difficult trail travelled by any member of the expedition, crosses this plateau. From a point several kilometers south of Cevicos, where it first climbs to the plateau, the trail follows the course of an underground stream, which is marked by a chain of deep sinkholes connected by low passes. The surprised traveller scrambles down one side of a sink and up the other, over jagged masses of sharp limestone, only to find another sink, equally difficult and dangerous, just before him. There are said to be 24 of these holes to be crossed, but the weary traveller loses count long before he emerges upon the level plain of the Vega Real.

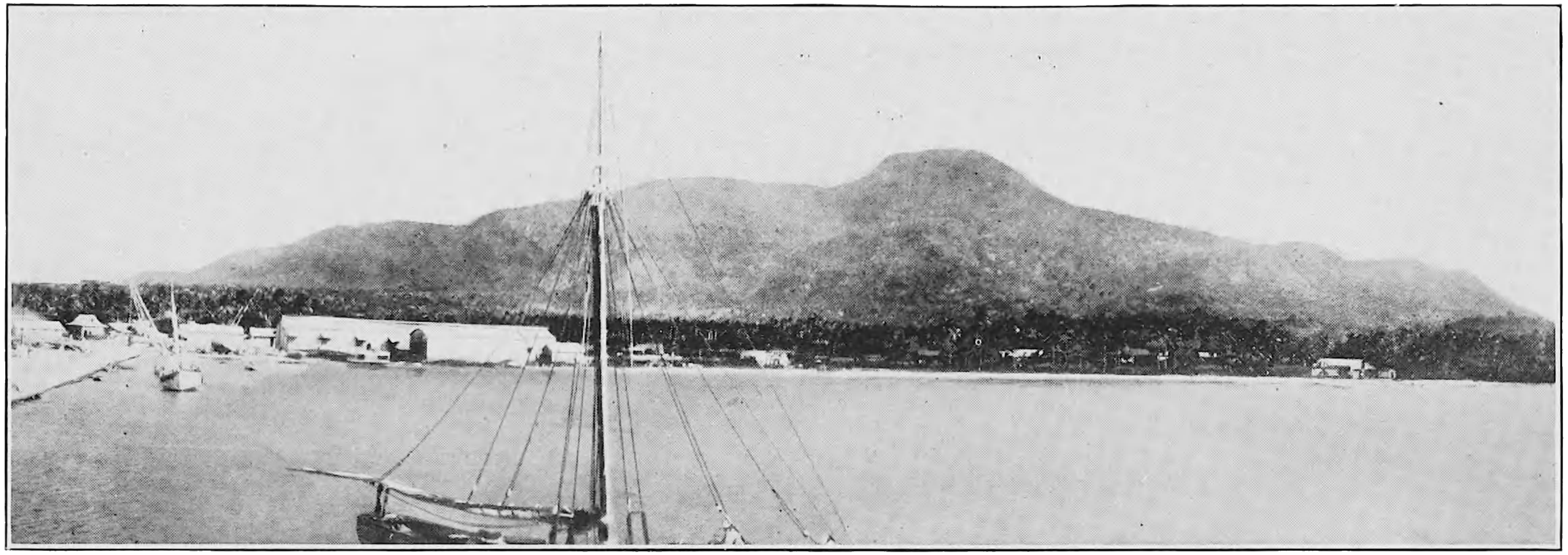
The part of the Cibao Valley that lies east of Santiago is abundantly watered (Pl. IV, *A*), but the part west of Santiago becomes progressively more arid westward, and open grassy meadows give way to cactus and mesquite clad plains (Pl. IV, *B*). Most of the water used for domestic purposes in this western area is carried on the backs of burros from Rio Yaque or its tributaries, in some places for as much as 20 kilometers.

The Cibao Valley is thickly settled, progressive, and prosperous. Santiago de los Caballeros, the second largest city in the country, is the metropolis of the region. It has direct rail connection with Puerto Plata by the Ferrocarril Central Dominicana, a government-owned railroad. which connects at Moca with the Ferrocarril de Santiago y Samaná, giving access to the port of Samaná. Other towns worthy of mention are Moca, La Vega, San Francisco de Macorís, and Villa Rivas on the east, and Navarrete, Valverde or Mao, Guayubin, and Monte Cristi on the west.

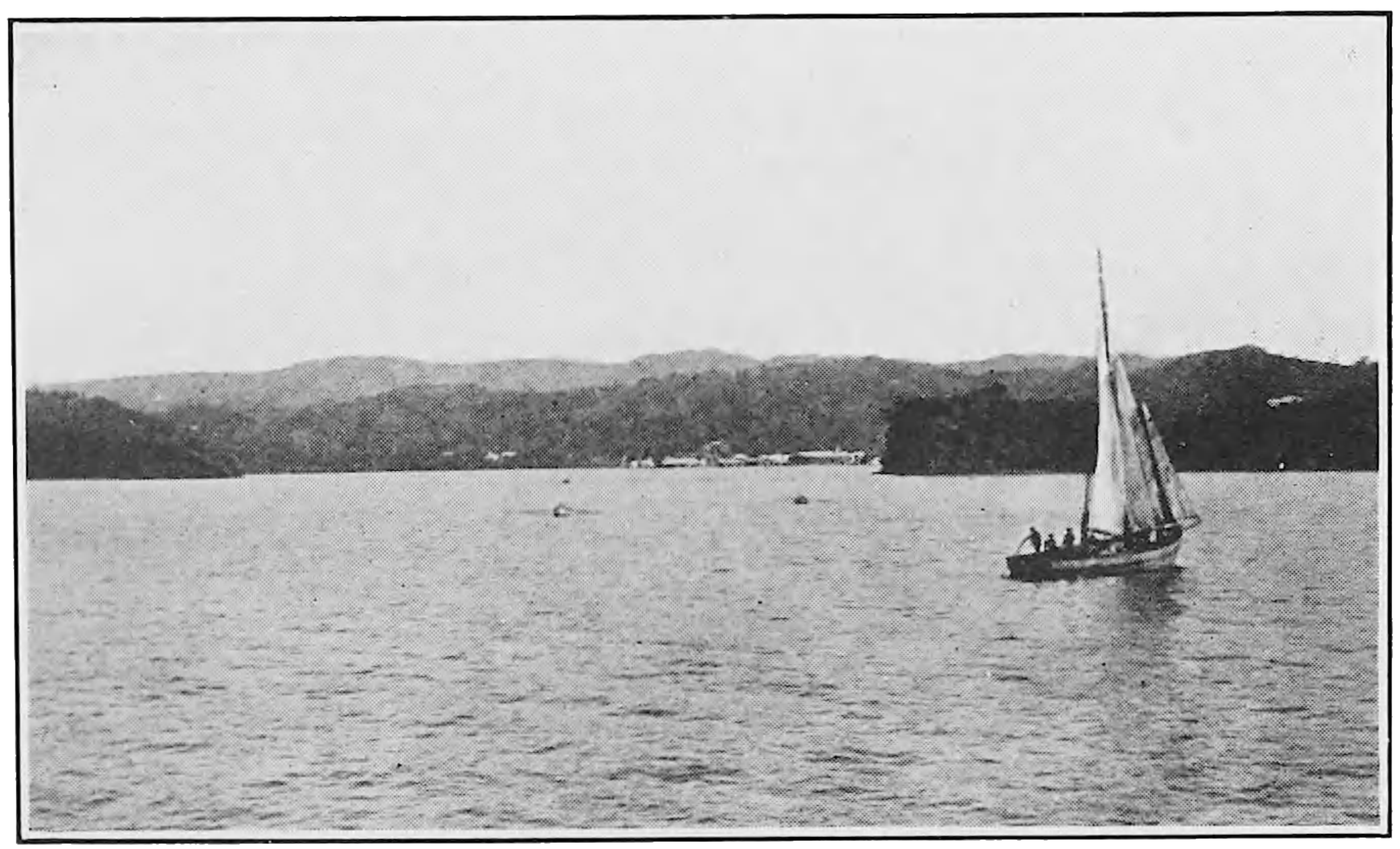
CORDILLERA CENTRAL.

GENERAL FEATURES.

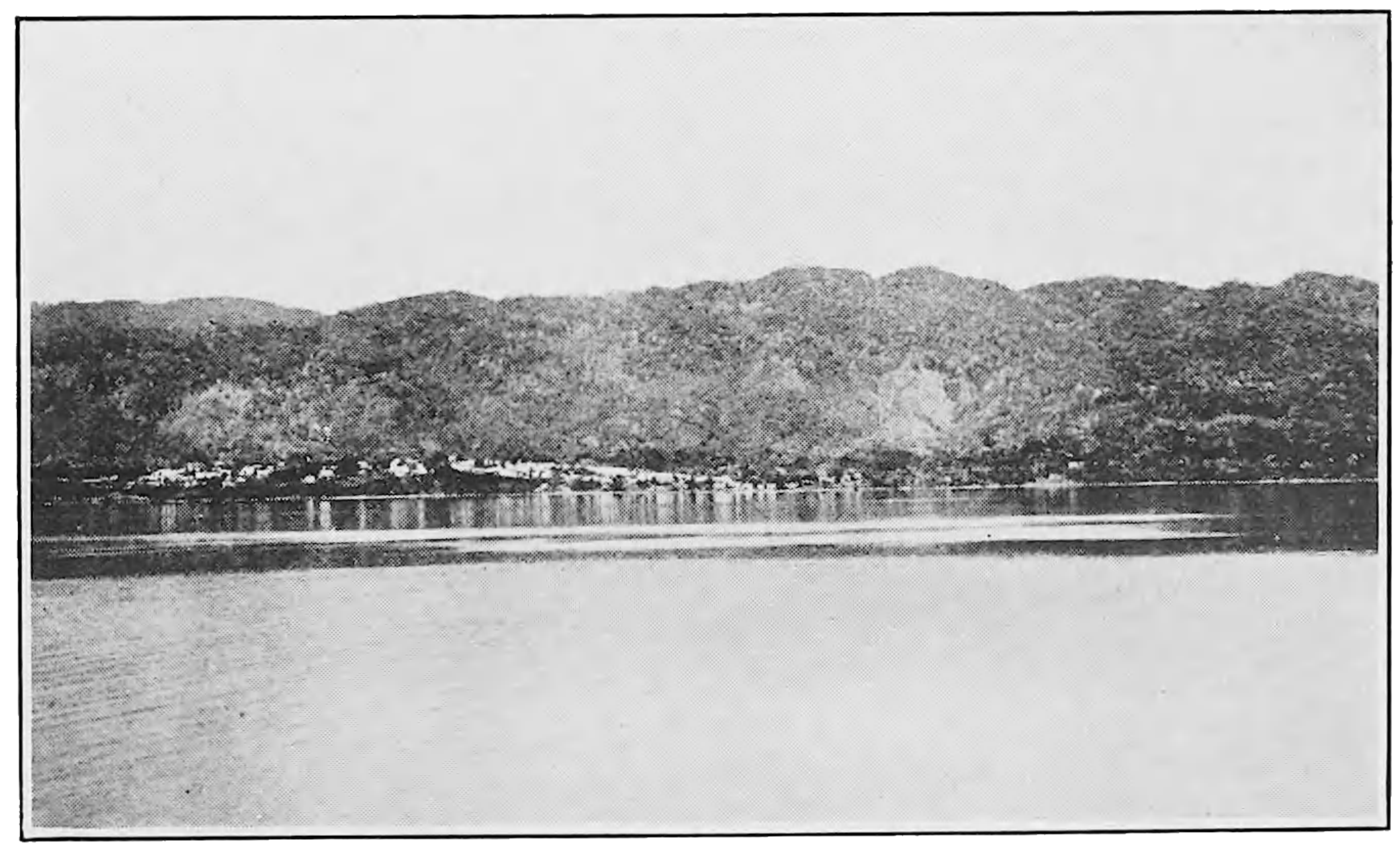
The great mountainous backbone of the Dominican Republic, the Cordillera Central, starts from low hills at the extreme east end of the island, rises gradually towards the west and attains its greatest height in the west-central part of the island. Its westward extension forms the north range of the Republic of Haiti and is connected by the Montagne Noir with the Sierra de Neiba. The range is widest in the middle, where it attains a width of 130 kilometers, extending from a point near Santiago to the latitude of Azua and sending a spur to the shore of the Caribbean Sea at Sabanabuey.



A. MONTE ISABEL DE TORRES.



B. SANTA BÁRBARA DE SAMANÁ.



C. SÁNCHEZ, SHOWING TERRACES BETWEEN THE HILLS AND THE SHORE.

To the traveller on the few trails across the mountains no systematic arrangement of the elements composing the Cordillera is perceptible. The range appears to be a jumble of ridges and peaks, with occasional unexpected beautiful little flat-bottomed valleys nestling at their feet. The causes of this irregularity are to be sought in the complex geologic composition and structure of the Cordillera. Not only does the central mountain mass include many different kinds of rocks—effusive and intrusive igneous rocks, schists and other metamorphics, and a great variety of sedimentary rocks—each of which has its own characteristic topographic development, but much of it has been faulted along several different axes and otherwise disturbed. Examples of discordant ridges due to faulting are Loma El Número, east of Ocoa Bay, and the mountain front north of Azua. Both of these ridges, which run nearly at right angles to one another, are outlined by faults.

BONAO TRAIL.

The route across the Cordillera Central most frequently used by travelers between the capital and towns in the Cibao Valley is the Bonao trail. This route leads from Santo Domingo City through Los Alcarrizos and Bonao to La Vega. The Duarte Highway (Carretera Duarte), now under construction, follows this old trail for a considerable distance but departs from it at places in order to take advantage of easier grades.

Hatillo, 28.5 kilometers from the capital, is in the low hills at the southern border of the Cordillera Central. The approach to Hatillo is over a gradually rising, rolling country, much of which is cultivated. The camp at this place marked the end of the part of the Carretera Duarte leading from Santo Domingo City which had been completed by April 1, 1919.

Between Hatillo and El Madrigal, a settlement of a few scattered houses, the country is rather open. Many of the valleys are steep-sided and the ridges are rather sharp, but the soil is deep and not much rock is exposed. (See Pl. V, *A* and *B*.) The higher mountains to the west are more rugged. Rio Jaina, where crossed, is clear and rapid, about one meter deep, 90 meters wide, and strewn with boulders. Near El Madrigal (see Pl. V, *C*) two terraces at heights of 26 and 49 meters respectively above the river were noted.

Between El Madrigal and Sabana Grande, which is marked by a single house, the route lies along the valleys of Rio Jaina and Arroyo Guananitos. The valley of Rio Jaina at El Madrigal is nearly 5 kilometers wide and has steep wooded hills on both sides. It is floored with clay, loam, and gravel, and is covered with a fairly dense growth of bushes, interspersed with somewhat swampy savannas. Arroyo Guananitos, above La Mata, is a small meandering stream having a fall of 4 or 5 meters per kilometer. Its channel is choked with logs and trees, and terraces of gravel and sand were noted at several places in its valley. The upper part of the valley of Arroyo

Guananitos is broad and nearly flat. At Sabana Grande, which is about 250 meters above sea level, it is more than 6 kilometers wide. The floors of the stream valleys, although wide and flat, are bordered by mountains. (See Pl. VI, *B*.) The scenery along the route is attractive in many ways and very picturesque.

The main divide of the Cordillera Central between Sabana Grande and Bonao is crossed by the Bonao trail at an altitude of about 430 meters above sea level. The trail is somewhat steep but not difficult in dry weather, but here, as in many other parts of it, mud is very troublesome at all times except near the end of the dry season. Small pines grow at altitudes above 340 meters. Mahogany was noted between Piedra Blanca and Hato del Bonao. The growth of bushes and small trees of many kinds is in most places very thick, and some tree ferns were seen.

Rio Juan Manuel, Arroyo Maimón, and several other clear, swift streams are passed between the summit of the divide and Bonao. No falls were seen, but there are numerous small rapids. None of the streams are large, but several are large enough to supply a small town with water, and perhaps also with some power.

Bonao, a town of about 1,000 inhabitants and by far the largest settlement between the capital and La Vega, stands on the fertile alluvial flat that borders Rio Yuna. It is the center of an agricultural community, which produces considerable quantities of cacao, tobacco, coffee, beans, and many kinds of fruits.

Rio Yuna, a broad stream about a meter and a half deep, is forded about 1 kilometer north of Bonao. The trail thence leads across a low divide into the valley of Rio Jima, a much smaller stream, crosses a low pine-clad ridge, and comes to Loma Miranda.

Loma Miranda is crossed at an altitude of about 290 meters above sea level. Its grades are among the steepest on the Bonao trail, the descent on the northwestern side to the Vega Real being especially abrupt. The Carretera Duarte avoids this mountain by making a detour down the valley of Rio Jima. At El Pino, near the foot of Loma Miranda, the trail joins the Carretera Duarte and follows the nearly level floor of the Vega Real to Concepción de La Vega.

SIERRA DE OCOA.

The name Sierra de Ocoa is applied to the part of the Cordillera Central that lies south of Rio de las Cuevas and west of Rio Nizao. This region is well watered, presenting a striking contrast to the thirsty plains of Azua that adjoin it on the south. In the midst of the mountains is the thickly settled, fertile, terraced valley of Rio Ocoa, which drâins almost the entire region and passes southward out of it through a gorge extending from San José de Ocoa to Los Ranchitos, near which it emerges upon the plain.

San José de Ocoa, better known by its old name of Maniel, is charmingly situated on an outwash slope and well-developed terrace at an altitude of about 50 meters above Rio Ocoa and about 450 meters above sea level. The town is nearly surrounded by sharp ridges of limestone, but from it can be seen the high mountains at the headwaters of the Ocoa. It boasts a church and plaza and three coffee mills, in which the coffee berries are shelled through hoppers. Besides coffee, the neighborhood produces large quantities of red beans (habichuelas). A small detachment of the Guardia Nacional is stationed here.

Communication with the outside world is maintained over three difficult trails. One little used trail leads northeastward across Loma Nizao (altitude of pass about 875 meters above sea level) to Nizao Arriba and thence to Cotuí, meeting the Bonao trail from Santo Domingo to La Vega at Piedra Blanca. Another very hilly trail, which is slippery in rainy weather, after passing numerous ridges descends from Loma de Portezuelo, which is about 650 meters above sea level, and comes out upon the plain at the village of Estebanía, from which an easy trail leads to Azua. The third descends the gorge of Rio Ocoa, fording the river 15 times between San José de Ocoa and the little settlement of Los Ranchitos, where it turns southeastward to Baní. This trail, of course, is impassable when the river is in flood.

The highest mountains on the island rise from the area north of the Sierra de Ocoa. The top of Loma Tina, said to be the highest peak in the West Indies, is reputed to be 3,140 meters above sea level. Monte Culo de Maco, less famed but perhaps equally lofty, towers out of the cañon of Rio del Medio opposite the little settlement of Las Cañitas. As viewed from the west the mountain resembles a great wedge with a long, smooth, southward-sloping flank, strongly suggestive of a dip slope of sedimentary rocks and steeply truncated at the north end. The western face is very steep. El Rucillo, or Pico del Yaque, said to be 2,955 meters high, is nearly midway between San José de las Matas and Túbano and about 20 kilometers north of Monte Culo de Maco.

CONSTANZA TRAIL.

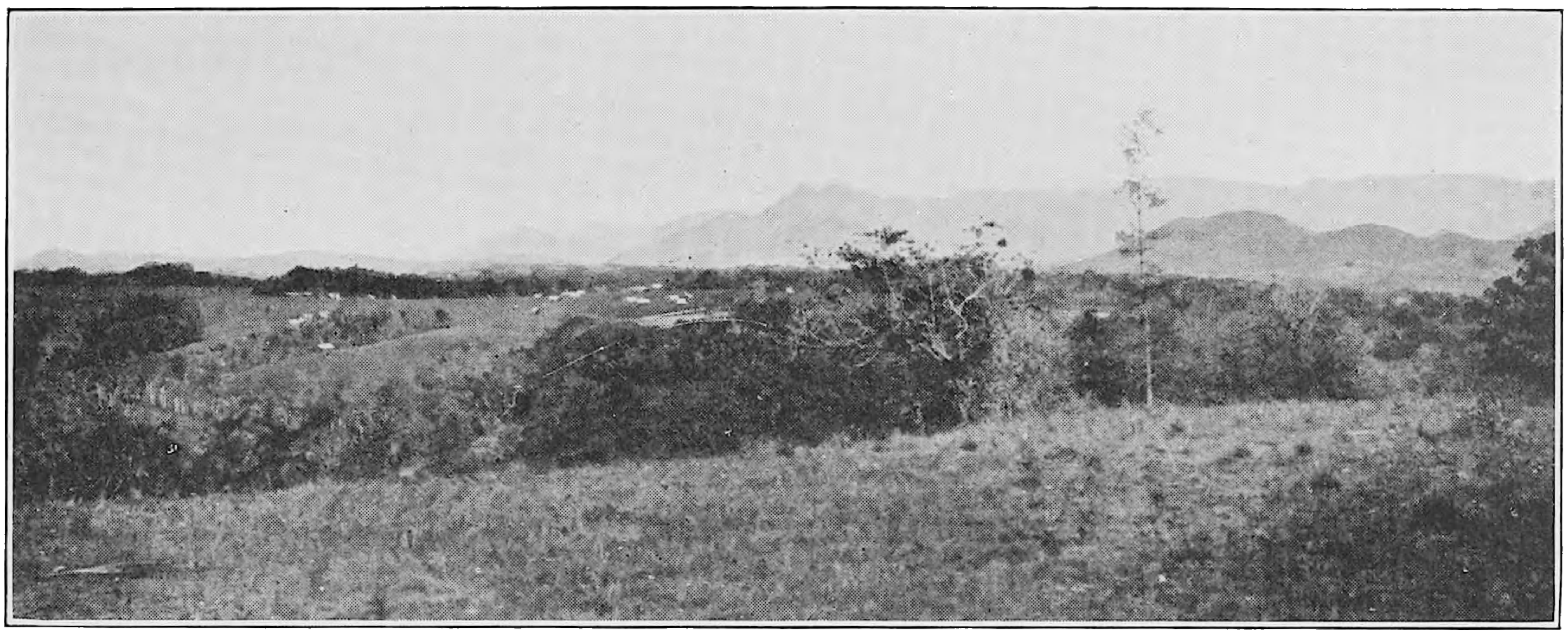
The part of the Cordillera Central that lies north of the Sierra de Ocoa is crossed by the Constanza trail, which leads from Santiago and La Vega through Jarabacoa and Constanza to San Juan and Túbano. From Santiago the trail leads up the east side of Rio Yaque del Norte and two or three kilometers below Angostura enters hills of coralliferous limestone and massive Miocene conglomerate. From Baitoa, a village of several hundred inhabitants, the trail passes southward or southeastward across steeply tilted conglomerate (Tabera formation) for about 2 kilometers, circles around a prominent double peak of hard limestone, and winds along a narrow, crooked ridge, which maintains a general southward trend and reaches a maximum altitude of about 415 meters above sea level. It then drops abruptly to Tabera, a little hamlet nestling in the Yaque Valley, surrounded by steep conical hills of conglomerate and brown shale just big enough to afford a perch for one or two houses. From Tabera the trail ascends gradually for 3 or 4 kilometers and then climbs a steep hill to an altitude of about 200 meters above sea level, where it is joined by a trail from La Vega.

From the summit of Loma Llanada or Loma de Joa (altitude about 630 meters), a great mass of serpentine, one can look southward across the wide valleys of Rio Yaque and Rio Jimenoa, and can get, far to the north, vistas of the Cibao Valley and the Monte Cristi Range, looming up beyond it. The south side of Loma Llanada is covered with an open pine forest, which gives way, near the base, to plant types more characteristic of the tropics, such as the royal palm, guava, and wild orange. In the lower, damp places the rose apple ("pomarrosa") flourishes in great luxuriance. Between Loma de Joa and Rio Jimenoa there are low hills and several small streams.

Jarabacoa, a compact little town of perhaps 1,000 inhabitants, is built on a terrace on the left bank of Rio Yaque del Norte at an altitude of about 480 meters above sea level. A well-defined higher terrace begins at the edge of the town, and corresponding terraces can be seen on the opposite side of the river. El Barrero (altitude about 1,000 meters) dominates the view on the south. From the top of hills near Jarabacoa can be seen the rounded peak of El Rucillo, and far away to the north the even profile of the Cordillera Septentrional.

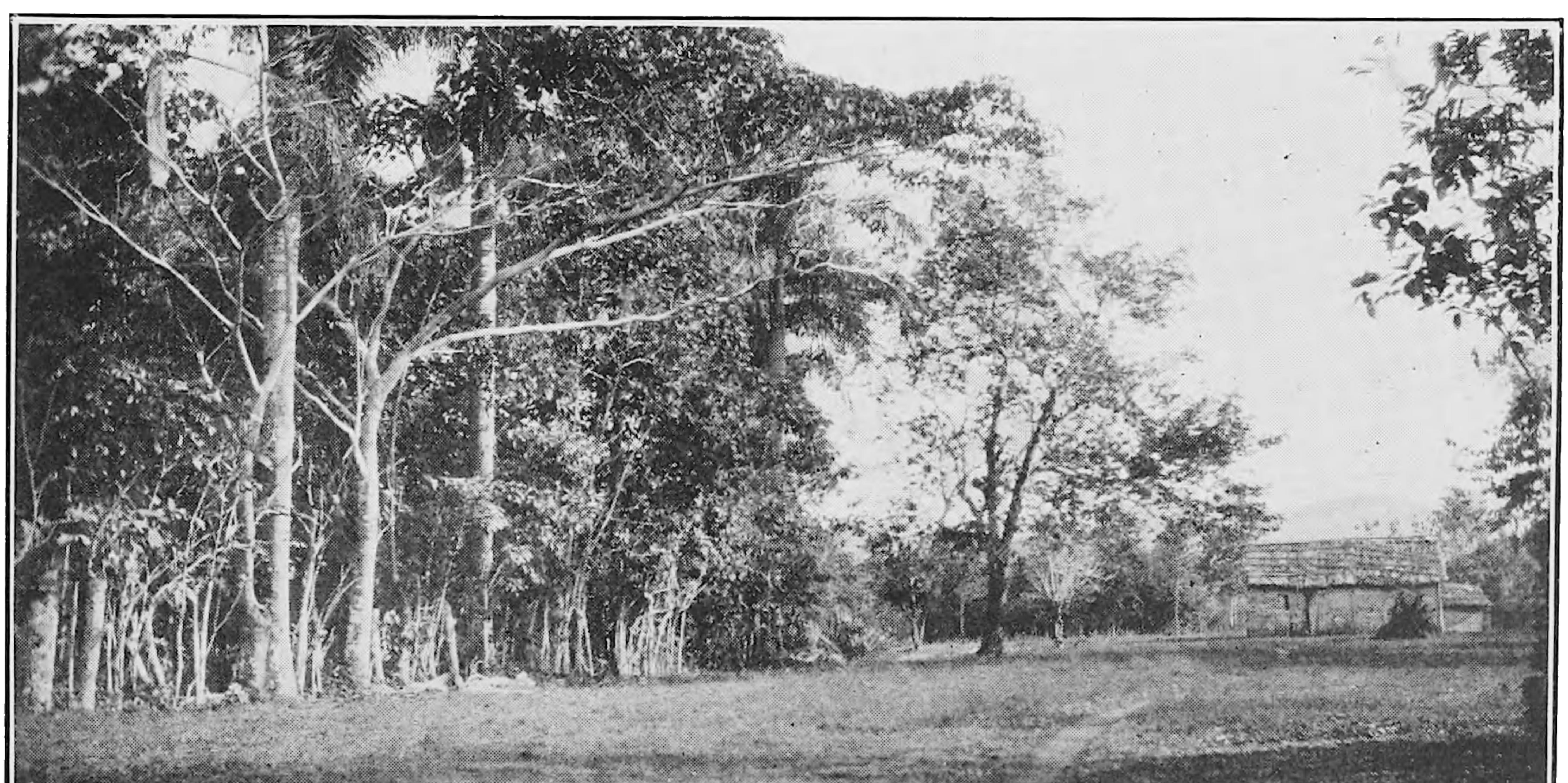
A steady climb of an hour and a half brings one from Arroyo Baiguate to a grassy knoll at the top of El Barrero, from which the road circles westward down the southern side and climbs by easy stages to El Paso Bajito and past La Piedra del Toro to the ford of Rio Jimenoa at El Rio. All trails in this region follow the crests of ridges that extend like buttresses away from the main mountain mass.

From the top of Loma del Valle a beautiful view can be had of the flat-floored valley of Constanza and of the rugged, cloud-capped mountains that shut it away from the outside world. The valley occupies an area of perhaps 30 square kilometers at an altitude of about 1,100 meters above the sea. It is drained by Rio Limón, which has etched a narrow outlet through the mountains to the west. Because of the high altitude the climate of the valley of Constanza is delightfully invigorating. The nights are cool all the year round and frost is sometimes formed in winter. Mosquitoes, the bane of the tropics, appear to be unknown in this valley. About 1 kilometer from Constanza the Department of Agriculture maintains an experiment station for raising products of the temperate zone. Constanza is a forlorn village of several score of cabins, and except its beautiful location and healthful climate, has few attractions to the outsider.



A. VIEW NORTHWARD FROM HATILLO, 28.5 KILOMETERS NORTHWEST OF THE CITY OF SANTO DOMINGO.

B. VIEW SOUTHWARD FROM LOMA COCO, BETWEEN HATILLO AND EL MADRIGAL.



C. TERRACE FLAT AT EL MADRIGAL, ON RIO JAINA.

Beyond Constanza the trail runs westward, crossing Loma Chingüela at an altitude of about 1,150 meters, perhaps 350 meters below its summit. The descent to Rio del Medio, 300 meters below, is very steep.

On the west side of Loma Chingüela there is a sudden change in the character of the vegetation. The open pine woods stop abruptly, giving way to nearly bare slopes that bear only an occasional tree.

From the foot of Loma Chingüela the road descends the gorge of Rio del Medio, at some places clinging high up on the side of the gorge in a trail too narrow for two horses to pass, at others descending to the bank of the river, which it crosses twelve times. At Arroyo El Górbano it begins the ascent of Loma La Fortuna, scattered over whose side among the clouds, at an altitude of nearly 1,100 meters, is the settlement of Las Cañitas. The west flank of this mountain overlooks the Sierra del Agua into the Valley of San Juan.

After fording Rio del Medio for the thirteenth time the trail climbs the steep northern side of Loma la Laguna (altitude about 1,006 meters) and descends the longer, much gentler slope on the south to the boulder-strewn bed of Rio de las Cuevas, which it follows downstream for 9 or 10 kilometers to Túbano.

TRAIL FROM SABANETA TO SAN JUAN.

Near the Haitian border the Cordillera Central is crossed by several trails, none of which is an important thoroughfare. The trail followed by Messrs. Condit and Ross, upon whose notes this description is based, leads from Sabaneta, in the Province of Monte Cristi, southwestward to Restauración, near the Haitian border, thence through La Cruz, Guayajayuco, and Joca, to Las Matas, in the valley of San Juan. The usual route south from Restauración passes through an eastward projecting corner of Haiti to Bánica, but it was deemed advisable to follow the somewhat more difficult trail in order to remain in Dominican territory and thus to avoid conflicts with bandits and revolutionists.

For three kilometers southwest of Sabaneta the trail traverses grassy savannas, winds over hills of gradually increasing height and steepness, and crosses clear, gravelly brooks and small rivers to La Loma. Loma Peñita, locally famous for the wild hogs that roam over it, is the most impressive peak seen from the trail. (See Pl. VI, *A*). The highest point reached on this part of the trail is roughly 420 meters above sea level, at which altitude there is an extensive and well-marked dissected upland bench, apparently free from gravel. La Loma, a village of a few score houses in a valley about 160 meters below the level of the upland bench, is the center of an agricultural community.

From La Loma the trail rises to the level of the upland bench, and thence climbs to the crest of a ridge that stands at an altitude of about 550 meters above sea level, from which Manzanillo Bay and El Morro de Monte Cristi are visible in the distance. Just beyond this ridge the trail forks, one branch leading to Dajabon and the other southeastward along a steep ridge between deep valleys.

Near El Carrizal there is an even-topped pine-clad ridge about 713 meters above sea level. The pines are tall and spindling. One tree 63.5 centimeters in diameter was measured, but few are as much as 45 centimeters through. The ridge widens to a gently rolling upland at an altitude of about 715 meters, the highest point registered by the barometer east of Restauración. The country is open, the soil is deep, and there are no rock outcrops. The trail here is broader and more work has apparently been done on it than in most other mountain districts in this country, possibly on account of the military importance of a road so near the Haitian boundary.

From El Carrizal the trail descends to Restauración at an altitude of about 650 meters above sea level. Restauración, although it is one of the larger towns in the region and contains a small detachment of the Guardia Nacional, presents a poverty-stricken appearance and shows few signs of activity.

The country between Restauración and Joca is more mountainous than that to the north and east. After crossing Rio Neita, a small stream near Restauración, the trail gradually rises toward the southeast to a ridge about 755 meters above sea level. The country here is rugged and is covered with the usual small pines and grass. Below the ridge, and perhaps 15 kilometers from Restauración, is La Cruz, a solitary house among the pines. From the top of the next rise, which affords extensive vistas southwestward into Haiti (see Pl. XVI, *B*), the trail winds down into the valley of Rio Guayajayuco to a gravel-covered bench at an altitude of about 500 meters above sea level.

Rio Guayajayuco or Artibonito, here a swift stream about 18 meters wide flowing in a steep-walled sandstone gorge, is crossed near the small settlement of Guayajayuco. From Guayajayuco the trail leads over steep hills for 9 or 10 kilometers, follows the bed of Rio Guayajayuco for about one kilometer, and then ascends to the grassy bench upon which stands the little settlement of El Amacey.

At El Amacey begins the steep ascent of Loma Vieja. The trail climbs some 650 meters above the river to an altitude of approximately 1,035 meters above sea level, but Loma Vieja still towers above the trail, its summit lost in the mists. The vegetation is mostly shrubbery interspersed with a few small pines. An abundance of filmy, greenish-gray hanging moss gives it a ghostly appearance.

The trail follows narrow ridges on the flanks of Loma Vieja for two or three kilometers, then plunges down into the valley of Rio Joca, a swift

stream several meters wide flowing in a gorge about 40 meters deep. Joca, on the south side of the valley, is a station of the Guardia Nacional. From this lonely post patrols of two men are daily sent to meet the patrols from Restauración at Guayajayuco. Constant vigilance is needed to prevent the passage of bandits and smugglers across the Haitian boundary.

VALLEY OF SAN JUAN.

The great valley of San Juan occupies an area in the western part of Azua Province lying between the Cordillera Central on the north and the Sierra de Neiba on the south. On the west it merges into the central plain of Haiti; on the east it is separated from the Azua Plain by spurs from the Cordillera Central and the Sierra de Neiba. A low divide near Las Matas forms the watershed between Rio Macasía, which flows westward into Riviére Artibonite, and Rio San Juan, one of the larger tributaries of Rio Yaque del Sur. The part of the valley within the Dominican Republic extends northwestward for about 80 kilometers and ranges in width from 15 to 20 kilometers. It includes low hills, rolling plains, and large tracts of nearly level prairies or savannas.

Glowing accounts of the beauty and fertility of the valley of San Juan are brought out by travellers. The valley is favored with a larger and more evenly distributed rainfall than that of the adjoining Azua Plain, so that water for irrigation is more abundant.

San Juan de la Maguana is the center of the social and commercial life of the valley. It is connected with Azua by a wagon road, which is at most times passable by automobiles, and which, when the improvements now in progress shall have been completed, will afford easy access by motor car to Azua. Automobiles can also continue westward nearly or quite to Commendador. The valley is so nearly level that roads can easily be opened in most parts of it. The greatest obstacles to travel are the thick brush and the superabundant gravel in some areas.

AZUA PLAIN.

The Azua Plain extends from the foothills of the Sierra de Ocoa of the Cordillera Central on the north to the Sierra de Martín García on the south, and from Rio Yaque del Sur in the vicinity of Los Güiros to the foot of Loma El Número east of Bahía de Ocoa. The continuity of the plain along the shore is interrupted by Loma de la Vigía, a limestone ridge rising from the water's edge at the entrance to the Bahía de Ocoa to an altitude of about 425 meters above sea level. Inland the plain is broken by several hilly areas.

The Azua Plain is drained by Rio Tábara, Rio Jura, Rio Vía, and several smaller streams. All these streams are intermittent in their lower courses, but their perennial headwaters furnish water for domestic use and for irrigation.

The Azua Plain is hot and semiarid. The rainfall is somewhat greater than the vegetation would indicate, but as much of it is torrential the run-off is excessive, so that much of the water is lost. A large part of the plain is overgrown with thickets of cacti and mesquite, which make travel across it tedious and painful except along beaten trails. A low, shrubby cactus, guazabara, is particularly annoying. The soil is fertile and responds readily to irrigation.

Azua, the only large town in the neighborhood, is 5 kilometers inland from its port on Bahía de Ocoa, with which it is connected by an improved highway and a narrow-gauge railroad. South of the town are several large sugar plantations. A wagon road passable by automobiles furnishes an outlet from the fertile Valley of San Juan to Azua, and another wagon road leads from Azua across El Número to Baní and thence to the capital. The trail to Barahona by way of Quita Coraza is usually traveled at night in order to avoid the heat and the glare of midday. A little-used trail across the Sierra de Martín García furnishes a difficult alternate route to Barahona.

SIERRA DE NEIBA.

The Sierra de Neiba is a range of high mountains lying south of the valley of San Juan and forming the boundary between the provinces of Azua and Barahona. The western extension of these mountains forms the central range of Haiti. The east end of the Sierra de Neiba is separated from the Sierra de Martín García by Rio Yaque del Sur. South of the mountains is the deep trough of Enriquillo Basin.

The Sierra de Neiba is composed chiefly of ridges of limestone ranging in altitude from 1,000 to 1,500 meters above sea level and having a fairly even profile, only a few peaks projecting above it, in this respect differing markedly from the rugged Cordillera Central. This uniformity gives a clue to the geological composition and structure of the range, which is formed of tilted blocks of hard limestone and other bedded rocks.

SIERRA DE MARTÍN GARCÍA.

East of the Sierra de Neiba and separated from it by Rio Yaque del Sur is the Sierra de Martín García, a short mountain range culminating in Monte Busú at an altitude of 1,340 meters above sea level. The range terminates in a row of hills, the Cerros de la Terraza, on the shore of the Caribbean Sea. The Sierra de Martín García overlooks the Azua Plain on the north and Neiba Bay on the south, and partly shuts off Enriquillo Basin on the west. From the vicinity of Azua or Barahona the Sierra de Martín García looms up as a lofty, rugged mountain. It is composed in part of limestones similar to those of the Sierra de Neiba.

ENRIQUILLO BASIN.

The Enriquillo Basin is the eastward continuation of the Cul-de-sac region of Haiti. The two together form a valley about 15 kilometers wide, extending from the Bahía de Neiba, which itself is part of the same physiographic province, to Port-au-Prince, in Haiti. This valley, which in late geologic times was a strait, was uplifted so recently that it has been little modified by erosion. The visitor to the Enriquillo Basin has the unique experience of walking dry-shod on the bottom of the sea across shell-strewn sands and of wandering among forests of coral that appear so fresh that the water might have been withdrawn only yesterday. The Enriquillo Basin has been uplifted 35 meters or more, but some depressions in it stil remain considerably below sea level. Lake Enriquillo, a large remnant of the original strait, occupies one such depression. Its surface now stands 44 meters below sea level and is gradually being lowered by evaporation. In 1892, according to Wells,[1] the surface of Lake Enriquillo stood practically level with the sea. In 1900, according to Tippenhauer,[2] its surface stood 34 meters below sea level. The water in Lake Enriquillo is much saltier than sea water, owing mostly to its concentration by evaporation and partly to additions of saline matter carried by streams.

The waters of the Bahía de Neiba are kept out of the depression containing Lake Enriquillo by the delta deposits of Rio Yaque del Sur, which has built a dam across the head of the bay. During unusually high floods part of the water from Rio Yaque is diverted westward into Lake Enriquillo. Some of the flood water of Rio Yaque is stored in the Laguna del Rincón, a large fresh or slightly brackish lake connected with the Yaque by a channel near the village of Cabral.

The Étang Saumâtre, or Laguna del Fondo, occupies another depression west of Lake Enriquillo. When visited by Wells,[3] in 1892, its water was slightly brackish, but potable, and its surface stood 58 meters above sea level. According to levels run in 1900[4] the Étang Saumâtre stood 20 meters above sea level.

SIERRA DE BAHORUCO.

South of the Enriquillo Basin is a range of high mountains, the Sierra de Bahoruco, which forms the eastward prolongation of the south range of Haiti. These mountains come down to the sea near Barahona. The width of the range along the sea front is about 25 kilometers. Several peaks visible from the sea rise more than 1,400 meters above sea level, and one reaches 2,075 meters. The Montagne de la Selle, in the south range of Haiti, is said to be 2,700 meters high. The mountains are clothed with open pine forests and are carpeted with grass that affords pasturage for

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[1] Wells, J. W., A survey journey in Santo Domingo, West Indies: Royal Geog. Soc. Sup. Pap., vol. 3, p. 595, 1893.

[2] Tippenhauer, L. G., Beiträge zur Geologie Haitis, V: Petermann's Mitt., Band 47, VII, p. 169, 1901.

[3] Wells, J. W., op., cit., p. 595.

[4] Tippenhauer, L. G., op. cit., p. 170.

many cattle. The north front of the range is composed chiefly of massive, steeply tilted, overturned and faulted limestone. The Cerros de Sal, foothills 150 to 200 meters high west of Laguna del Rincón, consist of nearly vertical beds of rock salt, gypsum, shale, and sandstone.

Tucked away in the mountains south of Duvergé is Puerto Escondido, a settlement of prosperous, contented farmers. A trail leads through this village southward past Rancho Viejo, a cattleman's shelter, to Pedernales, on the Caribbean Sea at the Haitian border.

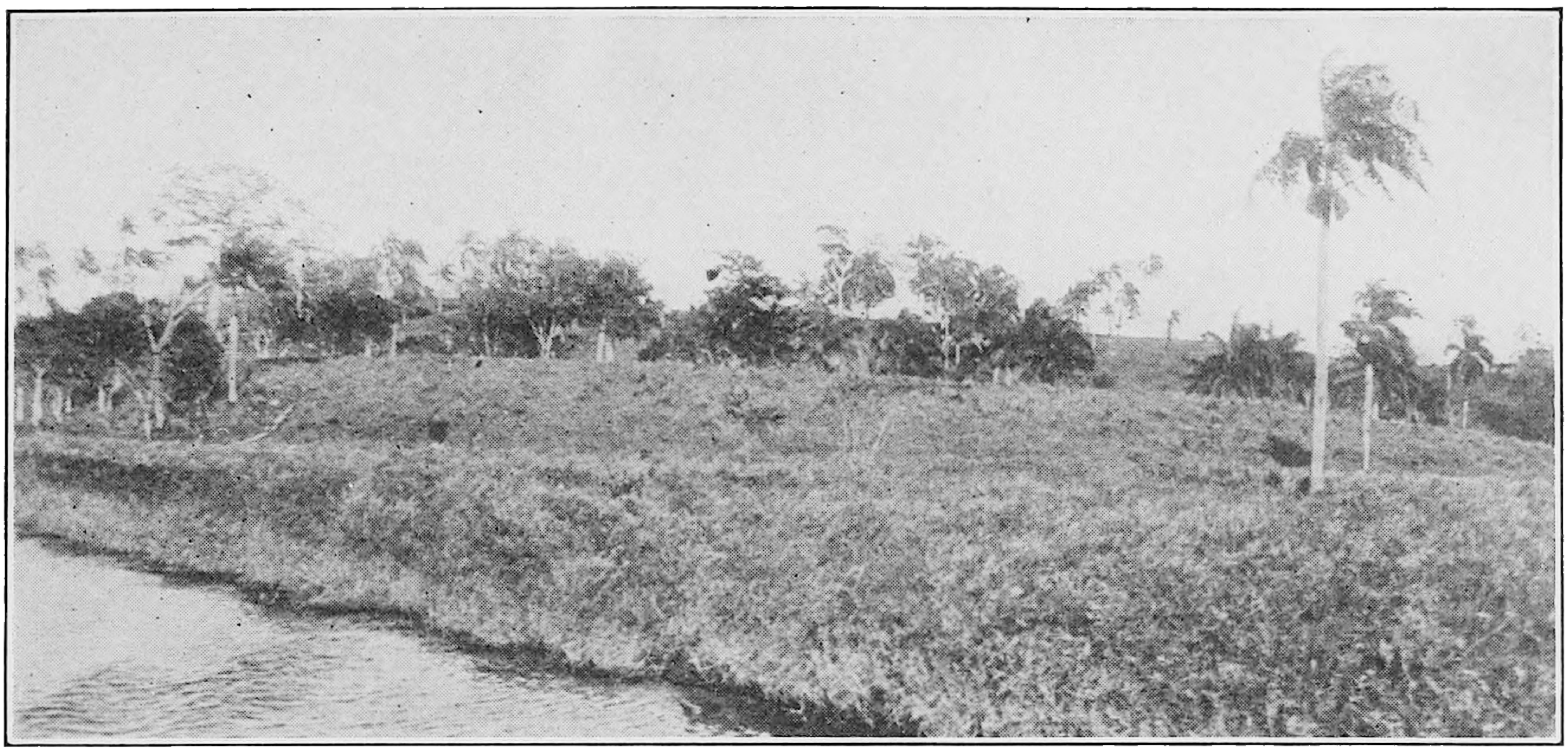
SOUTHERN PENINSULA.

The peninsula south of the Sierra de Bahoruco was not visited during this reconnaissance. The coast charts show a spur of the Sierra de Bahoruco reaching nearly to the shore at Cabo Falso and a range of hills parallel to the coast and not far inland, extending from Cabo Falso to the southern extremity of the peninsula. The triangular areas between these two ridges and the Sierra de Bahoruco are probably terraced plains. The region is said to be thickly wooded and to have a more abundant rainfall than the regions farther north.

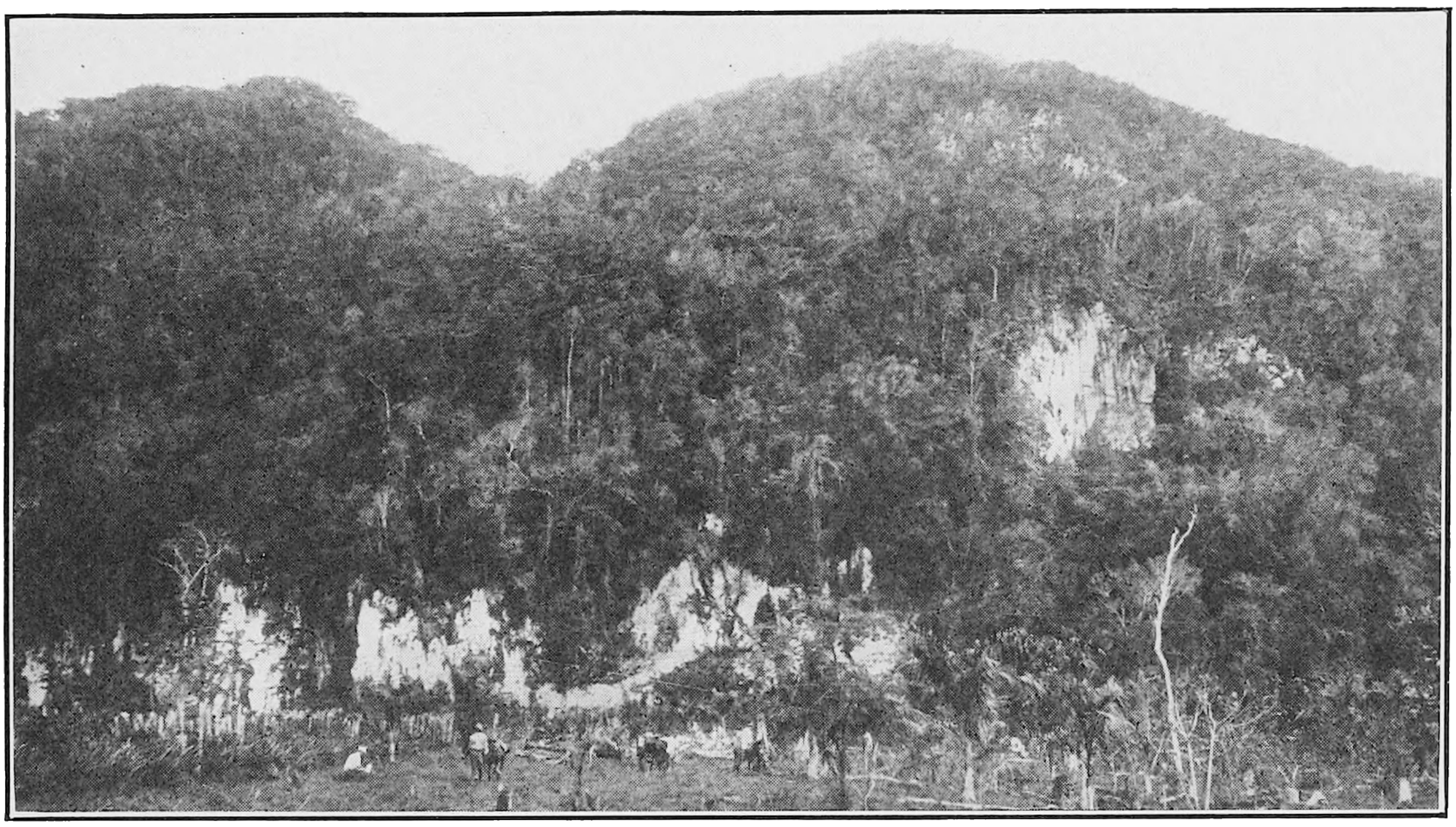
COASTAL PLAIN.

Fringing the Caribbean Sea from Calderas Bay to the eastern extremity of the island is a series of terraces, which rise gradually from the shore to an altitude of 100 meters or more at the edge of the foothills of the Cordillera Central. The coastal plain, as the entire area may be called, increases in width from a narrow fringe only a few kilometers wide at the west end to a maximum width of perhaps 65 kilometers (including Saona Island) in the vicinity of Higüey. Near Santo Domingo the coastal plain is about 16 kilometers wide. The part of the coastal plain east of Rio Jaina is sometimes called the Eastern Valley, or the Seibo Plain, and the narrower western part is called the Baní Plain. The Seibo Plain is more humid than the Baní Plain, which verges on aridity and is dependent partly upon irrigation. The Seibo Plain contains extensive forests and savannas. The soil is fertile and productive. Sugar cane is the most valuable crop. Several sugar mills have been established in the vicinity of San Pedro de Macorís and La Romana.

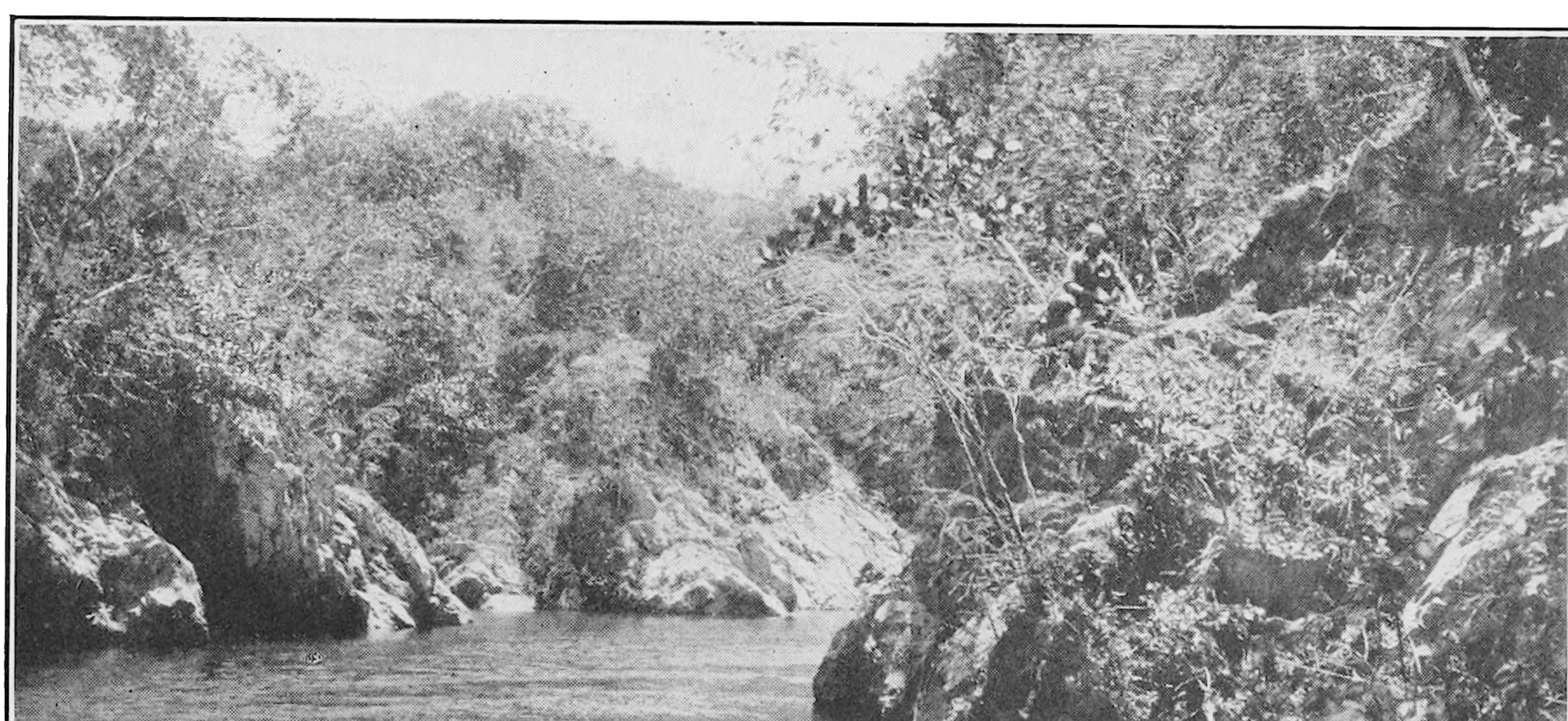
Three terraces are crossed on the road from San Pedro de Macorís to Consuelo. (See Pl. VII, *A*.) The lowest slopes gently from a little less than 6 meters at San Pedro de Macorís to 9 meters at kilometer 1.4 from that city. An intermediate terrace plain, 18 meters above sea level at kilometer 1.8, rises gradually to 26.5 meters at kilometer 5. The upper plain, which is very slightly dissected, ranges in altitude from 42 meters at its outer margin (kilometer 5.7) to about 51 meters above sea level. It extends to kilometer 25.5 on the road to Hato Mayor.



A. TERRACES ON RIO MAGUA ABOVE SAN PEDRO DE MACORÍS.



B. SIERRA PRIETA; CLIFF OF WHITE LIMESTONE.



C. GORGE OF RIO MAO ABOVE BULLA.

Haitian border and north of the main watershed. The Amina, Mao, and Cana carry a considerable volume of clear, pure water. Rio Gurabo is a smaller, sluggish stream, but is the only source of drinking water for the villages along its banks. Rio Guayubín and the watercourses west of it are mere arroyos, dry most of the time but raging torrents in wet weather.

SOUTH SLOPE OF THE CORDILLERA CENTRAL.

The drainage from the south slope of the Cordillera Central falls into three principal groups—the through-flowing streams of the coastal plain, the basin of the Rio Yaque del Sur, and the headwaters of the Artibonite.

Many large rivers cross the coastal plain and enter the Caribbean Sea, most of them in directions normal to the coast. Though none of these are ong in comparison to the rivers in other parts of the island, yet because of the large rainfall in this region they carry a surprisingly large volume of water and are subject to sudden floods. The larger rivers of the coastal plain, named from east to west, are the Chavón, the Soco, the Macorís and its principal tributaries (the Maguá and the Iguamo), the Ozama, the Jaina, the Nigua, the Nizao, and the Ocoa. Many of the smaller streams, such as Rio Baní, have broad, boulder-strewn beds capable of carrying a large volume of flood water. The Ozama and the Macorís are navigable for some distance above their mouths.

Rio Yaque del Sur, one of the three largest rivers, rises on the south flank of El Rucillo not far from the source of Rio Yaque del Norte. Its principal tributaries are Rio del Medio, a brawling torrent that twists through a deep gorge between Monte La Fortuna and Monte Culo de Maco; Rio de las Cuevas, whose milky waters, anastomosing over a broad, boulder-strewn bed, come from the direction of Monte Tina; and Rio San Juan, which drains a large mountainous area and the east end of the valley of San Juan. The Yaque receives no large tributaries below the mouth of Rio San Juan. It cuts across the end of the Sierra de Neiba, runs back of the Sierra de Martín García, and builds its delta at the head of the Bahía de Neiba.

Riviére Artibonite, formed by the confluence near the Haitian border of Rio Macasía and Rio Guayajayuco, flows westward across Haiti and drains the western part of the valley of San Juan and its continuation, the central plain of Haiti, as well as part of the Cordillera Central. Along the Haitian boundary the Guayajayuco flows through a deep cañon cut in shales and slates. This river system shows anomalies that offer interesting problems to be solved when accurate maps and more detailed knowledge of the geology are available.

CORDILLERA SEPTENTRIONAL.

The divide between the drainage basins of the Cibao Valley and the Atlantic coast is the high ridge that forms the south front of the Cordillera Septentrional. From the south slope of this ridge small streams flow southward into Rio Camú and Rio Yaque del Norte. The principal drainage lines north of the divide follow the longitudinal valleys, some streams flowing eastward into Escocesa Bay, others flowing northwestward into the Atlantic, but some streams cut across the obstructing ridges and find their way to the sea by shorter courses. The principal streams are Rio Boba and Rio Isabel, flowing east and west, respectively, and Rio Yásica, which cuts across the "grain" of the country. Many other smaller streams flow northward into the ocean.

MINOR WATERSHEDS.

Samaná Peninsula is too small to support any large streams. A number of rivulets, most of them having their sources in springs at the foot of the front range, find their way into Samaná Bay. So far as known, no streams break through the front range from the higher land farther north. The limestone plateau at the east end of the peninsula is drained by subterranean channels, some of which terminate as springs along the shore. The streams on the north side are on the whole longer and larger than those on the south, for more than half the peninsula is drained to the north.

Because of the low rainfall in the southwestern part of the Republic no large streams have their source in the Sierra de Neiba. The headwaters of Rio Macasía, one of the tributaries of the Artibonite, come from the north slope of the Sierra de Neiba, and a few small tributaries of Rio San Juan head farther east in the same range. Some large springs that are tributary to Lake Enriquillo issue at the foot of the mountains south of the lake. A few ephemeral rivulets trickle down the southeast end of the range only to lose themselves in the thirsty soil of Enriquillo Basin.

The Sierra de Bahoruco probably receives more rain than the Sierra de Neiba, but no large streams have their source in it. Rio de las Damas flows northward into Lake Enriquillo, as do also several smaller brooks. Little is known of the drainage of the south side of the range and of the southern peninsula, but neither probably contains any large streams.

TRANSPORTATION.

RAILROADS.

There are two public railroads in the Dominican Republic, both narrow-gauge, and both serving only part of the Cibao Valley—the area north of the Cordillera Central. The Ferrocarril Central Dominicano is a government-owned line extending from Puerto Plata across the Cordillera Septentrional to Santiago and thence by way of Peña to Moca, where it connects with the Ferrocarril de Santiago y Samaná. The Ferrocarril Central Dominicano crosses the mountains on grades so steep that it can only with great difficulty maintain traffic, which is at times wholly interrupted because of slippery rails. It crosses the divide in a tunnel near Altamira at an altitude of about 490 meters. The main line of the Ferrocarril de

Santiago y Samaná, sometimes called the "Scotch Railroad" because of the nationality of its promoters, extends from La Vega to a terminal on Samaná Bay at Sánchez, and one branch runs northward to San Francisco de Macorís and another to Salcedo and Moca.

Several large sugar estates have constructed short railways for their own use. These roads are most numerous in the vicinity of San Pedro de Macorís, Azua, and other towns on the south coast.

ROADS AND TRAILS.

Highway construction in the Dominican Republic is now being vigorously prosecuted by the Departamento de Obras Públicas, but the mileage of roads passable for wheeled vehicles is still lamentably small. The most important road projected is the Carretera Duarte, which will run from Santo Domingo through La Vega and Santiago to Monte Cristi. Much of this road, which will connect the capital with the Cibao Valley, is already open to traffic, and the final and most difficult section, that across the Cordillera Central, is now under construction.

Nearly all overland traffic uses trails that are absolutely impassable for wheeled vehicles and that appear to have received few repairs since the time of Columbus. The sharp hoofs of innumerable mules and burros, heavily laden with the varied products of the country, have cut the softer stretches of road into remarkably even transverse furrows, some of them nearly belly deep, which fill with a sticky mixture of mud and water during rains and rarely become dry. The hard ridges between the furrows offer a precarious footing to pedestrians, but the canny donkey prefers to follow in the footsteps of his ancestors. As many of these mudholes occur on steep mountain sides very little labor in digging ditches would greatly reduce their number. Mud is more to be dreaded than mountains.

The most formidable obstacle to travel in the Dominican Republic is the Cordillera Central. This great mountain range is crossed by several trails, all of them rather difficult. The passes across the east end of the range are low and very muddy. The trails across the central and western parts of the range are not so muddy but are very rough and steep. In the course of this investigation the Cordillera was crossed by three trails—the Bonao trail, which leads from the capital through Los Alcarrizos, Piedra Blanca, and Bonao to La Vega; the Constanza trail; and a trail from Sabaneta to Restauración and thence along the cañon of the Guayajayuco to the vicinity of Bánica and on to San Juan.

COAST LINE AND SHORE FEATURES.

MANZANILLO BAY.

At the mouth of Rio Massacre, the boundary between the Dominican Republic and the Republic of Haiti, a V-shaped tongue of deep water, probably formed by a down-dropped fault block, pushes into the land.

On the south side of this V the 100-fathom line hugs the north coast of Haiti, but on the north side it sweeps northwestward about 40 kilometers to the outer end of Monte Cristi Bank, a submerged platform that projects from the mainland of the province of Monte Cristi. Manzanillo Bay, at the head of this V-shaped deep, is one of the best harbors on the north coast of the island. It is large and well protected, and its deep water extends close up to the shore. The east and north shores of the bay, which are formed by the delta of Rio Yaque del Norte, are low and swampy, and are penetrated by several abandoned distributaries of the river. Manzanillo Bay is now very little used, but when a railroad from Santiago is extended to terminals on deep water, it should become the outlet for a large commerce.

MONTE CRISTI BANK.

Several islets on the submerged platform called the Monte Cristi Bank now rise a few feet above sea level or lie awash, and an uplift of 40 meters would convert the greater part of the bank into dry land. The sides of the bank slope steeply into water exceeding in depth 100 fathoms (183 meters). Off Monte Cristi the bank is about 22 kilometers wide, but it gradually narrows eastward to Punta Rucia, some 50 kilometers from Monte Cristi, where deep water extends close to shore. The delta of Rio Yaque del Norte is gradually pushing westward across the Monte Cristi Bank. Corals grow plentifully on much of the bank, and barrier reefs separated from the shore by lagoons extend along part of its eastern end.

Monte Cristi Bay is an open roadstead, sheltered from the trade winds by Cabra Island and the headland of El Morro, a prominent butte 275 meters high. As the water near the shore is too shallow for any but small boats, sea-going vessels are compelled to anchor 2 or 3 kilometers out and transfer their cargoes to lighters.

The shore near Monte Cristi is low and shelving and is bordered by salt marshes, which are protected from the sea by a low sand bar. South of the town is the broad delta of Rio Yaque del Norte. The main channel of the river is about 3 kilometers from the town, but old, abandoned distributaries ramify across the delta to the south. The land back of the town rises into a low, semicircular ridge, which leads northeastward to the foothills of the Cordillera Septentrional, or Monte Cristi Range. El Morro, nearly 5 kilometers north of Monte Cristi (Pl. II, *B*), is separated from it by salt marshes. Flat terraces, some of them strewn with conch shells, indicate relatively recent uplifts along this part of the coast.

PUERTO PLATA BAY.

The circular harbor of Puerto Plata indents the north shore of the Republic about 70 kilometers east of Monte Cristi. The harbor is entered through a narrow channel between coral reefs that extend in a line of foam from West Point, on the west, nearly across its entrance. The battered hulks of wrecks on the reefs bear silent testimony to the perils of navigation in this treacherous spot. On the east rise the time-stained walls of Fort San Felipe, at the top of a low cliff, and on a gentle rise behind the fort is the lighthouse.

Except along the promontories of East Point and West Point, the bay is bordered by a narrow strip of palm-fringed sandy beach, broken through on the southwest by Rio San Marcos, a sluggish stream that wanders in a swampy alluvial plain. On the south rise the steep sides of Monte Isabel de Torres, a conspicuous landmark from the sea (Pl. III, *A*), and on the outwash slopes at its feet is built the picturesque town of Puerto Plata. Along the western skyline rise the jagged profiles of several sharp conical hills.

Puerto Plata Bay appears to be the drowned mouth of the valley of Rio San Marcos, but a dead coral reef 10 feet above sea level adjoining the living reef at the mouth of the bay shows that there has been emergence as well as submergence in this region.

PUERTO PLATA TO CAPE SAMANÁ.

East of Puerto Plata gentle slopes that extend back several kilometers from the shore give room for farms and plantations between the mountains and the sea. Much of the coast between Puerto Plata and Cape Francés Viejo is bordered by coral reefs through which narrow openings lead to the indentations in the shore forming the ports of Sosúa and Cabarete.

Cape Francés Viejo is a bold, lofty headland that stands less than 6 kilometers from the shore and rises 346 meters above sea level. It is visible 50 kilometers from the shore. From far out at sea off this cape can be seen Loma Quita Espuela, a peak on the south front of the Cordillera Septentrional overlooking the Vega Real near San Francisco de Macorís.

From Cape Francés Viejo the coast runs southward past the village of Matanzas to the mouth of the Gran Estero, the swampy area that separates the peninsula of Samaná from the mainland. The great bight in the angle between Samaná Peninsula and Cape Francés Viejo is known as Escocesa Bay. A submerged bank supporting reefs and a few small cays extends from Matanzas to Cape Cabrón and attains a maximum width of about 12 kilometers off Puerto Escondido.

The deep bight between Cape Cabrón and Cape Samaná, called Rincón Bay, contains several small cays skirted by a reef. The bottom of the bay is a submerged bank that is in most places less than 20 fathoms (37 meters) below sea level.

SAMANÁ BAY.

Samaná Bay is justly famous as one of the best and most beautiful harbors in the West Indies. Ships entering the bay pass first the bold, rocky, southwestward-trending shore between Cape Samaná and Ballandra Point, against which the waves spout high in air. Several step-like terraces lead down from the two headlands to the lower plateau between them. From Ballandra Point the bay extends westward about 45 kilometers to the flat delta of Rio Yuna, maintaining an average width of about 16 kilometers and a depth great enough to admit the largest ships nearly to the head of the bay. Shoal water at the mouth of the bay restricts entrance to an easily defended channel near the northern shore, but within the bay there is ample room for many ships to maneuver or to lie safely at anchor.

Along most of the eastern half of the north shore the mountains rise almost from the water's edge, but at Santa Barbara de Samaná they are lower and more broken and the shore is indented by a little bay, which is shut off from the greater bay by several pretty little wooded rocky islets. (See Pl. III, *B*.) The west half of the north shore is bordered by a narrow fringe of terraced lowlands, back of which the mountains rise steeply. Near the west end of this terraced area is the town of Sánchez, the terminus of the Ferrocarril de Santiago y Samaná and a port of entry. As the town is a considerable distance from deep water large vessels are unable to dock there and have to load and unload cargo from lighters.

From the head of the bay to San Lorenzo Bay the south shore is jagged with cliffed spurs that extend into the water from a lofty, even-profiled limestone plateau. East of San Lorenzo Bay is a stretch of low, thickly wooded country, back of which rise low, jagged mountains. Sabana de la Mar, the only village worthy of notice on the south shore, cannot be reached by ships because of very shallow water.

Samaná Bay is the drowned extremity of the great Cibao Valley, but traces of rather recent slight emergence are seen in raised beaches, raised coral reefs, and sea caves that now stand above tide. Many such caves have been found west of San Lorenzo Bay.

EAST COAST.

From Cape Rafael, a low point at the entrance to Samaná Bay, the coast trends southeastward, in line with the end of Samaná Peninsula, to Cape Engaño. It is skirted by a broken reef. Cape Engaño is a low, reef-locked point that rises several kilometers inland into low hills. A bank, which at its outer margin is in places only 30 fathoms below the surface, extends eastward from Cape Engaño for 50 kilometers into the Mona Passage. This bank may be the cause of the heavy swells that prevail in this part of the Mona Passage. A lateral extension of this bank borders the coast at Point Espada, a prominent cliff over 90 meters high.

Between Point Espada and the east end of Saona Island is a semicircular indentation in which deep water reaches within a short distance of the shore. Most of the shore along this indentation is bold and rocky, and part of it is bordered by a raised coral reef. Yuma Bay, north of Cabo Falso, receives Rio Yuma, which drains a considerable area in the eastern peninsula.

SOUTH COAST.

The peninsula extending southward from Yuma Bay to Catalinita Bay continues as a partly submerged boot-shaped bank for a considerable distance into the Caribbean Sea. Saona Island, on this bank, is about 22 kilometers long (from east to west) and about 3 to 5½ kilometers wide. The greater part of the island is low, but at its eastern end there is a rocky bluff 35 meters high. In Catalinita Bay, the shallow channel separating Saona Island from the mainland, there are several small islands and cays.

From Saona Island to Punta Salinas the south shore of Santo Domingo presents little diversity. Rocky cliffs 3 to 4½ meters high, against which the waves break and dash high in air, extend for leagues. Wooded plains reach inland to the foot of the hills, which can be dimly discerned far away to the north but which approach closer to the shore west of Santo Domingo City. Low Catalina Island, off the port of La Romana, marks the end of a bank that fringes the shore as far west as Andres Bay and attains a maximum width of 11 kilometers off San Pedro de Macorís. Another triangular bank between Punta Palenque, near the mouth of Rio Nizao, and Punta Salinas is 9 kilometers wide. At San Pedro de Macorís and Santo Domingo raised coral reefs and terrace plains show that this part of the coast stands higher with respect to the sea than formerly. The terraces near Macorís are described on page 40.

Between Punta Salinas and Punta Avarena, a distance of 55 kilometers, the south coast of Santo Domingo is deeply indented by three bays. Las Calderas Bay, cut off from the Caribbean Sea by the long sandy spit terminating in Punta Salinas and Punta Calderas, is the smallest and most sheltered of the three. Ocoa Bay is much larger and is wide open to the south. Its bottom is a submerged bank whose outer edge runs westward from the mouth of Rio Ocoa to Punta Martín García. Loma El Número rises steeply from its eastern edge, and Loma de la Vigía, on the opposite side, partly protects the port of Azua from south winds. Puerto Viejo, the old port of Azua, southwest of the Loma de la Vigía, has the appearance of the drowned mouth of a valley, but is partly enclosed by raised coral reefs 3 meters above sea level. Neiba Bay, on the south side of which is the village of Barahona, is the continuation of Enriquillo Basin, from which it has been separated by the delta of Rio Yaque del Sur. It lies between the lofty Sierra de Martín García on the north and the Sierra de Bahoruco on the south. A bight of very deep water extends from the southeast nearly to the mouth of Rio Yaque del Sur, at the head of the bay, but the shallower water along the sides is obstructed by reefs and shoals.

From the mouth of Neiba Bay the shore trends southwestward to Punta Beata, at the end of the southern peninsula, and the edges of the banks of Beata Island and Alta Vela maintain the same direction for 35 kilometers beyond the point. A channel exceeding 100 fathoms in depth separates the

CHAPTER IV.

STRATIGRAPHIC AND STRUCTURAL GEOLOGY AND GEOLOGIC HISTORY.

By Wythe Cooke.

STRATIGRAPHY.

BASAL COMPLEX.

CHARACTER AND EXTENT.

The oldest rocks in the Dominican Republic form a complex group of schists, serpentines, intrusive and extrusive igneous rocks, tuffs, and more or less altered conglomerates, shales, and limestones. These ancient basal rocks resemble the basal rocks in Cuba, Porto Rico, and the Virgin Islands, are genetically related to them, and have suffered similar metamorphism. This basal complex forms the axis of the Cordillera Central and makes up a large part of Samanâ Peninsula. (See Pl. VIII.)

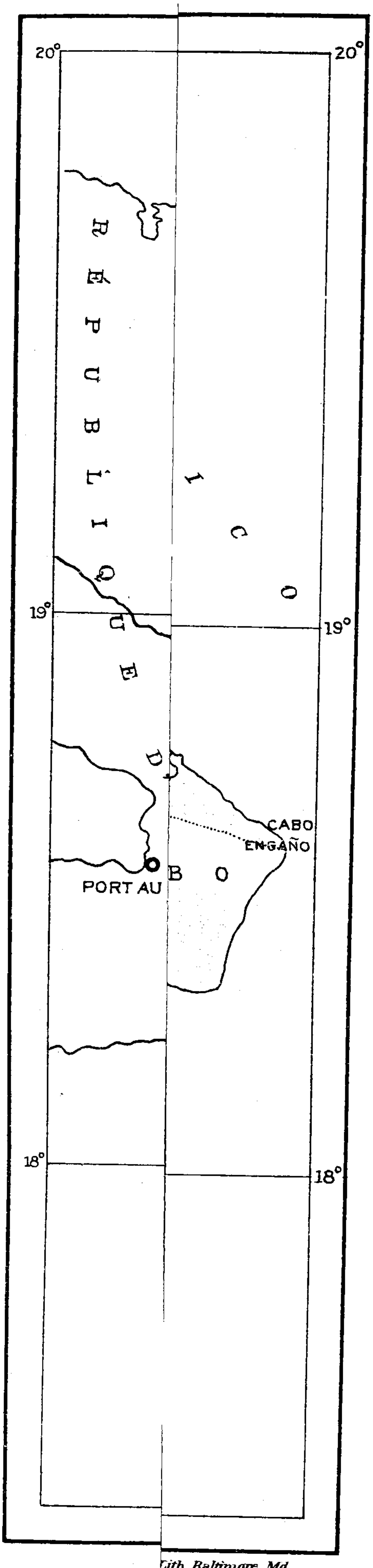
The complex includes rocks of many kinds, and a part of it certainly dates from Cretaceous time, but part is probably older. Some of the igneous and pyroclastic rocks that are now included in it are of Tertiary age, for they are intruded into or interbedded with Tertiary sediments. To untangle the intricacies of the basal complex, to map its component parts, and to ascertain the relative ages of the various rocks will require long and intensive work in both field and laboratory—work which cannot be done until suitable base maps have been made.

CORDILLERA CENTRAL.

Along the Bonao trail from Santo Domingo to La Vega the first outcrop of rocks referable to the basal complex is about 5 kilometers north of Los Alcarrizos, where brecciated augite andesite that weathers into spheroidal masses, outlined by rhombohedral joints, is exposed. No other outcrops were noted on this trail before Hatillo was reached.

Most of the rock exposed between Hatillo and El Madrigal is schistose serpentine. In the road cuts near Hatillo the serpentine is much sheared and folded, and is metamorphosed into a talcose slate. The rock was probably originally lava and pyroclastic material of intermediate composition. It is cut in places by dikes of fresher and less sheared black rock, which shows a tendency to ophitic texture.

Several of the hills between Hatillo and El Madrigal are capped with limonitic boulders and pebbles. Near Rio Jaina there are several exposures of creamy-yellow rock, probably weathered sandstone. In the bed of Rio Jaina at the first crossing there are many boulders of dioritic gneiss, but



Lith. Baltimore, Md.

EXPLICACION
EXPLANATION

ROCAS SEDIMENTARIAS
SEDIMENTARY ROCKS

QUATERNARIO — *QUATERNARY*

Reciente — *Recent*

Aluvial

Alluvial deposits

Plistoceno — *Pleistocene*

"Coast limestone", calizas de coral en la Hoya de Enriquillo

"Coast limestone", coralliferous limestone in Enriquillo Basin.

TERCIARIO — *TERTIARY*

Plioceno — *Pliocene*

Formación Las Matas, cascajos y marga

Las Matas formation. Gravel and marl.

Mioceno — *Miocene*

Conglomerado, arenisca, esquita, caliza de coral, sal y yeso.

Conglomerate, sandstone, shale, coralliferous limestone, salt and gypsum.

Oligoceno — *Oligocene*

Caliza y conglomerado

Limestone and conglomerate.

Eoceno — *Eocene*

Principalmente caliza. Contiene algunas rocas Cretaceos.

Principally limestone. Includes some Cretaceous rocks.

ROCAS VULCÁNICAS
VOLCANIC ROCKS

TERCIARIO Y QUATERNARIO — *TERTIARY AND QUATERNARY*

Pleistoceno y Plioceno (?) — *Pleistocene and Pliocene (?)*

Lavas, basálticas

Basaltic lavas.

ROCAS METAMÓRFICAS
METAMORPHIC ROCKS

ANTETERCIARIO — *PRE-TERTIARY*

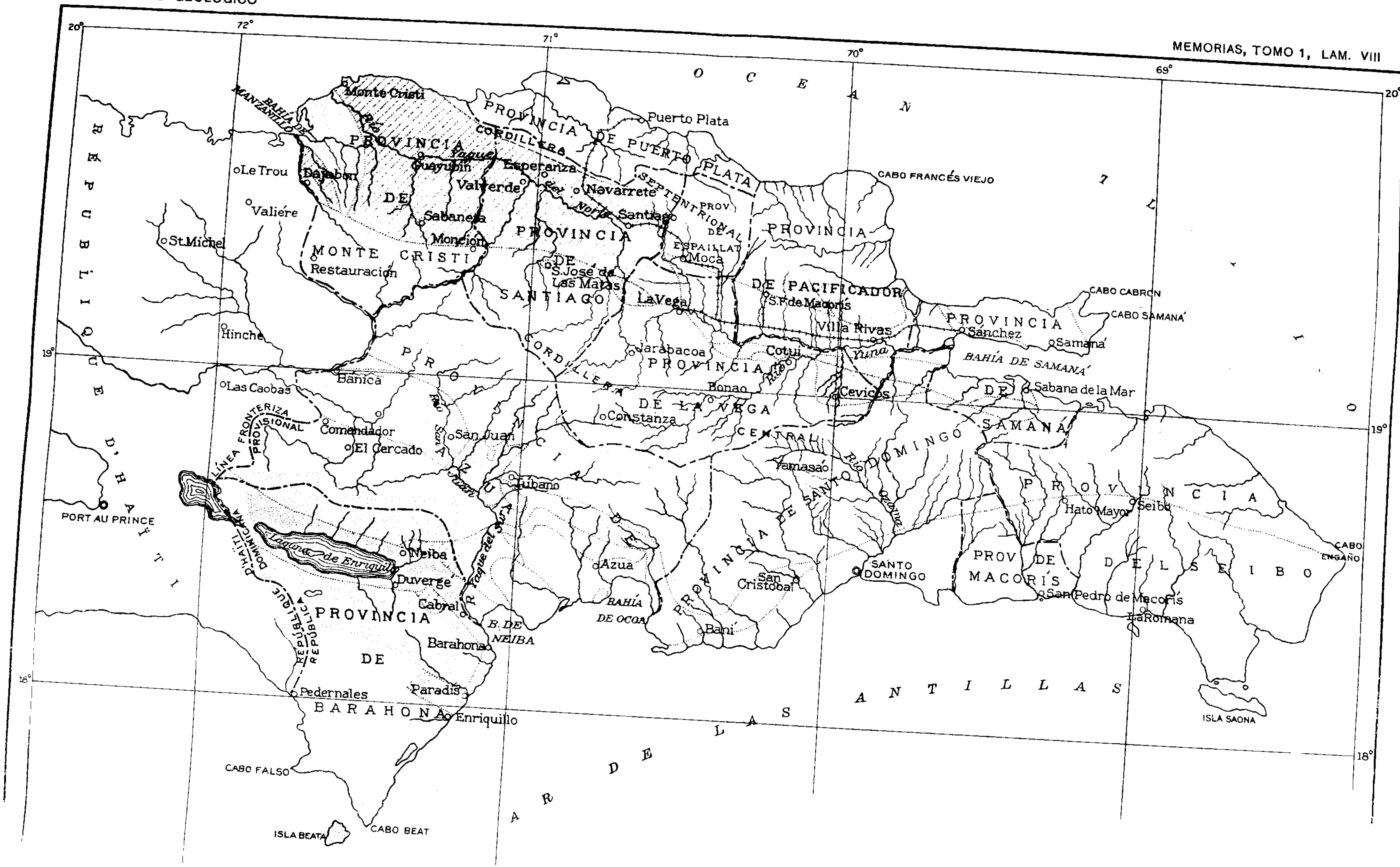
Cretáceo y masantiguo — *Cretaceous and older*

Rocas metamórficas de orígines ambos sedimentarias y ígneas. Contiene algunas rocas vulcánicas Tertiarias

Basal complex. Metamorphosed rocks, both sedimentary and igneous. Includes some Tertiary volcanic rocks.

REPÚBLICA DOMINICANA
SERVICIO GEOLÓGICO

MEMORIAS, TOMO 1, LAM. VIII



the bedrock is green chloritic schist. The profile of some of the mountains far west of this point suggests that they are composed of thick-bedded sediments that dip gently southward.

At the second crossing of Rio Jaina, about 12 kilometers upstream from El Madrigal, an outcrop of weathered tuff or similar rock was seen. The gravel in the river here consists of diorite, a crystalline dark igneous rock, and a smaller amount of more siliceous intrusive rock that contains dark inclusions. No pebbles of sedimentary rocks were seen. Arroyo Guananitos at its junction with Rio Jaina flows over hard, tough, and somewhat schistose greenish amphibolite, which weathers to a soft, rusty brown rock above river level. Near Sabana Grande the bedrock is gray dioritic gneiss containing much biotite.

Between Sabana Grande and Bonao all the rocks are metamorphic. They are mostly micaceous, chloritic, sericitic, and quartzose schists and various metamorphosed intrusives. Between Rio Juan Manuel and Rio Maimon a dark, schistose amphibolite is exposed. The cobbles in Rio Maimon are principally coarse and slightly gneissoid diorite, but the bedrock is a greenish slate or phyllite, in places cut and altered by dikes.

Between Bonao and Jayaco no outcrops of hard rock were noted. The alluvial plains in this region are composed of clay and loam interbedded with gravel, which should be a valuable source of well-water. The gravel in the bed of Rio Jima consists largely of porphyritic andesite but includes some banded slate and basalt. Near the last ford on Rio Jima pebbles of lignite were noted, which were probably derived from a low bluff near by.

Loma Miranda, the last mountain crossed on this trail, is composed of sericite schist and schistose serpentine cut by dikes of andesite or basalt, which show little or no schistosity. Outcrops of brilliant red gossan and quartz veins containing numerous leached cavities show the effect of mineralizing solutions, which probably were associated with the intrusion of the dikes mentioned above. Some prospecting for copper has been carried on in this vicinity, but so far without marked success. Cuts along the new Duarte Highway will afford good fresh exposures of rocks of the basal complex. In the bed of Rio Jima near kilometer 96 from Santo Domingo on this road there are boulders of conglomerate that contain pebbles distorted by squeezing.

Along the road from La Vega to Cevicos, on a low ridge 2 kilometers west of the crossing of Rio Yuna, fragments of white tuff were noted, and 2 kilometers east of the river there is a higher ridge composed of fine-grained granitic rock associated with tuffs. On the low round hills known as the Cerros de la Travesía, west of Rio Chacuey, there are exposures of light gray or yellowish tuff. The first ridge east of Rio Chacuey contains greenish-gray volcanic rocks. Loma de los Palos is composed of basalt. The tuffs and effusives along the northern foothills of the Cordillera

Central are probably much younger than the schists and serpentines of the basal complex, which are exposed a few kilometers farther south, on the road from Cotuí to Maimón.

Most of the hills in the vicinity of Maimón are composed of serpentine that appears to be an alteration product of some basic igneous rock. On Loma Pegado, about 4 kilometers southwest of Maimón, the serpentine has weathered at the surface to a brick-red, highly ferruginous soil similar to the lateritic iron ores of Cuba but too thin, where seen, to be of commercial value. Near the top of Loma Pegado the serpentine is cut by a dike of hornblende diabase. Near the foot of a low mountain southeast of Hatillo there are exposures of granitic gneiss, but the mountain is composed chiefly of chloritic schist, which near the summit of the mountain is impregnated with copper ore. Near Hatillo the clay soil contains small boulders of magnetite. A more detailed description of the iron and copper prospects of this region is given on pages 228-231.

The Constanza trail crosses slates, schists, tuffs, diorites, and serpentines, which are cut by several kinds of dike rocks. The mountain at Las Minas, northwest of Jarabacoa, consists of schist. El Barrero, south of Jarabacoa, is composed of serpentine. At Constanza there is greenish basalt tuff cut by dikes of a fine-grained lamprophyre. Rio Limón and Rio del Medio, southwest of Constanza, cut through fine-grained red and green rocks and serpentine.

A fault block of muscovite-chloritic schist, chloritic schist, calcareous argillite, and diorite-gneiss north of San José de las Matas is separated from the main body of the basal complex, which is bounded south of the town by conglomerates and limestones, probably all of Oligocene age. At Bulla, Rio Mao emerges from a gorge cut in laminated chloritic schist, which is overlain unconformably by Miocene gravels. Outcrops of schist similar to that near San José de las Matas were seen also along the headwaters of Rio Gurabo near the point where it is crossed by the trail from Monción to Sabaneta. Near the edge of the basal complex south of Sabaneta there are exposures of blue sericite schist or phyllite, more or less gneissoid quartz diorite, and hornblende schist. Associated with the schists, but probably much younger, are lavas, tuffs, and porphyritic intrusions. Most of the trail from Sabaneta to Restauración passes over quartz diorite, which is apparently intruded into schist and quartz diorite gneiss. Over the first 4 or 5 kilometers east of Restauración green volcanic agglomerate and tuff apparently rest with depositional contact upon the quartz diorite.

Between Restauración and Joca the geology differs considerably from that farther east. Black basaltic rock, weathering to a serpentine-green in places, local beds of coarse agglomerate, and a few siliceous dikes are exposed over the first 8 or 10 kilometers from Restauración. Beyond this is hard purplish limestone, much jointed and veined and dipping steeply

Mesozoic molluscs as a *Trigonia*, an ammonite, and a baculite (?), he undoubtedly was correct in referring the bed containing them to the Cretaceous, but it seems very unlikely that all of the great variety of rocks correlated by Gabb with this fossiliferous limestone are of the same age. Alberti[1] found Cretaceous fossils near Guayubin.

East of the Azua-Baní road at Monte Mamón there are two hills, Cerros los Piñones, the backbone of which is a vertical ledge of limestone, 3 or 4 meters thick, striking N. 10° W. On the east side of the ledge is dark gray shale. Both hills are capped by a nearly horizontal deposit of loosely cemented conglomerate having a calcareous matrix ("caliche"). Foraminifera from one of these hills were examined by Doctor Cushman, who submits the following memorandum regarding them:

> Station 8612. Very peculiar material. I have not yet been able to make out whether this is Cretaceous or Eocene. If Eocene, these species are different from those of any Eocene known previously in the West Indies. I have no good Cretaceous specimens with which to compare them.

If this rock is Cretaceous, as seems probable, much of the shale and limestone exposed along Rio Ocoa below San José de Ocoa and in Loma el Número, which appear to be part of the same formation, is probably of Cretaceous age. Limestone containing indistinct mollusks, fragments of which are scattered along the ascent of Loma de Portezuela on the trail from Azua to San José de Ocoa about 200 meters above the foot of the mountain, may be part of the same formation.

Dense, hard, dark-blue banded, slightly magnesian calcareous argillite, which breaks into rectangular fragments, underlies the Eocene limestone in the front range of the Cordillera Septentrional near Damajagua, northwest of Navarrete. As fragments of this rock are included in the Eocene limestone they must at least be older than upper Eocene. This rock closely resembles certain parts of the Cretaceous formations in Porto Rico and the Virgin Islands and is regarded as of Cretaceous age.

Cretaceous rocks were noted at two localities near Gurabo, in the Province of Monte Cristi. The sedimentary rocks south of the village of Gurabo probably abut against the schists in fault contact. The schist is similar to that on Rio Mao above Bulla but is more metamorphosed and finely banded. The following descending sequence of beds, which strike N. 60° W. and dip 75° NE., was crossed in traveling southwest beyond the contact with the schist: (1) reddish-brown shales, sandstone, and dark gray limestone, which contain a network of white calcite seams and poorly preserved fossils (station 10274; for list of fossils see p. 55); (2) limestone conglomerate; (3) amygdaloidal basalt; (4) more limestone.

The level valley floor of Arroyo Clavijo, which is about 3 kilometers west of Gurabo and stands about 288 meters above sea level, is composed

[1] Alberti y Bosch, N., Apuntes para la prehistoria de Quisqueya, tom. 1, p. 27, La Vega, 1912.

of coarse conglomerate. A short distance downstream from the trail an outcrop of this conglomerate forms a bluff 20 meters high along the stream. This rock is similar to the basal Miocene conglomerate exposed along Rio Mao at Bulla. At the last crossing of the trail over Arroyo Clavijo there is an outcrop of basalt that shows rude bedding and resembles the basalt interbedded with limestone of Cretaceous age in the hills south of Gurabo. West of this locality similar flows and pyroclastics crop out most of the way to Sabaneta. About 11 kilometers east of Sabaneta (station 10275; list of fossils given below) tuff is interbedded with a thin layer of bluish limestone conglomerate, the pebbles of which contain poorly preserved fossils similar to those found in the limestone south of Gurabo.

The fossils collected at stations 10274 and 10275 were submitted to Dr. T. W. Stanton, whose report is as follows:

Although most of the small fragments of limestone show sections of fragmentary fossils on weathered surfaces none of the fossils could be freed from the matrix by the ordinary methods of preparation. It was therefore necessary to depend on the study of sections as shown on weathered surfaces and on the polished surfaces of eleven selected specimens, which were ground down and polished.

Station 10274 (D. C. 68). Limestone about 1.5 kilometers south of Gurabo village near Monción:

Coral. Undetermined genus.

Radiolites sp. Fragment showing shell structure similar to *R. nicholasi* Whitfield.

Station 10275 (D. C. 69). About 11 kilometers east of Sabaneta, on telegraph line to Guaraguanca; limestone interbedded with tuff:

Coral. Undetermined genus.

Radiolites sp. Fragments with some shell structure as in specimen from station 10274.

Caprinula (?) sp. Three fragments of a rudistid with shell structure like that of *Caprinula*.

Gastropod. Section of small, slender shell of undetermined genus.

The fragments of *Radiolites* and *Caprinula* (?) give conclusive proof of the Cretaceous age of the rocks in which they are found, and they suggest correlation with the fossiliferous Cretaceous rocks of Jamaica, Cuba, and the Virgin Islands.

Near Sabaneta there are extensive level plains consisting of sand and gravel that are only slightly cemented. In some of the ravines there are outcrops of the volcanic tuff above described. A broad bench at an altitude of 225 meters is cut by deep ravines here and there. The rocks exposed in the ravines are coarse sand and conglomerate interbedded with clay shale locally containing lignitic bands.

Other outcrops of volcanic rocks similar to those associated with the Cretaceous limestone near Gurabo and probably of the same age were found south of Sabaneta. Similar rocks outcrop about 5 kilometers south of Sabaneta. A short distance to the south are foothills, which rise to an altitude of about 450 meters. The rocks composing them are of several igneous and metamorphic types, but have been so much weathered that they could not be classified in the time available. Perfect exposures were seen in the gorge of Rio Yaquejal, which was followed for a distance of several kilometers. Along the lower part of the gorge there are exposures of dark bluish to serpentine green volcanic rock, similar to the basalt east of Sabaneta, but more indurated and containing coarse veins and much epidote. The mass has been greatly broken by minor faulting. Intruded into the volcanic rock are irregular dikes of granitic or dioritic porphyry, at least 5 meters wide. Farther up the river this volcanic rock lies in contact with a blue sericite schist or phyllite, which also is cut by numerous large irregular dikes similar to those that cut the greenish volcanic rock down the river. It is significant that the volcanic rock of serpentine green color cut by the granitic dikes is similar in appearance to the basalt found east of Sabaneta interbedded with fossiliferous limestone conglomerate of Cretaceous age. Whether these two rocks are of the same age could probably be determined by carefully tracing the outcrops between the two localities. It would be interesting to learn whether the granitic dikes were formed before or after the Cretaceous limestone conglomerate.

TERTIARY SYSTEM.

Rocks of Tertiary age occupy probably two-thirds of the area of the Dominican Republic. Lower and perhaps middle Eocene deposits were not seen, but upper Eocene, middle and upper Oligocene, Miocene, and Pliocene deposits have been recognized. The names of the Tertiary formations and those of some of their supposed equivalents are shown in the following correlation table:

Tentative correlation table of the Tertiary sedimentary formations of the Dominican Republic.

American time subdivisions.		Dominican Republic. North side.		Dominican Republic. South side.	Localities of some of the other American equivalents.	European time subdivisions.
Pliocene.				Las Matas formation.	Panama, Jamaica, Cuba, and Costa Rica.	Sicilian. Astian. Plaisancian.
Miocene.	Upper.			Cerros de Sal formation.	Not known elsewhere in the West Indies. Yorktown and Duplin formations of Virginia and North Carolina.	Pontian. Sarmatian. Tortonian.
Miocene.	Middle.	Yaque group.	Mao clay. Mao Adentro limestone. Gurabo formation. (*Sconsia laevigata* zone).	Yaque group (not yet divided into formations).	La Cruz marl of Cuba; Bowden marl of Jamaica; upper part of Gatun formation, Panama; Porto Rico; Calvert, Choptank, and St. Marys formations of Maryland and Virginia.	Helvetian.
Miocene.	Lower.	Yaque group.	Cercado formation. (*Aphera islacolonis* zone). Baitoa formation.[1] Bulla conglomerate.[1]		Middle part of Gatun formation, Panama; Porto Rico; Shoal River marl and Oak Grove sand members of Alum Bluff formation of Florida. Lower part of Gatun formation, Panama; Chipola marl member of Alum Bluff formation of Florida; eastern Porto Rico; St. Croix.	Burdigalian.
Oligocene.	Upper.	Cevicos limestone.		East of Baní and elsewhere.	Anguilla; St. Croix; Porto Rico; Cuba; Panama; Tampa, Florida.	Aquitanian. Chattian.
Oligocene.	Middle.	Tabera formation.[2]		Near Túbano.	Antigua; St. Croix; Porto Rico; Cuba; Bainbridge, Georgia; eastern Mexico; Panama, etc.	Rupelian.
Oligocene.	Lower.				Vicksburg group of Mississippi, Alabama, Florida, and Georgia.	Lattorfian.
Eocene.	Upper.	Limestone at Damajagua and elsewhere.		Limestone in Sierra de Neiba, Sierra de Bahoruco, and elsewhere.	St. Bartholomew limestone; Plaisance limestone of Republic of Haiti; Ocala limestone of Florida; Jackson formation of Mississippi, etc.	Ludian. Bartonian.

[1] Largely contemporaneous.

[2] May include lower Oligocene.

EOCENE SERIES.

The Eocene rocks in the Dominican Republic, though widely distributed, are almost exclusively limestones. Eocene limestone has been recognized on both the north and south slopes of the Cordillera Septentrional, on the south slope of the Sierra de Ocoa, and farther east, near Baní, in the Province of Santo Domingo. Similar Eocene limestone forms a large part of the Sierra de Bahoruco and the Sierra de Neiba, and probably also of the Sierra de Martín García. Patches of limestone along the northern slope of the Cordillera Central are supposed but not proved to be of Eocene age.

The relations of the Eocene limestone to the underlying deposits are not definitely known, but limestone of Eocene age overlies deposits apparently of Cretaceous age in the southern scarp of the Cordillera Septentrional near Damajagua, northwest of Navarrete. At Las Lajas, on the Ferrocarril Central Dominicano, between Bajabónico and Altamira, Eocene limestone and sandstone apparently lie directly on sheared greenish hornstone and banded slate of the basal complex. At this locality the rocks of the basal complex are vertical and strike N. 40° W.; the Eocene beds have the same strike, but dip southward about 60°. Other exposures in the vicinity of Las Lajas show that a conglomerate immediately overlies the rocks of the basal complex. Apparently the limestone and sandstone from which Eocene Foraminifera were collected (see list on p. 105, station 8708) are interbedded with the conglomerate.

The only identified fossils that have been obtained from the Eocene of the Dominican Republic are Foraminifera, which are listed on pages 105-106. A sufficient number of recognizable species have been identified to establish close correlations with the Eocene deposits of the Republic of Haiti and of the other islands of the West Indies.

The thickness of the Eocene limestones in the Dominican Republic is unknown. In Haiti, according to T. W. Vaughan, a considerable thickness of Eocene limestone occurs at Cape Haitien and in the mountains between Plaisance and Ennery. Similar limestone composes the main mountain mass from Ennery to Gonaïves, thence to Artibonite Valley, and between St. Marc and the north side of the Cul-de-Sac. For this Eocene limestone, as exposed between Plaisance and Ennery, he proposes the name Plaisance limestone. The type exposure is at an altitude of 705 meters up the mountain from Plaisance toward Ennery. Typical fossils are *Orthophragmina*, *Conulites*, and other Foraminifera. Southeast of Port-au-Prince, on the road to Furcy, W. F. Jones[1] reports a thickness of at least 8,000 feet (2,438 meters) of limestone which he refers to the Eocene and Oligocene. That any of this great thickness of limestone is younger than

[1] Jones, W. F., Jour. Geol., vol. 26, p. 733, 1918.

the Eocene has not been proved. The Eocene limestone of the Dominican Republic is probably not so thick.

On the lower slopes of the front range of the Cordillera Septentrional near Damajagua, in Santiago Province, there is hard light-gray limestone of Eocene age. Some of this rock contains inclusions of hard, brittle, banded calcareous argillite, which breaks with rectangular, smooth faces and was probably derived from the Cretaceous rocks that are believed to underlie the Eocene at this locality. In a fragment of the Eocene limestone picked up loose on the hillside, but evidently not far from place, Doctor Cushman identified the species of Foraminifera listed on page 105 as from station 8721. Rock in place near this locality contains identifiable Foraminifera, which are listed on page 105 (stations 8725 and 8725a), but they are neither so well preserved nor so abundant as the species at station 8721.

Limestone of Eocene age also outcrops at several places near Altamira, in the Province of Puerto Plata. The identifiable Eocene fossils collected in Santiago and Puerto Plata provinces are listed on page 105.

Besides the rocks in Puerto Plata Province that have been identified as of Eocene age, Eocene strata probably occur near the city of Puerto Plata. South of Rio San Marcos, along both the railroad and the trail to Bajabónico, the oldest rock examined in exposures was serpentine, above which is limestone that contains angular fragments of lava. The corals, probably Oligocene, from the north slope of Monte Isabel de Torres (station 8675), listed on page 111, came from a younger geologic formation. The limestone above mentioned would therefore be either of Upper Cretaceous or Eocene age, probably Eocene, but further study is needed before a positive opinion will be warranted.

The caves of Las Guácaras are in thick, massive, dark blue-gray siliceous limestone, so hard that it strikes fire with steel. This limestone forms many steep hills, some of them 100 meters high, in the Sierra Prieta west of Rio Yuna and south of the road from La Vega to Cotuí. (See Pl. VII, *B*.) The rock is so massive that it is difficult to ascertain its strike and dip. At El Comedero, one of the caves, the strike appears to be east, the dip 70° S. Some of these scattered limestone hills appear to be fault blocks. No fossils were obtained from this limestone, but the stratigraphic and structural relations indicate that it is of Eocene age.

Blue limestone similar to that at the caves of Las Guácaras is exposed in a small arroyo crossed by the road from La Vega to Cotuí several kilometers west of Rio Yuna.

In the vicinity of Hatillo, a village near Rio Yuna on the road from Cotuí to Piedra Blanca, there are several hills composed of hard limestone, which is in part dark blue and somewhat bituminous and in part cream-white. The rock strikes N. 10° W. and dips 25° to 30° S. At one locality large lumps of limestone breccia were found. The limestone hills are probably fault blocks in which the tilting did not produce folds in the limestone. The dip of the limestone, were there no fault, would carry the rock beneath sericite schists of the basal complex. The limestone is more thinly bedded than at the caves in Sierra Prieta but in other respects closely resembles it. Associated with the limestone on a hill west of Hatillo are many loose blocks of magnetite, the source of which has not been discovered. This is the celebrated "Iron Mountain," described in glowing terms by Gabb,[1] but there is evidently no large deposit of magnetite at this locality. Further remarks on the iron deposits of this region will be found in a paper by R. B. Brinsmade[2] and in the report on mineral deposits near Hatillo and Maimon on pages 228–231 of this volume.

Paleontologic evidence of the age of the limestone in Sierra Prieta and at Hatillo is lacking. The only organisms that were obtained from the rock are massive forms, which appear to be calcareous algae, and these have not yet been critically studied. This limestone is supposed to be of Eocene age because it resembles other Eocene rocks, but it may be older.

Specimens of limestone collected by Mr. Condit from the seashore about 8 kilometers south of Barahona (station 8576) contain Foraminifera that are regarded by Doctor Cushman as "very definitely upper Eocene." The same species are found in the upper Eocene of Cuba. Mr. Ross found limestone containing Foraminifera similar to those in the Plaisance limestone of Haiti on the southwest slope of Cañada de Rancho Viejo, in the Sierra de Bahoruco, south of Rancho Viejo (station 8627), and pebbles of similar limestone occur also in Oligocene or Miocene conglomerate in the vicinity of Rancho Viejo (station 8626).

Rubble containing the Foraminifera listed on page 106 (station 8595) was found by Mr. Condit in the Sierra de Neiba about 2.5 kilometers north of Barbacoa.

Rocks of Eocene age were identified at several localities in the Province of Azua. These are discussed on pages 199–200, and lists of the identifiable fossils found in them are given on page 106.

Along Rio Vía above Azua there is massive limestone conglomerate, probably not over 50 feet thick, containing pebbles of greenish rock. Apparently above the conglomerate there is a thicker series of massive blue-gray limestone and alternating thin beds of limestone and shale, followed, near the top, by a few beds of limestone and shale. This entire formation except the limestone conglomerate is very much sheared and cut by small overthrust faults. A larger fault causes repetition of the greater part of the formation, including the conglomerate. The strike of the forma-

[1] Gabb, W. M., On the topography and geology of Santo Domingo: Am Philos. Soc. Trans., vol. 15, n. s., pp. 141–142, 1873.
[2] Brinsmade, R. B., Iron in Santo Domingo: Min. and Sci. Press, vol. 117, pp. 356–358, 1918.

At San José de las Matas, and extending southward from the town a distance of about 1.5 kilometers, Mr. Condit found steeply inclined reddish conglomerate interbedded with shaly layers. The strike of the beds is N. 60° W. In the south bank of Arroyo Hondo at San José de las Matas there is an outcrop of gray semicrystalline limestone. Ferruginous conglomerate similar to that at San José de las Matas is exposed at a waterfall on Rio Inoa about 3 kilometers farther west and not far below the mouth of Arroyo Hondo. At the confluence of Rio Inoa and Rio Amina, about 3 kilometers below the waterfall, conglomerate and dark shaly sandstone dip westward at an angle of 20° to 40°. Mingled with igneous pebbles in the calcareous cement of the conglomerate are small lumps of limestone containing corals and orbitoidal Foraminifera. Some of the Foraminifera (*Lepidocyclina* sp.) are curved and are more than 25 millimeters in diameter. They lie between the pebbles of coarse conglomerate. On the basis of these Foraminifera the rock is correlated with the Tabera formation. The beds of the Tabera formation in the vicinity of San José de las Matas abut against gneissic igneous rocks to the south; to the north they are separated from the sediments of the Yaque group by a strip of sericite schist, perhaps 1.5 or 2 kilometers wide. The presence of these conglomerates and shales in the midst of the basal complex is doubtless due to faulting.

Nearly a kilometer down the valley of Rio Gurabo from the village of Gurabo are outcrops of sedimentary rocks that are believed to be, in part at least, of Oligocene age. The schist here is overlain by a basal conglomerate, or rather a ferruginous breccia, made up almost entirely of fragments derived from the adjacent schists. The fragments are angular and poorly assorted but show distinct stratification. This deposit grades upward into a fine-grained conglomerate that has a limestone matrix containing Foraminifera. A little higher stratigraphically there are beds of massive limestone rich in corals and Foraminifera. This series of conglomerates and limestones dips northeastward at an angle of about 15°. Unconformably beneath these gently dipping strata are nonfossiliferous, coarse-grained, bluish sandstone and dark conglomerate, which dip northwestward at a steep angle. The conglomerate of the lower series appears to contain no fragments from the adjacent schists. The deposits above the unconformity are not greatly indurated, and lithologically the finer-grained beds resemble some of those in the Tabera formation. Unfortunately the fossils collected in the upper limestone strata were lost in transit, so that the age can not be confirmed, but in the field the fossils were believed to be probably Oligocene. The beds below the unconformity are probably Cretaceous or Eocene.

Besides the deposits above described and referred to the Tabera formation, limestone containing similar fossils was found at several places in the northern part of the Republic—at El Limón, on the trail from Santiago to Altamira (station 8713); at Yaroa village, about 17 kilometers north of Peña (station 8719); at Las Cacaos, north of Peña, near the head of Rio Licey (station 8740); on Las Lavas Creek, above Las Lagunas, on the Santiago-Altamira trail (station 8704); and probably at Las Lagunas (station 8703). Lists of the fossils from these localities are given on pages 107, 108, 111.

In the Province of Puerto Plata deposits of probably Oligocene age were found on the north slope of Monte Isabel de Torres at an altitude of about 320 meters (station 8675). The fossils collected at this locality are listed on page 111. They resemble in their stratigraphic affinities the fauna of the Tabera formation.

Limestone containing fossils of middle Oligocene age was found on the south side, in the Province of Azua, at at least five localities. The precise localities for the fossils and their names are given on pages 108–109.

At the east end of the Sierra de Neiba limestone containing Foraminifera that are probably of Oligocene age was collected on the right bank of Rio Yaque del Sur opposite Bastia, about 1.6 kilometers northwest of La Trinchera. The Foraminifera are listed on page 112 (station 8569).

Cevicos Limestone.

The name Cevicos limestone is taken from the village of Cevicos, near the east end of the Province of La Vega. The formation has been explored only along the trails leading from Cotuí eastward to Cevicos and from Cevicos northward to Villa Rivas. On the trail from Cotuí the formation was first seen in Arroyo Blanco, at the eastern foot of Loma de los Palos, from which it extends, most of the way under cover, to Cevicos. It was traced several kilometers north of Cevicos but disappears beneath a thick reef-coral limestone, supposed to be of Miocene age, which forms the rugged plateau bordering the Vega Real. (See page 30).

The Cevicos limestone is yellow or cream-colored, more or less argillaceous, and in places nodular. It contains many fossils, but few of them are sufficiently well preserved to be identified. A species of *Orthaulax* (*O. aguadillensis*) is abundant at Arroyo Blanco but was not seen elsewhere. This species, as well as two echinoids, *Clypeaster concavus* Cotteau and *Brissopsis antillarum* Cotteau, correlates the Cevicos limestone closely with the fauna of the Anguilla formation of Anguilla, which, according to current American usage, is considered uppermost Oligocene.

Although it is here classified as Oligocene, the Cevicos limestone as well as the Anguilla formation of Anguilla and the Emperador limestone of Panama, with which it is tentatively correlated, may ultimately be referred to the lower Miocene. The coral faunas of these formations, according to Vaughan, are in some respects similar to Miocene faunas and can be separated from them only with difficulty. In its lithology and structure also the Cevicos limestone resembles the formations of the Yaque group much more closely than it resembles the Tabera formation. Its softness and lack of alteration and its comparatively slight deformation suggest an age considerably later than that of the Tabera formation.

The relations of the Cevicos limestone to the basalt that forms the Loma de los Palos have not been ascertained, but it seems probable that the limestone is younger and was deposited upon the basalt. Wherever beds of limestone have been observed they are very nearly horizontal, although they probably slope gently northward or northeastward. The massive reef-limestone that covers the Cevicos limestone to the north is evidently younger, but whether the reef was deposited conformably upon the Cevicos limestone or whether there is a stratigraphic break between was not determined.

In the bank of Arroyo Blanco outcrops of creamy yellow limestone, nodular on weathered surfaces, extend 12 to 15 meters above water level. The bedding is indistinct but appears to be nearly horizontal. Softer and more argillaceous nodular limestone is exposed at about the same altitude in the banks of Arroyo la Mora about 1.5 kilometers east of Arroyo Blanco. This bed contains numerous casts of mollusks, including species of *Arca*, *Cardium*, and several venerids. The only fossils collected in which the shell substance is preserved are a species of *Ostrea* and a crushed specimen of *Brissopsis antillarum* Cotteau. Yellow nodular limestone containing mollusks, corals, and Foraminifera is exposed to a thickness of less than 2 meters on the east side of Arroyo Barranca, the first arroyo northeast of Cevicos on the road to Villa Rivas. It is overlain by 12 to 15 meters of yellow loam. Similar rock containing a *Pecten*, apparently a variety of *Pecten vaun* Cooke, and other fossils was found on both sides of a stream supposed to be Arroyo Jerguen. The fossils from all these localities are listed on page 110.

Either the Cevicos limestone or formations similar to it extend eastward for a considerable distance. According to Mr. Ross the south shore of Samaná Bay as far east as San Lorenzo Bay is made up of massive pink to white cavernous limestone similar in general appearance to the coral-bearing limestone overlying the Cevicos limestone and perhaps identical with it. This rock forms a level plateau like that south of Villa Rivas and probably about as high. According to Gabb[1] the summit of Loma de los Muertos, 10 kilometers south of Sabana de la Mar, is capped with thick horizontal beds of limestone similar to that near Cevicos.

In the southern part of the island limestone containing corals of upper Oligocene facies is exposed in the slopes and foothills of Monte Calabaza near San Cristóbal and at a place 24 kilometers from Santo Domingo City on the road to San Cristóbal. Precise data on the localities and lists of the fossils are given on page 112.

[1] Gabb, W. M., On the topography and geology of Santo Domingo: Am. Philos. Soc. Trans., vol. 15 n. s., p. 148, 1873.

MIOCENE SERIES.

Yaque Group.

PREVIOUS STUDIES.

The Miocene formations of the Cibao Valley have been studied in greater detail and by more investigators who have published the results of their work than any other strata in the Dominican Republic. T. S. Heneken[1] described the geology of part of this region in 1853, but his conception of the geology contains many errors. The collections of fossils procured by him were studied by British paleontologists,[2] whose descriptions give the first account of the Miocene fauna of the island. Gabb[3] criticized scathingly the work of Heneken, but his own interpretation of the geology leaves much to be desired. Dr. Carlotta J. Maury[4] and her associates in the expedition to the Yaque Valley in 1916 brought back large collections of fossils, by means of which she discriminated two faunal zones, the *Sconsia laevigata* zone and the *Aphera islacolonis* zone, to which she later[5] applied the names Gurabo formation and Cercado formation, respectively.

SUBDIVISIONS.

The work of the expedition of 1919 increased the number of formations discriminated in the Miocene of the valley of Rio Yaque del Norte from two to six, of which the lower two are regarded as approximately contemporaneous. The names applied to these formations are the following:

Mao clay.
Mao Adentro limestone.
Gurabo formation.
Cercado formation.
Baitoa formation.
Bulla conglomerate.

For the six formations of Miocene age in the valley of Rio Yaque del Norte and its tributaries the name Yaque group is here proposed. This name is peculiarly appropriate, because the equivalent strata on the south side of the Cordillera Central are best exposed along Rio Yaque del Sur.

The formations of the Yaque group in the area south of the Cordillera Central have not been named, although five divisions that are probably worthy of formational rank have been discriminated by Condit and Ross. The generalized section of the Yaque group in the vicinity of Quita Coraza is described by Condit and Ross as follows:

[1] Heneken, T. S., On some Tertiary deposits in Santo Domingo, with notes on the fossil shells by J. C. Moore and on the fossil corals by W. Lonsdale: Geol. Soc. London Quart. Jour., vol. 9, pp. 115–134, 1853.

[2] Duncan, P. M., On the fossil corals (Madreporaria) of the West Indian Islands: Geol. Soc. London Quart. Jour., vol. 19, pp. 406–458, Pls. XIII–XVI, 1863; idem, vol. 20, pp. 20–24; 358–374, Pls. II–V, 1864; idem, vol. 24, pp. 9–33, Pls. I, II, 1867. Sowerby, G. B., Descriptions of new species of fossil shells found by T. S. Heneken: Geol Soc. London Quart. Jour., vol. 6, pp. 44–53, 1849.

[3] Gabb., W. M., On the topography and geology of Santo Domingo: Am. Philos. Soc. Trans., vol. 15 n. s., p. 95, 1873.

[4] Maury, C. J., Santo Domingo type sections and fossils: Bull. Am. Paleont., vol. 5, Nos. 29, 30, 1917.

[5] Maury, C. J., Science, new ser., vol. 50, p. 591, 1919.

Section of Yaque group (Miocene) near Quita Coraza.

	Thickness in meters.
5. Sandstone, coarse to conglomeratic, with shaly beds in the lower part; light olive to gray. Large Arcas and other fossils plentiful in the lower beds	600
4. Clay-limestone member; calcareous, containing branching corals and layers of limestone filled with fossils (station 8590)	200
3. Sandstone, conglomeratic	100
2. Shale, bluish with thin sandstone laminae; no fossils seen	400
1. Sandstone and conglomerate, bluish sandy shale, and thin, nonpersistent beds of limestone; some of the beds contain a few fossils, chiefly fragments of branching corals and oysters	1500 (?)

Lists of fossils collected from the Yaque group on the south side of the Cordillera Central are given on pages 155-162.

BAITOA FORMATION.

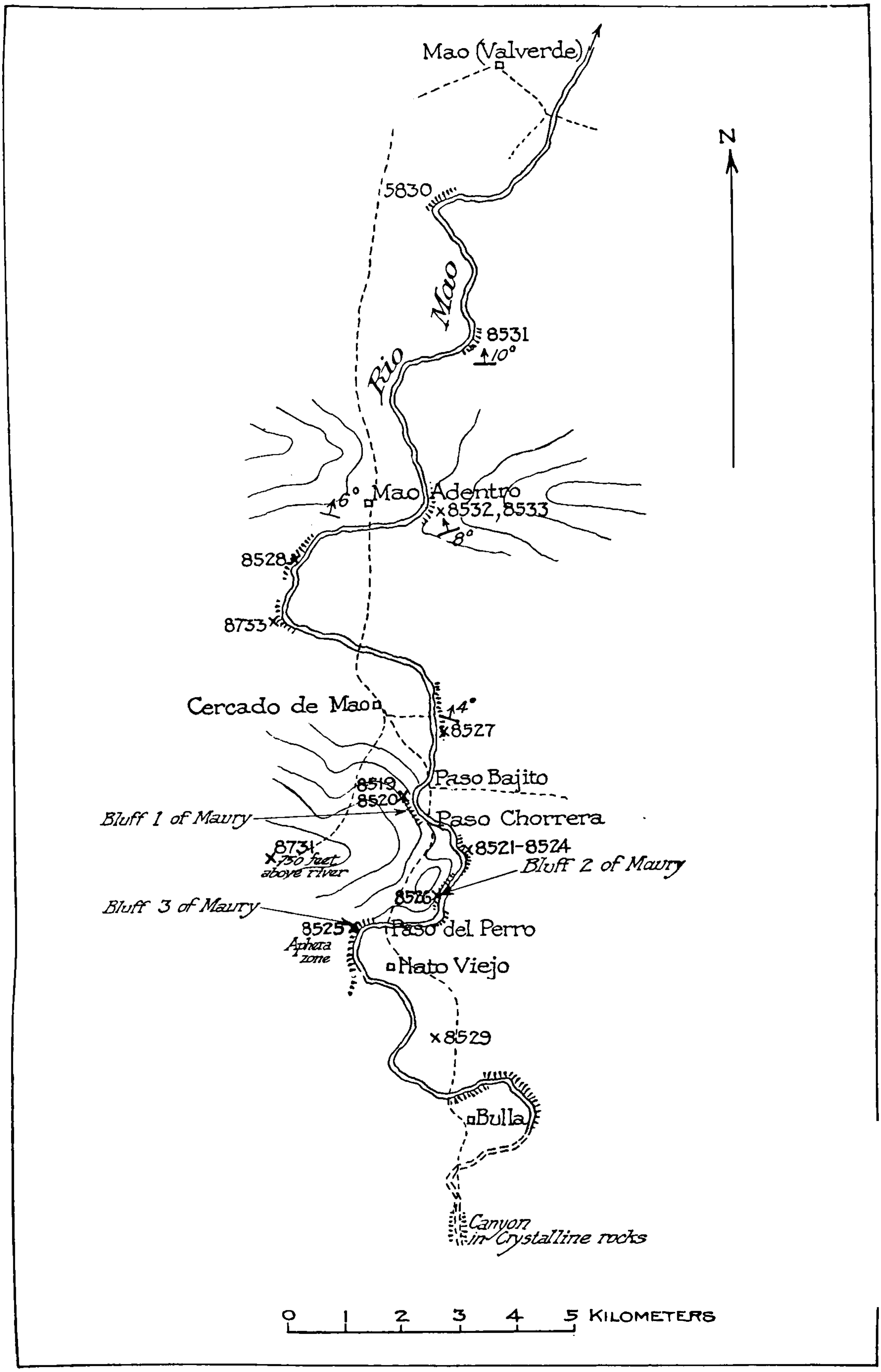
The Baitoa formation is named from a village on Rio Yaque del Norte on the road from Santiago to Jarabacoa. The formation at the type locality is a conglomeratic sandy marl containing an abundance of fossil shells. It rests with marked angular unconformity upon the upturned and beveled edges of the Tabera formation. Its upper limit has not been ascertained, but it is probably conformable with the Cercado formation. At Baitoa it dips gently northward. It is exposed in the bluff at Baitoa for a thickness of probably about 30 meters, but it may be considerably thicker.

The formation is best exposed in the high, horseshoe-shaped bluff on the right bank of Rio Yaque just below Baitoa, where it forms a nearly vertical cliff at the top of a very steep slope composed of blue-gray shales, sandstones, and conglomerates of the Tabera formation. The older formation is steeply tilted 40° toward the northeast and strikes N. 40° W. Upon the truncated edges of the dark strata of the Tabera formation lie the gently sloping, rusty-yellow conglomeratic sand and marl of the Baitoa formation. Even from a distance the contact is clearly visible, for the contrast between the formations is striking. The vertical climb of nearly 50 meters from Rio Yaque to the base of the Baitoa formation is difficult, and in many places it is impossible. The formation is more conveniently examined along the trail leading from Baitoa to Santiago, which passes up the hill and along the edge of the cliff, but the exposures here are poor and the fossils are not so abundant.

The fossils named in the lists given on pages 113-114 were collected from the Baitoa formation.

BULLA CONGLOMERATE.

The Bulla conglomerate, which is named from a village on the west side of Rio Mao near the crossing of the trail from San José de las Matas to Moncíón, rests with depositional contact upon schistose sediments of the



SKETCH MAP OF PART OF RIO MAO SHOWING POSITIONS OF STATIONS AT WHICH COLLECTIONS OF FOSSILS WERE MADE.

Pockets in the blue marl contain a great profusion of mollusks. *Aphera islacolonis* is regarded by Maury as characteristic of the Cercado formation.

The fossils that have been identified in the collections from the type locality of the Cercado formation (station 8525) are listed on pages 115-126.

According to information received from Maury, her Bluff No. 2 is the low bluff on the left side of the river between Paso del Perro and Paso Chorrera (station 8526; see sketch map, Pl. IX). The following is a section by T. W. Vaughan of the exposure there:

Section at station 8526, on Rio Mao.

	Meters.
Gravel, sand, and silt of a stream terrace deposit, unconformable on the underlying Miocene	3 to 6
Miocene (Cercado formation):	
1. Bluish fine silty sand, mostly fine-grained, with pockets and layers containing many mollusks as well as Foraminifera, which are in places so abundant as to produce a foraminiferal sandstone. The individual beds range in thickness from 0.3 to 1.5 meters and include hard layers	6 to 9
Total thickness of exposure	12

The beds dip northward at an angle of 4°. A list of the few fossils collected in the lower bed at this locality is given on pages 115-126.

The Cercado formation is exposed on Rio Cana at the ford of the trail from Las Caobas to Sabaneta, near the villages of Cana (east bank) and Caimito (west bank). The section below is given by T. W. Vaughan:

Section on Rio Cana at crossing of road from Las Caobas to Sabaneta.

	Meters.
Soil and river gravel at top.	
Miocene (Cercado formation):	
6. Sand, yellowish on weathered surface	2.1
5. Conglomerate and coarse sand	1.5
4. Greenish sandstone, some large grains as much as 6 mm. in diameter; a seam of pebbles	4.9
3. Bed of small pebbles; pebbles mostly less than 25 mm. long	0.3
2. Bluish sands; some pebbles. The sandstone weathers to yellowish sands. Contains many fossils in pockets	5.3
1. Dark-bluish sands, compact and somewhat indurated, interbedded with conglomerate. The lowest 1 meter is mostly sand with a little clay, and it contains a pebble seam a few centimeters thick. This is overlain by a pebble bed about 1.3 m. thick. The pebbles range in length from 3 to 15 centimeters. The edges of most of them are rounded, but many are subangular. Composed of igneous rock, laminated hornstone, etc	3.7

From bed 2 a considerable number of fossils were collected (station 8534; for list see pp. 115-124).

BULLA CONGLOMERATE INTERBEDDED WITH FOSSILIFEROUS SAND NORTHEAST OF BULLA, AT EAST EDGE OF FLAT OF RIO MAO.

At an altitude of 53 meters (by barometer) above the river a bed of large Teredo tubes similar to *Teredo incrassatus* (Gabb) was crossed on the east side of Rio Cana. This bed may correspond to that noted by Maury[1] on the river 3 kilometers below Caimito.

The section above described corresponds to Maury's Zone H.[2] Mollusks characteristic of the Cercado formation were also collected by the Maury expedition farther upstream, at a locality apparently about 3 kilometers above the crossing of the road from Las Caobas to Sabaneta. This locality is Maury's Zone I.[3]

The Cercado formation is exposed on Rio Gurabo between Rio Mao and Rio Cana, about 8.5 kilometers above Gurabo Adentro (see Pl. XI, stations 8737, 8738, 8739). The fossils from these localities are listed on pages 115-124, 127-129.

The Cercado formation has been recognized as far eastward as Rio Albano (station 8729), near San José de las Matas, where a characteristic faunule, which is listed on pages 116-124, was collected.

GURABO FORMATION.

The type locality of the Gurabo formation is on Rio Gurabo from "Zone A" to "Zone F," inclusive, of Maury,[4] near Los Quemados. As the descriptions of localities given by Doctor Maury are obscure it is rather difficult to identify some of the places she mentions. Apparently the locality to which she attached the name "Los Quemados" is the last crossing of Rio Gurabo on the trail from Gurabo Adentro to Los Quemados, about 3 kilometers west of Los Quemados. (See Pl. XI.) The exposures on Rio Gurabo are described by her in the section below. The lettered "zones" are the successive bluffs met on ascending the river.

Section at Los Quemados.

	Feet.
Concealed by vegetation and unexplored.	
Limestone with poorly preserved corals. Approximate thickness	50
Zone A. Hard light-blue clays forming vertical cliffs, slightly concave near the base. The clays weather yellowish white. Fossils rare or absent in the upper part of the bluffs; abundant below. Fauna chiefly *Gastropods*. A few pelecypods, such as *Venericardia* and *Echinochama*. Approximately	300
Zone B. Hard blue clays, blocky, not well stratified, weathering grayish. Fossils abundant. Thickness about	50
Zone C. Alternating clays and limestones, with a rather heavy bed of the latter above. Fossils very scarce; *Cassis sulcifera*. Thickness approximately	10
Zone D. Hard blue calcareous clays. Corals. *Cerithium* abundant. About	15
Zone E. Blue uniform clays with *Cerithium, Phos, Cypraea*. Approximately	20

[1] Maury, C. J., Am. Paleont. Bull., vol. 5, p. 441, 1917.
[2] Maury, op. cit.
[3] Maury, op. cit., p. 442.
[4] Maury, C. J., Science, new ser., vol. 50, p. 591, 1919; Am. Paleont. Bull., vol. 5, p. 434, 1917.

Zone F. Hard greenish clays with concretions. Corals, *Cassis*, *Zenophora*. Approximately	20
Zone G. Two miles above Los Quemados. Hard grayish-green clays with sandy layers and limonitic nodules. Strata in general unfossiliferous, but lenses very rich in fossils occur. *Amauropsis*. Few species in common with the preceding zones. Exposed thickness 10 feet; estimated total thickness at least	50

The Gurabo formation is exposed along Rio Gurabo from near the north end of the stretch of the river shown on Plate XI to a point several kilometers above the south end of the stretch shown on the map. For much of this distance the river winds through a narrow gorge cut in the siltstone of the Gurabo formation. The gorge is narrowest and virtually continuous along the upper reaches of the river. In many places great blocks of coralliferous Mao Adentro limestone have tumbled down from the top of the cliffs and cover the Gurabo formation.

On Rio Gurabo the top of the Gurabo formation is exposed at the bluff marked "U" (station 8556) on Plate XI, about 3 kilometers south of Gurabo Adentro. The following section at bluff "U" was measured by Mr. Condit:

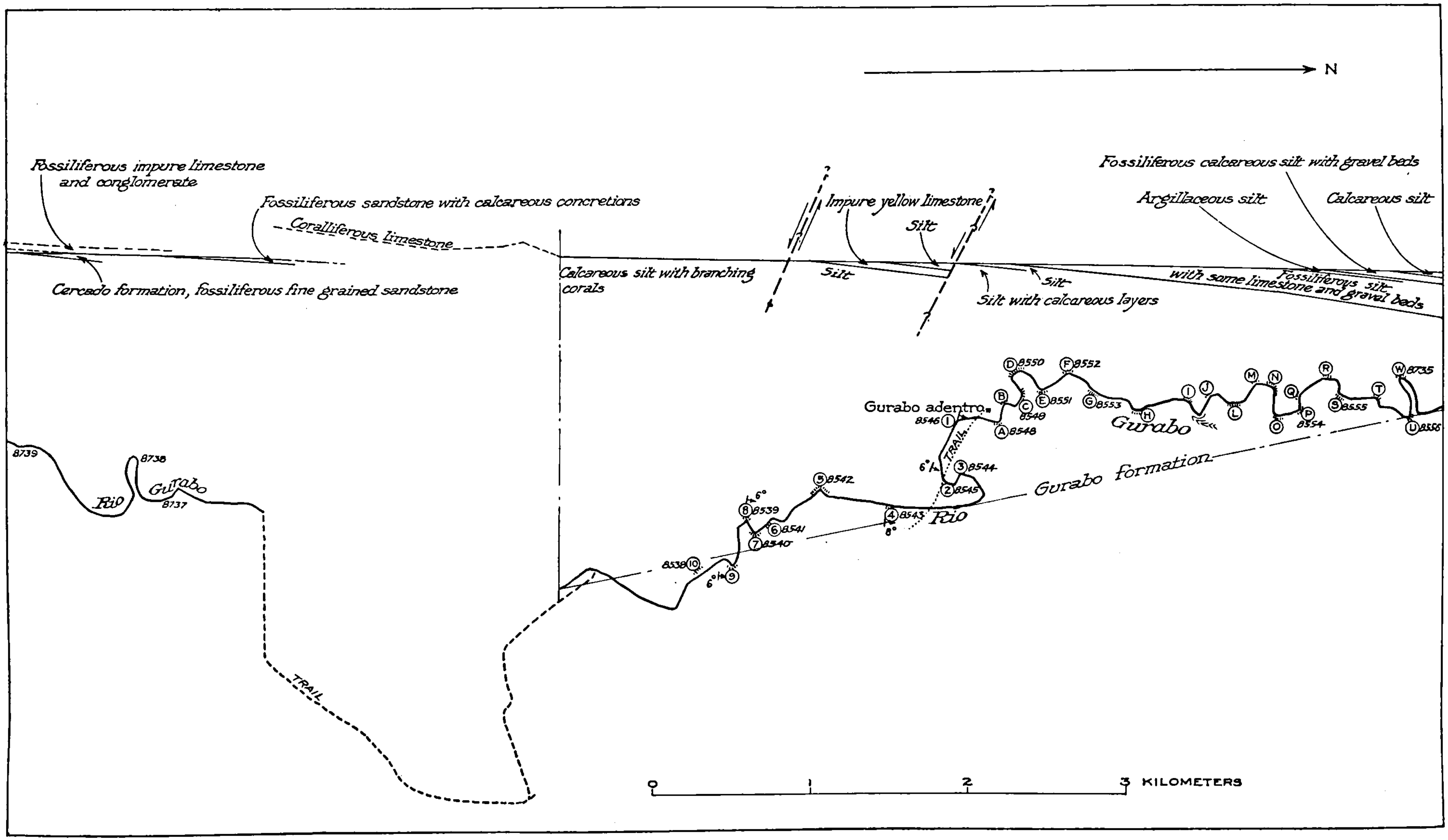
Section at bluff "U," Rio Gurabo, about 3 kilometers below Gurabo Adentro.

Top of Gurabo formation.	Meters.
4. Calcareous silt	0.9
3. Calcareous silt containing many branching corals	0.36
2. Fossiliferous calcareous silt	1.3
1. Conglomerate consisting chiefly of pebbles of igneous rock less than 75 mm. in diameter	0.46

The strike of the beds at bluff "U" is N. 60° W., and the dip is 15° NE.

The strata exposed along Rio Gurabo consist chiefly of beds of fine-grained siltstone. They include a few beds of rather coarse sandstone and some conglomeratic layers, but conglomerate is rare. The prevailing color is light brownish-green, but weathered surfaces are light brown or yellow. The silt in most of the beds is so fine as scarcely to feel gritty when rubbed between the fingers. All the beds are calcareous and some contain calcareous concretions. Several beds of limestone are intercalated between the silts. Many of the beds of both siltstone and limestone are rich in fossils, but in some beds fossils are scarce or lacking. The pebbles of the conglomerates are of metamorphic rocks, principally igneous, and in part fine-grained and porphyritic. The siltstone contains many glistening particles of a micaceous mineral resembling chlorite.

Mollusks are less numerous in the Gurabo than in the underlying Cercado formation. *Sconsia laevigata* is common and appears to be restricted to the Gurabo formation. Corals, both in number of species and in abundance of individuals, are more numerous than in the Cercado formation but less numerous than in the Mao Adentro limestone. Some of the reef-forming corals in the upper ledges of the Gurabo formation are very large; specimens



SKETCH MAP OF PART OF RIO GURABO SHOWING POSITIONS OF STATIONS AT WHICH COLLECTIONS OF FOSSILS WERE MADE.

Section on left bank of Rio Mao 1 kilometer above the ford at Cercado de Mao.

	Meters.
Pleistocene:	
4. Thin cover of river gravel, thickness variable.	
Miocene (Gurabo formation):	
3. Soft yellowish fine silty marl containing *Placocyathus*, *Amusium*, and *Amphistegina*. Contains a few harder nodular ledges, especially in the lower part. Forms a vertical or overhanging bluff	12.2
2. Thin-bedded hard yellowish limestone. Some ledges are platy. Collection of corals. Station 8520	9.1
1. Massive soft calcareous sand with a few locally indurated nodular ledges. Contains many mollusks and corals, especially in the lower part. "*Sconsia laevigata* zone." Station 8519	27.4

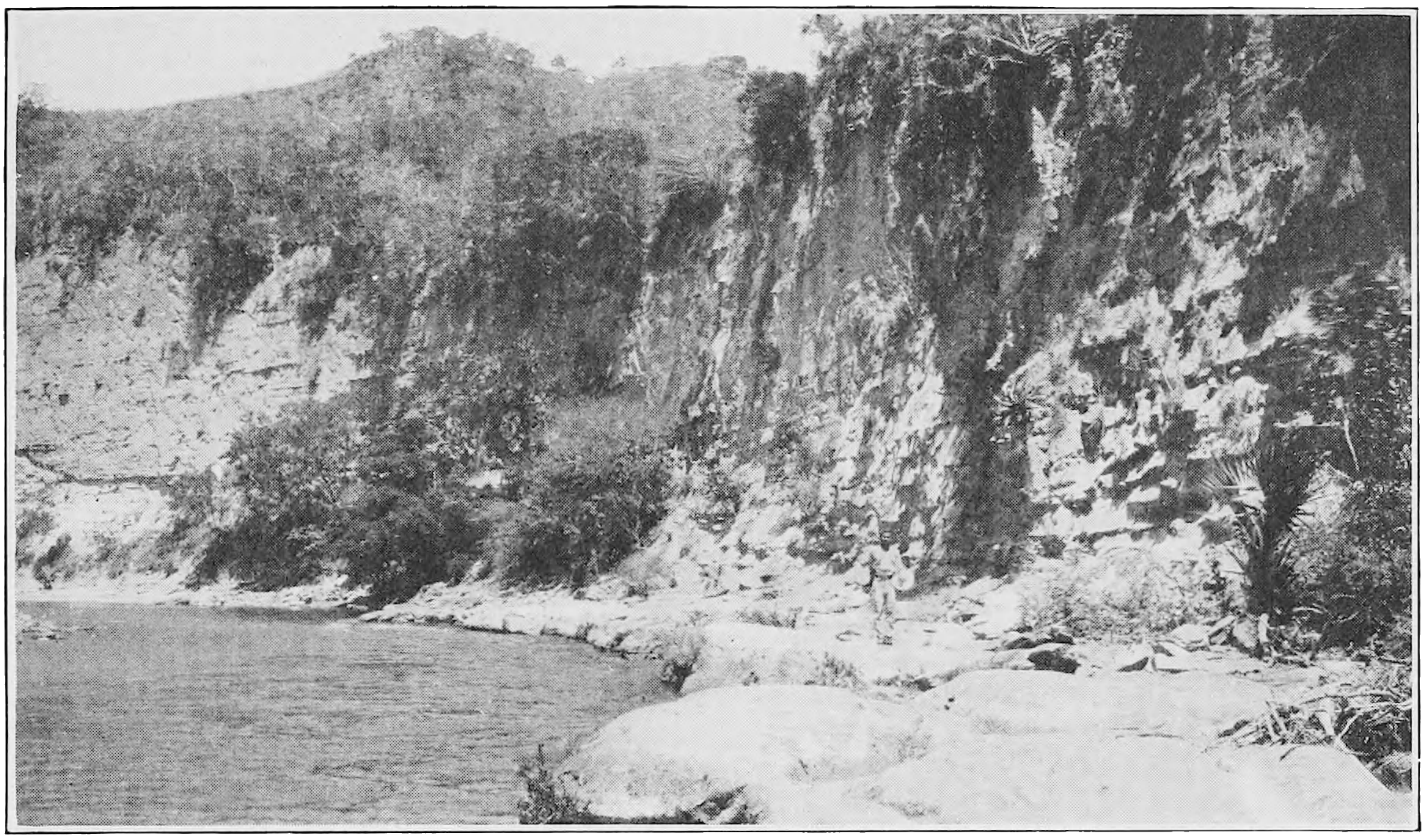
The bluff on the right bank of Rio Mao opposite Cercado de Mao, about 1 kilometer below Paso Bajito, the ford of the road to Potrero, shows about 12 meters of blue clay, light gray when dry, stained yellow with iron in places. This bed (station 8527), which contains many fossil corals, is the stratigraphic equivalent of bed 3 of the preceding section. This bed dips a few degrees east of north at an angle of about 4°. The fossiliferous bed is overlain by about 3 meters of gravel.

Very nearly the same horizon is represented in the two bluffs on the left bank of Rio Mao between Cercado de Mao and Mao Adentro (stations 8528 and 8734). The lowermost of these, which is about 25 meters high and is capped with gravel, is composed of bluish silty clay, bluish silt, and sand. The dip averages 7°, nearly due north. Plate XIII, *A*, is a view of the bluff at station 8528.

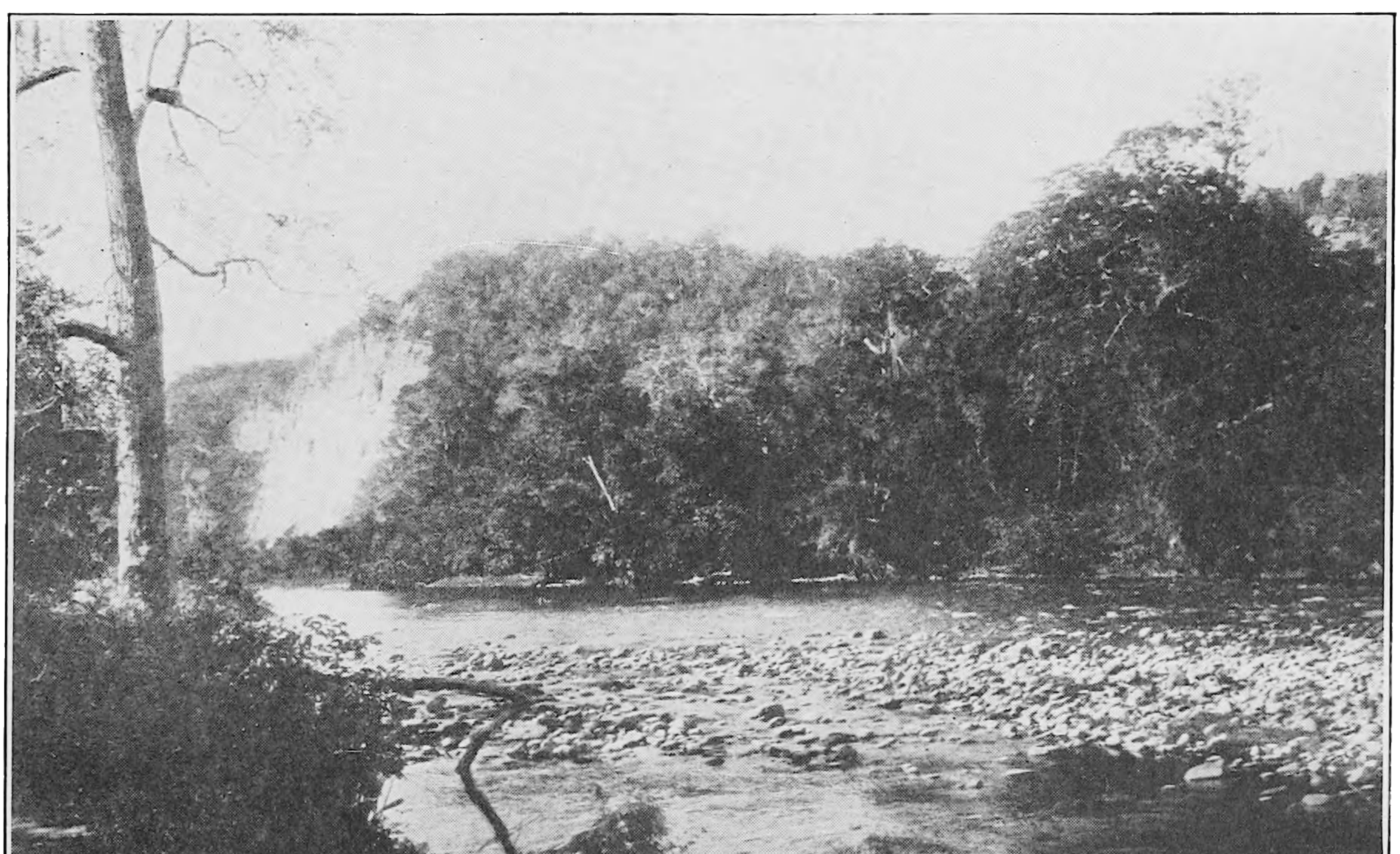
The entire thickness of the Gurabo formation is probably comprised within the interval between the top of the ridge south of Cercado de Mao, which is capped by the Mao Adentro limestone, and the river at its foot. According to a barometric reading the altitude of this ridge above the river is about 230 meters. The thickness of the Gurabo formation on Rio Mao is probably about 200 meters.

Excellent exposures of the Gurabo formation were noted on Rio Guanajuma at the crossing of the trail from Potrero to Cercado de Mao. The formation here has the same lithologic character and faunal content as on Rio Mao and Rio Amina.

Large collections of fossils were obtained from the Gurabo formation at Potrero, on Rio Amina (station 8516). The principal collection was made from a 15-meter bed of bluish silt overlain by river terrace gravel deposits, which are exposed in the right bank of the river from a point just above the ford at Potrero for about 300 meters upstream. The dip of the Gurabo formation in this bluff is about 6° toward the north.



A. CERCADO FORMATION ON RIO MAO OPPOSITE HATO VIEJO; STATION 8625.



B. GURABO FORMATION ON RIO MAO JUST ABOVE EL PASO BAJITO; STATIONS 8519, 8520

Obras Públicas for road metal. The rock is yellowish, soft, somewhat argillaceous coralliferous limestone, in which are lumps of harder limestone composed largely of corals and other fossils. The harder lumps are used as road metal and the soft matrix is discarded. The rock is exposed in numerous test pits scattered over the hills. In a quarry where a face over 30 meters wide is exposed a good section of the formation was observed. Here the lumps suitable for road metal occur in a bed about 3 meters thick that strikes approximately N. 30° E. and dips 15° N. This bed of harder material is underlain by calcareous clay, which is about 6 meters thick and contains a few small, hard lumps. Below the calcareous clay is an equal thickness of bedded sand, which has been disturbed by a small fault. The sand contains a few small coral lumps in the upper part and a few thin beds, about 5 centimeters thick, of hard, impure limestone in the lower part.

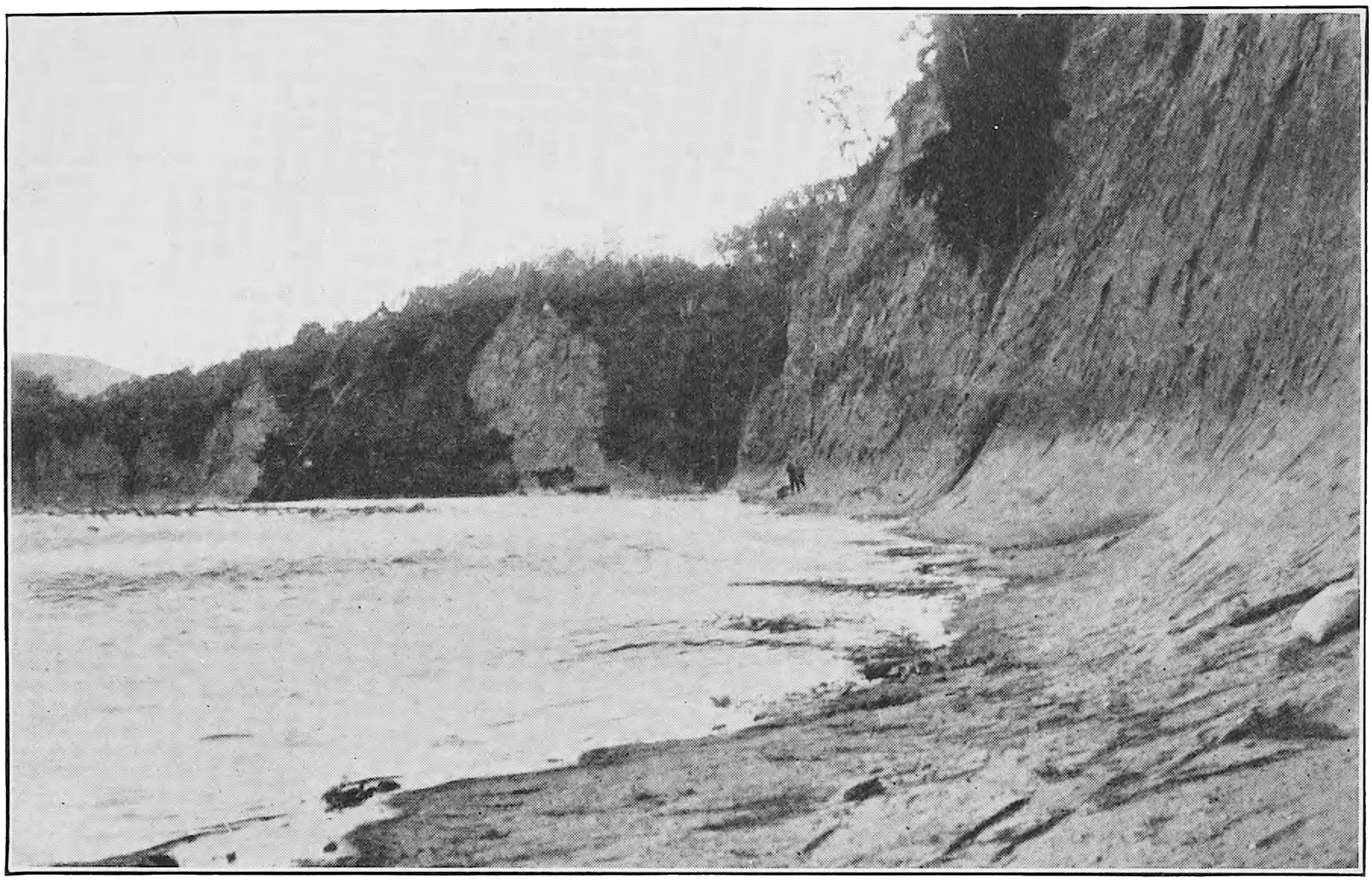
The Mao Adentro limestone is an important formation in the valley of Rio Yaque del Norte, for it seems to form the summits of most of the prominent hogback ridges there. Besides the ridges already mentioned there is Sierra del Viento, which is north of Rio Yaque and east of Rio Amina. This ridge is capped by a hard coralliferous limestone, which is underlain by an argillaceous or arenaceous deposit containing great numbers of branching corals. The beds in which branching corals are so numerous are tentatively considered a part of the Gurabo formation.

As the Gurabo formation appears to grade into the Mao Adentro limestone, notwithstanding the presence of beds of gravel near their contact and evidence of crustal disturbance in the area whence the gravels were derived, it was not practicable to decide with certainty as to which of the two formations some exposures should be referred. The Mao Adentro limestone probably possesses a peculiarity that will need to be considered in future field work. It is composed largely of corals, and in places it seems to be true coral-reef rock. Living coral reefs form broken ridges or chains or discontinuous patches of limestone, between and on the sides of which are contemporaneous sediments of different character. It is highly probable that the Mao Adentro limestone never formed a continuous rock sheet throughout its extent, but that it was composed of broken ridges and patches similar to the coral reefs of modern times. The relations of this limestone to older, contemporaneous, and younger deposits offer puzzling problems that can be solved only by detailed field studies.

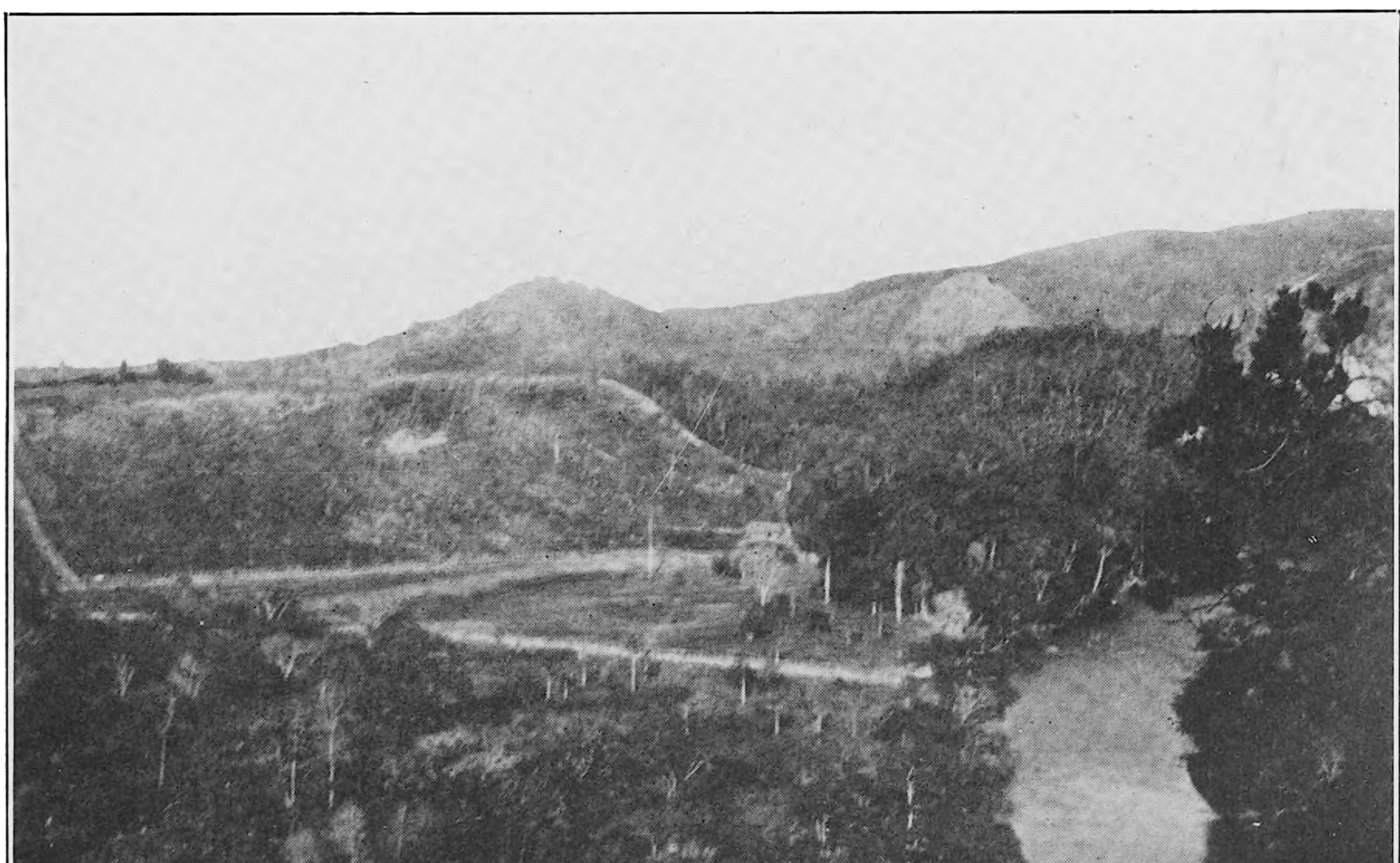
The fossils obtained in the Mao Adentro limestone are listed on pages 152-153.

MAO CLAY.

The Mao clay overlies the Mao Adentro limestone and forms the topmost division that has thus far been discriminated in the Yaque group. It is exposed in a bluff on the west side of Rio Mao 2 or 3 kilometers south of the town of Valverde (old name Mao). The sediment exposed in this bluff



A. GURABO FORMATION ON RIO MAO BELOW CERCADO DE MAO; STATION 8528.



B. RIO MAO SEEN FROM TOP OF BLUFF ABOVE EL PASO BAJITO.

MIOCENE OR PLIOCENE SERIES.

Plant-Bearing Beds at Sánchez.

Beginning at an exposure about 180 meters east of the pier at Sánchez, unconsolidated plant-bearing clay and sand containing seams of limonite crop out for several kilometers eastward along the south shore of Samaná Bay. In the exposure 180 meters east of the pier (station 8684) the strata dip eastward at an angle of 24°; 270 meters east of the pier (station 8685) they dip westward at an angle of 45°. At other localities farther east they show diversity in both strike and dip. More detail on this formation is given on page 184, and fossils from it are listed on page 165. The data at hand are inadequate for fixing the geologic age of the deposit, but as it is older than the terraces that bevel its surface around Sánchez it is tentatively referred to the Miocene or Pliocene.

PLIOCENE SERIES.

Las Matas Formation.

The name Las Matas formation is applied by Condit and Ross (p. 201 of this report) to loosely consolidated deposits of gravel, clay, and limestone in the valley of San Juan and adjacent areas. The name is taken from the village of Las Matas, in the province of Azua. The Las Matas formation lies unconformably upon the Yaque group. The contact is plainly shown at a place on Rio Yaque del Sur 3 kilometers upstream from Los Guiros, where the Yaque group is overlain with angular unconformity by the Las Matas formation. At this locality the strikes as well as the dips are discordant.

The formation consists chiefly of gravel but includes some marly limestone and clay. The gravel is yellowish-gray and is less firmly cemented than the conglomerate of the Yaque group. The clay is faint reddish to purplish, presenting a marked contrast to the bluish-gray to olive-green clay of the Yaque group. The formation looks like a subaerial deposit. The gravels resemble outwash material such as is now being laid down along the border of the mountains in this region.

No fossils have been found in the Las Matas formation, but it is evidently younger than the Miocene, and as it is certainly older than some deposits referred to the Pleistocene it is provisionally regarded as Pliocene, though it may be early Pleistocene.

QUATERNARY SYSTEM.

Raised coral reefs that are evidently not older than Pleistocene were seen at almost every place along the shore that was visited by members of the expedition, and the coast charts show raised reefs at many other places.

Adjoining the living reef that partly encloses the harbor of Puerto Plata is a dead reef, now standing 2.5 to 3 meters above sea level. At San Pedro de Macorís fossil reefs are even more conspicuous. The flat, rocky plain which there forms the point between the harbor and the ocean is a reef that stands about 2.5 meters above the sea. This plain is composed of hard, nodular, white or yellowish limestone containing many living species of corals. Doctor Vaughan recognized near or at the sea front the corals *Orbicella annularis, Maeandra strigosa, Manicina gyrosa, Siderastrea siderea, Acropora muricata,* and *Acropora palmata.* Back from the shore this hard rock merges laterally into soft, creamy-yellow nodular limestone. A cut near the steamer dock at Macorís exposes about 3 meters of this marl, in which there are many corals representing species characteristic of protected but clear water. The following species were identified by Doctor Vaughan:

Orbicella annularis (Ell. and Soll.).
Maeandra labyrinthiformis (Linn.).
Manicina gyrosa (Ell. and Sol.).
Agaricia agaricites (Linn.).
Siderastrea siderea (Ell. and Sol.).
Acropora muricata (Linn.). (Most abundant species.)
Porites porites Lam.
Porites astreoides Lam.

At Santo Domingo City the sea front in the vicinity of the wreck of the U. S. S. *Memphis* is bordered by a raised reef.

Lake Enriquillo is bordered by a terrace of coral limestone at an altitude of about 35 meters above sea level and about 79 meters above the present level of Lake Enriquillo. This coral reef is conspicuous at Neiba and Duvergé, but farther east it takes the form of a flat-lying bedded limestone. It is either of the same age as the conglomeratic "coast limestone," which extends from Cabral southeastward beyond Barahona, or it is a little younger. Plate XVII, *B* (p. 198), is a view of a part of this reef.

The "coast limestone," which was referred to the Pleistocene by Gabb, is not a unit but includes sediments ranging in age from Miocene to Recent. Much of it, however, is of Pleistocene age. A large part of it is soft, pulverulent, marly limestone, which is locally called "caliche." Some of this rock is conglomeratic and contains large boulders of older rocks of many kinds.

Raised rocky beaches, which still carry clinging shells, such as *Mytilus*, were seen at several widely separated places, notably several kilometers inland from San Pedro de Macorís, at an altitude of more than 30 meters above sea level, and along the shore northeast of Monte Cristi.

The fossils collected from Pleistocene or younger deposits are listed on pages 166–168.

STRUCTURE.

The structure of the Dominican Republic as a whole is simple, but its details are very intricate. The oldest rocks form a broad strip through the center of the island, and the younger rocks flank them on each side.

Except within the basal complex, where folding as well as faulting has been intense, faulting is the dominant element of the structure and folding is distinctly subordinate. Faults outline many of both the major and minor topographic features and determine the distribution of the geologic formations. The three longitudinal valleys that cross the island—the Cibao Valley, the San Juan-Azua area, and the Enriquillo Basin—are areas of Miocene and younger sediments that are partly outlined by faults. The mountain ridges that bound these valleys are composed of hard, older formations. Block faulting, both in the Cordillera Central and in the flanking areas, has caused frequent repetition of strata and greatly complicates the problem of interpreting the stratigraphy of the island.

The structure of the southwestern part of the Cibao Valley is monoclinal. The Miocene formations of the Yaque group dip gently northward and abut against the steep front of the Cordillera Septentrional, which, in the area between Santiago and Esperanza, is a fault scarp. At places, as in Arroyo las Lavas at the crossing of the Monte Cristi road, the edge of the Miocene formations has been dragged upward and the strata slightly overturned. At Damajagua, northwest of Navarrete, this great fault brings up Cretaceous "hornstone" and Eocene limestone high above the Miocene. The extension of this fault toward the northwest and southeast has not been traced. No faults of great magnitude were observed near Monte Cristi. Faulting has also taken place along the south side of the Cibao Valley, but the throw of the faults in that area is apparently not so great as that above described. The Oligocene Tabera formation, which dips steeply away from the Cordillera Central, is cut by many faults, but the throw of all that were examined is small. Block faulting of greater magnitude has taken place in the neighborhood of San José de las Matas and also near Dajabon.

The east end of the Cibao Valley is a gentle syncline. The Cevicos limestone in the neighborhood of Cevicos dips very gently northward, and the yellowish limestone that forms the foothills of the Cordillera Septentrional near Villa Rivas and Arenoso, which probably should be correlated with the Cevicos limestone, is inclined toward the south. No faulting was observed along the northern margin of the Cibao Valley east of San Francisco de Macorís. The large fault that forms the scarp near Navarrete either does not extend so far east or passes north of any route traversed by a member of the expedition.

Faults of undetermined magnitude involve schists and associated rocks of the basal complex and also hard limestones, probably of Eocene age, in the Lomas de Sierra Prieta near the margin of the Cibao Valley west of Rio Yuna and at Hatillo near Rio Yuna, southwest of Cotuí.

The mountain front north of Azua marks a fault which brings limestones and shales, probably Eocene or older, against beds of Miocene age. This

in line with the main tectonic features of the Antilles existed at the close of Paleozoic time. In fact, a gradually increasing body of evidence points to the existence of the major tectonic lines of the Antilles in late Paleozoic time.

It is inferred that during early Eocene time the site of the Dominican Republic was mostly a land area, because the widespread deposits of Eocene age all seem to belong to the latest subdivision of Eocene time. Until the geologic map of the Republic has been completed it will not be practicable to ascertain whether any part of it remained above sea during all of Eocene time, but the Eocene sediments contain large Foraminifera, such as *Lepidocyclina*, *Orthophragmina*, and *Nummulites*, that inhabited shallow tropical waters. The limestones in the areas occupied by Sierra de Neiba, Sierra de Bahoruco, and other mountains in the southwestern part of the Republic attained considerable thickness, and Eocene limestone with conclomerate at its base overlies the Cretaceous deposits in the Cordillera Septentrional. The Eocene limestones, however, appear to be thicker in Haiti than in the Dominican Republic. The intrusion of the great masses of dioritic rocks probably occurred before the deposition of the Eocene sediments.

It seems that after the deposition of the Eocene sediments there was a period of diastrophism, because the Tabera formation, of middle Oligocene age, is composed largely of coarse conglomerate, which indicates erosion at its source, and the Oligocene deposits in the vicinity of Los Bancos appear to be separated from Eocene deposits by a marked erosion unconformity. (See p. 95, Chapter VI.) Before middle Oligocene time there must have been a great deal of igneous activity to supply the material for the conglomerates and there may have been volcanic extrusions. Igneous activity during Oligocene time is shown by the interbedding of tuffs with fossiliferous deposits. Although middle Oligocene deposits occupy considerable areas in the Republic the whole of its surface was not under sea at this time. The earth movements during this period were evidently complex, and at the close of Oligocene time there appears to have been further diastrophic movement.

At the beginning of Miocene sedimentation the central axis of the Island was a mountainous ridge bordered by a shallow sea in which the basal conglomerate and sandy sediments of the Cibao Valley and of Azua Province were deposited to a thickness ranging from a few hundred to at least 1,500 meters. Active erosion of the adjacent land was almost continuous, and sandy sediments were spread over the sea bottom with only a temporary pause now and then permitting the deposition of thin beds of limestone. Nearly all the calcareous beds are made up of reef corals intermixed with some sandy material. No evidence of igneous activity in Miocene time is now known.

The events since Miocene time have included elevation and erosion, which were accompanied by pronounced faulting and folding and which lifted the Cordillera Central considerably higher than it stands now and brought into existence the Cordillera Septentrional, an uplifted block of Oligocene and older strata bounding the Miocene deposits of Cibao Valley on the north. Structural deformation of the Miocene strata, although not great in the Cibao Valley, proceeded apace in the southern region, where the beds were folded, faulted, and overturned. The great structural valleys, such as San Juan, Enriquillo, and Cibao, were probably produced during Pliocene time, and into them were carried the products of erosion of the central mountain chain, which were laid down at or near sea level. The work of block faulting in shaping the topography of Haiti and other islands of the West Indies group has been described by Vaughan.[1]

The events of late Pliocene time include mild folding and repeated elevation and depression, accompanied by more or less movement, which has continued down to the present and which produce the destructive earthquakes that occur from time to time. There is evidence of late vulcanism in the sheets of basaltic lava that cover the Las Matas formation along the upper valley of Rio Yaque del Sur.

During Pleistocene time there was a period of quiet, gradual submergence, which favored deposition of the "coast limestone," a marly porous rock of a type common throughout the West Indies, made up largely of reef corals of species still living in the Antillean seas. The "coast limestone" has been elevated so as to form an almost continuous line of cliffs along much of the coast and has undergone slight deformation. The paleontologic evidence indicates that its beds slope seaward, the youngest beds being exposed nearest the coast. These beds locally rest unconformably on Miocene strata, which appear a short distance inland in the province of Santo Domingo and in other areas to the east.

The extent to which the coast has undergone subsidence and emergence is indicated by sea-cut cliffs and terraces at different altitudes and by the presence of recent shell beds on these terraces. The amount of displacement differs at different places. Meinzer[2] reports that beds in eastern Cuba containing Pleistocene or younger fossils have been found up to an altitude of 200 meters above sea level. Doctor Berkey[3] has likewise found widespread evidence of depression and reelevation in Porto Rico. Similar evidence was found by our party, the best being seen near San Pedro de Macorís, where a shell bed some kilometers inland stands at an altitude of

[1] Vaughan, T. W., Geologic history of Central America and the West Indies during Cenozoic time: Geol. Soc. America Bull., vol. 29, 1918, p. 618.

[2] Meinzer, O. E., Geological reconnaissance of a region adjacent to Guantanamo, Cuba (unpublished report), quoted by Vaughan in Contributions to the geology and paleontology of the Canal Zone, Panama, and geologically related areas in Central America and the West Indies: U. S. Nat. Mus. Bull. 103, p. 265.

[3] r , C. P., Geological reconnaissance of Porto Rico: New York Acad. Sci. Annals, vol. 26, p. 60, 1915Be key

40 meters. Along the Barahona coast shells of species that are still extant were found on a terrace at an altitude of 20 meters.

The course of events along the Dominican coast subsequent to the deposition of the "coast limestone" may have been as follows:

1. Elevation of at least 100 meters, with intermittent pauses during which wave-cut terraces were formed.

2. Active erosion during which deep valley notches were cut across the "coast limestone."

3. Depression that produced drowned valleys, which indent the coast and furnish the harbors, such as Puerto Plata and Samaná Bay. The depression occupied by Lake Enriquillo probably dates from this time. It may have been cut off from Neiba Bay by delta deposits of Rio Yaque.

4. Elevation as the latest event. The elevation appears to have been about 35 meters in Barahona Province but was very different in other parts of the island. The chief evidence of elevation in Barahona Province is the well-defined coquina and coral reef terrace around Enriquillo Basin, which is very conspicuous at Barbacoa, Neiba, and Duvergé. To the traveller passing over this forest of corals, some still bearing their original colors, its resemblance to a modern coral reef as seen at low tide is striking. There is also evidence that a slight elevation was the latest event in other parts of the Republic, especially in the vicinity of Monte Cristi and Samaná Bay.

The course of events has probably been much more complex than that outlined above. There may have been in addition minor oscillations. The "coast limestone" itself is made up of strata of ages ranging from Miocene to Recent, and it may have been elevated above the sea in late Pleistocene or Recent time, for the corals and other fossils found in it along the sea front are identical with forms now found in the adjacent sea.

Volcanism probably recurred in early Pleistocene time and has been practically continuous almost to the present. There is no historic record of late volcanic activity, but it is denoted by the recent aspect of some of the volcanic vents and lava fields in the province of Azua. Hot springs that may be regarded as phenomena associated with final stages of volcanism are reported to occur at a few localities in the Cordillera Central.

GRANULAR INTRUSIVE ROCKS.

Diorite.—The granular intrusive rocks include none more siliceous than quartz diorite or granodiorite. Most of the specimens are quartz diorites. Rocks of this class are found in the provinces of Monte Cristi, Santiago, and Pacificador. The commonest type is medium-grained, gray, granitic-looking rock, rather rich in quartz, containing variable amounts of hornblende. Biotite is subordinate to hornblende in all the specimens and is quite absent from some. Most specimens contain little or no potash feldspar. Only one (D. C. 56b) contains enough to suggest its affinity to granodiorite. In one specimen (R. 33) the usual interstitial position of orthoclase is occupied by albite, which may be secondary after orthoclase. The poverty of these rocks in potash, combined with their rather high silicity, is noteworthy.

One specimen has a gneissic texture induced by pressure (D. C. 72). Two (D. C. 23d, D. C. 25) are tentatively grouped with the diorites; they have suffered deep-seated alteration and are possibly epidiorites derived from gabbro. The feldspar is abnormally sodic for rocks so rich in dark minerals.

Gabbro.—A single specimen of gabbro (D. C. 23c) was collected in the Province of Santiago. It consists essentially of labradorite, augite, and hornblende. The hornblende, which is more abundant than the augite, is probably in part secondary. Some of the altered rocks just mentioned, however, may have been derived from gabbro.

Peridotite.—A specimen (D. C. 3) of altered peridotite, consisting mainly of dull serpentine derived from olivine but sprinkled with satiny crystals of bastite, was collected near the town of Puerto Plata, and a hornblende-olivine rock was collected in the Province of La Vega (D. C. 23e).

Specimens of granular intrusive rocks.

No.	Name.	Locality.	Remarks.
R. 33	Quartz diorite	Juan Calvo Hills, 4 km. south of Dajabon, Province of Monte Cristi.	Cobble. Contains interstitial albite (replacing orthoclase?).
D. C. 72	Quartz diorite gneiss	Arroyo Blanco, road from Sabaneta to Restauración, Province of Monte Cristi.	No alkali feldspar present.
D. C. 3	Serpentine	Along railroad 5.8 km. west of Puerto Plata, Province of Puerto Plata.	An altered olivine-enstatite rock, also some limestone.
R. 12	Quartz diorite	Arroyo Arenasito, Cordillera Septentrional, near Villa Rivas, Province of Pacificador.	Cobble; quartz abundant.
R. 11	Quartz diorite, aplitic facies.	Arroyo Higuero, Cordillera Septentrional, near Villa Rivas, Province of Pacificador.	Cobble similar in composition to R. 12 but finer-grained.
D. C. 56b	Quartz diorite or granodiorite.	Rio Jinoa, about 5 km. southwest of San José de las Matas, Province of Santiago.	
D. C. 25	Diorite or epidiorite	Canyon of Rio Yaque del Norte above Tabera, Province of Santiago.	Much altered; amphibole is fibrous; might be altered gabbro.

Specimens of granular intrusive rocks—Continued.

No.	Name.	Locality	Remarks.
D. C. 23a	Quartz diorite	La Vega trail between summit of divide and Rio Maimón, Province of Santiago.	Hornblende abundant; feldspar bytownite; no potash feldspar present.
D. C. 23d	Quartz diorite or epidiorite.	Same as 23a, above	Texture indicates deep-seated alteration. Feldspar abnormally sodic.
D. C. 23f	Amphibolite schist	Same as 23a, above	Essentially quartz, hornblende, and albite. May be of same origin as 23d, but more thoroughly altered.
D. C. 23c	Gabbro	Same as 23a, above	Contains hornblende, probably in part secondary.
D. C. 23e	Hornblende peridotite	Same as 23a, above	Much altered; olivine wholly replaced.
C-76-19	Quartz diorite	Rio Medio, between 10th and 11th crossings, road from Constanza to Las Cañitas, Province of Azua.	Also a dark porphyritic rock, not determined.

DIKE ROCKS.

Many of the specimens are either described as occurring in dikes or, as their texture indicates, are obviously dike rocks. Some others are only tentatively classified as dike rocks in the absence of adequate information regarding their mode of occurrence.

Silicic dike rocks.—The most common sort of silicic dike rock in the collection is a whitish granite porphyry containing phenocrysts of quartz and albite and sparse vestiges of some altered ferromagnesian mineral in a groundmass of albite, quartz, and orthoclase. Specimens of such rock were collected in the Provinces of Santiago and Pacificador. An aplitic rock (D. C. 27a) from the Province of Santiago consists essentially of feldspar, abundant quartz, and a moderate amount of hornblende. The feldspar is albite or sodic anorthoclase. Both this aplite and the granite porphyry may be genetically related to the quartz diorites.

Intermediate dike rocks.—A dark-green sheared and highly altered diorite porphyry (D. C. 23b) was found in the Province of Santiago, and a very fresh gray diorite porphyry (D. C. 83) from the Province of Azua contains phenocrysts of labradorite, augite, hornblende, and biotite.

Mafic dike rocks.—The collection contains several specimens of diabase, which may be dike rocks, though some of them may be lavas. They are from the provinces of Azua and Santiago. Two specimens (R. 7 and D. C. 56a) have the texture of diabase but contain hornblende in place of augite; in D. C. 56a the feldspar is near albite and probably secondary.

Some other dark greenish dike rocks containing augite but not diabasic in texture are listed as lamprophyres. They were found in the provinces of Samaná, Monte Cristi, and Santo Domingo. They are considerably altered and in at least one (D. C. 68b) the feldspar is albite.

Specimens of dike rocks.

No.	Name.	Locality.	Remarks.
D. C. 68b	Lamprophyre	Cordillera Central, about 1.5 km. south of the village of Gurabo, Province of Monte Cristi.	Feldspar albite, possibly secondary.
R 12b	Granite porphyry	Cobble in Arroyo Arenasito in Cordillera Septentrional, near Villa Rivas, Province of Pacificador.	Phenocrysts of quartz and sodic plagioclase.
Samaná 6	Lamprophyre	Beach west of Las Cañitas, south shore of Samaná Bay, Province of Samaná.	Dike cutting schist; similar to Samaná 8, but more altered.
Samaná 8	Lamprophyre	Beach west of Las Cañitas on south shore of Samaná Bay, Province of Samaná.	Phenocrysts plagioclase and augite; much altered.
D. C. 27a	Aplite	Canyon of Rio Yaque del Norte at Baitoa, Province of Santiago.	No potash feldspar; feldspar sodic anorthoclase?
D. C. 66a	Metadiabase	Rio Inca near San José de las Matas, Province of Santiago.	Essentially plagioclase and secondary amphibole.
C–70–19	Lamprophyre	Hill on northeast edge of Constanza, Province of La Vega.	Small dike; cuts C–69–19.
C–67–19	Granite porphyry ?	About 3 km. south of El Paso Bajito on road from Jarabacoa to Constanza, Province of La Vega.	Weathered; no thin section.
D. C. 25b	Sheared diorite porphry.	La Vega trail between summit of divide and Rio Maimón, Province of La Vega.	Cobble; contains pseudomorphs after plagioclase and hornblende.
R 7	Hornblende diabase	Loma Pegado, near Maimón, Province of La Vega.	Contains periclase?
R 8	Granite porphyry	East of Cotuí, Province of La Vega	Phenocrysts of quartz and albite.
C–81–19	Diabase ?	Dike cutting conglomerate in Arroyo Lima, southeast of Túbano, Province of Azua.	No thin section.
D. C. 83	Diorite porphyry or andesite.	Left bank Rio Yaque del Sur on hill near Arroyo Salado, Province of Azua.	Very fresh; phenocrysts plagioclase, augite, hornblende, and biotite
C–91–19	Metadiabase ?	West slope of Loma Nizao between San José de Ocoa and Nizao Arriba, Province of Azua.	Feldspar is albite, idiomorphic against hornblende.

LAVAS.

Among the lavas, as among the granular intrusives, there are no decidedly silicic or alkalic types, but there are intermediate, basic, and ultrabasic types.

Andesites.—A gray poryphyritic typical hornblende-augite andesite was found in the Province of Azua (D. C. 74), and two other specimens, of which no thin sections are available, from the same province, apparently belong to hornblende andesite. A black augite andesite with phenocrysts of plagioclase and augite was collected in the Province of Santo Domingo.

Basalts.—The collection contains specimens of basalt from the provinces of Monte Cristi, La Vega, Azua, Barahona, and Santo Domingo, and also two specimens from the Département du Nord, Republic of Haiti. The rocks are variously altered, the olivine in many of them being replaced by chlorite or serpentine. Two extremely fresh specimens of very basic lava classifiable as limburgite rather than basalt are D. C. 76 and 79. One of these contains no feldspar, though feldspar might be present if the glass of the groundmass were crystallized.

A specimen (R 2, 3) of pale drab limestone collected in the Province of Puerto Plata contains fragments of green decomposed lava whose sharp angularity indicates that they were not carried far by currents and that they were erupted while the limestone was being formed.

A dark-gray calcareous rock from the Constanza-Túbano road, in the Province of La Vega (C 73-19), contains much noncalcareous material that forms a pale rind on its weathered surface. This material may be volcanic, as Dr. Vaughan has suggested, but the suggestion can not be verified without microscopic study. This rock probably belongs to the basal complex.

Specimens of tuffaceous rocks.

No.	Name.	Locality.	Remarks.
D. C. 1	Tuff (andesitic ?)	Southern edge of the city of Puerto Plata, Province of Puerto Plata.	
R 1	Tuff-sandstone	Trail to Santiago, about 300 meters west of San Marcos, Province of Puerto Plata.	
R 2, 3	Limestone containing fragments of lava.	Trail between Puerto Plata and Santiago, southwest of San Marcos, on the northeast slope of divide, Province of Puerto Plata.	Fragments angular.
R 17	Andesitic? tuff-sandstone.	Arroyo north of Los Ranchos, Cordillera Septentrional, near lignite prospect, Province of Pacificador.	Lignite is interbedded with similar material. Contains fluorite.
D. C. 27b	Andesitic tuff-sandstone.	Canyon of Rio Yaque del Norte at Baitoa, Province of Santiago.	Cretaceous?
C-66-19	Indurated tuff ?	About 1.5 km. south of El Paso Bajito, road from Jarabacoa to Constanza, Province of La Vega.	
C-69-19	Basalt tuff	Hill northeast of Constanza, Province of La Vega.	
C-73-19	Andesitic or basaltic tuff ?.	First crossing of Arroyo Hondo, road from Constanza to Túbano, Province of La Vega.	Dark red.
C-82-19	Andesite tuff	Cerro de las Chibras, Túbano, Province of Azua.	Very fresh.
R 81	Andesitic tuff	La Rama prospect, San Francisco Mining Concession, Province of Santo Domingo.	
R 86	Tuff ?	Chini prospect, near Arroyo Alga, San Francisco Mining Concession, Province of Santo Domingo.	Much altered.
R 55	Decomposed tuff ?	Sierra Bahoruco, north side of Cañada Diablo, south of Duvergé, Province of Barahona.	

CHAPTER VI.

TERTIARY AND QUATERNARY STRATIGRAPHIC PALEONTOLOGY.

By THOMAS WAYLAND VAUGHAN and WENDELL PHILLIPS WOODRING.

OBJECTS OF THE PALEONTOLOGIC WORK.

As is stated in the introductory chapter of this volume, one of the objects of the preliminary geologic work done in the Dominican Republic included the collection of fossils that would establish a more accurate geologic correlation of the formations in the Republic and that would aid in correlating them with formations in other West Indian islands, southern North America, Central America, and northern South America and in establishing geologic correlations of formations on the two sides of the Atlantic. The large collections obtained during the reconnaissance have been studied in a preliminary way and the information they afford is here presented. The only other collections made in the Dominican Republic that can aid in determining geologic correlations are those obtained by Dr. Carlotta J. Maury and her party in May and June, 1916.[1] The results of studies by specialists of the Foraminifera, Echinii, Bryozoa, and Crustacea collected by her party, as well as of some stratigraphic information contained in her report, have been used, for by thus combining the results of the studies of the two sets of collections we are able to give a summary of all that is now known of the Tertiary stratigraphic paleontology of the Dominican Republic. The small fauna of the known Cretaceous is discussed on pages 53-55.

The identification of the fossils has been a laborious undertaking, in which a number of investigators have collaborated. Credit for the determinations should be given as follows: Foraminifera, Dr. Joseph A. Cushman, of the United States Geological Survey; corals, Dr. T. Wayland Vaughan, of the United States Geological Survey; Echinii, Dr. Robert T. Jackson, of Peterborough, New Hampshire; Bryozoa, Dr. Ray S. Bassler, of the United States National Museum, and Monsieur F. Canu, of Versailles, France; Mollusca, Dr. W. P. Woodring and Mr. W. C. Mansfield, both of the United States Geological Survey; Crustacea, Dr. Mary J. Rathbun, of the United States National Museum. The few fossil phanerogamous plants were examined by Professor E. W. Berry, of Johns Hopkins University. It would possibly be no more than just to give the names of all these collaborators as joint authors of this chapter. In references to fossils given in the following lists the identifications should be credited to the

[1] Santo Domingo type sections and fossils: Bull. Am. Paleontology, vol. 5, pp. 165–459, Pls. 27–68, 1917.

specialists who made them. Dr. Marshall A. Howe, of the New York Botanical Garden, is preparing a report on the fossil calcareous algae, but the results of his study are not yet available.

The lists here given are only preliminary, because, although great care has been taken both in the identification of species and in the compilation of the lists, it has not yet been practicable to make monographic studies of the several groups of organisms represented. Many species have not yet been named and further field work will doubtless add greatly to the number already collected, but notwithstanding these limitations much valuable information was procured. The general biologic features of several of the formations have become fairly well known, and when the data are presented in detail they will help still further to solve problems of both local and regional geology.

PALEONTOLOGIC LITERATURE.

As it is not practicable to illustrate in this volume the fossils mentioned in the tables, it is desirable to give references to the more valuable illustrated reports on the West Indian and Central American representatives of the groups here considered. Three volumes of particular value have appeared during the last few years. They are as follows:

Carlotta J. Maury, Santo Domingo type sections and fossils: Bull. Am. Paleontology, vol. 5, pp. 165–459, pls. 27–68, 1917.

T. W. Vaughan and others, Contributions to the geology and paleontology of the Canal Zone, Panama, and geologically related areas in Central America and the West Indies, prepared under the direction of T. W. Vaughan: U. S. Nat. Mus. Bull. 103, 612 pp., 154 pls., 25 text-figs., 1918–1919. This volume contains memoirs on fossils as follows: Calcareous algae, by M. A. Howe; Higher plants, by E. W. Berry; Foraminifera, by J. A. Cushman; Echinii, by R. T. Jackson; Bryozoa, by F. Canu and R. S. Bassler; Decapod Crustacea, by Mary J. Rathbun; Cirrepedia, by H. A. Pilsbry; Corals, by T. W. Vaughan. The last paper in the volume is one by T. W. Vaughan summarizing the paleontologic data and discussing problems of correlation and of geologic history.

T. W. Vaughan and others, Contributions to the geology and paleontology of the West Indies, prepared under the direction of T. W. Vaughan: Carnegie Inst. Washington Pub. 291, 184 pp., 53 pls., 7 text-figs., 1919. Besides a brief introduction by T. W. Vaughan this volume contains papers on West Indian fossils as follows: Calcareous algae, by M. A. Howe; Foraminifera, by J. A. Cushman; Bryozoa, by F. Canu and R. S. Bassler; Mollusks, by C. W. Cooke; Decapod Crustacea, by M. J. Rathbun.

These volumes contain references to older works. Several other valuable papers on Foraminifera by Doctor Cushman have recently been published. Among these papers are "The American species of *Orthophragmina* and *Lepidocyclina*" (U. S. Geol. Survey Prof. Paper 125-D, pp. 39–105, pls. 7–35, text-figs., 1920) and "Lower Miocene Foraminifera of Florida" (U. S. Geol. Survey Prof. Paper 120-B, pp. 60–74, pl. 11, 1920).

The publications here cited, together with the references they contain and the bibliography given on pages 18-25, include nearly all the important papers on West Indian stratigraphic paleontology.

Correlations by diastrophic events, a method which is based on similarity in deformation or in succession of deformation or on similarity in degree of metamorphism, is also defective, for the whole crust of the earth is not simultaneously subjected to earth movements of the same kind and intensity. Parts of the earth's crust have remained almost undisturbed while other parts have been folded into mountain chains, and igneous activity was violent in some regions while there was none at all in others. Notwithstanding the limitations of the method of correlation by diastrophism, however, it is of great value, because the strata in some large parts of the earth did undergo deformation at nearly the same time, and in a study of those parts the complicated events of the past may be traced by carefully studying the relations of the rocks one to another and thereby learning something of the history of their deformation.

Correlation by means of fossil organisms depends upon the premise that the organisms which inhabited the earth in past geologic time have changed in character and in grouping from age to age and that the organisms which lived in each geologic age were similar. The defects of this method of correlation are numerous: (1) Many deposits, particularly those formed on the land, contain no organic remains; (2) land, water, or climatic barriers may not permit organisms to move freely to any part of the earth—that is, the organisms of one time and place may be restricted in their geographic distribution, and the organisms that lived at a certain time may have been very different in different regions; (3) if organisms had suddenly changed at the beginning of each geologic epoch and if all the organisms that lived during that epoch were characteristic of it there would be no great difficulty in recognizing the age of a deposit that contains abundant organic remains, but abrupt breaks do not generally occur between faunas of successive epochs. For instance, it seems that nearly all the species of the living shallow-water coral fauna of the West Indies already existed in Miocene time—probably in older Miocene time. The Miocene coral fauna of the West Indies is characterized by some genera and groups of species some of which are now extinct while others persist in the Indo-Pacific region. Almost all the superspecific groups of the Recent West Indian shallow-water Mollusca were also living in Miocene time in the West Indian region, but the Miocene Mollusca include groups that are now restricted to the west coast of America or to the Indo-Pacific region.

Correlation by means of fossils involves still other difficulties and liabilities to error. The original subdivision of the Tertiary system into Eocene, Miocene, and Pliocene was made by Lyell according to the percentage of living species of mollusks found in the rocks, the Eocene containing 3.5 per cent, the Miocene 17 per cent, and the Pliocene 30 to 50 per cent of species still living. Two other subdivisions of the Tertiary were afterward made, the Oligocene by Beyrich and the Paleocene by

Schimper, the Oligocene containing 10 to 15 per cent of living species of Mollusca and the Paleocene practically none. The comparison of faunas by means of such percentages is likely to lead to very serious errors and possesses significance only when all the species of a given ecologic complex are known and are compared with all the species of a similar ecologic complex. In the discussion of fossil faunas too little attention has been paid to differences in contemporaneous faunas due to differences in environment. The necessity of giving greater consideration to ecology in the study and geologic use of fossils has been recently emphasized by Vaughan.[1] If the percentage method of comparing faunas were applied to the living lagoon fauna and the living exposed barrier reef fauna of Cocos-Keeling Islands, on the assumption that the lagoon fauna is geologically Recent, the barrier fauna would be Miocene, and the fauna of the pools and flats behind the barrier reef would be oldest Pliocene. By this method much of the West Indian Miocene might be made Pliocene or even Pleistocene. Errors may be introduced because a fossil fauna may not be homogeneous. Marine Mollusca, for example, may be collected from different ecologic stations at a single locality within a single formation. Mud-burrowing and boring bivalves have been washed upshore and mixed with gastropods that lived only on intertidal sand flats; offshore and estuarine forms have been washed in among indigenous shoal-water species. Yet percentage comparisons are valuable if they are applied to complete faunas of a similar ecologic complex, and though one may seldom be sure of having collected all the members of any fauna, careful and thorough collecting may give a large proportion of it. The biologic method of correlation affords its best results only if it is applied after a study of the vertical distribution of species, particularly the minor variants of species, in accurately ascertained columnar sections. By studying in this way the faunas and the associated sediments over areas of moderate extent the stratigraphic range of many species and variants may be ascertained, and these species rather than percentages supply a basis for the correlation of similar deposits. Even this method of work involves liability to error, however, because the observed stratigraphic ranges of the organisms studied may not sufficiently represent the actual ranges.

In establishing the correlations of the formations of the Dominican Republic all three methods were used. It was not practicable in many places to trace the formations from one area to another even where it is possible to do so; the record of earth movements, although it has not been fully deciphered, was a valuable aid, but the most generally useful method, and that by which the ages of most of the formations were inferred, was

[1] Vaughan, T. W., Fossil corals from Central America, Cuba, and Porto Rico, with an account of the American Tertiary, Pleistocene, and Recent coral reefs: U. S. Nat. Mus. Bull. 103, pp. 190–193, 1918, (Section entitled "Geologic correlation by means of fossil corals.") Corals and the formation of coral reefs: Smithsonian Rept. for 1917, pp. 186–276, pls. 37, text-figs. 16, 1919.

the biologic. In some cases it was possible to apply both diastrophic and biologic criteria, as, for instance, in referring the Baitoa formation to the Miocene. The underlying Tabera formation, which, as is clearly shown by its fossils, is of the same or nearly the same age as the middle Oligocene Antigua formation, was folded and eroded before the Baitoa was deposited upon it. It may reasonably be inferred that this folding and erosion consumed a long time—probably all of upper Oligocene time—and that the Baitoa formation is of Miocene age. Moreover, the fauna of the Baitoa shows affinities with that of the other members of the Yaque group, not with the faunas of the older formations. The Baitoa is therefore referred to a stratigraphic position low in the Miocene. One result of this conclusion is to place in the Miocene the type species of the genus *Orthaulax, O. inornatus* Gabb, a species that had been supposed to be of Oligocene age.

RELATIONS OF DOMINICAN TERTIARY AND QUATERNARY BIOTA.

Within the last two years Vaughan has discussed in three papers the relations of the West Indian and Central American Tertiary marine invertebrate fauna,[1] and Dr. C. J. Maury[2] and Dr. Bela Hubbard[3] have more recently published two papers that are devoted particularly to Porto Rico. As rather full references to other literature are given in the papers cited, particularly the longer one by Vaughan, the present discussion is much condensed.

EOCENE.

The Dominican Eocene seems to be of very nearly the same if not the same geologic horizon on both the north and the south side of the island. The tables on pages 105-106 show that the same species are found on both. The same or a very similar fauna is found in Saint Bartholomew, Jamaica, Cuba, Nicaragua, Costa Rica, and Panama, and probably in Colombia and Trinidad. Vaughan also obtained it in Haiti at Cape Haïtien and between Plaisance and Ennery, at an altitude of about 705 meters above sea level, on the north side of the summit of Mount Puilboreau. The genera of Foraminifera in the Haitian deposits were determined by Doctor Cushman as *Globigerina, Calcarina, Orthophragmina, Conulites, Biloculina,* and *Quinqueloculina.* To the Eocene limestone that is so well exposed in northwestern Haiti Vaughan has applied the name Plaisance limestone.

This fauna is late Eocene, the same age as that of the Jackson formation and Ocala limestone of the southern and southeastern United States and

[1]Vaughan, T. W., Correlation of the Tertiary geologic formations of the southeastern United States, Central America, and the West Indies: Washington Acad. Sci. Jour., vol. 8, pp. 268-276, 1918. Geologic history of Central America and the West Indies during Cenozoic time: Geol. Soc. America Bull., vol. 29, pp. 615-630, 1919. The biologic character and geologic correlation of the sedimentary formations of Panama in their relation to the geologic history of Central America and the West Indies: U. S. Nat. Mus. Bull. 103, pp. 547-612, 1919.

[2]Maury, Carlotta J., On the correlation of Porto Rican Tertiary formations with other Antillean and mainland horizons: Am. Jour. Sci., vol. 48, pp. 209-215, 1919.

[3] Hubbard, Bela, The Tertiary formations of Porto Rico: Science, n. s., vol. 51, pp. 395, 396, 1920.

The upper Oligocene deposits consist of the Cevicos limestone, which is found in the Cibao Valley, and limestone on Monte Calavosa and near San Cristobal, on the south side. The faunas are meager and the correlation is uncertain, but if it is correct deposits of the same age occur in the islands of Anguilla, Porto Rico (according to Maury), and Cuba, and in Florida, Panama, and Trinidad. These deposits are tentatively correlated with the Chattian-Aquitanian of southern Europe. Doctor Cooke (see p. 63) has noted the uncertainty as to whether these deposits should be classified as uppermost Oligocene or basal Miocene.

MIOCENE.

YAQUE GROUP, NORTH SIDE.

Baitoa Formation.

Only the corals and mollusks and one bryozoan of the Baitoa formation have been identified. One species of coral, *Goniopora* sp., appears to be the same as that found in the Chipola marl of Florida. The bryozoan *Cupularia denticulata* Defr. ranges stratigraphically from the Chipola marl to Recent in America. The most abundant fossils are Mollusca. The most conspicuous faunal break in the Tertiary system of the Dominican Republic indicated by the Mollusca is that between the upper Oligocene and the Baitoa formation. The fauna of the Baitoa formation closely resembles the succeeding Miocene faunas. Only two of the Baitoa superspecific groups, the genera *Orthaulax* and *Cymia*, are not known in the later Miocene faunas of the valley of Rio Yaque del Norte. The curious stromboid genus *Orthaulax*, which is represented by the genotype *O. inornatus* Gabb, has been considered a typical Oligocene genus; but the faunal assemblage of the Baitoa formation clearly indicates its Miocene (Burdigalian) age. *Phos semicostatus* Gabb is the most characteristic mollusk of the formation. The horizon of the Baitoa formation, which has not been found elsewhere in the West Indies, is correlated with that of the Chipola marl of Florida.

Cooke[1] has recently discussed the stratigraphic significance of *Orthaulax*. In the Dominican Republic this genus, according to present information, appears to range from upper Oligocene to middle Miocene. In contending that the Quebradillas limestone of Porto Rico is upper Oligocene because it contains *Orthaulax* in abundance, Hubbard[2] is expressing an opinion once held, but unwarranted, that this genus is restricted to the Oligocene. Doctor Maury[3] has, however, referred the Quebradillas limestone to the lower Miocene.

Cercado Formation.

The faunal lists for the Cercado formation embrace all fossils collected in 1919 except the Foraminifera, which have not yet been studied, but lists of Foraminifera obtained by Doctor Maury are included. This formation

[1] Cooke, C. W., Abstract, Geol. Soc. America Bull., vol. 31, p. 206, 1920.
[2] Hubbard, Bela., Science, new ser., vol. 51, p. 396, 1920.
[3] Maury, C. J., Am. Jour. Sci., vol. 48, p. 212, 1919.

is of old Miocene age. The coral fauna comprises about 19 species, only about four of which, *Placocyathus* n. sp. b, *Stylophora* n. sp. with a commensal worm, *Thysanus corbicula* Duncan, and *Porites* n. sp. with a commensal worm, seem to be confined to the formation; most if not all the other species range upward into the Gurabo formation, and at least two species, *Solenastrea bournoni* M. Edw. and H. and *Siderastrea siderea* (Ell. and Sol.), have persisted until Recent time. The most abundant organisms are Mollusca, of which about 500 species have been recognized. The characteristic species are *Conus cercadensis* Maury, *Cancellaria* (*Aphera*) *islacolonis* Maury, *Arca* (*Scapharca*) *corcupidonis* Maury, *Arca* (*Scapharca*) *arthurpennelli* Maury, *Pecten* (*Aequipecten*) n. sp. a, *Cardium* (*Trachycardium*) *dominicanum* Dall, and *Corbula* (*Bothrocorbula*) *viminea* Guppy. The largest faunule, 260 species, was collected on Rio Mao at station 8525, which is Doctor Maury's "bluff 3."[1] The faunule on Rio Albano (station 8729) is remarkably like the faunule at station 8525, though the two localities are far apart geographically. The Cercado faunule on Rio Cana (station 8534) is characterized by the substitution of peculiar specific stocks for many species that are conspicuous at other localities of the Cercado formation.

Because of the apparent specific identity of several species of corals in this formation with species found in the Bowden marl of Jamaica Vaughan correlated it with the Bowden marl, but there is considerable similarity between the corals of the Gurabo formation and those of the Bowden, and this is true of other organisms, so that the Cercado formation is probably a little older than the Bowden. (For fuller discussion see pp. 98-99.)

Modified Cercado Fauna.

Cercado faunules that are modified by the first appearance of a number of species of mollusks that elsewhere are confined to the overlying Gurabo formation were collected on Rio Mao (station 8522) and on Rio Gurabo (station 8739). These species are *Terebra sulcifera* Sowerby, *Conus haytensis* Sowerby, *Conus multiliratus* Böse subsp. *gaza* Brown and Pilsbry, "*Clavatula*" *labiata* Gabb, *Cancellaria guppyi* Gabb, *Lyria pulchella* (Sowerby),[2] *Metulella venusta* (Sowerby), *Distortio simillima* (Sowerby), *Pecten* (*Aequipecten*) *eugrammatus* Dall and *Echinochama antiquata* Maury not Dall. All these species are abundant at one or more localities of the Gurabo formation and, moreover, the above list includes six superspecific groups that are not known in the typical Cercado fauna.

According to Doctor Maury's faunal lists her expedition collected a similarly modified Cercado faunule from "Zone G," Rio Gurabo.[3] The faunule of "Zone G" includes four species that are found in the Gurabo

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[1] Maury, C. J., Bull. Am. Paleontology, vol. 5, p. 425, 1917.
[2] This species is reported by Maury from the Cercado formation at "Bluff 3," Rio Mao (= station 8525).
[3] Maury, C. J., Bull. Am. Paleontology, vol. 5, pp. 439-440, 1917.

formation but not in the typical Cercado formation—*Conus consobrinus* Sowerby, *Conus marginatus* Sowerby, *Fasciolaria semistriata* Sowerby, and *Metulella venusta* (Sowerby).

Gurabo Formation.

The faunal lists for the Gurabo formation are incomplete, as the Foraminifera obtained in it have not been identified; the fauna here recorded consists mostly of corals and mollusks. One of the striking peculiarities of the formation is the relatively rich coral fauna, comprising between 70 and 80 species, a considerable number of which, particularly in its upper part, are of reef facies. Although several species also occur in the underlying Cercado formation and others range upward into the overlying Mao Adentro limestone, the assemblage differs from that of each of the adjacent formations and some species appear to be confined to it, for example, *Asterosmilia abnormalis* (Duncan), *A. exarata* Duncan, *A. profunda* (Duncan), *A. hilli* Vaughan, *Teleiophyllia grandis* Duncan, and *Syzygophyllia dentata* (Duncan). Several of the species occur in the Cercado formation and in the lower part of the Gurabo; others occur in the upper part of the Gurabo and in the Mao Adentro limestone. It is therefore possible to tell the part of the formation from which a fairly large collection of well-preserved corals came.

About 400 species of Mollusca have been recognized in the Gurabo formation, and almost half of these species are not known in the typical Cercado formation. The most abundant species that do not occur in the typical Cercado formation are *Terebra sulcifera* Sowerby, *Conus haytensis* Sowerby, *Conus symmetricus* Sowerby and subsp. *domingensis* Sowerby, "*Clavatula*" *labiata* Gabb, "*Drillia*" *venusta* (Sowerby), *Lyria pulchella* (Sowerby), *Murex domingensis* Sowerby, *Metulella venusta* (Sowerby), *Distortio simillima* (Sowerby), *Sconsia laevigata* (Sowerby), *Morum domingense* (Sowerby), *Crepaticella capula* Guppy, *Pecten* (*Aequipecten*) *eugrammatus* Dall, *Echinochama antiquata* Maury not Dall, and *Cytherea* (*Ventricola*) *blandiana* (Guppy). The largest shoal-water faunules were collected on Rio Mao at stations 8519 (Maury's Bluff 1) and 8734, and on Rio Ámina (station 8516). The large collection from Rio Yaque del Norte (station 8702) includes several groups, such as *Leucosyrinx*, *Pleurotomella*, *Caricella*, and *Verticordia* (*Trigonulina*), that indicate deeper water. Several species of Mollusca are confined to certain horizons within the Gurabo formation, so that subdivisions of the formation can be recognized.

The Bowden marl of Jamaica is apparently of about the same age as the Gurabo formation. Woodring has recently completed a monograph on the Mollusca of the Bowden marl, which has been submitted to the Carnegie Institution of Washington for publication.[1] The Bowden molluscan

[1] Vaughan, T. W., Carnegie Institution of Washington Year Book No. 18, p. 345, 1920.

Deposits of nearly the same age as the Gurabo formation are known in Costa Rica, Panama, Colombia, and other parts of northern South America, and probably in Trinidad and Martinique.

An attempt to correlate the Cercado and Gurabo formations with the Miocene deposits of the southeastern United States involves difficulties because of differences in faunal facies due to differences in climate. The Alum Bluff formation of Florida, comprising, in ascending order, the Chipola marl, Oak Grove sand, and Shoal River marl members, is considered Burdigalian in age. Of these three stratigraphic units the Chipola marl was deposited under climatic conditions that most closely approached the conditions in the West Indies, although the fauna of the Chipola marl is very warm temperate to subtropical and not tropical. The faunas of the Oak Grove sand and Shoal River marl have a cooler water facies. The Baitoa formation of the Dominican Republic appears to be the correlative of the Chipola marl. In Florida the only subtropical fauna that is younger than the Chipola is the Pliocene Caloosahatchee fauna. In many respects the molluscan faunas of the Cercado and Gurabo formations, as well as that of the Bowden marl, are more similar to the Caloosahatchee fauna than to the Chipola or other Alum Bluff faunas. In 1917 Woodring[1] stated that the Bowden marl is distinctly younger than the Alum Bluff formation, and as the Alum Bluff formation was then considered upper Oligocene he suggested that the Bowden marl was Burdigalian, but the Gurabo formation, like the Bowden marl, is doubtless younger than the Alum Bluff formation, and is probably the equivalent of part of the Chesapeake group, so that in European terminology it is of Helvetian age.

The correlation suggested in the foregoing paragraph differs from that of Vaughan published in 1918 and 1919[2] in that the Gurabo formation and its correlatives are now regarded as one stage younger and the lower three formations of the Chesapeake group as one stage older, or as the equivalent of the European Helvetian. This opinion is a return to that of Dall[3] as against that of Berry "that the Calvert flora indicates a Tortonian age is as conclusive as intercontinental correlations ever can be."[4] The table on page 57 is adjusted to these modifications in correlation, but as the correlations are still tentative readjustments may yet be made.

Mao Adentro Limestone.

Only the corals and mollusks of the Mao Adentro limestone have been identified, but the collections include a few calcareous algae and a considerable number of Foraminifera. The corals represent a reef-coral

[1] Woodring, W. P., Johns Hopkins University Circular, March, 1917, p. 254, 1917.

[2] U. S. Nat. Mus. Bull. 103, pp. 514–516, 586–593, tables opposite p. 569, 595, 1919.

[3] Dall, W. H., The relations of the Miocene of Maryland to that of other regions and to the Recent fauna: Maryland Geol. Survey, Miocene, p. cxliii, 1904.

[4] Berry, E. W., The physical conditions indicated by the flora of the Calvert formation: U. S. Geol. Survey Prof. Paper 98, p. 66, 1916.

fauna and in places constituted reefs. The type locality of the formation is at stations 8532 and 8533, opposite Mao Adentro, on Rio Mao, where 18 species of corals were collected. Station 8531 is on the same river farther downstream. The stratigraphic relations of these exposures to the Gurabo formation are entirely clear. The total number of species of corals collected at the two localities is 26. The exposure at station 8663, on Arroyo las Lavas, is correlated with the Mao Adentro limestone because of faunal similarity, as about 14 out of 18 species (about 80 per cent) of the corals collected at the type locality of the formation occur also at station 8663. However, the total number of species obtained at station 8663 is about 34. A comparison of the list of species of the Mao Adentro limestone with that of the Gurabo formation shows that the faunas of the two formations have many species in common; in fact there is very little difference between the fauna of the upper part of the Gurabo and that of the Mao Adentro. The strata exposed at stations 8556 and 8735, bluffs U and W on Rio Gurabo, might, according to the fossils, be referred with almost equal propriety to either of the formations.

The molluscan fauna of most coral reefs is meager, and it is therefore not surprising that only 19 species were collected from the Mao Adentro limestone. Most of these were collected at Arroyo las Lavas (station 8663). All the species determined except one, which is confined to this horizon, occur also in the Gurabo formation. Although most of these species have been found in the upper part of the Gurabo formation, *Conocerithium gurabense* (Maury), the most abundant species at station 8663, occurs in the lower part of the Gurabo formation at stations 8715 and 8519.

As the Mao Adentro limestone is faunally so similar to the Gurabo formation it should probably be considered middle Miocene, slightly younger than the Gurabo.

Mao Clay.

The fauna of the Mao clay is very meager. It includes one species of coral and nine species of Mollusca. Only one of the determinable species of Mollusca is confined to this horizon. All the other species occur in the Gurabo formation, and one of them, *Cancellaria* (*Bivetia*) *epistomifera* Guppy, is also found in the Cercado formation. There is no evident faunal basis for recognizing the Mao clay as a separate formation. The reason for assigning a distinctive name to it is given on page 75.

Monte Cristi District.

As it is not practicable to apply with certainty the formation names used east of Rio Cana to the deposits examined by Mr. Ross in the vicinity of Monte Cristi the collections made near that town are listed separately from those made from the Miocene formations of the north side of the Republic. (See pp. 153-154.) The exposure at station 8780 represents a horizon either near the top of the Gurabo formation or the Mao Adentro limestone. The collection from station 8783 (El Morro de Monte Cristi, altitude 153 meters) represents the Gurabo formation, and that from station 8774 (altitude 155 meters) probably belongs to the same formation. These determinations essentially corroborate the opinion of Doctor Maury regarding the age of these beds.[1] The collections from stations 8777 and 8778 are apparently from a horizon high in the Yaque group, for they include *Arca* (*Scapharca*) *patricia* Sowerby, which was collected by the Maury expedition[2] on Rio Cana from beds in the upper part of the Gurabo formation or above the Gurabo formation. This species was not collected by the expedition of 1919 on the south side of the valley of Rio Yaque del Norte.

YAQUE GROUP, SOUTH SIDE.

Although the fossils collected from the Yaque group on the south side of the Republic are numerous and comprise more than 50 species of corals, about 120 species of mollusks, and many other organisms, including abundant unidentified Foraminifera, they afford no adequate basis for precise correlation of the formations of the south side with those of the valley of Rio Yaque del Norte. This is due to lack of precision in the data on the stratigraphic relations of the beds from which the collections were made and to apparent mixtures of faunas of different ages at some of the localities. One locality that appears to be the correlative of the upper part of the Gurabo formation is station 8622, where at least 9 out of 14 species of corals seem to be common to the Gurabo. At station 8621, however, which according to the field notes is stratigraphically higher than station 8622, the Mollusca indicate that the horizon is that of the Cercado formation.

The collections from stations 8572, 8590, and 8760 include a species of *Orthaulax* that, according to Doctor Cooke, is *Orthaulax aguadillensis* Maury, which is found also in the upper Oligocene Cevicos limestone of the Cibao Valley and in the Aguadilla limestone of Porto Rico. The collections from stations 8572 and 8590 probably represent more than one horizon. The Mollusca collected at stations 8570 and 8760, apparently from a single horizon, indicate that the south side *Orthaulax* horizon occupies a position between the Baitoa formation and the Cercado formation or even higher. Aside from *Orthaulax* this horizon is characterized by a new species of *Scapharca* that closely resembles *Arca* (*Scapharca*) *patricia* Sowerby. In the valley of Rio Yaque del Norte *A. patricia* is apparently confined to a horizon in the upper part of the Yaque group.

Perhaps some beds at other localities may be correlated with some on the north side after the collections have been more critically studied, but as the collections can not be referred to their precise positions in the stratigraphic

[1] Maury, C. J., Bull. Am. Paleontology, vol. 5, p. 450, 1917.
[2] Idem, p. 441.

remains of species of corals that are still living. By referring to page 82 it will be seen that this coralliferous limestone is crossed by streams whose lower stretches have been slightly submerged and that there may have been slight emergence after the submergence. These events indicate a considerable lapse of time after the limestone was formed and would appear to justify its reference to the Pleistocene series.

Other possible evidence of the age of this limestone may also be considered. Most geologists who have studied the subject hold that during the existence of the continental ice caps the sea level was lowered in the tropics because so much water was locked up in the glaciers. After the glaciers melted the sea level was raised by the return of the water to the ocean. It is therefore at least probable that the drowning of the mouths of the valleys that cross the limestone containing species still living was due to water returned to the ocean by the melting of the Wisconsin ice sheet. The limestone may therefore be of Pleistocene age.[1]

The considerations thus presented apply particularly to the elevated coral-reef limestone of the District of Macorís and the Province of Santo Domingo. Parts of the "coast limestone" may be later than Pleistocene. (For a discussion of the phenomena around Enriquillo Basin see page 77.)

EXTINCT MAMMALS OF THE DOMINICAN REPUBLIC.

No mammalian remains were collected during the geologic reconnaissance but as such remains have a bearing on the geologic history of the West Indies it may be noted that G. S. Miller, Jr., has recorded[2] the rodents *Isolobodon portoricensis* Allen, *Plagiodontia aedium* F. Cuvier, and *Brotomys voratus* Miller, from collections made in kitchen middens at San Pedro de Macorís by Dr. Theodor de Booy and at San Lorenzo by Dr. W. L. Abbott. The geologic significance of these animals becomes obvious when they are considered in connection with the faunas of Cuba, Porto Rico, and other West Indian islands. Miller says, regarding the West Indian hystricine rodents:

> They suggest direct descent from such a part of a general South American fauna, probably not less ancient than that of the Miocene, as might have been isolated by a splitting off of the Archipelago from the mainland. Of later influence from the continent there is no trace.

In subsequent field work in the Republic it is highly important that Indian dwelling sites and caves should be thoroughly explored for vertebrate remains in order to increase our knowledge of the extinct mammals.

[1] For a discussion of West Indian shore-line features, see Vaughan, T. W., Fossil corals from Central America, Cuba, and Porto Rico, with an account of the American Tertiary, Pleistocene, and Recent coral reefs: U. S. Nat. Mus. Bull. 103, pp. 189–524, pls. 68–152, 1919, especially pp. 263–306.

[2] Bones of mammals from Indian sites in Cuba and Santo Domingo: Smithsonian Misc. Coll., vol. 66, No. 12, pp. 10, 1 pl., 1916.

LISTS OF LOCALITIES AND FOSSILS.

EOCENE.

List of stations on north side.

8705 (D. C. 35). Province of Puerto Plata, along railroad above Altamira, north slope. Specimens from limestone in conglomerate boulders. D. D. Condit, collector. April 22, 1919.

8707 (D. C. 36). Province of Puerto Plata, 0.8 kilometer south of Sabana de Pérez, along the railroad from Puerto Plata to Altamira. D. D. Condit, collector. April 22, 1919.

8708 (D. C. 38). Province of Puerto Plata, Las Lajas, sandstone in contact with basal complex. D. D. Condit, collector. April 22, 1919.

8711 (D. C. 40). Province of Puerto Plata, 0.8 kilometer southeast of Altamira. D. D. Condit, collector. April 23, 1919.

8721. Province of Santiago, southern foot of Monte Cristi Range, north side of Damajagua. Limestone float. T. W. Vaughan, collector. April 29, 1919.

8722 (D. C. 48). Province of Santiago, head of Yaroa Creek. D. D. Condit, collector. April 26, 1919.

8725 (D. C. 51). Province of Santiago, between Damajagua, a camp at base of mountains north of Esperanza, and the southern foot of the Monte Cristi Range. T. W. Vaughan and D. D. Condit, collectors. April 29, 1919.

8725*a*. Same locality as 8725.

Faunal list.

Species.	Stations.							
	Prov. Puerto Plata.				Prov. Santiago.			
	8705	8707	8708	8711	8721	8722	8725	8725a
Foraminifera:								
Textularia sp.[1]					×		×	
Globigerina sp.					×	×	×	
Conulites sp.			×					
Rotalia? sp.								×
Carpenteria proteus Cushman							×	?
Carpenteria sp. cf. C. proteus Cushman						×		
Amphistegina sp.					×	×	×	
Nummulites sp.					×			
Orthophragmina minima Cushman				×				
Orthophragmina sp. cf. O. minima Cushman					×			
Orthophragmina sp. (stellate species)				×	×			
Orthophragmina sp.		×						
Lepidocyclina antillea Cushman					×			
Lepidocyclina sp. cf. L. antillea Cushman				×		×		
Lepidocyclina macdonaldi Cushman					×			
Lepidocyclina sp. cf. L. subraulinii Cushman	×					×		
Lepidocyclina sp.			×					×
Lepidocyclina ? sp.		×						
Operculina sp.					×			
Heterostegina sp.						×		
Spiroloculina sp.					×	×		
Quinqueloculina sp.					×	×	×	
Triloculina sp.							×	

[1] Throughout the faunal lists undetermined species of a genus are listed together on the same line in the ocality columns, although the species at those localities may not be identical.

List of stations on south side.

8614. Province of Santo Domingo, road from Baní to San Cristobal about 0.8 kilometer east of Cruz de los dos Caminos and about 5.2 kilometers east of Baní. C. W. Cooke and D. D. Condit, collectors. June 10, 1919.

8562 (D. C. 75). Province of Azua, Foraminiferal limestone from gravels on the Bánica-Las Matas road at half-way point. D. D. Condit, collector. May 17, 1919.

8608 (C. 84). Province of Azua, rubble on roadside north of Arroyo Salado near Higuero Largo; road from Túbano to Las Yayas, altitude 495 meters above sea level. C. W. Cooke, collector. May 26, 1919.

8644. Province of Azua. Loose rubble from Higuerito, Azua oil fields. D. D. Condit, collector. 1919.

8595 (D. C. 94). Province of Barahona, Foraminiferal limestone from point on mountain slope 2.5 kilometers north of Barbacoa, altitude about 180 meters; none of the material was in place. D. D. Condit, collector. May 29, 1919.

8626 (R. 57). Province of Barahona. Limestone pebbles with Foraminifera from point near Rancho Viejo; traverse of June 3, 1919, Sierra de Bahoruco. C. P. Ross, collector.

8627 (R. 58). Province of Barahona, Foraminiferal limestone, traverse of June 3, 1919, Sierra de Bahoruco, west slope of Cañada de Rancho Viejo. C. P. Ross, collector.

8576 (D. C. 97). Province of Barahona, rubble from near sea beach south side of Rio Caña and about 8.5 kilometers south of Barahona. D. D. Condit, collector. June 4, 1919.

Faunal list.

Species.	Stations.							
	Prov. Santo Domingo.	Prov. Azua.			Prov. Barahona.			
	8614	8562	8608	8644	8595	8626	8627	8576
Foraminifera:								
Textularia sp. cf. T. agglutinans d'Orbigny					×			
Textularia sp. (coarse species)			×					
Textularia sp.							×	
Textularia ? sp.				×				
Globigerina sp. (large species)								×
Conulites americana Cushman		×	×					
Conulites sp.							×	
Carpenteria monticularis Carter?					×			
Nummulites sp. (large species)								×
Nummulites? sp.		×		×	×	×		
Orthophragmina sp. cf. O. subtaramellei Cushman				×				
Orthophragmina sp. (stellate species)		×						
Lepidocyclina antillea Cushman						×		
Lepidocyclina sp. cf. L. antillea Cushman			×					
Lepidocyclina subraulinii Cushman	×				×	×		
Lepidocyclina sp. cf. L. subraulinii Cushman		×						
Lepidocyclina perundosa Cushman	×							
Lepidocyclina sp. cf. L. duplicata Cushman	×							
Operculina? sp.				×				
Bigenerina? sp.							×	
Spiroloculina sp.			×					
Quinqueloculina sp.			×					
Triloculina sp.			×					
Gen. ? and sp. ? (same as species from upper Eocene of Cuba)								×

Faunal list—Continued.

Species.	Stations.						
	Prov. La Vega.		Prov. Santiago, Rio Yaque del Norte.				
	8669	8713	8672	8557	8673	8741	8704
Corals:							
Pocillopora n. sp.				×			
Stylophora n. sp. (cf. an unpublished species from Anguilla)				×			
Stylophora n. sp.				×			
Astrocoenia decaturensis Vaughan		×					
Astrocoenia sp.						×	
Antiguastrea cellulosa (Duncan)				×		×	
Orbicella sp. aff. O. canalis Vaughan				×			
Orbicella insignis (Duncan)		×					
Orbicella sp., probably O. costata (Duncan)					×		
Orbicella sp.				×			
Orbicella? sp.	×						
Orbicellid coral? (perhaps Astreopora)		×					
Cyathomorpha tenuis (Duncan)		×	?	×	×		
Cyathomorpha antiguensis (Duncan)			?		×		×
Cyathomorpha ? sp. cf. C. hilli Vaughan						×	
Psammocora sp.						×	
Astreopora sp. (near species in Antigua and the Pepino formation of Porto Rico)				×			
Acropora sp. (near an Antiguan species)				×			
Actinacis sp. (near an Antiguan species)				×			
Actinacis? sp.	×					×	
Goniopora sp. aff. G. microscopica (Duncan)				×			
Goniopora sp. aff. G. regularis (Duncan)		×					
Goniopora sp.		×					
Fungioid coral		×					

	8557	8672
Mollusca:		
Gastropoda:		
Conus sp.	×	
Echtracheliza ? sp.	×	
Echtracheliza ? sp.	×	
Strombus sp.	×	
Cerithium sp. (large species)	×	
Cerithium sp.	×	
Potamides (?) ormei Maury	×	
Pelecypoda:		
Ostrea sp. indt.	×	×
Chama sp.	×	
Pecten (Aequipecten) sp. indt.	×	
Pecten (Plagioctenium?) sp.		×

List of stations on south side.

8565 (D. C. 77 B). Province of Azua, left bank of Rio San Juan, about 1.7 kilometers west of Los Bancos, fossils from a point about 100 meters higher stratigraphically than those at station 8564 (D. C. 77A). D. D. Condit, collector. May 21, 1919.

8564 (D. C. 77A). Same locality as 8565, but about 100 meters lower stratigraphically. D. D. Condit, collector. May 22, 1919.

8567 (D. C. 80). Province of Azua, from limestone along right bank of Rio de las Cuevas, about 2.5 kilometers west of Túbano. D. D. Condit, collector. May 22, 1919.

8617 (R. 41). Province of Azua, Las Cuevas, on Rio San Juan, north of San Juan. C. P. Ross, collector. May 19, 1919.

8618 (R. 42). Province of Azua, from limestone hill at Majagual, on Rio San Juan north of San Juan. C. P. Ross, collector. May 19, 1919.

8619 (R. 43). Province of Azua, from station 5 of traverse of May 22, on Rio Yaque del Sur near Los Bancos. C. P. Ross, collector. May 22, 1919.

Faunal list.

Species.	Stations.			
	Rio Yaque del Sur.	Prov. Azua.		
		Rio de las Cuevas.	Rio San Juan.	
	8619	8567	8617	8618
Corals:				
Stylophora sp.	×	×		
Antiguastrea cellulosa (Duncan)				×
Cyathomorpha tenuis (Duncan)				×
Cyathomorpha antiguensis (Duncan)?				×
Cyathomorpha ? sp.		×		
Astreopora sp. cf. A. antiguensis Vaughan		×		
Astreopora sp.			×	

	Prov. Azua.	
	8565	8619
Mollusca:		
Gastropoda:		
Bullaria sp.	×	
"Mangilia" sp.	×	
Fusus sp. indt.	×	
Xancus ? sp.	×	
Phos ? sp. indt.	×	
Echtracheliza ? sp.	×	
Natica sp.	×	
Neretina sp.	×	
Scaphopoda:		
Cadulus n. sp.	×	
Pelecypoda:		
Limopsis n. sp. a		×
Glycymeris ? sp.	×	
Ostrea sp.	×	×
Pecten (Pseudamusium) sp.	×	
Dreissena ? sp.	×	
Venericardia sp.	×	

Plants:
Sophora cookei Berry .... Station 8564

UPPER OLIGOCENE.

List of stations on north side.

8598 (C-8). Province of La Vega, east side of Arroyo Blanco (?), east of Loma de los Palos, on road from Cotuí to Cevicos. C. W. Cooke and C. P. Ross, collectors. April 21, 1919.

8600 (C-10). Province of La Vega, east of Cevicos, on northeast side of Arroyo Barranca, on road to Villa Rivas. C. W. Cooke and C. P. Ross, collectors. April 22, 1919.

8601 (C-11). Province of La Vega, Arroyo Jerguen; road from Cevicos to Villa Rivas. C. W. Cooke and C. P. Ross, collectors. April 22, 1919.

8602 (C-12). Province of La Vega, northeast side of Arroyo Jerguen, about 4.5 meters below top of hill. C. W. Cooke and C. P. Ross, collectors. April 22, 1919.

8603 (C-13). Province of La Vega, at second (?) crossing of Arroyo Barranca on trail from Cevicos to Villa Rivas. C. W. Cooke, collector. April 22, 1919.

8604 (C-14). Province of La Vega, at second (?) crossing of Arroyo Barranca on trail from Cevicos to Villa Rivas, 9-12 meters above 8603 (C-13). C. W. Cooke, collector. April 22, 1919.

Faunal list.

Species.	Stations.			
	Prov. La Vega.			
	8598	8600	8603	8604
Foraminifera:				
Biloculina ? sp.		×		
Orbitolites (Sorites) duplex Carpenter		?		×
Orbitolites sp. cf. species at station 8600			×	
Heterosteginoides ? sp.			×	
Corals:				
Orbicella sp. or Cyathomorpha sp.				×
Echinii:				
Clypeaster concavus Cotteau	×			
Brissopsis antillarum Cotteau	×			
	8598	8601	8602	8603
Mollusca:				
Gastropoda:				
Bullaria sp.	×			
Orthaulax aquadillensis Maury	×			
Turritella sp.				×
Natica ? sp. indt.		×		
Pelecypoda:				
Ostrea sp. indt.	×			
Pecten (Aequipecten) sp. cf. P. vaun Cooke		×		
Pecten (Aequipecten) sp.		×		×
Cardium ? sp.		×		
Cardium (Trachycardium) sp.			×	
Cardium (Trigonicardia) sp.		×		
Cardium (Laevicardium?) sp.			×	
Protocardia ? sp.		×		
Pitaria ? sp.				×
Chione (Lirophora) sp.				×
Cephalopoda:				
Aturia ? sp.		×		

Faunal list.

Species.	Station.
	8569
Foraminifera:	
Globigerina sp	×
Amphistegina ? sp	×
Heterostegina ? sp. or Operculina ? sp	×
Gypsina globulus Reuss, small form	×

APPARENTLY UPPER OLIGOCENE.

List of stations on south side.

8691 (D. C. 12). Province of Santo Domingo, foothills of Monte Calabaza, 3.5 kilometers north of San Cristóbal. C. W. Cooke and D. D. Condit, collectors. April 7, 1919.

8692 (D. C. 13). Province of Santo Domingo, foot of Monte Calabaza, about 3.5 kilometers north of San Cristóbal. C. W. Cooke and D. D. Condit, collectors. April 7, 1919.

8693 (D. C. 14). Province of Santo Domingo, slope of Monte Calabaza. C. W. Cooke and D. D. Condit, collectors. April 7, 1919.

8674. Province of Santo Domingo, 24 kilometers from Santo Domingo City on road to San Cristóbal; altitude about 60 meters above sea level. T. W. Vaughan, collector. April 6, 1919.

Faunal list.

Species.	Prov. Santo Domingo.			
	8691[a]	8692	8693	8674
Corals:				
Orbicella canalis Vaughan	×	×		
Orbicella imperatoris Vaughan				×
Agaricia, probably 2 species	×			
Cyathomorpha n. sp		×		
Psammocora sp. (seems to be the same species as at station 8741)			×	
Mollusca:				
Gastropoda:				
Turris ? sp. a	×			
Turris ? sp. b	×			
"Drillia" ? sp	×			
Strombus sp. indt	×			
Pelecypoda:				
Leda sp. indt	×			
Pecten sp	×			
Spondylus sp		×		
Venericardia sp	×			

a The limestone at this locality consists principally of calcareous algae

MIOCENE.

YAQUE GROUP, NORTH SIDE.

Baitoa Formation.

List of stations.

8668 (D. C. 29). Province of Santiago, Baitoa, bluff of yellow sandstone along Rio Yaque del Norte. D. D. Condit, collector. April 19, 1919.

8558 (C-64). Province of Santiago, fossils fallen from upper part of bluff on right bank of Rio Yaque del Norte below Baitoa. C. W. Cooke, collector. May 14, 1919.

8559 (C-65). Province of Santiago, roadside at top of hill leading down to Baitoa on road from Santiago. C. W. Cooke, collector. May 15, 1919.

Faunal list.

Species.	Río Yaque del Norte.		
	8668	8558	8559
Corals:			
Stylophora sp.	×		
Madracis sp. (with only 8 principal septa)			×
Antillia ? sp.	×		
Orbicella sp., cf. species from lower Miocene of Trinidad	×		
Psammocora ? sp., cf. species from lower Miocene of Trinidad	×		
Goniopora sp., cf. species from Chipola marl of Florida	×		
Bryozoa:			
Cupularia denticulata Defrance	×		
Mollusca:			
Gastropoda:			
Ringicula n. sp. a, cf. R. dominicensis Maury	×		
Terebra (Strioterebra) gatunensis Toula	×		
Terebra (Strioterebra) sp. indt.	×	×	
Conus williamgabbi Maury		×	?
Conus n. sp. b	×	×	
Conus n. sp. e		×	
Conus n. sp. p	×	×	
Surcula (Pleurofusia) n. sp. b, n. subsp. a′	×		
Turris (Pleuroliria) haitensis (Sowerby)?			×
"Drillia" henekeni (Sowerby) n. subsp. a′	×		
"Drillia" consors (Sowerby) n. subsp. a′	×	×	
"Drillia" n. sp. x	×		
"Drillia" sp. indt.	×		
Microdrillia n. sp. a	×		
Cancellaria n. sp. a	×	×	
Oliva n. sp. b	×		
Marginella n. sp. j	×	×	
Mitra (Cancilla) n. sp. a, cf. M. henekeni Sowerby	×	×	
Mitra (Cancilla) n. sp. b, cf. M. longa Gabb	×		
Mitra (Cancilla) sp. indt.	×		
Vasum tuberculatum Gabb	×		
Melongena consors (Sowerby)	×	×	
Fasciolaria kempi Maury	×	×	
Xancus validus (Sowerby)	×	×	
Phos semicostatus Gabb	×	×	×
Phos costatus Gabb	×	×	
Alectrion sp.			×
Strombina sp. cf. S. cyphonotus Pilsbry and Johnson	×		
Cymia henekeni Maury	×	×	
Distortio simillima (Sowerby)?	×		
Orthaulax inornatus Gabb	×		
Cerithium (Vulgocerithium) sp.			×
Potamides sp.	×		
Clava n. sp. c		×	

Faunal list—Continued.

Species.	Río Yaque del Norte.		
	8668	8558	8559
Mollusca—Continued:			
Gastropoda—Continued:			
Turritella praecellens Pilsbry and Brown	×	×	
Turritella n. sp. b a, cf. T. gatunensis Conrad			×
Natica sp. indt.	×		
Neverita nereidis Maury	×		
Pyramidellidae	2 spp.		
Scaphopoda:			
Cadulus phenax Pilsbry and Sharp	×		
Cadulus sp. indt.	×		
Pelecypoda:			
Nucula tenuisculpta Gabb, n. subsp. a′	×		
Leda sp.	×		
Arca (Scapharca) hispaniolensis Maury	×	×	
Arca (Scapharca) arthurpennelli Maury n. subsp b′	×	×	×
Arca (Argina) n. sp. b, cf. A. tolepia Dall	×		
Glycymeris acuticostatus (Sowerby)?			×
Ostrea folium Linnaeus	×		
Ostrea insularis Pilsbry and Brown ?	×	×	×
Chama sp. indt.	×		
Phacoides (Parvilucina) n. sp. a, cf. P. yaquensis (Gabb)	×		
Phacoides (Parvilucina) n. sp. b	×		
Divaricella sp. indt.	×		
Alveinus n. sp cf. A. rotundus Dall	×		
Chione sp. indt.		×	
Ervilia n. sp. a	×		
Corbula dominicensis Gabb	×		
Corbula sp. indt.	×		

Cercado Formation.

List of stations.

(See Plates IX and XI for maps of Rio Mao and Rio Gurabo.)

7786. Province of Santiago, Rio Mao, "Bluff 3, 5 miles above Cercado de Mao." C. J. Maury, collector. May 1916. (Same as station 8525 of Vaughan and Cooke.)

Province of Santiago, Rio Mao, "Bluff 2, 4 miles above Cercado de Mao." C. J. Maury, collector. May 1916. (Same locality as station 8526 of Vaughan and Cooke.)

7781. Province of Monte Cristi, "Rio Cana, zone H, at Caimito." C. J. Maury, collector. May 1916. (This is the same locality as station 8534 of Vaughan and Cooke.)

Province of Monte Cristi, Rio Cana, above Caimito, zone I. C. J. Maury, collector. May 1916.

8729 (D. C. 55). Province of Santiago, Rio Albano near San José de las Matas. D. D. Condit, collector. May 2, 1919.

8529 (C–35). Province of Santiago, fossils from near top of bluff on right side of Rio Mao about 1.0 kilometer by trail N. 40° E. of Bulla and about 1.7 kilometers above the ford El Paso de los Perros. T. W. Vaughan, C. W. Cooke, and D. D. Condit, collectors. May 5, 1919.

8525 (C–31). Province of Santiago, long bluff on left bank of Rio Mao opposite Hato Viejo, about 5 kilometers above the ford (Paso Bajito) at Cercado de Mao. T. W. Vaughan, C. W. Cooke, and D. D. Condit, collectors. May 5, 1919.

8526 (C–32). Province of Santiago, second bluff on left side of Rio Mao about 3.5 kilometers by trail above the ford (Paso Bajito) at Cercado de Mao. T. W. Vaughan and C. W. Cooke, collectors. May 6, 1919.

8521 (C–27). Province of Santiago, bluff on right bank of Rio Mao about 1.7 kilometers above Paso Bajito at Cercado de Mao, fossils from basal 4.5 meters of section. T. W. Vaughan and C. W. Cooke, collectors. May 4, 1919.

Faunal list—Continued.

Species.	Bluff 3, Rio Mao (=7786).	8525 (additional species).	Bluff 2, Rio Mao (=8526).	8521.	8737.	Zone H, Rio Cana (=8534).	8534 (additional species).	7781 (Zone I, Rio Cana).
Bryozoa:								
Membranipora vaughani Canu and Bassler	×							
Cupuladria canariensis Busk	×							×
Acanthodesia savarti (Savigny-Audouin) forma monilifera Canu and Bassler	×							
Nellia oculata Busk	×							
Cupularia umbellata Defrance	×		×					
Cupularia denticulata Defrance		×		×	×			
Corynostylus labiatus Canu and Bassler	×							
Corynostylus ellipticus Canu and Bassler	×							
Thalamoporella biperforata Canu and Bassler								×
Steganoporella parvicella Canu and Bassler	×							
Schizopodrella ? mutabilis Canu and Bassler	×							
Hippomenella infratelum Canu and Bassler	×							
Smittina ? brevis Canu and Bassler	×							
Rhynchozoon vaughani Canu and Bassler	×							
Metrarabdotos colligatum Canu and Bassler	×				×	×		
Adsona porosa Canu and Bassler	×							
Holoporella albirostris Smitt		×					×	
Stichoporina tuberosa Canu and Bassler				×			×	
Idmonea milneana d'Orbigny	×							

Species.	Rio Albano.	Rio Mao.				Rio Gurabo.		Rio Cana.
	8729	8529	8525	8526	8521	8737	8738	8534
Mollusca:								
Gastropoda:								
Cavolina n. sp. a			×					
Cavolina sp.			×					
Acteon riomaensis Maury			×			×		
Acteon tornatilis Gabb not Linnaeus	×							
Ringicula dominicensis Maury			×					
Acteocina recta Maury not d'Orbigny	×		×			×		×
Acteocina canaliculata Maury not Say			×					
Acteocina n. sp. a					×			
Acteocina n. sp. b					×			
Retusa sulcata Gabb not d'Orbigny			×					
Cylichnella trictum-tritonis Maury	×		×					
Cylichnella n. sp. a					×			
Volvula cylindrica Gabb	×		×		×	×	×	×
Bullaria paupercula (Sowerby) n. subsp. a'	×		×					
Bullaria n. sp. a			×					×
Atys n. sp. a			×		×		?	

Faunal list—Continued.

Species.	Rio Albano.	Rio Mao.				Rio Gurabo.		Rio Cana.
	8729	8529	8525	8526	8521	8737	8738	8534
Mollusca—Continued:								
Gastropoda—Continued:								
Atys n. sp. b			×					
Atys n. sp. c			×					
Atys n. sp. d			×					
Atys (Alicula) yaquensis (Maury)			×		×	×		×
Atys (Alicula) n. sp. a	×		×					
Atys (Alicula) n. sp. b			×					
Atys (Roxania) doliola Maury			×					
Terebra (Strioterebra) cambiarsoi Maury			×					
Terebra (Strioterebra) cambiarsoi Maury n. subsp. a′					×			
Terebra (Strioterebra) cambiarsoi Maury n. subsp. b′								×
Terebra (Strioterebra) cambiarsoi Maury n. subsp. c′								×
Terebra (Strioterebra) cambiarsoi n. subsp. *d′*								×
Terebra (Strioterebra) cirra Dall subsp. a′	×		×					
Terebra (Strioterebra) oligomitra Maury not Dall			×	×			×	
Terebra (Strioterebra) spirifera Maury not Dall					×			
Terebra (Strioterebra) berlinerae Maury								×
Terebra (Strioterebra) gatunensis Toula n. subsp.			×		×			
Terebra (Strioterebra) n. sp. a			×					
Terebra (Strioterebra) laevifasciola Maury	×		×		×			
Terebra (Strioterebra) n. sp. b			×					
Terebra (Strioterebra) n. sp. b, n. subsp. a′			×		×			
Terebra (Strioterebra) n. sp. b, n. subsp. b′			×					
Terebra (Strioterebra) n. sp. c			×					
Terebra (Strioterebra) n. sp. d			×					
Terebra (Strioterebra) n. sp. e			×					
Terebra (Strioterebra) n. sp. f					×			
Terebra (Strioterebra) n. sp. g					×			
Terebra (Strioterebra) n. sp. h					×			
Terebra (Strioterebra) n. sp. i								×
Terebra (Strioterebra) n. sp. j								×
Terebra (Strioterebra) sp. indt.						×		
Terebra (new section A) n. sp. a			×					
Terebra (new section A) n. sp. a, n. subsp. a′				×				
Terebra (new section A) n. sp. a, n. subsp. b′								×
Terebra (new section B) n. sp. a								×
Hastula n. sp. a			×					
Hastula n. sp. b								×
Conus cercadensis Maury	×	×	×	×	×			
Conus furvoides Gabb			×					×
Conus kitteredgi Maury								×
Conus recognitus Maury not Guppy								×
Conus gracilissimus Guppy n. subsp. a′								×
Conus n. sp. a			×		×			
Conus n. sp. b			×		×			
Conus n. sp. c			×	×				

Faunal list—Continued.

Species.	Rio Albano.	Rio Mao.				Rio Gurabo.		Rio Cana.
	8729	8529	8525	8526	8521	8737	8738	8534
Mollusca—Continued:								
Gastropoda—Continued:								
Conus n. sp. d				×				
Conus n. sp. e								×
Conus n. sp. f								×
Conus sp. indt							×	
Surcula (Pleurofusia) n. sp. a					×			
Surcula (Pleurofusia) sp					×			
Surcula (Cochlespira) n. sp. a					×			
Turris (Pleuroliria) haitensis (Sowerby)			×					
Turris (Pleuroliria) n. sp. a					×			×
Turris (Pleuroliria) sp. indt				×				
"Drillia" maoisriparum Maury			×					
"Drillia" henekeni Sowerby			?	×	×			×
"Drillia" n. sp. a			×					
"Drillia" n. sp. b			×					
"Drillia" n. sp. c					×			
"Drillia" n. sp. d					×			
"Drillia" n. sp. e					×			
"Drillia" n. sp. f					×			
"Drillia" n. sp. g					×			
"Drillia" n. sp. h					×			
"Drillia" n. sp. i					×			
"Drillia" n. sp. j					×			
"Drillia" n. sp. k					×			
"Drillia" n. sp. l					×			
"Drillia" n. sp. m					×			
Mangilia maoica Maury			×					
"Mangilia" laloni s Maury			×		×			
"Mangilia" n. sp. a	×		×					
"Mangilia" n. sp. b			×					
"Mangilia" n. sp. c			×					
"Mangilia" n. sp. d					×			
"Mangilia" n. sp. e					×			
Mangilia (Bellaspira) n. sp. a					×			
"Cythara" polygona (Gabb)	×		×					
"Cythara" elongata (Gabb)			×					
"Cythara" heptagona (Gabb)					×			
"Cythara" n. sp. a					×			
"Cythara" n. sp. b					×			
"Cythara" n. sp. c					×			
"Cythara" n. sp. d					×			
"Cythara" n. sp. e					×			
"Clathurella" n. sp. a			×					
"Clathurella" n. sp. b					×			
Glyphostoma n. sp. a					×			
Glyphostoma n. sp. b					×			
Glyphostoma n. sp. c					×			
Microdrillia sp					×			
Cancellaria barretti Maury not Guppy			×					
Cancellaria (Bivetia) epistomifera Guppy			×	×				
Cancellaria (Bivetia) harrisi Maury								×
Cancellaria (Aphera) islacolonis Maury			×		×			×
Oliva cylindrica Sowerby			×					×
Oliva brevispira Gabb	×		×		×		×	×
Oliva gradata Gabb				×				×
Oliva sp						×	×	
Olivella n. sp. a	×		×					

Faunal list—Continued.

Species.	Rio Albano.	Rio Mao.				Rio Gurabo.		Rio Cana.
	8729	8529	8525	8526	8521	8737	8738	8534
Mollusca—Continued:								
Gastropoda—Continued:								
Dolium (Malea) camura (Guppy)	×		×	×	×			
Pyrula sp. indt.					×			
Cypraea sp.						×		×
Cypraea sp. indet.			×					
Trivia islahispaniolensis Maury			×					
Erato maugeriae Gray subsp. dominigensis Maury					×			
Ovula (Radius) wisewoodae Maury			×					
Strombus proximus Sowerby			×					
Strombus haitensis Sowerby								×
Strombus bifrons Sowerby			×					×
Cerithium sp.				×				
Clava plebeia (Sowerby)					×			
Clava n. sp. a.					×			
Potamides (Cerithidea) n. sp.			×					
Bittium asperoides Gabb	×	×	×					
Bittium n. sp. a			×					
Bittium n. sp. b			×					
Bittium n. sp. c			×					×
Bittium n. sp. d			×					
Bittium n. sp. e			×					
Bittium n. sp. f			×					
Bittium n. sp. g			×					
Bittium n. sp. h					×			
Bittiolum n. sp. a			×					
Cerithropsis n. sp. a			×					
Cerithropsis n. sp. b								×
Triforis calypsonis Maury			×					
Triforis n. sp.			×					
Alahina canaliculata (Gabb)			×			×	×	
Alabina costata (Gabb)			×					
Alabina n. sp. a			×					×
Alabina n. sp. b			×					
Alabina n. sp. c			×					
Epitonium (Epitonium) sp.			×					
Epitonium (Lamelliscala) n. sp.			×					
Epitonium (Spiniscala) gabbi (de Boury)	×		×					
Epitonium (Spiniscala) n. sp. a			×				×	
Epitonium (Striatascala) cercadicum Maury			×					
Epitonium (Striatascala) n. sp. a	×							
Epitonium (Clathrus) n. sp.								×
Epitonium (Fuscoscala) riparum Maury		×	×					
Acrilla n. sp.					×			
Serpulorbis papulosa (Guppy)								×
Serpulorbis sp.			×	×				
Petaloconchus domingensis Sowerby					×			
Vermicularia spirata (Philippi) n. subsp. a'					×			
Caecum n. sp. a					×			
Architectonica quadriseriata (Sowerby)					×	×		×
Architectonica stonemanae (Maury)					×			
Architectonica n. sp. a			×					
Architectonica n. sp. b					×			
Rissoina sagraiana Maury not d'Orbigny			×		×			

Faunal list—Continued.

Species.	Rio Albano.	Rio Mao.				Rio Gurabo.		Rio Cana.
	8729	8529	8525	8526	8521	8737	8738	8534
Mollusca—Continued:								
Gastropoda—Continued:								
Rissoina crassilabris (Gabb)			×		×			×
Rissoina n. sp. a					×			
Crucibulum n. sp. a			×		×			
Amalthea n. sp. a				×	×			×
Capulus n. sp. a					×			
Xenophora delecta Guppy?					×	×		
Natica canrena Linnaeus n. subsp. a'			×	×				×
Natica canrena Linnaeus n. subsp. b'	×				×			
Natica guppiana Toula	×							
Natica youngi Maury					×			
Natica n. sp. a			×					
Natica (Stigmaulax) sulcata Born			×	×	×	×	×	×
Natica (Cryptonatica) n. sp. a	×	×			×	×		×
Polynices subclausa (Sowerby)	×		×		×			×
Neverita nereidis Maury								×
Amauropsis guppyi Gabb			×	×	×	?		×
Eunaticina n. sp. a			×		×	×		
Sinum gatunense Maury not Toula			×					×
Collonia n. sp. a			×		×			×
Collonia n. sp. b								×
Cyclostrema striata Gabb			×					×
Adeorbis pentagona (Gabb)			×					
Solariorbis n. sp. a			×					
Solariobis n. sp. b			×					
Teinostoma sandomingense Maury		×						
Teinostoma n. sp. a			×					
Pseudorotella n. sp.								×
Discopsis derbyi Maury			×					
Turbo dominicensis Gabb			×				×	
Turbo dominicensis Gabb subsp. laloi Maury			×			×		
Turbo dominicensis Gabb n. subsp. a'						×		
Turbo crenulatoides Maury								×
Astralium sublongispinum Maury			×					
Astralium karlschmidti Maury						×		×
Phasianella (Eucosomia) punctata (Gabb)			×		×	×	×	
Calliostoma n. sp. a			×					×
Calliostoma n. sp. b			×		×	×		
Calliostoma n. sp. c			×					
Calliostoma n. sp. d								×
Calliostoma n. sp. e						×	×	
Calliostoma grabaui Maury					?			
Euchelus n. sp. a			×		×			
Neretina (Puperita) fulgopicta Maury								×
Neretina (Smaragdia) viridimaris Maury	×		×		×	×		
Fissuridea alternata Maury not Say			×					
Atlanta rotunda Gabb			×					
Atlanta cordiformis Gabb			×					
Melanella tethyos Maury			×					
Melanella maoica Maury			×					
Melanella cercadica Maury			×					
Melanella n. sp. a			×					
Melanella n. sp. b					×			×

Faunal list—Continued.

Species.	Rio Albano.	Rio Mao.				Rio Gurabo.		Rio Cana.
	8729	8529	8525	8526	8621	8737	8738	8534
Mollusca—Continued:								
Gastropoda—Continued:								
Melanella n. sp. c					×	×		
Melanella n. sp. d					×			×
Strombiformis n. sp. a	×		×		×			×
Strombiformis n. sp. b			×					
Sabinella n. sp. a			×					
Sabinella n. sp. b					×			
Niso grandis Maury not Gabb			×		×			
Niso n. sp.								×
Pyramidellidae	2 sp.		45 sp.	1 sp.	7 sp.	1 sp.	1 sp.	5 sp.
Scaphopoda:								
Dentalium dissimile Guppy			×	×	×			
Dentalium dissimile Guppy subsp. ponderosum Gabb					×			
Dentalium haytense Gabb	×		×		×	×		×
Dentalium glaucoterrarum Maury					×			
Dentalium pyrum Pilsbry and Sharp						×	×	×
Dentalium praecursor Pilsbry and Sharp						×		
Dentalium n. sp. a			×					
Dentalium sp.					×			
"Dentalium" rudis Gabb					×			
Cadulus phenax Pilsbry and Sharp		×	×					
Cadulus elegantissimus Pilsbry and Sharp			×			×		×
Cadulus colobus Pilsbry and Sharp	×		×					
Pelecypoda:								
Nncula tenuisculpta Gabb			×		×	×	×	
Leda peltella Maury not Dall	×		×	×	×	×	×	
Leda n. sp. a					×			
Arca (Arca) yaquensis Maury			×		×		×	×
Arca (Calloarca) n. sp. a								×
Arca (Sheldonella) maoica Maury			×					
Arca (Scapharca) cibaoica Maury	×	×	×	×	×	×		
Arca (Scapharca) henekeni Maury				?	×	?		
Arca (Scapharca) corcupidonis Maury	×		×			×		
Arca (Scapharca) arthurpennelli Maury	×	×	×		×			
Arca (Scapharca) arthurpennelli Maury n. subsp. a′			×					
Arca (Scapharca) willardausteni Maury								×
Arca (Scapharca) caimicta Maury								×
Arca (Scapharca) riocanensis Maury								×
Glycymeris acuticostata (Sowerby)				×	×			
Glycymeris acuticostata (Sowerby) n. subsp. a′			×					
Glycymeris jamaicensis Dall								×
Glycymeris n. sp. a			×					
Glycymeris n. sp. b								×
Pteria inornata Gabb	×		×					
Ostrea folium Linnaeus			×					
Ostrea sp.				×				
Pecten (Pecten) soror Gabb				×	×			
Pecten (Aequipecten) thetidis Maury not Sowerby				×	×			×

Faunal list—Continued.

Species.	Rio Albano.	Rio Mao.				Rio Gurabo.		Rio Cana.
	8729	8529	8525	8526	8621	8737	8738	8534
Mollusca—Continued:								
Pelecypoda—Continued:								
Cardium (Trigoniocardia) haitense Sowerby subsp. cercadicum Maury				×	×	×		
Cardium (Laevicardium) venustum Gabb			×		×			
Transennella n. sp. a			×					
Transennella n. sp. b					×	×	×	×
Callocardia n. sp. a					×			×
Gafrarium (Gouldia) n. sp. a			×					
Pitaria (Lamelliconcha) planivieta (Guppy)			?	×	×	×		
Pitaria (Lamelliconcha) cercadica Maury			×					
Fitaria (Lamelliconcha) circinata (Born)								×
Fitaria (Lamelliconcha) acuticostata (Gabb)	×							
Chione woodwardi (Guppy)					×	×	×	
Chione n. sp. a			×	×				
Chione n. sp. b			×	×				
Chione sp. indt								×
Chione (Lirophora) hendersoni Dall								×
Cytherea sp. indt				×				
Tellina (Eurytellina) maoica Maury			×					
Tellina (Eurytellina) riocanensis Maury						?		×
Tellina (Eurytellina) cibaoica Maury								×
Tellina (Eurytellina) n. sp. a								×
Tellina (Moerella) n. sp. a			×					
Tellina (Merisea?) islahispaniolae Maury			×					
Tellina (Merisca) crystallina Maury not Chemnitz			×					
Tellina (Scissula) eereadica Maury			×					
Tellina (Scissula) scitula Dall	×		×			×	×	×
Tellina (Scissula) n. sp. a			×					
Tellina sp. indt					×		×	×
Strigilla pisiformis (Linnaeus)	×		×		×	×		
Macoma n. sp. a			×					
Macoma n. sp. b								×
Macoma (Psammacoma) yaquensis Maury			×					
Semele claytoni Maury			×					×
Donax aequalis Gabb			×			×	×	×
Donax n. sp. a			×					
Psammosolen sanctidominici Maury	×		×	?	?			
Spisula n. sp. a			×	×				×
Ervilia n. sp. b	×							
Corbula cercadica Maury	×	×	×	×	×			
Corbula (Aloidis) vieta Guppy			×		×	×		×
Corbula (Brothrocorbula) viminea Guppy			×	×	×	×	×	×
Teredo incrassata (Gabb)			×			×	×	×
Clavigella sp.								×

According to Dr. Maury's faunal lists the following additional species of Mollusca were collected by the Maury expedition from the Cercado formation.

Faunal list.

	Rio Mao.		Rio Cana.	
	Bluff 3.	Bluff 2.	Zone H.	Zone I.
Mollusca:				
Gastropoda:				
Bullaria granosa (Sowerby)				×
Bullaria sarahberlinerae Maury				×
Conus baytensis Sowerby			×	
Conus molis Brown and Pilsbry	×			
Conus proteus Hwass			×	
"Drillia" islalindae Maury				×
"Cythara" gibba Guppy		×		
"Cythara" caimitica Maury				×
Glyphostoma golfoyaquensis Maury				×
Oliva cristobalcoloni Maury			×	×
Lyria pulchella (Sowerby)	×			
Latirus fusiformis Gabb		×		
Fusus henekeni Sowerby subsp. haitensis Sowerby	×			
Fusus heneknei Sowerby subsp. veatchi Maury			×	
Phos fasciolatus Dall	×		×	×
Bursa amphitrites Maury	×			
Pyrula pilsbryi Smith				×
Cypraea henekeni Sowerby			×	×
Cypraea spurca Linnaeus				×
Trivia suffusa Gray subsp. sanctidominici Maury	+			
Trivia globosa Gray				×
Cerithium uniseriale Sowerby		×		
Turritella planigyrata Guppy		×		
Fissuridea henekeni Maury			×	
Aclis acuminatoides Maury	+			
Melanella jaculum Maury	+			
Pelecypoda:				
Arca occidentalis Philippi			×	
Area umbonata Lamarck			×	
Area (Acar) reticulata Gmelin	×			
Arca (Calloarca) submarylandica Maury			×	
Arca (Scapharca) golfoyaquensis Maury			×	
Arca (Scapharca) inaequilateralis Guppy				×
Ostrea virginica Gmelin	×			
Pecten cercadica Maury		×		
Pecten caimitica Maury				×
Pecten nodosus Linnaeus			×	
Modiolus cercadicus Maury	×			
Modiolus maonis Maury	×			
Botula hispaniolae Maury			×	
Lithophaga antillarum d'Orbigny			×	
Lithophaga nigra d'Orbigny			×	
Mytilopsis domingensis Recluz			×	
Coralliophila coralliophila (Gmelin)			×	
Chama caimitica Maury			×	
Chama congregatoides Maury			×	
Chama riocanensis Maury			×	
Codakia orbicularis (Linnaeus)			×	
Phacoides domingensis Dall		×		
Phacoides (Lucinisca) cercadica Maury	×			
Phacoides (Miltha) riocanensis Maury			×	
Phacoides (Bellucina) actinus Dall			×	
Montacuta cercadica Maury	×			
Cardium (Trachycardium) linguatigris Maury			×	
Antigona tarquinina Dall			×	
Petricola caimitica Maury			×	
Petricola (Rupellaria) riocanensis Maury			×	

Faunal list—Continued.

	8729, Rio Mao.	Rio Mao, Bluff 3 (=7786)	8525 (additional spp.)	Rio Mao, Bluff 2 (=8526)
Mollusca—Continued:				
Pelecypoda—Continued:				
Tellina (Merisca) sanctidominici Maury	×			
Strigilla caimitica Maury			×	
Macoma sp. cf. M. constricta Bruguière				×
Macoma (Cymatoica) hispaniolae Maury	×			
Sanguinolaria (Psammotella) smithwoodwardi Maury	×		×	×
Solen obliquus Spengler				×
Siliqua subaequalis Gabb	×		×	
Mactrella sp. cf. M. alata Spengler	×			
Corbula caimitica Maury			×	
Corbula dominicensis Gabb			×	
Martesia sanctidominici Maury			×	
Martesia sanctipauli Maury	×			
Decapod Crustacea:				
Cragonidae gen. and sp. indt		×		
Eryonidae gen. and sp. indt		×		
Callianassa latidigita Rathbun		×		
Callianassa pellucida Rathbun ?			×	
Petrochirus inaequalis Rathbun			×	
Paguridae gen. and sp. indt		×		
Calappa flammea (Herbst)	×	×		
Calappella ? sp		×		
Cycloes bairdii Stimpson		×		
Persephona prepunctata Rathbun		×		×
Scylla costata Rathbun			×	
Portunus gabbi Rathbun		×		
Portunus tenuis Rathbun		×		
Portunus sp. indt		×		
Callinectes declivis Rathbun		×		
Callinectes sp. indt		×		
Podophthalmus domingensis Rathbun			×	
Pilumnus subequus Rathbun		×		
Panopeus sp. indt		×		
Xanthidae gen. and sp. indt		×		
Parthenope (Platylambrus) obscura Rathbun		×		
Parthenope sp. indt		×		
Mesorhoae mauryae Rathbun		×		
Nephrops maoensis Rathbun			×	
Nephrops aequus Rathbun				×

Modified Cercado Fauna.

List of stations.

Province of Monte Cristi, Rio Gurabo, Zone G, 2 miles above Los Quemados. C. J. Maury, collector. May, 1916.

8522 (C-28). Province of Santiago, bluff on right bank of Rio Mao, about 3 to 3.5 kilometers above Cercado de Mao; fossils from 4.5 to 9 meters above water. T. W. Vaughan and C. W. Cooke, collectors. May 4, 1919.

8739 (D. C. 65). Province of Monte Cristi, about 9.5 kilometers up Rio Gurabo from Gurabo Adentro; fossils from below conglomerate. D. D. Condit, collector. May 9, 1919.

Faunal list.

Foraminifera:

Asterigerina rotundata Cushman .... Zone G, Rio Gurabo.

Orbiculina adunca (Fichtel & Moll).

Faunal list—Continued.

Species.	Rio Mao 8522	Rio Gurabo 8739
Mollusca—Continued:		
Gastropoda—Continued:		
Lyria pulchella (Sowerby)	×	×
Xancus praeovoideus Maury		×
Melongena consors (Sowerby)	×	×
Fusus henekeni Sowerby	×	
Phos gabbi Dall	×	×
Alectrion cercadensis Maury		×
Alectrion losquemadica Maury	×	
Metulella venusta (Sowerby)	×	×
Atilia n. sp. a	×	
Atilia (Columbellopsis) exilis (Gabb)		×
Strombina pseudohaitensis Maury subsp. gurabensis Maury		×
Murex messorius Maury not Sowerby		×
Murex sp. indt	×	
Distortio simillima (Sowerby)	×	
Cassis sulcifera (Sowerby)	×	
Cassis (Semicassis) reclusa Guppy		?
Pyrula sp. indt	×	
Cypraea n. sp. a		×
Strombus proximus Sowerby		×
Clava plebeia (Sowerby)	×	×
Clava n. sp. a	×	
Bittium sp. indt		×
Alahina canaliculata (Gabb)		×
Petaloconchus domingensis Sowerby	×	×
Petaloconchus laddfranklinae Maury	×	
Vermicularia spirata (Philippi) n. subsp. a′	×	
Architectonica quadriseriata (Sowerby)	×	
Architectonica n. sp. a	×	
Rissoina crassilabris (Gabb)	×	×
Rissoina sp	×	
Crucibulum n. sp. a		×
Natica canrena Linnaeus n. subsp. a′		×
Natica youngi Maury	×	
Natica (Stigmaulax) sulcata Born		×
Natica (Cryptonatica) n. sp. a	×	×
Amauropsis guppyi Gabb	×	
Teinostoma sandomingense Maury		×
Phasianella (Eucosomia) punctata (Gabb)	×	×
Calliostoma sp. indt	×	
Neritina (Smaragdia) viridimaris Maury	×	
Melanella n. sp. e		×
Pyramidellidae		6 spp.
Scaphopoda:		
Dentalium dissimile Guppy	×	
Dentalium sp. indt	×	
Cadulus elegantissimus Pilsbry and Sharp		×
Pelecypoda:		
Leda peltella Maury not Dall		×
Leda n. sp. a	×	
Arca (Arca) yaquensis Maury	×	×
Arca (Calloarca) n. sp. a	×	×
Arca (Scapharca) cibaoica Maury	×	×
Arca (Scapharca) golfoyaquensis Maury	×	×
Arca (Scapharca) riocanensis Maury		×
Arca (Scapharca) n. sp. a		×
Glycymeris acuticostata (Sowerby)	×	
Glycymeris acuticostata (Sowerby) n. sub. sp. a′		×
Glycymeris jamaicensis Dall		×
Glycymeris n. sp. a	×	
Pteria inornata Gabb		?
Ostrea gilbertharrisi Maury	×	
Pecten (Aequipecten) inaequalis Sowerby	×	×
Pecten (Aequipecten) oxygonum Sowerby	×	

Faunal list—Continued.

Species.	Rio Mao 8522	Rio Gurabo 8739
Mollusca—Continued:		
Pelecypoda—Continued:		
Pecten (Aequipecten) thetidis Maury not Sowerby	×	
Pecten (Aequipecten) eugrammatus Dall	×	
Pecten (Amusium) papyraceum (Gabb)	×	×
Spondylus bostrychites Guppy	×	
Anomia simplex d'Orbigny	×	
Crenella divaricata Maury not d'Orbigny	×	
Crassinella guppyi Maury not Dall		×
Crassinella n. sp. a		×
Echinochama antiquata Maury not Dall	×	×
Phacoides (Callucina) n. sp. a	×	
Phacoides (Parvilucina) yaquensis (Gabb)		×
Cadrium (Trigoniocardia) haitense Sowerby	×	
Cardium (Trigoniocardia) haitense Sowerby subsp. cercadium Maury		×
Cardium (Laevicardium) venustum Gabb		?
Transennella n. sp. b	×	
Tivela n. sp. a		×
Pitaria (Lamelliconcha) planivieta (Guppy)	×	×
Fitaria (Lamelliconcha) circinata (Born)		×
Pitaria (Hyphantosoma) carbasea (Guppy)		×
Chione woodwardi (Guppy)	×	×
Chione n. sp. a		×
Chione (Lirophora) hendersoni Dall		×
Tellina (Eurytellina) riocanensis Maury		×
Tellina (Scissula) scitula Dall		×
Strigilla pisiformis (Linnaeus)		×
Semele (Semelina) n. sp. a		×
Abra n. sp. a		×
Donax aequalis Gabb		×
Corbula cercadica Maury	×	×
Corbula (Aloidis) vieta Guppy	×	
Corbula (Bothrocorbula) viminea Guppy	×	×
Decapod Crustacea:		
Petrochirus inequalis Rathbun	×	
Calappa flammea (Herbst)		×
Portunus oblongus Rathbun	×	
Plants:		
Melastomites sp		×

According to Dr. Maury's faunal list the following additional species of mollusks were collected from "Zone G," Rio Gurabo:

Gastropoda:

- Conus consobrinus Sowerby.
- Conus tortuostriatus Toula.
- Conus marginatus Scwerby.
- Conus bonaczyi Gabb.
- Cancellaria (Aphera) islacolonis Maury.
- Fasciolaria semistriata Sowerby.
- Strombina nuestrasenovae Maury.
- Cassis (Phalium) monilifera Guppy.
- Dolium (Malea) camura (Guppy).
- Cypraea henekeni Sowerby.
- Strombus haitensis Sowerby.
- Amauropsis guppi Gabb subsp. gurabensis Maury.

Sinum gatunense (Toula).
Turbo dominicensis Gabb subsp. laloi Maury.
Calliostoma grabaui Maury.

Scaphopoda:
Dentalium dissimile Guppy subsp. ponderosum Gabb.
Cadulus denticulus-tigris Maury.

Pelecypoda:
Arca (Scapharca) inaequilateralis Guppy.
Venericardia scabiicostata Guppy.
Protocardia gurabica Maury.
Pitaria (Lamelliconcha) acuticostata Gabb.
Tellina waylandvaughani Maury.

Gurabo Formation.

List of stations.

(For maps of Rio Mao and Rio Gurabo see Plates IX and XI.)

Province of Santiago, Potrero, Rio Ámina. C. J. Maury, collector. May 22, 1916.

Province of Santiago, Ric Mao, Bluff 1, a mile above Cercado. C. J. Maury, collector. May 1919.

Province of Monte Cristi, Rio Gurabo, zone A at Los Quemados. C. J. Maury, collector. May 1916.

Province of Monte Cristi, Rio Gurabo, zones B, D, E, and F, above Los Quemados. C. J. Maury, collector. May 1916.

7791. Province of Monte Cristi, Los Quemados, limestone. C. J. Maury, collector. May 1916.

8714 (D. C. 44). Province of Santiago, Rio Yaque del Norte, about 3.5 kilometers S. 25° W. of wireless tower at Santiago. D. D. Condit, collector. April 24, 1919.

8715 (D. C. 45). Province of Santiago, Rio Yaque del Norte, station 5 of traverse above Santiago, above Las Charcas. D. D. Condit, collector. April 24, 1919.

8726 (D. C. 52). Province of Santiago, La Canela, south side of Rio Yaque del Norte, 15 kilometers west of Santiago. T. W. Vaughan and C. W. Cooke, collectors. May 1, 1919.

8727 (D. C. 53). Province of Santiago, 13 kilometers from Potrero on trail to San José de Las Matas. D. D. Condit, collector. May 2, 1919.

8728 (D. C. 54). Province of Santiago, about 14 kilometers from Potrero on trail to San José de los Matas. D. D. Condit, collector. May 2, 1919.

8516 (C–22). Province of Santiago, bluff on right bank Rio Ámina at ford near Potrero. T. W. Vaughan and C. W. Cooke, collectors. May 2, 1919.

8517 (C 8517 (C–23). Province of Santiago, left bank of Rio Ámina about 0.5 kilometer upstream from crossing at Potrero. T. W. Vaughan and C. W. Cooke, collectors. May 2, 1919.

8518 (C–24). Province of Santiago, left bank Rio Ámina about 0.8 kilometer above crossing at Potrero; next horizon below 8516 (C–22). T. W. Vaughan and C. W. Cooke, collectors. May 2, 1919.

8523 (C–29). Province of Santiago, bluff on right bank of Rio Mao about 1.7 kilometers above Cercado de Mao, 33 meters above water level. C. W. Cooke, collector. May 4, 1919.

8519 (C–25). Province of Santiago, left bank of Rio Mao about 0.8 kilometer above the ford at Cercado de Mao; specimens mostly from lower part of bluff. T. W. Vaughan and C. W. Cooke, collectors. May 3, 1919.

8551 (C-57). Province of Monte Cristi, right bank of Rio Gurabo; third bluff on right bank below lower ford at Gurabo Adentro, bluff E of traverse. T. W. Vaughan and C. W. Cooke, collectors. May 8, 1919.

8552 (C-58). Province of Monte Cristi, left bank of Rio Gurabo, about 0.8 kilometer below lower ford at Gurabo Adentro, bluff F of traverse. T. W. Vaughan and C. W. Cooke, collectors. May 8, 1919.

8553 (C-59). Province of Monte Cristi, right bank of Rio Gurabo, 180 meters downstream from collection 8552 (C-58), bluff G of traverse. T. W. Vaughan and C. W. Cooke, collectors. May 8, 1919.

8554 (C-60). Province of Monte Cristi, right bank of Rio Gurabo, about 2 kilometers due north of lower ford at Gurabo Adentro, bluff P of traverse. T. W. Vaughan and C. W. Cooke, collectors. May 8, 1919.

8555 (C-61). Province of Monte Cristi, right bank of Rio Gurabo, about 0.4 kilometer northwest of bluff G, station 8553 (C-59), bluff S of traverse. T. W. Vaughan and C. W. Cooke, collectors. May 8, 1919.

8556 (C-62). Province of Monte Cristi, right bank of Rio Gurabo, about 3 kilometers north of the lower ford at Gurabo Adentro, bluff U of traverse. T. W. Vaughan and C. W. Cooke, collectors. May 8, 1919.

8735 (D. C. 63). Province of Monte Cristi, left bank of Rio Gurabo, about 3.4 kilometers below Gurabo Adentro, bluff W of traverse, near base of cliff. D. D. Condit, collector. May 8, 1919.

8536 (C-42). Province of Monte Cristi, road from Gurabo Adentro to Las Caobas, up slope from Rio Gurabo, between 70 to 85 meters above the river bed. T. W. Vaughan, collector. May 10, 1919.

8537 (C-43). Province of Monte Cristi, road from Gurabo Adentro to Las Caobas on slope from Rio Gurabo, 12 to 18 meters above river bed. T. W. Vaughan, collector. May 10, 1919.

8535 (C-41). Province of Monte Cristi, road from Caimito to Gurabo Adentro, about 0.8 kilometer west of Las Caobas. T. W. Vaughan and C. W. Cooke, collectors. May 10, 1919.

Faunal list.

	Station.
Foraminifera:	
Orbulina universa D'Orbigny	Zone A, Rio Gurabo
Amphistegina lessonii D'Orbigny, flat var	Zone A, Rio Gurabo

Faunal list—Continued.

Species.	Stations. Rio Yaque del Norte.			Rio Ámina.					Rio Mao.										Rio Gurabo.															
	8714	8715	8726	8727	8728	8516	8517	8518	8523	8519	8520	8527	8733	8734	8528	8538	8539	8540	8541	8542	8543	8544	8545	8546	8548	8549	8550	8552	8555	8556	8735	8536	8537	8535
Corals:																																		
Flabellum sp. a			×										×																		×			
Flabellum sp. b													×																		×			
Placocyathus variabilis Duncan						×	×	×		×	×	×			×	×										×								×
Placocyathus costatus Duncan						×				×	×	×						×					×	×						×				
Placocyathus n. sp. a				×		×				×	×		×	×	×	×							×	×		×							×	
Placocyathus n. sp. c			×			×																												
Placocyathus n. sp. d			×							×				×								×												
Placocyathus n. sp. e																	×				×									×				
[illegible]thus n. sp. f			×																															
Placocyathus sp.	×				×							×																						
Caryophyllia ? n. sp. a																															×			
Paracyathus n. sp. a																															×			
Paracyathus sp.																		×				×												
Stylophora affinis Duncan			×								×																		×	×	×			
[illegible]ra minor Duncan											×			×	×	×	×	×	×	×	×					×	×		×		×			
[illegible]ra granulata [illegible]										?						×			?	?		?				?								
[illegible]ra n. sp. a		×	×													×	×	×	×										×	×	×			
Stylophora sp.																		×																
Madracis [illegible]is (Lyman)										×								×	×	×	×		×				×		×	×	×			
Madracis [illegible]ilis (Duch and Micht.)																						×												
Pocillopora [illegible]sa Duncan										×	×						×		×											×	×			
[illegible]ia abnormalis (Duncan)						×				×																								
Asterosmilia [illegible]ata Duncan												×	×		×							?		×	×	×				×				
Asterosmilia [illegible]da (Duncan)													×																					
Asterosmilia hilli Vaughan													×																					
Asterosmilia n. sp. a																								×										
Asterosmilia sp.														×																				

Faunal list—Continued.

Species.	Stations. Rio Yaque del Norte.			Rio Amina.					Rio Mao.										Rio Gurabo.															
	8714	8715	8726	8727	8728	8516	8517	8518	8523	8519	8520	2527	8733	8734	8528	8538	8539	8540	8541	8542	8543	8544	8545	8546	8548	8549	8550	8552	8555	8556	8735	8536	8537	8535
Corals—Continued:																																		
Stephanocoenia intersepta (Esper)					×						×					×	×	×	×	×			×							×	×			
Dichocoenia tuberosa Duncan																			×															
Dichocoenia sp.																															×			
Antillia dubia (Duncan)				×	?	×			×	×	×	×																						×
Antillia bilobata Duncan						×	×			×																								×
A[illegible]ia sp.										×										×		×	×			×				×				
Orbicella limbata (Duncan)											×						×	×	×				×								×			
O[illegible]lla sp. aff. O. limbata (Duncan)										×					×		×	×		×							×		×		×			
Orbicella brevis (Duncan)																	×	×	×				×											
Orbicella [illegible] (Linn.) var. endothecata (Duncan)																	×	×																
Orbicella [illegible] (Linn.) var.											×												×					×				×		
O[illegible]lla sp. aff. O. altissima (Duncan)																				×														
[illegible]a sp., [illegible]all calices					×																													
Orbicella sp., large calices					×																													
Orbicella sp.		×																																
Sol[illegible]ea bournoni M. Edw. and H.														×				×	×															
Solenastrea hyades (Dana)																		×												×				
Thysanus n. sp. a (type from Bowden, Jamaica)																					×													
Teleiophyllia grandis Duncan						×				×	×												×											
Teleiophyllia sp., near T. grandis Duncan					×																													×
[illegible]llia n. sp. a			×									×						×								×				×				
[illegible]llia n. sp. a., var.																					×													
[illegible]ra sp. aff. M. labyrinthiformis (Linn.)					×																		×								×			
Maeandra n. sp. a																	×	×																
[illegible]ra sp., probably M. n. sp. a								×																										
Syzgophyllia [illegible] ([illegible]ncan)						×				×	×	×	×								×		×	×		×								
Syzgophyllia sp. aff. S. [illegible]ntata (Duncan)																		×																

Faunal list—Continued.

Species.	Rio Ámina.	Rio Mao.				Rio Gurabo.
	8516	8519	8527	8733	8734	Zone D.
Bryozoa:						
Cupuladria canariensis Dusk						×
Lunularia sp.						×
Cupularia umbellata Defrance				×	×	×
Cupularia denticulata Defrance	×	×	×			
Thalamoporella granulata Levinsen					×	
Thalamoporella biperforata Canu and Bassler					×	
Stichoporina tuberosa Canu and Bassler					×	
Labiopora miocenica Canu and Bassler					×	

Species.	Rio Mao.	Rio Gurabo.
	8519	7791
Echinii:		
Cidaris melitensis Forbes	×	
Clypeaster caudatus Jackson n. sp.		[1] ×

[1] Collected loose at foot of bluff; probably from "Zone C."

Faunal list—Continued.

Species.	Rio Yaque del Norte.			Rio Ámi-na.	Rio Mao.					Rio Gurabo.																	
	8714	8715	8726	8516	8519	8527	8733	8734	8528	8538	8539	8540	8541	8544	8545	8546	8548	8549	8550	8551	8552	8553	8554	8555	8556	8735	8537	8535
Mollusca:																												
Gastropoda:																												
Cavolina tridentata Forskål n. subsp.					X																							
Acteonidea oryza Gabb			X																									
Acteocina n. sp. a					X			X																				
Acteocina n. sp. b			X																									
Acteocina sp.							X																					
Volvula cylindrica Gabb					X			X																				
Volvula n. sp. a			X																									
[illegible]ia paepercula (Sowerby)				X				X		X																		
Bularia sp.										X																		
[illegible]ys [illegible]a) [illegible]is (Maury)					X											?												
Terebra (Strioterebra) bipartitia Sowerby							X																					
[illegible]a ([illegible]ra) n. sp. k					X		X																					
Terebra (Strioterebra) n. sp. l							X		X																			
Terebra (Strioterebra) sp.								X	X																			
[illegible]a (new subgenus, Gardner Mss.) sulcifera Sowerby				X	X					X		X						X										
[illegible]us haytensis Sowerby		X		X	X				X					X	X					X								
[illegible]us haytensis Sowerby subsp. sewalli Maury					X					X						X	X	X		X							?	
Conus [illegible]ricus Sowerby	X	X		X			X	X	X	X		X		X	X	X	X	X	X		X	X						
[illegible]us symmetricus Sowerby subsp. domingensis Sowerby	X			X	X	X																						
[illegible]us consobrinus Sowerby				X	X				X						X			X										
Conus catenatus Sowerby		X		X			X																					
Conus stenostomus Sowerby				X	X										X													
Conus [illegible]us Böse subsp. gaza Brown and Pilsbry				X	X	X									X		X	X	X									
[illegible]us gracilissimus Guppy n. subsp. b′				X	X			X		X								X										
Conus [illegible]us Guppy n. subsp. c′																						X						
Conus karlschmidti Maury				X	X		X		X					X	X	X		X	X	X								
Conus marginatus Sowerby																											?	
Conus vanatti Maury					X										X													
[illegible]us [illegible]oni Maury											X	X																
[illegible]us dalli Maury not Toula				X															X									
[illegible]us n. sp. e				X																								

Faunal list—Continued.

Species.	Rio Yaque del Norte.			Rio Ámina.	Rio Mao.					Rio Gurabo.																		
	8714	8715	8726	8516	8519	8527	8733	8734	8528	8538	8539	8540	8541	8544	8545	8546	8548	8549	8550	8551	8552	8553	8554	8555	8556	8535	8537	8535
Mollusca—Continued:																												
Gastropoda—Continued:																												
Conus n. sp. i					×							×																
Conus n. sp. j					×																							
Conus n. sp. k					×																							
Conus n. sp. l				×														×										
Conus n. sp. m				×																								
Conus n. sp. n				×					×																			
Conus n. sp. o															×													
"Clavatula" labiata Gabb				×	×		×			×																		
Surcula (Pleurofusia) n. sp. b							×																					
Surcula (Pleurofusia) n. sp. c							×		×																			
Surcula (Pleurofusia) n. sp. d									×																			
Surcula (Cochlespira) n. sp. a					×																							
Surcula (Cochlespira) n. sp. b									×																			
Turris (Pleurotoma) haitensis (Sowerby)	×	×	×	×	×	×	×	?	×	×		×		×	×	?	×	×	×		×	×		×	?	×		
"Drillia" henekeni (Sowerby)				×	×					×																		
"Drillia" venusta (Sowerby)			×	×	×		×	×	×	×		×		×	×	×		×	×	?	×							
"Drillia" consors (Sowerby)		×												×		×	×	×	×				×					
"Drillia" squamosa (Gabb)							×		×					×														
"Drillia" fusiformis (Gabb)	×			×	×	×	×		×	×	×							×										
"Drillia" cercadonis Maury				×	×		×																					
"Drillia" riogurabonis Maury				×	×		×	×										×										
"Drillia" n. sp. h					×			×																				
"Drillia" n. sp. n				×	×				×							×			×									
"Drillia" n. sp. o					×																							
"Drillia" n. sp. p					×			×																				
"Drillia" n. sp. q			×	×	×				×																			
"Drillia" n. sp. r		×																										
"Drillia" n. sp. s				×																								
"Drillia" n. sp. t									×																			
"Drillia" n. sp. u																			×									
"Drillia" n. sp. v																								×				
"Drillia" n. sp. w																										×		

Faunal list—Continued.

Species.	Rio Yaque del Norte.			Rio Ámina.	Rio Mao.					Rio Gurabo.																	
	8714	8715	8726	8516	8519	8527	8733	8734	8528	8538	8539	8540	8541	8544	8545	8546	8548	8549	8550	8551	8552	8553	8554	8555	8556	8535	8537	8535
Mollusca—Continued:																												
Gastropoda—Continued:																												
Mitra (Uromitra) tortuosa Gabb					×																							
Mitra (Uromitra) n. sp. f				×	×																							
Mitra (Uromitra) n. sp. g				×												×												
Mitra (Uromitra) n. sp. h								×																				
Mitra (Fusimitra?) n. sp. a								×																				
Lyria pulchella (Sowerby)				×	×		×		×	×		×		×	×	×			×									
Lyria pulchella (Sowerby) n. subsp. a′				×																								
Xancus praeovoideus Maury					×																							
Latirus exilis Gabb					×		×		×																			
Latirus fusiformis Gabb											×																	
Latirus infundibulum (Gmelin)									×					×	×						×							
Vasum dominicense Gabb									×																			
Vasum gurabicum Maury											×							×										
Vasum sp. indt								×																				
Melongena consors (Sowerby)					×													×										
Melongena sp. indt								×																				
Fasciolaria semistriata Sowerby					×																							
Fusus henekeni Sowerby				×	×		×			×		×			×		×		×									
Fusus henekeni Sowerby subsp. haitensis Sowerby												×																
Phos gabbi Dall	×	×	×	×	×					×					×													
Phos elegans Guppy					×	×	×		×	×	×			×			×	×	×							×		
Phos guppyi Gabb									×																			
Phos n. sp. b																										×		
Phos sp. indt								×																				
Alectrion losquemadica Maury	×				×	×		?																				
Alectrion gurabensis Maury	×																											
Alectrion n. sp. a								×																				
Metula cancellata Gabb					×		×		×	×									×									
Nassarina n. sp. a	×		×																									
Metulella venusta (Sowerby)				×	×																							
Metulella n. sp. b								×																				
Columbella (Alia) n. sp. a											×																	

Atilia n. sp. a							×	×																				
Atilia n. sp. b								×																				
Atilia sp.								×																				
Atilia (Columbellopsis) haitensis (Sowerby)																										×		
Strombina carribae Gabb							×																					
Strombina bassi Maury								?		×																		
Murex domingensis Sowerby	×			×	×	×	×	×	×	×	×			×	×	×	×	×	×	×	×							
Murex (Phyllonotus) cornurectus Guppy					×						×								×									
Murex (Phyllonotus) prepauxillus Maury											×																	
Typhis alatus Sowerby									×																			
Coralliophila n. sp. b																										×		
Aspella scalaroides Maury not Blainville														×														
Aspella sp.												×																
Trophon ? sp.														×														
Tritonium (Lampusia) pileare Maury not Lamarck														×				×										
Tritonium (Cymatium) praefemorale (Maury)					×																							
Tritonium (Ranularia) gurabonicum (Maury)									×																			
Distortio simillima (Sowerby)	×			×	×		×		×	×				×	×	×	×	×	×	×								
Bursa amphitrites Maury	×				×				×																			
Bursa bufoniopsis Maury														×														
Cassis sulcifera Sowerby			×	×	×				×	×		×			×													
Cassis (Semicassis) reclusa Guppy					×																							
Sconsia laevigata (Sowerby)	×		×	×	×	×			×	×	×	×	×	×	×	×	×	×	×	×	×						×	
Morum domingense (Sowerby)	×			×	×																							
Dolium (Malea) camura (Guppy)			×	×	×	×		?		×				×										×				
Cypraea henekeni Sowerby				×	×	×																						
Cypraea noueli Maury					×				?																			
Cypraea dominicensis Gabb					×																							
Cypraea spurcoides Gabb																						×						
Cypraea spurca Linnaeus?				×	×																							
Pustularia gabbiana (Guppy)					×																							
Trivia [illegible]a Gray subsp. sanctidominici Maury				×	×																							
Strombus haitensis Sowerby	×				×				×					×														
Strombus proximus Sowerby					×										×													
Strombus bifrons Sowerby	×			×	×					×		×			×	×			×		×							
Strombus pugiloides Guppy ?											×													×				
Strombus maoensis Maury					×																							
Cerithium (Vulgocerithium) microlineatum Gabb											×	×																
Cerithium (Vulgocerithium) russeli Maury											×	×		×		×		×										
Cerithium (Vulgocerithium) dominicense Gabb										×																		
Cerithium (Vulgocerithium) n. sp. a					×																							
Clava plebeia (Sowerby)				×	×	×	×	×		×				×	×	×		×										
Clava n. sp. a			×	×	×																×							
Clava n. sp. b									?			×																
Conocerithium gurabense (Maury)		×			×																							

Faunal list—Continued.

Species.	Rio Yaque del Norte.			Rio Ámi-na.	Rio Mao.					Rio Gurabo.																		
	8714	8715	8726	8516	8519	8527	8733	8734	8528	8538	8539	8540	8541	8544	8545	8546	8548	8549	8550	8551	8552	8553	8554	8555	8556	8735	8537	8535
Mollusca—Continued:																												
Gastropoda—Continued:																												
Conocerithium uniseriale (Sowerby)		×											×															
Bittium sp.								×																				
Cerithiopsis sp.								×																				
Triforis sp.								×																				
Alibina canaliculata (Gabb)					×			?																				
Modulus sp.								×						×														
Crepitacella capula Guppy							×		×					×										×		×		
Alaba sp.								×																				
Cirsostrema textuvistitum (Maury)																			×									
Serpulorbis papulosa (Guppy)	×			×	×																					×		
Serpulorbis granifera (Say)?						×																				×		
Petaloconchus domingensis Sowerby	×	×	×	×	×			×		×				×		×	×		×									
Petalaloconchus laddfranklinae Maury	×		×	×	×		×	×	×					×				×										
Siliquaria gurabensis Maury					×										×													
Vermicularia spirata (Philippi) n. subsp. a′								×																				
Turritella tornata Maury not Guppy				×	×			×		×	×																	
Turritella planigyrata Maury not Guppy					×						×																	
Turritella submortoni Maury						×		×																		×		
Caecum n. sp. b								×																				
Architectonica quadriseriata (Sowerby)				×	×									×				×	×									
Architectonica n. sp. b			×		×			×							×													
Rissoina crassilabris (Gabb)			×					×																				
Rissoina n. sp. b			×	×	×				×					×														
Rissoina n. sp. c			×																									
Rissoina n. sp. d								×	×					×												×		
Rissoina sagraiana Maury not d'Orbigny								×																				
Rissoina sp.								×																				
Amalthea n. sp. b									×																			
Xenophora delecta (Guppy)									×					×				×		×	?							
Xenophora (Tugurium) imperforata (Gabb)					×				×						×													
Natica canrena Linnaeus n. subsp. a′				×	?		?		?																			
Natica canrena Linnaeus n. subsp. b′										×																		

Faunal list—Continued.

Species.	Rio Yaque del Norte.			Rio Ámina.	Rio Mao.					Rio Gurabo.																		
	8714	8715	8726	8516	8519	8527	8733	8734	8528	8538	8539	8540	8541	8544	8545	8546	8548	8549	8550	8551	8552	8553	8554	8555	8556	8535	8537	8535
Mollusca—Continued:																												
Pelecypoda:																												
Nucula n. sp. a																									×	×		
Leda n. sp. a			×																									
Yoldia ovalis Gabb													×												×			
Limopsis ovalis Gabb							×		×											×			×	×	×	×		
Arca (Arca) occidentalis Philippi			×																									
Arca (Arca) [illegible]is Maury			×		×			×																				
Arca (Barbatia) n. sp. a														×	×													
Arca (Acar) [illegible]ta Gmelin														×														
Arca (Scapharca) golfoyaquensis Maury			×		×					×					×	×			×							×		
Arca (Scapharca) riogurabonica Maury				×	×		×		×					×														
Arca (Scapharca) cercadica Maury					×	×	×																					
Arca (Scapharca) cibaoica Maury			×					×																				
Arca (Scapharca) losquemadica Maury																										?		
Arca (Scapharca) n. sp. b												×	×															
Arca ([illegible]a) n. sp. a																										×		
[illegible]is acuticostata (Sowerby)	×			×	×			×				×		×	×	×		×	×					?		?	×	
Glycymeris n. sp. c							×		×																			
Glycymeris n. sp. d							×																					
[illegible]is n. sp. e			×																									
Ostrea haitensis Sowerby				×																					×	×		×
Ostrea megodon Hanley																												?
Ostrea gilbertharrisi Maury					×									?														
Ostrea sp.								×																				
Pecten (Pecten) soror Gabb			?												×													×
Pecten (Chlamys) vaginulus Dall?			×																									
Pecten [illegible]) inaequalis Sowerby			?	×	×	×	?																					
Pecten (Aequipecten) eugrammatus Dall				×	×			×		?				×				×										×
Pecten (Aequipecten) n. sp. d							×		×									×										
[illegible]en [illegible]en) n. sp. e																									×	×		
Pecten (Nodipecten) nodosus Linnaeus?											×			×														
Pecten (Nodipecten) n. sp. a														×	×													
Pecten (Nodipecten) n. sp. b			×																									

Pecten (Amusium) papyraceus (Gabb)				×	×																							×
Pecten (Pseudamusium) sp.			×																									
Spondylus bostrychites Guppy				×	×										×		×	×							×			×
Plicatula n. sp. a			×																									
Limaea solida Dall														×														
Anomia sp.								×																				
Julia n. sp. a			×					×																				
Crassinella n. sp. a			×					×																				
Venericardia scabricostata (Guppy)				×	×			×						×	×		×	×	×									
Chama involuta Guppy			×		×			×						×				×										
Echinochama antiquata Maury not Dall				×	×				×							×	×	×	×									
Echinochama yaquensis Maury														×					×									
Erycina quadrata (Gabb)					×																							
Cardium (Trachycardium) cinderellae Maury			?			×								×														
Cardium (Fragum) medium Linnaeus		×																										
Cardium (Trigoniocardia) haitense Sowerby			×		×	×												×										
Cardium (Trigoniocardia) aminense Dall				×	×									×														
Cardium (Laevicardium) serratum Linnaeus	×				×																							
Cardium (Laevicardium) venustum Gabb					×																							
Protocardia sp. indt.								×				×													×	×		
Gafrarium (Gouldia) n. sp. a								×										×										
Pitaria (Lamelliconcha) planivieta (Guppy)						×																						
Antigona (Ventricola) blandiana (Guppy)			×	×	×	×								×	×	×	×	×	×									
Chione woodwardi (Guppy)			×					?																				
Chione (Lirophora) hendersoni Dall					×			×																				
Psammosolen sancti-dominici Maury								×						×														
Corbula cercadica Maury			×	×	×	×	×	×							×			×								×		
Corbula (Aloidis) vieta Guppy					×			?	×					×														

According to Doctor Maury's faunal lists the following additional species of Mollusca were collected from the Gurabo formation by the Maury expedition.

Species.	Rio Ámina.	Rio Mao.	Rio Gurabo.				
	Potrero.	Bluff 1.	Zone A.	Zone B.	Zone D.	Zone E.	Zone F
Mollusca:							
Gastropoda:							
Terebra inaequalis Sowerby					×	×	
Terebra petiti Maury			×				
Conus haytensis Sowerby subsp. gurabensis Maury				×			
Conus tortuostriatus Toula						×	
Conus proteus Hwass					×		
Surcula riomaonis Maury		×					
"Drillia" losquemadica Maury					×		
"Drillia" donalbertonis Maury					×		
"Drillia" hispaniolae Maury					×		
"Clathurella" vendryesiana Dall					×		
Cancellaria barretti Guppy		×					
Cancellaria (Narona) losquemadica Maury						×	
Olivella sanctidominici Maury					×		
Mitra quemadica Maury					×		
Mitra berlinerae Maury		×					
Mitra (Strigatella?) pertubatrix Maury					×	×	
Turricula (Costellaria) bullen-newtoni Maury					×	×	
Fasciolaria carminimaris Maury		×					
Vasum haitense (Sowerby)			×	×		×	
Phos moorei Guppy		×				×	×
Nitidella cibaoica Maury					×		
Typhis cercadicus Maury		×					
Coralliophila miocenica (Guppy)					×		
Cypraea patrespatriae Maury		×					
Triforis calypsonis Maury					×		
Xenophora conchyliophora Born						×	×
Turbo crenulatoides Maury				×			
Pelecypoda:							
Limopsis hatoviejonis Maury	×						
Arca (Barbatia) sp. cf. A. bonacyzi Gabb					×		
Arca (Scapharca) henekeni Maury				×			
Ostrea virginica Gmelin					×		
Pecten excentricus Gabb		×					
Pecten hatoviejonis Maury	×						
Venericardia islahispaniolae Maury			×				
Protocardia islahispaniolae Maury				×			

According to Dr. Maury's faunal lists the following additional species of Mollusca were collected by the Maury expedition from yellow clays presumably belonging to the Gurabo formation at an altitude of 540 feet near the foot of the Samba Hills between Las Caobas and Rompino:

Arca lomasdesamba Maury.
Cardium (Trigoniocardia) sambaicum Maury.

Mollusca:

Gastropoda:

Ringicula tridentata Guppy ?
Acteocina recta Maury not d'Orbigny.
Acteocina sp.
Cylichna n. sp. a.
Cylichnella trictum-tritonis (Maury).
Volvula cylindrica Gabb.
Bullaria paupercula (Sowerby).
Terebra (Strioterebra) cirra Maury not Dall?
Terebra (Strioterebra) n. sp. f.
Terebra (Strioterebra) n. sp. n.
Terebra (Strioterebra) n. sp. o.
Terebra (Strioterebra) sp.
Terebra (new subgenus Gardner MS.) sulcifera Sowerby.
Terebra (Fusoterebra) n. sp. a.
Conus fulvoides Gabb.
Conus gracilissimus Guppy n. subsp. d'.
Conus n. sp. q.
Conus n. sp. r.
Conus sp.
Surcula humerosa (Gabb).
Surcula longicaudata (Gabb).
Surcula n. sp. a.
Surcula n. sp. b.
Surcula (Pleurofusia) parkeri (Gabb).
Surcula (Leucosyrinx) n. sp. a.
Turris n. sp. a.
Turris (Pleuroliria) n. sp. a.
"Drillia" venusta (Sowerby).
"Drillia" riogurabonica Maury.
"Drillia" n. sp. n.
"Drillia" n. sp. cc.
"Drillia" n. sp. dd.
"Drillia" n. sp. ee.
"Drillia" n. sp. ff.
"Drillia" n. sp. gg.
"Drillia" n. sp. hh.
"Drillia" n. sp. ii.
"Drillia" sp.
"Mangilia" n. sp. c.
"Mangilia" n. sp. o.
"Mangilia" n. sp. p.
"Mangilia" sp.
"Cythara" elongata (Gabb).
"Cythara" n. sp. g.
"Cythara" n. sp. h.
"Cythara" n. sp. i.
Pleurotomella sp.
Glyphostoma n. sp. f.
Oliva brevispira Gabb.
Oliva cylindrica Sowerby ?
Olivella n. sp. b.
Olivella (Lamprodroma) muticoides (Gabb).
Olivella (Lamprodroma) indivisa Maury not Guppy.

Mollusca—Continued:

Gastropoda—Continued:

Olivella (Lamprodroma) sp.
Marginella coniformis Sowerby.
Marginella hispaniolensis Maury.
Marginella n. sp. c.
Marginella n. sp. i ?
Marginella n. sp. j.
Marginella n. sp. k.
Marginella n. sp. 1.
Marginella (Closia) n. sp. a.
Mitra (Uromitra) n. sp. g ?
Mitra (Uromitra) n. sp. i.
Mitra (Fusimitra) n. sp. b.
Mitra (Fusimitra) n. sp. c.
Lyria pulchella (Sowerby).
Caricella striata (Gabb).
Fusus henekeni Sowerby.
Phos gabbi Dall.
Phos elegans Guppy.
Phos sp.
Alectrion losquemadica Maury.
Alectrion n. sp. a.
Nassarina n. sp. c.
Metulella venusta (Sowerby).
Metulella williamgabbi Maury.
Metulella sp.
Atilia n. sp. a.
Atilia (Columbellopsis) exilis (Gabb).
Atilia (Columbellopsis) n. sp. c.
Mitrella n. sp. a.
Strombina nuestrasenorae Maury.
Strombina bassi Maury.
Murex domingensis Sowerby.
Cassis sulcifera Sowerby.
Sconsia laevigata (Sowerby).
Sconsia n. sp. a.
Morum domingense (Sowerby).
Dolium (Malea) camura Guppy ?
Strombus haitensis Sowerby ?
Clava plebeia (Sowerby).
Bittium n. sp. i.
Bittium sp.
Cerithiopsis sp.
Triforis sp.
Alabina canaliculata (Gabb).
Modulus n. sp. a.
Modulus n. sp. b.
Alaba n. sp. a.
Alaba sp.
Serpulorbis papulosa (Guppy)
Serpulorbis sp.
Petaloconchus domingensis Sowerby.
Petaloconchus laddfranklinae Maury.
Turritella tornata Maury not Guppy.
Turritella planigyrata Maury not Guppy.
Fossarus ? (Gottoina?) n. sp. a.

Mollusca—Continued:
- Gastropoda—Continued:
  - Architectonica n. sp. b.
  - Rissoina crassilabris (Gabb).
  - Risscina sagraiana Maury not d'Orbigny.
  - Rissoina n. sp. b ?
  - Rissoina n. sp. c.
  - Amalthea n. sp. a.
  - Natica canrena Linnaeus n. subsp. b'.
  - Natica (Stigmaulax) sulcata Born.
  - Natica (Cryptonatica) n. sp. a.
  - Polynices subclausa (Sowerby).
  - Amauropsis guppyi Gabb ?
  - Cyclostrema striata Gabb.
  - Cyclostrema ? n. sp. a.
  - Adeorbis pentagona (Gabb).
  - Teinostoma n. sp. a.
  - Turbo dominicensis Gabb ?
  - Astralium sublongispinum Maury.
  - Phasianella (Eucosomia) punctata (Gabb).
  - Calliostoma sp. indt.
  - Neretina (Smaragdia) viridimaris Maury.
  - Fissuridea sp. indt.
  - Melanella n. sp. f.
  - Melanella sp.
  - Strombiformis sp.
  - Niso sp.
  - Pyramidellidae 3 spp.
- Scaphopoda:
  - Dentalium dissimile Guppy.
  - Dentalium praecursor Pilsbry & Sharp.
  - Dentalium glaucoterrarum Maury.
  - Dentalium n. sp. d.
  - Dentalium sp.
  - Cadulus n. sp. b.
- Pelecypoda:
  - Nucula tenuisculpta Gabb.
  - Leda n. sp. c.
  - Arca (Fossularca) adamsi Dall.
  - Arca (Scapharca) cibaoica Maury.
  - Arca (Scapharca) golfoyaquensis Maury.
  - Arca (Scapharca) losquemadica Maury.
  - Arca (Scapharca) sp.
  - Glycymeris acuticostata (Sowerby).
  - Pteria inornata Gabb.
  - Ostrea sp. indt.
  - Pecten (Pecten) soror Gabb.
  - Pecten (Aequipecten) thetidis Sowerby
  - Pecten (Amusium) sp. indt.
  - Spondylus bostrychites Guppy ?
  - Julia n. sp. a.
  - Verticordia (Trigonulina) n. sp. a.
  - Venericardia scabricostata Guppy ?

8736 (D. C. 63 A). Province of Monte Cristi, left bank of Rio Gurabo about 3.4 kilometers below Gurabo Adentro, loose material from limestone up the hill. D. D. Condit, collector. May 8, 1919.

Faunal list.

Species.	Stations.									
	8716	8717	8723	8724	Arroyo Las Lavas. 8663	8531	Rio Mao. 8532	8533	8731	Rio Gurabo. 8736
Corals:										
Placocyathus sp. aff. P. variabilis Duncan					×					
Placocyathus costatus Duncan					×	?				
Placocyathus n. sp. e					×					
Placocyathus n. sp. g					×					
Paracyathus henekeni (Duncan)					×					
Stylophora affinis Duncan					×	×	×			
Stylophora minor Duncan					×	×	×			
Stylophora n. sp. a					×		×			
Stylophora sp.			×	×						×
Madracis decactis (Lyman)					×		×			
Pocillopora crassoramosa Duncan					×		×	×		
Stephanocoenia intersepta (Esper)				×	×	×			×	
Dichocoenia tuberosa Duncan					×					
Meandrina sp. cf. M. maeandrites (Linn.)						×				
Antillia dominicensis Vaughan, ms.					×	×				
Antillia sp.					3 spp.		×			×
Orbicella limbata (Duncan)			×	×	×	×	×			
Orbicella sp. aff. O. limbata (Duncan)				×	×	×	×	×	×	×
Orbicella cavernosa (Linn.)					×					
Orbicella cavernosa (Linn.) var						×				
Orbicella sp. aff. O. cavernosa (Linn.)									×	×
Orbicella sp.	×	×							×	
Teleiophyllia magnifica Vaughan, ms.					×					
Teleiophyllia ? sp., resembles T. n. sp. a.									×	
Teleiophyllia sp.	×									
Maeandra sp. aff. M. labyrinthiformis (Linn.)	×	×				×	×			
Maeandra sp. aff. M. pliocenica (Gane)							×			
Maeandra sp. aff. M. areolata (Linn.)							×			
Maeandra sp. aff. M. strigosa (Dana)					×					
Maeandra sp.	×									
Manicina sp. aff. M. gyrosa (Ell. and Sol.)				×						
Mussa sp., probably new						×				
Mussa sp.					3 spp.		×			
Mussoid coral, probably Mycetophyllia sp.	×									
Mycetophyllia sp.										×
Agaricia dominicensis Vaughan					×					
Agaricia n. sp. c					×	×	×			
Agaricia n. sp. d					×					
Agaricia n. sp. f					×		×			
Agaricia n. sp. h					×	×	×			
Agaricia n. sp. i						×			×	
Siderastrea siderea (Ell. and Sol.)				×	×	×	×		×	
Siderastrea sp. aff. S. radians (Pallas)	×									
Goniopora jacobiana Vaughan							×			
Porites sp. aff. P. furcata Linn.					×					
Porites sp. aff. P. astreoides Linn.					×					
Porites sp. aff. P. baracoaensis Vaughan										×
Porites sp.			×		2 spp.		×			

Faunal list—Continued.

Species.	Stations.			
	8724	8663	8531	8532
Mollusca:				
Gastropoda—				
Coralliophila sp. indt		×		
Strombus sp. (larger than the other Miocene species)	×			
Strombus sp. indt		×		
Conocerithium gurabense (Maury)		×		
Conocerithium uniseriale (Sowerby)		×		
Conocerithium n. sp. a		×		
Turritella submortoni Maury		×		
Pelecypoda—				
Arca (Scapharca) golfoyaquensis Maury		×		
Area (Scapharca) sp. indt		×		
Area (Argina) n. sp. a		×		
Ostrea folium Linnaeus		×		
Ostrea gilbertharrisi Maury			×	×
Pecten (Aequipecten) sp	×			
Spondylus guamanomocon Pilsbry and Johnson		×	×	
Chama sp		×		
Lucina sp	×			
Phacoides (Miltha?) sp	×			
Gafrarium (Gouldia) sp		×		
Metis sp	×			
Corbula cercadica Maury		×		

Mao Clay.

A collection of fossils was made from this formation at only one locality, as follows:

8530 (C–36). Province of Santiago, bluff on left side of Rio Mao, about 3.4 kilometers above intake of irrigation ditch at Valverde (Mao), first bluff above the town. C. W. Cooke, D. D. Condit, collectors. May 7, 1919.

Faunal list.

Corals:
- Stylophora sp.

Mollusca:
- Gastropoda:
  - Conus haytensis Sowerby.
  - Conus sp.
  - Turris (Pleuroliria) haitensis (Sowerby)?.
  - Cancellaria (Bivetia) epistomifera Guppy.
  - Murex domingensis Sowerby.
  - Cassis (Semicassis) sp. indt.
  - Crepitacella capula Guppy.
- Pelecypoda.
  - Leda n. sp. b.
  - Pecten (Aequipecten ?) sp. indt.

MIOCENE OR OLDER.

List of stations.

8772 (R. 20). Province of Monte Cristi, El Morro, southern side, altitude 45 meters above sea level. C. P. Ross, collector. May 2, 1919.

8773 (R. 21). Province of Monte Cristi, El Morro, southern side, altitude 63 meters above sea level. C. P. Ross, collector. May 2, 1919.

Faunal list.

Corals:	Station.
Placocyathus ? sp.	8772
Leptoria sp.	8773

Yaque Group, Province of Monte Cristi.

List of stations.

8782 (R 22). Province of Monte Cristi, El Morro, southern side, altitude 105 meters above sea level. C. P. Ross, collector. May 2, 1919.

8783 (R 23). Province of Monte Cristi, El Morro, southern side, altitude 153 meters above sea level. C. P. Ross, collector. May 2, 1919.

8774 (R 24). Province of Monte Cristi, El Morro, southern side, altitude 155 meters above sea level. C. P. Ross, collector. May 2, 1919.

8777 (R 30). Province of Monte Cristi, La Subida de la Salina, a hill about 12 kilometers southeast of house of Señor Rodríguez, which is about 25 kilometers northeast of Monte Cristi, altitude 165 meters above sea level. C. P. Ross, collector. May 4, 1919.

8778 (R. 31?). Province of Monte Cristi, on trail between Sabana Cruz and Santana, at La Plata, 27 kilometers from Monte Cristi on Santiago road. C. P. Ross, collector. May 6, 1919.

8780 (R. 39). Province of Monte Cristi, on road from Dajabón to Monte Cristi, 2.5 kilometers from La Barca. C. P. Ross, collector. May 7, 1919.

8779 (R. 37). Province of Monte Cristi, hill 10 kilometers north of Dajabón, near Copey on road between Dajabón and Copey, altitude 12 meters above sea level. C. P. Ross, collector. May 7, 1919.

Faunal list.

Species.	Stations.						
	8782	8783	8774	8777	8778	8780	8779
Corals:							
Stylophora affinis Duncan						×	
Stylophora sp.	×						
Stephanocoenia intersepta (Esper)						×	×
Antillia ? sp.	×						
Orbicella cavernosa (Linn.) var.							×
Favia fragum (Esper)						×	
Maeandra sp.						×	
Siderastrea siderea (Ell. and Sol.)						×	
Porites sp.						×	
Poorly preserved corals of Miocene aspect			×				
Mollusca:							
Gastropoda:							
Cavolina sp.		×					
Conus sp.		×					
Olivella sp.		×					
Melongena sp.				×	×		
Strombus sp.		×	×				
Sconsia laevigata (Sowerby)		×					
Turbo sp.			×			?	
Pelecypoda:							
Arca (Scapharca) patricia Sowerby				×	×		
Arca (Scapharca) sp.		×	×				
Glycymeris sp.			×				
Pecten sp.			×				
Phacoides sp.		×	×				
Cardium (Trigoniocardia) sp.			×				

stations "B" and "C" of traverse of Rio Yaque del Sur. C. P. Ross, collector. May 25, 1919.

8570 (D. C. 84). Province of Azua, channel of Rio Yaque del Sur about 5 kilometers down stream from Boca Mula, beds in contact with Quarternary series. D. D. Condit, C. P. Ross, collectors. May 24, 1919.

8572 (D. C. 87). Province of Azua, left bank of Rio Yaque del Sur at upper edge of village of Los Güiros. D. D. Condit, collector. May 26, 1919.

8590 (D. C. 88). Province of Azua, west bank of Rio Yaque del Sur opposite Palo Copado, D. D. Condit, collector. May 27, 1919.

Faunal list.

	Station.
Foraminifera:	
Amphistegina ? sp.	8568
Alveolina ? sp.	8568

Faunal list—Continued.

Species.	Prov. Macorís.				Prov. Santo Domingo.		Province Azua.													
	8687a	8687b	8687c	8689	8699	8700	8609	8664	8645	8608	8610	8579	8568	8566	8563	8571	8621	8622	8572	8590
Corals:																				
Placocyathus n. sp. h																		×	×	×
Placocyathus ? sp.												×								
Sdra minor Duncan													×							
Sdra n. sp. a													×							×
Sdra sp. a														×	×					
Sdra sp. b							×						×						×	
Stylophora sp. c											×								×	
Stylophora sp.			×	×	×	×											×			
Madracis decactis (Lyman)							×													×
Pocillopora crassoramosa Duncan																		×		
Pocillopora baracoaensis Vaughan											×		×	×						
Pocillopora sp.																	×			
Pocillopora ? sp.							×													
Asterosmilia exarata Duncan																		×		
Asterosmilia sp. (also at station 8546, Rio Gurabo)																	×			
Stephanocoenia intersepta (Esper)	×																			
Euphyllia n. sp. a																				×
Eusmilia sp.							×													
Dichocoenia sp.																		×		
Dichocoenia ? sp.																				×
Antillia bilobata Duncan																			×	×
Antillia walli Duncan							×													
Antillia sp.							×											×		
Antillia ? sp.				×																
Leptomussa sp.							×													
Leptomussa ? sp.							×													
Orbicella limbata (Duncan)							×			×									×	×
Orbicella sp. aff. O. limbata (Duncan)								×					×						×	
Orbicella cavernosa (Linn.)																				×
Orbicella sp. aff. O. canalis Vaughan																				×
Orbicella sp.							(1)			×								(2)		×

[1] 1 sp. [2] 2 spp.

Faunal list—Continued.

Species.	Prov. Macorís.				Prov. Santo Domingo.		Prov. Azua.													
	8687a	8687b	7687c	8689	8699	8700	8609	8664	8645	8608	8610	8579	8568	8566	8563	8571	8621	8622	8572	8590
Corals—Continued:																				
Cladocora ? sp.			×																	
Solenastrea bournoni M. Edw. and H.									×										×	×
Solenastrea sp. aff. S. bournoni M. Edw. and H.							×													
Solenastrea sp.									×											
Solenastrea ? sp.												×								
Favia ? sp., small-caliced species										×										
Teleiophyllia sp. aff. T. grandis Duncan							×													
Teleiophyllia ? sp.		×			×											×				
Maeandra sp. aff. M. labrinthiformis (Linn.)																			×	
Maeandra sp.										×										×
Manicina sp. aff. M. gyrosa (Ell. and Sol.)							×													
Syzygophyllia dentata (Duncan)																		×		
Agaricia dominicensis Vaughan											×							×		×
Agaricia n. sp. a																		×		×
Agaricia n. sp. b																			×	
Agaricia n. sp. h. var							×											×		×
Agaricia n. sp. i		×																		
Agaricia sp.	×			×			×												×	
Siderastrea siderea (Ell. and Sol.)																			×	
Siderastrea sp.																	×			×
Goniopora sp. aff. G. jacobiana Vaughan							×													
Goniopora n. sp. a							×													
Goniopora ? sp.					×															×
Psammocora sp.																		×		
Porites sp.		×					×			(1)	×			×				×	(2)	×

Bryozoa:
Steganoporella sp. cf. S. magnilabris Busk. Station 8609

[1] 2 spp. [2] 3 spp.

Faunal list—Continued.

Species.	Prov. Macorís.				Prov. Santo Domingo.		Prov. Azua.										
	8687a	8687b	8687c	8689	8680	8696	8609	8610	8760	8566	8563	8571	8621	8622	8570	8572	8590
Mollusca—Continued:																	
Gastropoda—Continued:																	
Melongena consors (Sowerby)									?							×	
Fusus sp.																×	
Plochelaea? sp.																×	
Phos gabbi Dall																	×
Phos. sp.																×	
Nassarina ? sp.																	×
Atilia (Columbellopsis) n. sp. d																	×
Mitrella n. sp. b, cf. M. debooyi (Maury)																	×
Strombina pseudohaitensis Maury													×				
Murex sp. indt.													×				
Murex (Phyllonotus) sp. indt.																×	
Muricidea ? sp. indt.																×	
Cypraea henekeni Sowerby ?																×	
Orthaulax aquadillensis									×							×	×
Strombus n. sp. a, cf. S. pugiloides Guppy																	×
Strombus sp. indt.														×			
Cerithium sp.				×										×			×
Cerithium sp. indt.																×	
Conocerithium sp.																	×
Conocerithium ? sp.																×	
Clava ? sp. indt.																×	
Potamides (Prazysinus ?) sp.																×	
Bittium sp.																×	
Triforis sp.																×	×
Alaba sp.																×	×
Serpulorbis sp.																	×
Turritella n. sp. d														×			
Turritella sp.							×										
Rissoina sp.																	×
Crepidula sp.																×	
Natica sp.				×	×		×					×	×			×	
Polynices subclausa (Sowerby)									×							×	
Amauropsis sp.																	×

Turbo dominicensis Gabb?																	×
Astralium sp.												×					
Calliostoma sp.																(1)	
Neretina (Smargdia) viridimaris Maury													×				
Neretina sp. indt.																×	
Acmaea ? sp.																	×
Melanella sp. indt.																×	
Pyramidellidae																(1)	
Scaphopoda:																	
[redacted]lium sp.																×	
Pelecypoda:																	
[redacted]a l[redacted]a Gabb																×	
A[redacted]a ([redacted]a) n. sp. c																×	
A[redacted]a (Scapharca) n. sp. d																×	
A[redacted]a (Scapharca) n. sp. e, cf. A. (S.) patricia Sowerby									×						×	×	
A[redacted]a (Scapharca) n. sp. f																	×
A[redacted]a (Scapharca) sp.						×			×						×		
A[redacted]a ([redacted]a) n. sp. a													×				
[redacted]s n. sp. f														×			
Glycymeris sp.								×									
Pteria sp. indt.																×	
[redacted]a haitensis Sowerby																	×
[redacted]a sp.						×	×				×	×	×		×	×	
Pecten (Pecten) sp.						×									×		
Pecten (Aequipecten) sp., cf. P. (A.) inaequalis Sowerby						×											
Pecten (Aequipecten) sp.												×		×		×	×
Pecten (Plagioctenium) thompsoni Maury						×											
Pecten (Nodipecten ?) sp.														×			
Pecten sp.	×						×				×						
Pecten (Amusium) sp. indt.						×								×			
Spondylus sp. indt.				×													
Lima sp.			×														
Anomia sp.																×	
Lithophaga sp.			×	×													
Crassatellites sp.						×											
Crassinella n. sp. b																×	
Chama sp.						×										×	×
Codakia (Jagonia) n. sp. a													×				
Codakia sp.																×	
Lucina sp. cf. L. chrysostoma Philippi									×								
Lucina sp.														×		×	
Phacoides sp.																×	
Cardium (Trachycardium) sp.															×		
Cardium (Trigoniocardia) sp.									×							×	×
Cardium (Laevicardium) serratum Linn.?																×	×

[1] 2 spp.

Faunal list—Continued.

Species.	Prov. Macorís.				Prov. Santo Domingo.		Prov. Azua.										
	8687a	8687b	8687c	8689	8580	8698	8609	8610	8760	8566	8563	8571	8621	8622	8570	8572	8590
Mollusca—Continued:																	
Pelecypoda—Continued:																	
Antigone n. sp. a																×	×
Chione sp. indt.															×	×	
Cylichnella n. sp. a																	×
Cytherea ? sp.						×											
Pitaria ? sp.						×											
Tellina sp.												×				×	
Metis sp.									×								
Metis ? sp.																×	
Donax aequalis Gabb													×				
Corbula cercadica Maury													×				?
Corbula sp.																×	
Teredo incrassata (Gabb)										×							

	Station.
Decapod Crustacea:	
Callianassa latidigita Rathbun	8996

Faunal list—Continued.

Species.	Prov. Barahona.			
	8574	8742	8591	8761
Mollusca—Continued:				
Gastropoda—Continued:				
Potamides (Prazisinus ?) n. sp. a		×		
Bittiolum n. sp. b	×			
Seila sp			×	
Triforis sp			×	
Modulus ? sp		×		
Acrilla ? sp			×	
Serpulorbis n. sp. a, cf. S. papulosa (Guppy)		×		
Siliquaria n. sp. a, cf. S. squamata (Blainville)			×	
Turritella n. sp. c, cf. T. guppyi Cossmann	×		×	
Natica sp	×		×	
Rissoina sp	×			
Crepidula sp			×	
Neretina (Puperita) figulopicta Maury	×			
Fissuridea sp			×	
Pyramidellidae			1 sp.	
Scaphopoda:				
Dentalium sp	×			
Pelecypoda:				
Arca (Arca) occidentalis Philippi			×	
Arca (Arca) sp. indt			×	
Arca (Calloarca) candida Gmelin			×	
Arca (Calloarca) sp. indt			×	
Arca (Granoarca) n. sp. a			×	
Arca (Scapharca) cibaoica Maury	×			
Arca (Scapharca) auriculata Lamarck, n. subsp. a′			×	
Arca (Scapharca) n. sp. g, cf. A. (S.) halidonata Dall			×	
Arca (Scapharca) n. sp.? h, cf. young of A. (S.) corcupidonis Maury	×			
Arca (Scapharca) patricia Sowerby		×		
Arca (Cunearca) n. sp. a	×	×	×	
Glycymeris n. sp. g, cf. G. pectinata (Gmelin)			×	
Pinna sp				×
Melina sp			×	
Ostrea sp	×	×	×	×
Pecten (EnVola) sp. indt			×	
Pecten (Aequipecten) thetidis Maury not Sowerby ?	×			
Pecten (Aequipecten) sp	×		×	
Pecten (Chlamys) sp			×	
Pecten (Plagioctenium) n. sp. a		×	×	
Spondylus sp. indt			×	
Plicatula n. sp. b			×	
Lithophaga sp		×		
Crassinella n. sp. c	×		×	
Chama n. sp. a, cf. C. inVoluta Guppy			×	
Lucina sp			×	
Phacoides (Phacoides) n. sp. a		×		
Cardium (Fragum) medium Linnaeus			×	
Cardium (Trigoniocardia) n. sp. a	×	×		
Chione sp				×
Chione (Clausinella) n. sp. a	×	×		
Anomalocardia sp		×	×	
Cytherea ? sp				×
Psammosolen sp. indt	×			
Corbula cercadica Maury	×			
Corbula n. sp. a			×	
Corbula n. sp. b			×	
Corbula sp			×	

MIOCENE OR PLIOCENE, PROVINCE OF SAMANÁ.

List of stations.

8607 (C–21). Province of Sanamá, bluff on north coast of Samaná Bay, about 2.5 kilometers east of Sánchez. C. W. Cooke, collector, April 26, 1919.

8764. (R. 3). Province of Samaná, north shore of Samaná Bay, 1.7 kilometers east of pier at Sánchez. C. P. Ross, collector. June 27, 1919.

8684 (D. C. 4). Province of Samaná, eastward-dipping clay beds in cut near pier at Sánchez. C. W. Cooke and D. D. Condit, collectors. April 1, 1919.

8685 (D. C. 5). Province of Samaná, beach on Samaná Bay, 90 meters east of station 8684, near pier at Sánchez. C. W. Cooke and D. D. Condit, collectors. April 1, 1919.

Faunal list.

Species.	8607	8764	8684	8685
Mollusca:				
Hemisinus sp.	×	×	×	×
Ampullaria ? sp.		×		×
Ostrea sp.			×	
Plants:				
Poacites sp.		×		
Pisonia conditi Berry		×		
Inga sanchezensis Berry		×		
Inga sp. indet.				×
Pithecolobium samanensis Berry		×		
Sapindus hispaniolaca Berry		×		
Calyptranthes domingensis Berry	×			
Bucida sanchezensis Berry		×		
Melastomites domingensis Berry		×		
Bumelia reclinata folia Berry		×		
Guettardia cookei Berry		×		

PLIOCENE OR PLEISTOCENE, PROVINCE OF MONTE CRISTI.

List of stations.

8560. Province of Monte Cristi, between Copey and Dajabon, at north edge of flat, on north side of Dajabon. T. W. Vaughan, collector. April 26, 1919.

8633 (R. 38). Province of Monte Cristi, on main road from Monte Cristi to Dajabon, at north edge of town of Copey. C. P. Ross, collector. May 7, 1919.

Faunal list.

Species.	8560	8633
Corals:		
Stephanocoenia intersepta (Esper)	×	
Orbicella cavernosa (Linn.)	×	
Maeandra labyrinthiformis (Linn.)	×	
Siderastrea sidera (Ell. and Sol.)	×	×
Porites astreoides Lam.	×	

PLEISTOCENE OR YOUNGER.

Station on north side.

8776 (R. 27). Province of Monte Cristi, from sea-beach at Rodríguez house, about 25 kilometers northeast of Monte Cristi; altitude, 7.5 meters above sea-level. C. P. Ross, collector. May 4, 1919.

Mollusca:	Station.
Strombus gigas Linnaeus ?	8776
Codakia orbicularis (Linnaeus)	8776

List of stations on south side.

8688 (D. C. 7). Province of Macorís, 1.4 kilometers from San Pedro de Macorís, on Camino Real to Platanitos; altitude, 9 meters above sea-level. T. W. Vaughan, collector. April 3, 1919.

8690 (D. C. 11). Province of Macorís, from limestone underlying San Pedro de Macorís. D. D. Condit, collector. April 3, 1919.

8695 (D. C. 16). Province of Santo Domingo, road from Santo Domingo to San Cristóbal, 24.5+ kilometers from Santo Domingo; altitude, 80 meters above sea-level. T. W. Vaughan and others, collectors. April 6, 1919.

8674. Province of Santo Domingo, road from Santo Domingo to San Cristóbal, about 24 kilometers from Santo Domingo; altitude, 57 meters above sea-level. T. W. Vaughan and others, collectors. April 6, 1919.

8697 (D. C. 18). Province of Santo Domingo, road from Santo Domingo to San Cristóbal, 23+ kilometers west of Santo Domingo; altitude, 36 meters above sea-level. T. W. Vaughan and other, collectors. April 6, 1919.

8698 (D. C. 19). Province of Santo Domingo, west side of Rio Jaina, north of west end of bridge on road from Santo Domingo to San Cristobal. T. W. Vaughan and others, collectors. April 6, 1919.

8573 (D. C. 89). Province of Barahona, from "coast limestone" at Cabral. D. D. Condit, collector. May 28, 1919.

8593 (D. C. 92). Province of Barahona, "coast limestone" fossils from village of Barbacoa, altitude ranging from 33 meters below sea-level to about sea-level along the shore of Lake Enriquillo. D. D. Condit, collector. May 27, 1919.

8629 (R. 63). Province of Barahona, from coral limestone along the road from San José to Lake Enriquillo. C. P. Ross, collector. June 4, 1919.

8625 (R. 52). Province of Barahona on road from Duvergé to Palma Dulce. C. P. Ross, collector. June 1, 1919.

8630 (R. 64). Province of Barahona, from sand in road west of Duvergé, a short distance beyond the place where the road reaches the shore of Lake Enriquillo, in entrance of pass into hills. C. P. Ross, collector. June 4, 1919.

Faunal list—Continued.

Species.	Prov. Macoris.	Prov. Barahona.				
	8690	8573	8593	8629	8625	8630
Mollusca—Continued:						
Gastropoda—Continued:						
Cerithium (Vulgocerithium) variable Adams			×	?		×
Bittium sp.						×
Modulus modulus (Linnaeus)			×			×
Caecum imbricatum Carpenter						×
Caecum deccusatum de Folin						×
Caecum sp.						×
Rissoina elegantissima d'Orbigny			×	×		×
Rissoina sp.						×
Assimnea sp.			×			×
Astralium americanum (Gmelin)			×			
Natica (Cryptonatica) pusilla Say			×			
Neretina pupa Linn.			×			
Neretina meleagris Lamarck			×			
Fissuridea alternata Say			×			
Pelecypoda:						
Arca (Arca) occidentalis Philippi			×			
Area (Arca) umbonata Lamarck			×	×		
Arca (Calloarca) candida Gmelin			×			
Arca (Fossularca) adamsi Dall						×
Arca (Scapharca) auriculata Lamarck		×	×		×	
Arca (Scapharca) sp.						×
Arca (Cunearca) chemnitzii Philippi			×			
Pteria sp.						×
Atrina listeri (d'Orbigny)?						×
Ostrea sp.	×		×	×		
Spondylus americanus Lamarck			×	×		
Modiolus (Horomya) sp.						×
Dreissena rossmassleri (Dunker)						×
Crassinella guadalupensis (d'Orbigny)						×
Chama macerophylla Gmelin			×	×	×	
Codakia (Jagonia) orbiculata (Montagu)			×			×
Lucina chrysostoma Philippi				×		?
Phacoides (Here) pennsylvanicus (Linnaeus)			×			
Diplodonta punctata Say			×			×
Cardium (Trachycardium) muricatum Linnaeus						×
Cardium (Trachycardium) isocardia Linnaeus						×
Cardium (Fragum) medium Linnaeus						×
Cardium (Trigoniocardia) antillarum d'Orbigny			×			
Cardium (Laevicardium) serratum Linnaeus			×	×		×
Macrocallista (Chionella) maculata (Linnaeus)			×			×
Chione cancellata (Linnaeus)			×			×
Chione (Lirophora) paphia (Linnaeus)						×
Cytherea listeri (Gray)				×		
Gafrarium (Gouldia) insularis Dall & Simpson						×
Anomalocardia flexuosa (Born)			×			
Tellina (Angulus) pauperata d'Orbigny			×			
Ervilia nitens Turton						×
Tageus gibbus (Spengler)						×
Corbula swiftiana Adams			×			
Corbula aequivalvis Philippi ?			×			

CHAPTER VII.

GEOLOGY AND WATER RESOURCES OF THE VICINITY OF MONTE CRISTI.

By Clyde P. Ross.

CHARACTER AND PURPOSE OF THE WORK DONE.

The town of Monte Cristi, the metropolis of the western part of the Cibao Valley, is on the north side of the mouth of Rio Yaque del Norte, near the seacoast, in the northwestern part of the Province of Monte Cristi. The area here considered, which includes most of the irrigated country under cultivation around Monte Cristi, extends about 30 kilometers east of the town and is bounded on the north by the Monte Cristi Range and on the south by the Cordillera Central. (See map, Pl. XIV.) Reconnaissance trips were made not only in the valley but through neighboring parts of the Monte Cristi Range and in the foothills of the Cordillera Central near Dajabon.

The object of this investigation was to gain a general knowledge of the geology of the region and to ascertain the probability of obtaining supplies of groundwater, particularly artesian flows. Supplies of stored water are greatly needed in this region for, according to the most reliable information obtainable, the rainfall here amounts to only about 31 centimeters a year.[1] The success of the principal local industries, farming by irrigation and stock raising, is therefore dependent upon water derived from sources other than direct rainfall. The present principal source of water is Rio Yaque. The few wells in the region are shallow, and the water in many of them is salty. The water obtained from these wells is used for cattle and, if not too salty, for domestic purposes.

The examinations on which this report is based were necessarily hurried. More detailed investigations, aided by the drilling of test wells, would be necessary to warrant any but the most general conclusions as to the possibility of obtaining a sufficient supply of groundwater.

TOPOGRAPHY.

The dominant topographic features of this region are the broad valley of Rio Yaque and the two mountain ranges that bound it—on the north the Monte Cristi Range; on the south the Cordillera Central and its outliers, the Cerros de Jácuba.

Rio Yaque del Norte, the largest stream in the Republic, is nearly 240 kilometers long and is about 100 meters wide near its mouth. In the lower part of its valley the river has built an extensive delta, across which run

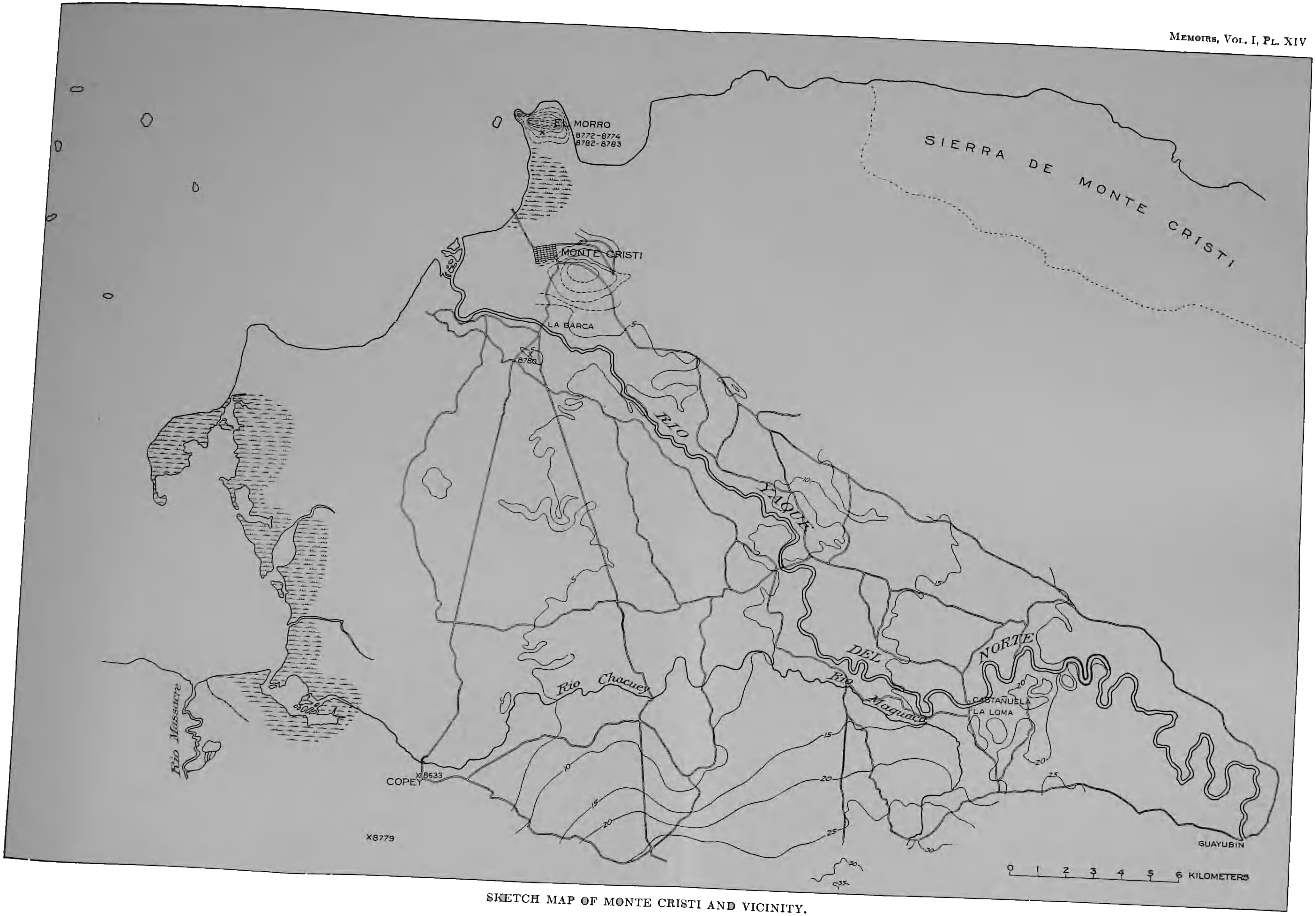
[1] Oral communication from Mr. D. C. Terry, of Monte Cristi.

a number of ramifying channels. The river formerly emptied into Manzanillo Bay, but it now enters the ocean at the southwest end of Monte Cristi Bay, about 3 kilometers from the town of Monte Cristi and 15 kilometers north of its former mouth. Its course is said to have been diverted several years ago by the construction of a dam near Las Cañas, about 13 kilometers upstream from the present mouth of the river. The dam has apparently concentrated all the water in the present channel, which probably was formerly one of many channels that extended across the delta.

The gradient of the river is about one meter to the kilometer, but the valley is in general a nearly level seaward-sloping plain. In the main valley the eminences that project above the plain are few and inconspicuous. The surface of the plain rises gradually to the foothills of the Monte Cristi Range on the north and to the Cerros de Jácuba and other outliers of the Cordillera Central on the south. The site of the town of Monte Cristi is bordered on its landward side by a low semicircular ridge and on its seaward side by salt marshes, which are protected from the sea by a low sand bar. The custom house and wharf are at one end of this sand bar. Almost 5 kilometers north of the town is a wedge-shaped butte about 225 meters high, called El Morro. (See Pl. II, *B*.) The butte is accessible by land only from the sand bar, for the sea washes its north and west sides and salt marshes stand on its other sides.

The Monte Cristi Range is composed of irregularly arranged hills and small mountains. Although some of the hills are steep, and even rough, none of them rise to a great altitude. The range was crossed on the trail from Monte Cristi through Isabel de los Torres to the sea at the finca of Señor Rodríguez, about 25 kilometers northeast of Monte Cristi town, where there is an old rope-fiber factory. Along this trail the range consists of isolated hills, 100 meters or more high, which rise abruptly from a rolling terrane that stands probably not much more than 10 meters above sea level. These hills, though rocky, are rounded rather than serrate. The hills southeast of the house of Señor Rodríguez are higher and the country there is not so open. The trail from this house to Sabana Cruz, after passing Arroyo Guanito, climbs nearly 70 meters up a steep slope called La Subida de la Salina. At the top of this slope is a plain, which stands about 170 meters above sea level, and scattered hills rise abruptly 70 to 100 meters higher. This plain extends eastward, though it becomes rolling and more dissected in that direction until it merges into the open valley of Rio Yaque near La Plata.

The rugged mountains of the Cordillera Central, which bound the valley of Rio Yaque on the south, rise abruptly from the savannas that occupy the area between the main mountain mass and its outliers. Hummocks of gravel are scattered over the savannas. The Cerros de Jácuba, one of the



SKETCH MAP OF MONTE CRISTI AND VICINITY.

Several hills north of Dajabón show exposures of hard, gray massive limestone similar in lithology to the rock in the Monte Cristi Range. which contains Foraminifera, probably of upper Oligocene age.

Immediately north of these hills, on Sabana Cañongo along the trail from La Loma to Dajabón, is an outcrop of hard sandstone, which grades into conglomerate. This sandstone contains numerous fragments of the shells of marine mollusks. Although the bedding is indistinct the strike is apparently east and the dip is rather gentle to the north. This sandstone is considered older than the Miocene sediments because of its greater induration.

Hard, calcareous sandstone, overlain by conglomerate interbedded with sun-cracked sandstone, was also observed in the Monte Cristi Range east of the rope-fiber factory on the seacoast about 25 kilometers northeast of Monte Cristi. The beds strike N. 65° W. and dip 55° NE.

OLIGOCENE TUFFS.

Tuffs were observed at two localities in the Monte Cristi Range. Green weathered tuff outcrops along the coast at an altitude of about 45 meters above sea-level in an arroyo approximately 5 kilometers southeast of the rope-fiber factory. The tuff is not bedded, but a short distance upstream it is interbedded with coarse-grained sandstone, which strikes north and dips eastward. Corals that are apparently of Oligocene age and that are listed on page 111 (station 8775) were collected from thin calcareous beds intercalated in the sandstone.

Green jointed rock, which is apparently a fine-grained tuff, is exposed at an altitude of about 75 meters above sea level in Arroyo Guanito on the trail to Barranca Blanca, 9 or 10 kilometers from the rope-fiber factory. At this locality the tuff grades upward into a conglomerate composed of pebbles that have a maximum diameter of 15 centimeters. The conglomerate is overlain by hard, buff-colored, indistinctly bedded limestone. The beds strike N. 60° W. and dip about 70° SW.

Pebbles of green chloritized tuff and lava are of widespread occurrence in this region and similar tuff and lava were found in place in the Cordillera Central south of Sabaneta.[1]

MIOCENE SEDIMENTARY ROCKS.

Limestone, sandstone, and shale and less consolidated sand and clay of Miocene age are widely spread in the vicinity of Monte Cristi. Obviously the Miocene series includes several formations, but their relations were not definitely ascertained. The exposures on the slopes of El Morro, near Monte Cristi, indicate that Miocene sedimentary rocks form a large part of the western Monte Cristi Range. Rocks of the same age or slightly younger underlie the entire lower part of the Yaque Valley.

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[1] See p. 52 of this report.

The following section was measured on the steep, bare slopes of El Morro. A barometer was used to determine altitudes. The fossils are listed on page 154.

Section at El Morro.

	Meters.
8. Sandy porous limestone containing a few fossils (station 8774, at an altitude of 155 m.)	63
7. Thin beds of limestone alternating with fossiliferous clay (station 8783)	1.5
Unexposed	4
6. Soft sandy clay	9
5. Soft clay and impure limestone	25
4. Thin-bedded layers of sandstone, clay, and impure limestone, containing a few fossils (station 8782, at an altitude of 105 m.)	40
3. Buff to reddish fossiliferous calcareous sandstone (station 8773)	12
2. Hard, porous, buff-colored fossiliferous limestone, weathering gray (station 8772)	18
Unexposed	45
1. Buff limestone conglomerate	1
	218.5

The beds that form El Morro strike N. 80° E. and dip 5° NW. The basal member of the above section is exposed at sea level about 600 meters south of El Morro. Members 4 and 5 are not actually exposed, but the lithology was determined from an examination of the surface débris. Although the collection of corals from member 3 (station 8773) is too small to warrant a definite determination of age, the other collections indicate that the beds exposed on El Morro are of the same age as the Yaque group of the middle part of the Yaque Valley. *Sconsia laevigata* (Sowerby), which is confined to the Gurabo formation in the middle Yaque Valley, was collected from member 7 (station 8783). Dr. Maury[1] collected the same species at this locality.

Cross-bedded argillaceous sandstone and sandy clay are exposed on a hill immediately west of Isabel de los Torres, in the Monte Cristi Range, about 9 kilometers northeast of Monte Cristi. The beds strike N. 60° E. and dip gently northward. No fossils were observed, but the beds resemble those exposed on El Morro, both in lithology and in structural relations.

Similar sedimentary rocks were observed at two localities on Rio Yaque. Thin-bedded sandstone and limestone, which strike N. 45° E. and dip 20° SE., crop out a short distance downstream from the manager's house on Manzanillo Plantation. Thin-bedded sandy limestone, which strikes N. 60° E. and dips 20° SE., is exposed on the south bank of Rio Yaqueat La Barca immediately upstream from the ferry landing.

Thin beds of clay, sandstone, and impure limestone are exposed in many cuts along the automobile road from Monte Cristi to Santiago. The gen-

[1] Maury, C. J., Bull. Am. Paleontology, vol. 5, p. 450, 1917.

eral strike of the beds is northeast and the dip is southeast at an angle less than 25°. These rocks are exposed from Monte Cristi to a place 23.75 kilometers east of Monte Cristi, where younger unconsolidated sand and gravel are encountered.

In the vicinity of Barranca Blanca, in the Monte Cristi Range, sandstone, sandy calcareous clays and soft white limestone are exposed in the arroyos. The beds are more disturbed here than in other areas of Miocene rocks, although the sediments are less consolidated. The strike shifts from north to east and the dip ranges from 15° to 60°.

In addition to the beds described in the above paragraph the Miocene series includes a younger group of less consolidated sand and gravel. Such beds are exposed along the road from Monte Cristi to Santiago east of a place 23.75 kilometers from Monte Cristi. Although local dips as high as 10° were observed the beds are almost horizontal. The road to Guayubin and Sabaneta branches off the main road 24 kilometers from Monte Cristi. At La Plata, 27 kilometers from Monte Cristi, the fossil marine mollusks listed on page 154 (station 8778) were found partly embedded in the yellow soil that covers the plain. As the shells are numerous and widely spread they seem to be in place. They indicate a horizon high in the Miocene, probably higher than any of the horizons in the Yaque group of the middle Yaque Valley.

Fossils of the same species were collected at La Subida de la Salina, on the trail through the Monte Cristi Range (station 8777, p. 154). Soft, friable reddish-brown sandstone, which contains the fossils, is exposed along a steep slope almost 60 meters high. The beds strike N. 35° W. and dip 30° SE. At the top of the slope is a level plain, above which rise a few rounded hills. On the flank of one of the hills, west of the trail, there is a shallow syncline in reddish-brown sandstone.

Several low hills near La Barca, on the south side of Rio Yaque, are composed of undisturbed coralliferous limestone and sand. The corals (see list on p. 154, station 8780) represent a horizon high in the Miocene, perhaps equivalent to the horizon of the Mao Adentro limestone of the upper Yaque Valley.

The town of Copey, which stands between Monte Cristi and Dajabón, is built on rather soft, indistinctly bedded coralliferous light-gray sand and clay, which are well exposed immediately south of the town along the road to Dajabón (station 8779, p. 154). These deposits are apparently of Miocene age but may be younger.

Farther north, on the south side of Rio Yaque between La Barca and Caño de Botijuela, several hummocks that rise above the plain are composed of horizontal beds of coralliferous limestone and subordinate amounts of detritus from the limestone. The patches of limestone clearly are coral reefs, which are probably of the same age as the coralliferous deposits at

STRUCTURE.

The structure of the rocks under the lower part of the Yaque Valley has an important bearing on possible supplies of underground water. The structure of the beds in this region is not a result of deformation during a single period but was developed progressively; each one of the sedimentary formations described above was deformed before the next younger formation was deposited. There has been both folding and faulting, but the deformation was not so intense as to produce great dynamic metamorphism. The older formations are somewhat metamorphosed, but the younger ones have been very slightly affected.

On the south side of the valley are the foothills of the Cordillera Central, which are evidently fault blocks. The quartz diorite appears abruptly in one of the foothills in Juan Calvo Hills near Dajabón, and there is a distinct shear zone. The topography of other outlying hills, Cerros de Jácuba, suggests faulting, and the correctness of this view is supported by the presence in them of limestone apparently of Oligocene age.

On the north side of the valley, along the southern foot of the Monte Cristi Range, no indications of faults of great magnitude were observed, but in some places there has been folding sufficient to produce dips as high as 70°. The rocks that underlie the valley were seen also in the Monte Cristi Range, where they are more disturbed than in the valley, and at Barranca Blanca Miocene strata have been faulted. The strike of the structural lines is prevailingly east and west. A study of El Morro de Monte Cristi (see section on p. 173) shows the presence there of strata equivalent to the Gurabo formation between altitudes of 153 and 155 meters above sea level, and the hill is 57 meters higher. Near La Barca, on the south side of Rio Yaque opposite the town of Monte Cristi (station 8780, p. 154), fossils representing either the upper part of the Gurabo formation or the Mao Adentro limestone were collected about 5 meters above sea level. The bed at this station represents a horizon stratigraphically as high as or higher than the horizon of the bed exposed in El Morro de Monte Cristi at an altitude 150 meters or more higher topographically. The dip on the Morro is 5° N., but the beds at station 8780 are almost undisturbed. These relations imply considerable deformation and perhaps a fault along or near the south side of the Morro, with downthrow to the south and upthrow to the north. The observations here recorded invalidate the opinion of Gabb and Hencken, quoted by Maury, that the limestone capping the Morro is "a continuation of that capping the Samba Hills, the intervening part having been removed by denudation."[1]

The floor of the lower part of the Yaque Valley is formed of strata of Miocene age, which are either exposed or lie under a thin cover of younger deposits. These strata are slightly inclined, crossed by gently undulatory

[1] Maury, Carlotta J., Bull. Am. Paleontology, vol. 5, p. 450, 1917.

folds, and in places dislocated by small faults. The prevalent strike is transverse to the axis of the valley and the dips are more commonly westward than eastward. In places the same bed can be traced for considerable distances by continuous outcrop, although the valley floor slopes westward. If therefore seems probable that the strata have a general westward dip, which is varied by small transverse folds. One fold noted was a dome between La Barca and the town of Monte Cristi, and probably there are others. Although the dips are usually low and westward, they are in some places fairly high and southeastward. Along the road from Monte Cristi to Santiago, for instance, there are southeastward dips at angles as steep as 20°.

The general structural features of the part of the Yaque Valley near Monte Cristi appear to be favorable to the occurrence of artesian water, but this opinion is only preliminary and should be verified by more detailed examination.

WATER RESOURCES.

SURFACE WATER SUPPLY.

There is no permanent stream in the part of the Monte Cristi Range considered in this report, and the water in the streams that emerge from the Cordillera Central is available only in their immediate vicinity. Rio Yaque is the sole present source of water for irrigating the farms in the lower valley and is the principal source of water for domestic use, for which it is packed on burros for distances of 30 kilometers or more from the river. Unfortunately neither discharge records nor analyses of the water of this river are available. No springs are known in the area. After rains water is retained for long periods in pools in the channels of intermittent streams in the Monte Cristi Range, but most of these pools become dry during long droughts.

UNDERGROUND WATER SUPPLY.

POSSIBILITY OF OBTAINING GROUND WATER.

Only a few shallow wells, none of which have been carried more than a meter below the water table, have been dug in the area under consideration. All have been dug by hand and none are more than 10 meters deep. Some of these wells are merely holes in the channels of intermittent streams, have not penetrated the permanent zone of saturation, and are dependent on precipitation for their supply of water. Many of the wells are not reliable at all seasons and would have to be sunk deeper in order to obtain a permanent supply of ground water. The fact that water is found in wells 6 to 10 meters deep shows that the water table stands relatively close to the surface.

The presence of salt water in all the wells has discouraged further development of the underground supply, but the amount of salt in several of the older wells is said to have decreased so much that their water is potable.

The salt in the ground immediately adjoining these wells appears to have been washed out, and if the wells had been energetically pumped the salt might have been removed much more quickly.

Though the wells are shallow and inadequate, enough of them have been sunk to show that ground water can be obtained in the lower part of the valley of Rio Yaque. The porous beds in the underlying rocks form a large reservoir for the storage of ground water. The drainage from the well-watered region about Santiago and from the Cordillera Central furnishes an ample supply of water to fill this reservoir. Wells sunk almost anywhere in the lower part of the Yaque Valley would probably strike water, and a permanent supply might be obtained by pumping wells that penetrate the permanent water table. The quantity of water obtainable would be ample for domestic use and it might be sufficient for irrigation.

Definite statements concerning the mineral content of the water from such wells are unwarranted. The water obtained in shallow wells that have been dug is at first invariably salty, but several of the older wells now yield potable water. Most of these wells have been sunk in the alluvium, but several were dug in Miocene rocks. Evidently salt is present a short distance below the surface in both the alluvium and in the older rocks. In some places the salt appears in salt flats on the surface. The presence of potable water in some of the old wells shows that the salt in the soil or in the rocks near these walls is rapidly removed. If modern pumping methods were applied the salt might be removed even more rapidly and effectively. As many of the Miocene rocks are calcareous the water in some of the deep wells may be too hard for use in the laundry. Water obtained from the crystalline rocks near Dajabon would have a much lower mineral content.

POSSIBILITY OF OBTAINING ARTESIAN WATER.

The well-watered region of the middle part of the Yaque Valley and the part of the Cordillera Central that bounds the area on the south would evidently furnish an adequate supply of ground water, and as these areas are considerably higher than the lower Yaque Valley the water would be under adequate pressure, yet the information obtained does not warrant definite conclusions as to the possibility of obtaining artesian water in the valley. As older Miocene rocks dip from the south northward under younger rocks in the upper and middle parts of the Yaque Valley and pass below the rocks exposed around Monte Cristi, and as the valley floor slopes toward the mouth of the river, underground water from the middle parts of the valley might drain into the Miocene beds that underlie its lower parts. However, as the Miocene strata of the lower valley are faulted against the foothills of the Cordillera Central, the quantity of water that enters the Miocene strata may not be so great as might enter if the strata were upturned along the mountain front.

obtained at less depth. For such a test a pipe 15-centimeters in diameter will be sufficient, and a strainer will be necessary if the water-bearing beds are composed of fine sand. An accurate record of the strata penetrated and of the quantity and quality of water encountered at each water-bearing stratum should be kept in order to obtain data for drilling other wells. Samples of the water from each water-bearing stratum should be collected in clean bottles that are stoppered with unused corks. Samples of the rocks that are penetrated should also be collected. A well of this size, though large enough to furnish a test, will not be large enough to supply water for irrigation. If the results of the test well are satisfactory a well with a 30-centimeter casing should be drilled on high ground in the vicinity of the test well.

Although it is possible that a well 100 meters deep may obtain an artesian flow, an adequate test for artesian water will require a much deeper well, for failure to get water under pressure in a well at such a depth will not prove that artesian flows can not be found in this region. To make an adequate test for artesian water a well should be drilled to a depth of 500 to 700 meters unless a satisfactory supply is found at less depth or unless the stratified rocks are passed through and hard crystalline or metamorphic rocks are penetrated. A site farther upstream than the experimental farm—one near Guayubin, for example—would be more favorable for an artesian test well. Favorable artesian structure in this neighborhood is suggested by the fact that the Miocene sedimentary strata in the hills south of Guayubin dip gently northward, toward the valley. The ground water near Guayubin is nearer its source and is therefore probably less mineralized than that farther downstream. If favorable results are obtained from a test well sunk at this locality other deep test wells, both up and downstream, would be warranted. No single well will furnish conclusive proof as to the ground water conditions throughout the region around Monte Cristi, but one well properly drilled and tested will add to the knowledge of the ground water conditions and will furnish data that will afford more intelligent direction to further prospecting.

CHAPTER VIII.

GEOLOGY OF THE PROVINCE OF SAMANÁ.

By Clyde P. Ross.

The conclusions here recorded concerning the geology of the Province of Samaná are based on observations made by the writer during a two weeks' reconnaissance between Sánchez and Santa Bárbara de Samaná, on the north shore, and during a trip by motor boat along the south coast of Samaná Bay, as well as on observations made by Wythe Cooke at the west end of Samaná Peninsula and on observations made by T. W. Vaughan, D. D. Condit, Wythe Cooke, and the writer during a day spent at Sánchez while en route to Santo Domingo City.

TOPOGRAPHY.

SAMANÁ PENINSULA.

Relatively low, rugged mountains cover almost the entire area of Samaná Peninsula. The mountains at the west end of the peninsula are seperated from the Cordillera Septentrional by a flat, swampy area called El Gran Estero, which was in relatively recent time beneath the sea, when Samaná Peninsula was an island. Recent species of corals and oysters were found in the soil along the road between Sánchez and Matanzas, at the west end of the mountains, at an altitude of less than 15 meters above sea level. As the peninsula is shown as an island on some of the earlier maps the sea probably continued to occupy this area even within early historic time.

The mountains of the peninsula consist of three parallel ranges. The southernmost range has a maximum altitude of about 300 meters above sea level, but the central range rises to at least 480 meters. The central range is drained northward. All the streams that enter Samaná Bay drain only the southernmost range and the narrow coastal plain. In the area between Sánchez and Los Cocos the streams originate in springs at the base of the southernmost range.

The east end of the peninsula is a more or less flat limestone plateau, which rises to an altitude of probably 100 meters above the sea and merges westward into the mountains. The streams on this plateau disappear in sink holes and flow underground to the sea, where some of them are said to emerge as springs along the beach.

A narrow strip of low, rolling country, which probably includes the dissected remnants of a series of sea terraces, fringes the mountains along the south coast of the peninsula between Sánchez and Los Cocos. (See Pl. III, *C*.) The highest parts of this rolling terrane stand about 30 meters above sea level. The altitude at Sânchez is 15 to 20 meters; immediately east of Sânchez it is 10 to 15 meters. The change from the subdued topography of the rolling terrane to the rugged topography of the mountains is extremely abrupt. The mouths of all the smaller streams in this area are blocked by sand bars.

Between Los Cocos and Samanâ the mountains descend directly to the sea. (See Pl. III, *B*.) Hills 150 and 180 meters in altitude rise almost sheer from the water. At Samanâ a narrow valley interrupts the mountains and off the coast there are several small rocky islands. East of Samanâ the hills again reach the coast.

SOUTH SHORE OF SAMANÁ BAY.

During a trip by motor boat along the south shore of Samanâ Bay landings were made at a cove a short distance west of Punta de Boca del Infierno, at Sabana de la Mar, and at Las Cañitas. The outline of the shore is shown on the United States Hydrographic Office chart No. 917.

West of Sabana de la Mar the hills rise abruptly from the water and a number of small islands lie off the coast. On both the mainland and the islands sea cliffs that rise 3 to 12 meters above the water have been cut in the limestone. Sea caves and horizontal channels, some of which are 3 meters above high tide, lead back from the cliffs. The skyline along this part of the coast is remarkably even. As viewed from the bay the hills seem to form a plateau which has an altitude of about 180 meters above sea level. Near Sabana de la Mar the hills probably reach an altitude of 200 meters above sea level.

East of Sabana de la Mar the topography is decidedly different. The hills are higher, are distinctly serrate, and apparently form several ranges. Except at a few places, the hills descend directly to the shore, but much less steeply than those to the west.

GEOLOGY.

The following geologic subdivisions were recognized along the north shore of Samanâ Bay.

Recent deposits.
Pleistocene or Recent terraces and coral reefs.
Miocene or Pliocene clay, sand and conglomerate.
Oligocene or Miocene limestone.
Early Tertiary limestone conglomerate.
Basal complex.

BASAL COMPLEX.

The rocks of the basal complex form the mountains of Samanâ Peninsula and are therefore widely distributed. Metamorphic rocks were found in place and pebbles of pegmatites, felsites, and other igneous rocks in younger conglomerates indicate that such rocks are probably intruded into the metamorphic rocks. Micaceous schist and schistose limestone are exposed

line of some parts of the mountains suggests the presence of undisturbed sedimentary rocks that are younger than the rocks of the basal complex.

The flat-topped hills west of Sabana de la Mar, south of the western part of the bay, are principally or entirely underlain by massive pink to white limestone, which is apparently almost horizontal. Although the limestone is fossiliferous no determinable fossils were found in it during the reconnaissance. As has already been suggested (p. 64), this limestone may be an eastward extension of the limestone that overlies the Cevicos limestone, but additional studies are needed to determine the geologic age and relations of these limestones.

MIOCENE OR PLIOCENE CLAY, SAND, AND CONGLOMERATE.

Barely consolidated sands and clays underlie the low, rolling country that borders the mountains between Sánchez and Rancho Español. Some of the clays contain so much organic matter that they resemble lignite. A bed of lignitic clay 2.5 meters thick was examined near Punta de Santa Paula. A bed 35 centimeters thick, which contains a higher percentage of organic matter, is exposed near the warehouse at Sánchez. None of the beds of lignitic clay examined, however, have any value as fuel. The sands, which are interbedded with the clays, are for the most part fine-grained but locally contain pebbles.

Although these beds are only slightly disturbed they are folded and faulted at some places, where the dips may be as steep as 45°. Many small folds and a few normal faults of slight displacement are exposed along the shore between Sánchez and Punta de Santa Paula. The beds strike generally N. 50°–60° W. and except in the disturbed areas dip gently toward the southwest. The terrace flats described on page 181 bevel the deformed strata of this formation.

The fossil coastal plants and brackish water mollusks that were collected from clays of this deposit near Sánchez (see lists on p. 165, stations 8607, 8764, 8684, and 8685) are probably of Miocene or Pliocene age.

The heavy coarse conglomerate that forms the islands and much of the steep parts of the shore near Samaná is probably of the same age. The pebbles composing this conglomerate comprise metamorphosed limestone, limestone conglomerate, and different kinds of igneous rocks, embedded in a soft calcareous matrix.

The marly coralliferous limestone in the vicinity of Los Rosales and Rancho Español and the oyster-bearing limestone bed near Punta Gorda may also be of the same age.

PLEISTOCENE OR RECENT TERRACES AND CORAL REEFS.

The presence of terrace flats whose surfaces bevel the plant-bearing clays and sands at and near Sánchez has already been mentioned (p. 184). The terraces are probably of Pleistocene age.

Impure coral limestone, which lies nearly or quite horizontal, is exposed along the entire north shore of Samanâ Bay at altitudes of less than 3 to 6 meters above sea level. The limestone closely resembles modern coral reef limestone and probably represents reefs that have recently emerged from the sea. Punta de los Corozos, Cabeza de Toros, Punta de Santa Paula, Punta Gorda, and almost all the other points along the coast between Punta de los Corozos and Sânchez are composed largely of this limestone.

RECENT DEPOSITS.

Rio Yuna is bringing a large volume of sediment to the head of Samanâ Bay and depositing it there while coral débris and beach sands are being deposited along the coast. The deposits in the streams are boulders, cobbles, and gravel, which the water has not sufficient power to carry beyond the steeper slopes.

The deposits of finer sediments are mostly in the western part of Samanâ Bay, so that the water of the bay elsewhere is mostly clean and affords conditions suitable for the growth of corals, especially those that thrive best in rather quiet but pure water. Off the mouth of the harbor at Santa Bârbara de Samanâ fine colonies of the staghorn coral and the closely related palmate coral (*Acropora muricata* and *A. palmata*) were seen. The general conditions under which the coral patches and the coral reefs in Samanâ Bay are living accord with what is known regarding similar coral formations in other parts of the West Indies, indicating that the bay is due to submergence in geologically very late if not Recent time.

ECONOMIC GEOLOGY.

The country bordering Samanâ Bay was examined with special reference to water supply and material for highway construction or other engineering enterprises. Analyses of waters are given on pages 249-254, and the results of tests of rock and clay-sand are given on pages 247-248.

CHAPTER IX.

GEOLOGY OF THE PROVINCES OF BARAHONA AND AZUA.

By D. Dale Condit and Clyde P. Ross.

AREA EXAMINED.

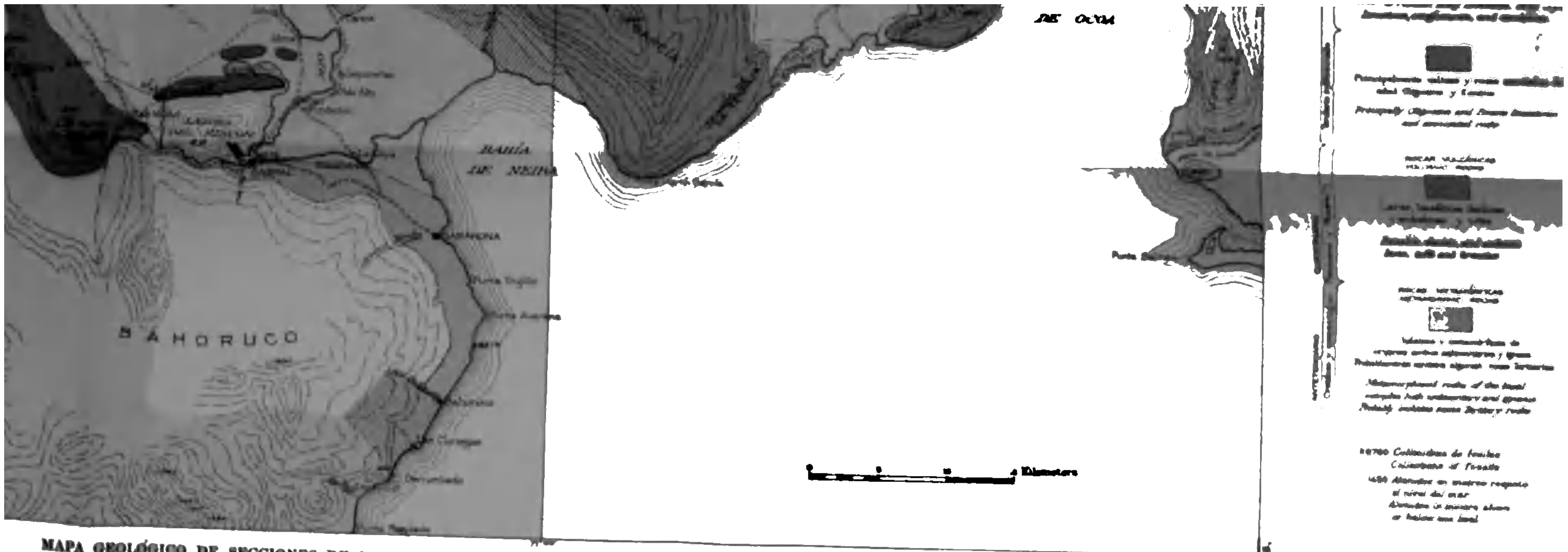
A brief reconnaissance was made late in May and early in June, 1919, in the Provinces of Barahona and Azua (see Pl. XV), which were then geologically unknown, for the purpose of outlining the geology and of determining whether the mineral resources offer sufficient promise to warrant a more detailed investigation. Seepages of oil, beds of rock salt, and indications of metalliferous deposits of various kinds have been known in these provinces for many years, but aside from drilling for oil near Azua and the quarrying of rock salt in Enriquillo Basin practically no systematic search has been made in them for mineral deposits. Both provinces are remote from the ordinary lines of travel and are so inaccessible that most of their natural resources have been unexplored.

The reconnaissance included a journey from Bânica, near the Haitian border, eastward through Las Matas and San Juan to Rio Yaque del Sur. A rough traverse of this river was made from the vicinity of Túbano to Cabral and side trips were made to points of interest along the route. One day was spent in the vicinity of Neiba, on the north shore of Lake Enriquillo, and about a week was spent on the south side of the Enriquillo Basin, between Cabral and Duvergé. A short trip was made southward from Barahona and several trips were made in different directions from Azua. Most of the work in the vicinity of Azua was done by Wythe Cooke, who also furnished notes on the region from Constanza southward through Túbano to Azua, and on the country east of Azua. All other parts of the area were covered by the authors.

We are indebted to officials of the Barahona Company for an excellent map of the lower part of Rio Yaque del Sur and the neighboring country to the west and for material assistance in other ways during the course of the work. Our thanks are due also to Captain Hoenes of the Guardia Nacional, who assisted us in many ways, and to Mr. Richard D. Upham of the Interocean Oil Co., who placed at our disposal maps and geologic reports on the Azua district.

GEOGRAPHY.

The Provinces of Barahona and Azua are in the southwestern part of the Dominican Republic, along the Haitian frontier. (See Pl. I.) The position of the international boundary line is so uncertain that the exact areas of the provinces are unknown, but they comprise about one-third of the entire Republic, the total area of which is roughly 28,872 square kilometers. In longitude they range from about 70° 30′ to 71° 50′ W., and in latitude from 17° 30′ to 19° 15′ N.



MAPA GEOLÓGICO DE SECCIONES DE LAS PROVINCIAS DE AZUA Y DE BARAHONA

GEOLOGIC MAP OF PARTS OF THE PROVINCES OF AZUA AND BARAHONA

are too salty to support plant growth for a distance of several kilometers from the lake but which gradually merge into dense thickets of mesquite and cacti.

As the rainfall in all parts of the basin is more than 50 centimeters a year the somewhat desolate aspect of the region is due not to deficient rainfall alone but rather to the fact that most of the rain falls in torrents in one short rainy season and is thus of minimum benefit. Most of the bare lowlands are "saladas" caused by conditions other than scant rainfall.

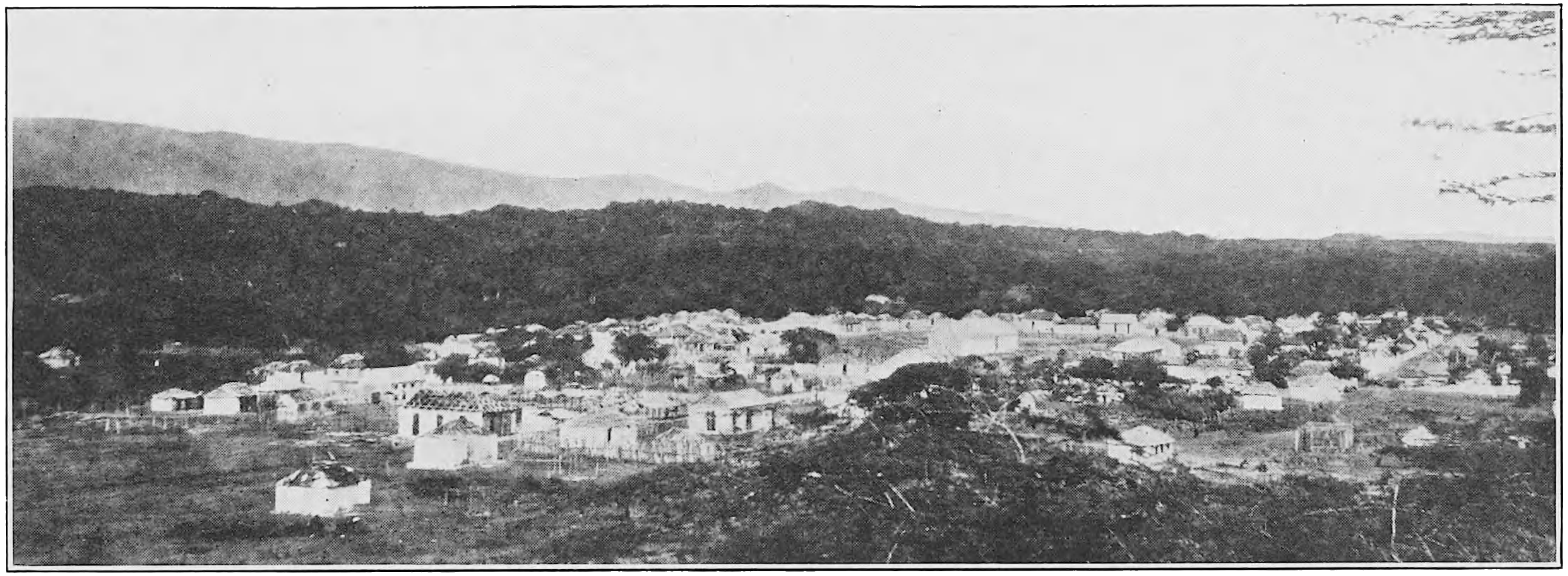
It is said that the ground-water level throughout the lowlands is within a meter or two of the surface and that the water is in most places more or less saline. The irrigation of such land will certainly raise the water table and where the ground water is saline it will render the land unfit for cultivation, but such loss may be temporary, for prolonged flooding may flush the salt water out of the ground. The success of this process will be aided by digging deep drainage ditches at rather short distances apart to carry the salt water toward Lake Enriquillo. By such means an area much larger than that included in the present project of the Barahona Company might ultimately be reclaimed. The great fertility of the soil and its prospective value for raising sugar-cane and long staple cotton seem to warrant the expenditure of a large sum of money on the project. The methods used should be similar to those employed by the United States Reclamation Service in certain parts of Arizona.

PROVINCE OF AZUA.

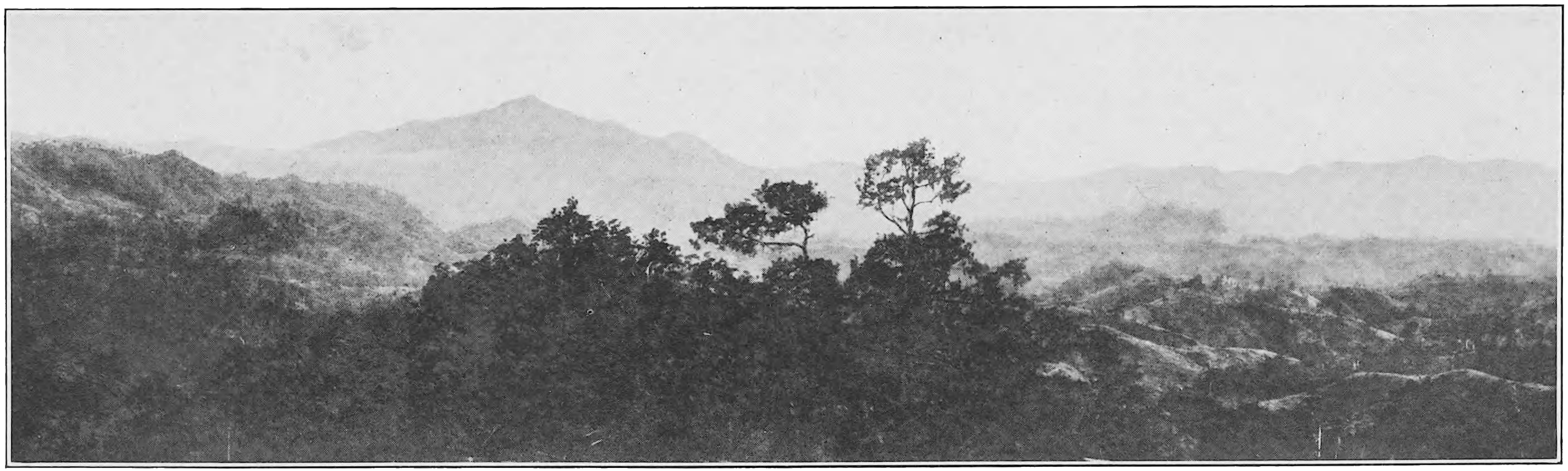
The Province of Azua is somewhat more mountainous than the Province of Barahona, especially in its northern part, which includes many high peaks of the Cordillera Central. The most prominent peaks are Lomas Tina, Rucillo, and Gallo, probably the highest in the islands. It is said that Loma Tina stands 3,100 meters above sea level, but it is doubtful whether the peak has ever been accurately measured or even ascended.

Spurs extend southward from the principal mountains to the great central valley of San Juan, which, like Enriquillo Valley, to the south, trends a little north of west, reaching westward into the Republic of Haiti. The Neiba Mountains, which lie south of the San Juan Valley, are 1,000 to 1,500 meters high and differ from the jagged Cordillera Central in that they consist largely of limestone and other sedimentary rocks that form hogback ridges of fairly even profile. (See Pl. XVI.)

The central valley of San Juan ranges in width from 15 to 20 kilometers and the part of it that lies within the Dominican Republic extends from east to west for about 80 kilometers. Within the valley are low hills and rolling country as well as large tracts of nearly level savannas. The most extensive savannas are near the town of San Juan and consist of flat, treeless stretches that lie only a few meters above the level of the river and slope gently southward.



A. LAS MATAS DE FARFAN AND SIERRA DE NEIBA AS SEEN FROM THE EAST.



B. VIEW IN THE CORDILLERA CENTRAL SOUTHWESTWARD FROM A POINT ON THE BÁNICA-RESTAURACIÓN TRAIL NEAR LA CRUZ.

Much of the gently rolling plain that stretches eastward from Rio Yaque to Azua is a waterless wilderness. Rio Tâbara drains the country that extends southward from Las Yayas almost to Puerto Viejo. It is nearly 50 kilometers long, but as a large part of the country it crosses has a somewhat scanty rainfall the stream is ephemeral except in its upper part, where there is probably some flow at all seasons.

Rio Jura is a similar stream somewhat shorter than the Tâbara. It drains the country just east of that served by Rio Tâbara. When seen in June, 1919, near Azua it contained a small quantity of water and may not completely dry up at any season.

The eastern part of the Province of Azua is drained by Rio Ocoa and its tributaries and by the headwaters of Rio Nizao. Rio Ocoa is about 65 kilometers long. It flows in a rock gorge above Arenoso, but below Arenoso it widens and flows in braided channels in a gravel bed. Rio Nizao is 80 kilometers long, about 35 kilometers of which are in the Province of Azua. Throughout its course it is a swift stream and flows over many rapids.

A number of short streams flow into Lake Enriquillo from both the north and the south. Rio de las Damas, which passes through Duvergé, was the only one examined during this investigation except the very short streams fed by springs near the lake. Rio de las Damas is about 15 kilometers long. It is about 8 to 10 meters wide and nearly 2 meters deep at Puerto Escondido, and only about 3 meters wide and 1 meter deep above Duvergé. Part of the loss between these places is caused by irrigation in Escondido Valley, but part is probably due to seepage into the cavernous limestone which here forms the country rock. On this stream between Puerto Escondido and Duvergé there are said to be two waterfalls that may furnish water power.

Several fair-sized streams about 30 kilometers in length flow into the sea along the coast south of Barahona, among them Rio Bahoruco, Rio de los Patos, and Rio Cito.

LAKES.

Lake Enriquillo is by far the largest inland body of water in the island. As already stated, it occupies a depression which in Pleistocene time was probably an arm of the sea and which was probably separated from it by delta deposits of Rio Yaque together with a regional elevation of about 35 meters. Although the lake receives more or less water from Rio Yaque in times of flood and a considerable volume from springs and streams, it appears to be progressively shrinking through evaporation. Its surface now stands about 44 meters below sea level. The map of Enriquillo Basin made by James W. Wells[1] in 1893 gives the altitude of Lake Enriquillo

[1] Wells, J. W., A survey journey in Santo Domingo; West Indies: Roy. Geographic Soc. Supplementary Papers, vol. 3, 1893.

at that time as 2 feet (61 centimeters) above sea level. Although his estimates of altitude were made with a barometer and are therefore only approximately accurate it would seem that there has been very considerable evaporation since his map was prepared. According to Tippenhauer[1] the surface of the water was 34 meters below sea level in 1900.

The water is nearly 50 per cent more saline than sea water. The accompanying analyses show that its composition is in general similar but that the ratio between calcium and magnesium is reversed. Although Lake Enriquillo was undoubtedly at one time an arm of the sea its water has since then been considerably concentrated by evaporation, which is high in this region, for it has no outlet. The drainage from the surrounding limestone mountains has caused an increase in the percentage of calcium.

Mineral analysis and classification of water from Lake Enriquillo near Barbacoa, Province of Barahona.

[Sample collected by C. P. Ross, May 29, 1919. Analyst, Addie T. Geiger.]

	Milligrams per liter.
Calcium (Ca)	1,649
Magnesium (Mg)	378
Sodium (Na)	15,973
Potassium (K)	[a] 503
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	512
Sulphate radicle (SO_4)	3,833
Chloride radicle (Cl)	25,547
Foaming constituents (computed)	44,000
Alkali coefficient (inches) (computed)	.1
Organic matter	270
Total dissolved solids at 180° C.	48,902

[a] Equivalent to 0.0006 per cent potash (K_2O) in liquid brine or 1.23 per cent K_2O in total solids.

Comparison of the composition of ocean water with that of Lake Enriquillo.

[Percentage of dissolved solids.]

	Lake Enriquillo.[a]	Average ocean water.[b]
Cl	52.2	55.29
Na	32.7	30.59
SO	7.8	7.79
Ca_4	3.3	1.20
CO_3	1.0	0.21
K	1.0	1.11
Mg	0.8	3.73
Br		0.20
Total	98.8	100.00
Salinity	4.8902	3.301-3 800

[a] Analysis made in water resources laboratory of U. S. Geol. Survey.
[b] Clarke, F. W., Data of geochemistry: U. S. Geol. Survey Bull. 616, p. 123, 1916.

[1] Tippenhauer, L. G., Beiträge zur Geologie Haïtis, V: Petermann's Mitteilungen, Band 47, VII, p. 169, 1901.

Lake Rincón is a much smaller lake near the east end of Enriquillo Basin. It differs from Lake Enriquillo in being only slightly brackish and in lying nearly 5 meters above sea level. A channel at Cabral connects it with Rio Yaque, through which the river water flows in times of flood. The lake abounds in fish, affording a means of livelihood for the people of neighboring villages. Lake Enriquillo, on the other hand, is reported to contain no fish at all. Alligators are reported to live in both lakes, and flamingoes and cranes of several species may be seen in large flocks along the low, muddy shores.

Lake Limón, which lies south of and only a few kilometers away from Lake Enriquillo, is reported to contain fresh water. It is separated from Enriquillo Basin by hills and occupies an independent depression that has no outlet.

Laguna de las Marias, shown on the map by Wells mentioned above and on the de Moya map, is reported to be no longer in existence. Wells[1] describes it as a lagoon thickly studded with palm groves near a short range of bare hills called Sierra de los Remedios. The altitude of the lake shown on his map is 160 feet (49 meters) above sea level. This may be too high, as the altitudes given on this part of his map do not appear quite consistent. The map shows the area of overflow of Lake Enriquillo during the rainy season. An altitude of 32 feet (9.7 meters) is given at a point in this area near its eastern edge. If this is correct there was a rise of over 9 meters in the level of the lake during the rainy season, which is considerably more than seems probable.

SPRINGS.

In the area covered by this report springs are rather numerous and many of them are large. In some areas, notably in Enriquillo Basin, they are used for irrigation. A few, such as those at El Puerto, near Las Matas de Farfan, are reputed to have medicinal value, principally for the cure of skin diseases and rheumatism.

Sulphur springs are known at El Puerto, which is on Rio Macasía near Las Matas, as well as at several places along Rio Yaque between Villarpando and Boca Mula and near the head of Arroyo Quita Coraza, where there is a spring known as Agua Montilla. There are springs at many places on both sides of Enriquillo Basin. Many of them emit a strong odor of hydrogen sulphide, which is probably a constituent of the water in all these springs. Other sulphur springs are reported in many parts of the area.

There are springs that discharge strongly saline water in Arroyo Quita Coraza near the settlement of that name and there are others on the sea coast about 4 kilometers south of Barahona. Salt springs are also reported at Guanarate, at Fondo Negro, near Azua, between Barahona and Cabral, and at other localities.

[1] Wells, J. W., op. cit., p. 603.

Classification.	Parts per million.
Character	$CaCO_3$
Quality for domestic use	Fair[a]
Quality for boiler use	Poor.
Quality for irrigation	Good.
Mineral content	Modeiate.

[a] Satisfactory for drinking.

Partial mineral analysis and classification of spring water from Arroyo Quita Corazo, Province of Azua.

[Samples collected by C. P. Ross, May 27, 1919; analyzed by Addie T. Geiger.]

Constituents.	Parts per million.
Calcium (Ca)	820
Sodium (Na)	2149
Potassium (K)	12
Chloride radicle (Cl)	4786
Organic matter	4.0
Total dissolved solids at 180° C.	8234
Classification.[a]	
Chemical character	NaCl
Quality for domestic use	Unfit.[b]
Quality for boiler use	Unfit.
Mineral content	Very high.

[a] Based upon relatively few determinations but sufficient to establish the classification.
[b] Unfit for drinking except possibly in small quantities by the passing traveller.

Mineral analysis and classification of spring water from 5 kilometers south of Barahona, Province of Barahona.

[Samples collected by C. P. Ross, June 5, 1919; analyzed by Addie T. Geiger.]

Constituents.	Parts per million.
Calcium (Ca)	180
Sodium (Na)	1951
Potassium (K)[a]	75
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	349
Chloride radicle (Cl)	3484
Organic matter	86
Total dissolved solids	6594
Classification.[b]	
Character	NaCl
Quality for domestic use	Unfit.
Quality for boiler use	Unfit.
Quality for irrigation	Bad.
Mineral content	Very high.

[a] Equivalent to 0.00009 per cent potash (K_2O) in liquid brine or 1.36 per cent K_2O in total solids.
[b] Based upon relatively few determinations but sufficient in number to establish classification.

TOWNS AND VILLAGES.

No reliable figures to show the population of the Provinces of Barahona and Azua are available. Most of the people live in towns and villages along the principal rivers or near springs, much of the interior being without a water supply and therefore uninhabited. Many of the place names on the map are applied to agricultural communities spread over several square kilometers of fertile land in river bottoms or near springs that are used for irrigation. Some contain no more than two or three huts; others are villages of several hundred households. Some of the best farming land is on mountain slopes where the rainfall is generally sufficient for cultivation without irrigation.

Azua, the center of a large sugar industry, is the principal town in the region and by far the most progressive. It has a population of about 3,000 people and is surrounded by thickly settled country. The town is built on a broad plain that extends from Loma El Número on the east to the Yaque watershed on the west. Azua itself stands about 80 meters above sea level and a little more than 5 kilometers from the coast. About 15 kilometers southwest of Azua is Puerto Viejo, near which are the ruins of the old town of Azua, which is said to have been destroyed by an earthquake about 200 years ago. South of Azua are the Azuano and Ansonia sugar estates, which are connected with the port, to the east, by narrow-gage railroads.

San Juan, a town of about 2,000 inhabitants, is in the central part of the fertile San Juan Valley, about 75 kilometers northwest of Azua. Beans, rice, tobacco, and other products of the country are marketed here in exchange for goods from the outside world. Las Matas and Comendador, smaller towns that stand farther west, are also in the great San Juan Valley, which will be highly productive when communication with the coast is facilitated by good roads.

Barahona, the capital of the Province of that name, is little more than a village. It is on the west side of Neiba Bay. A wharf is accessible to small ocean-going steamships, but the only boats that call regularly are sailing craft, which carry away large quantities of coffee as well as lignum vitae, mahogany, and other hard woods. Extensive improvements will be necessary to make the port fit for use by large steamships.

Along Rio Yaque north of Barahona there is a large agricultural population. Cabral, Peñón, Hatico, and Alpargatal are the principal villages. The people, by irrigation in a primitive manner, have brought under cultivation much of the valley bottom. In this same region is the site of the large irrigation project of the Barahona Company, which plans to establish one of the largest sugar plantations in the world.

The basin that includes Lake Enriquillo, although semi-arid and of saline soil, is bordered by mountains along whose bases emerge large springs that are used for irrigation and that form the centers of a number of agricultural communities. The principal villages are Neiba, which has 600 or 700 inhabitants, and Duvergé, which has nearly 1,500. There are also other villages that contain several hundred people. Several villages are scattered through the valleys of Sierra Bahoruco. Puerto Escondido, for example, is a prosperous farming community of over 500 people.

Practically all the people lead an exceedingly primitive life. Their labor is almost entirely agricultural and is carried on intermittently in a haphazard manner. They have little idea of modern implements or their use, but they are intelligent and readily learn where attempts are made to teach them. The assurance of a stable government has been a great stimulus to increased effort, as is shown in the enlargement of areas under cultivation and the increase in cattle raising. Under the old state of affairs there was little encouragement to industry, for the farmer was at the mercy of roving bandits and revolutionists.

Although showing the effects of intermingling with the black people across the Haitian border, the features of a large percentage of the population of the Provinces of Azua and Barahona suggest Indian ancestry with a mixture of Spanish. Some of the influential people of the larger towns are of direct Spanish origin.

These border provinces have borne a reputation of lawlessness and unfriendliness to strangers that made travel difficult if not dangerous, yet our party had no experience whatever that would indicate unfriendliness and was invariably treated courteously and nearly everywhere hospitably.

ROUTES OF TRAVEL.

The total length of regularly constructed highways in the two districts is about 30 kilometers, all of which are near Azua. An excellent gravel road leads northwestward from Azua for 22 kilometers. At a distance of 15 kilometers the road to San Juan branches to the left from this road. In dry weather, when Rio Yaque is low, light automobiles are used for travel from Azua to San Juan, a distance of about 75 kilometers, and also to Las Matas, about 12 kilometers farther. They also traverse the road from Azua eastward to the capital city when conditions are favorable, but during the rainy months this road can be traveled only with difficulty even by saddle horses.

Wheeled vehicles can go from Barahona north to Cabral, thence west through Las Salinas to Neiba and Barbacoa, on the north shore of Lake Enriquillo, and to Duvergé, on the south shore. The distance from Barahona to Neiba is about 55 kilometers and that to Duvergé a little less. From Cabral a cart route has also been cleared northward to the vicinity of Jobo and thence westward. In Barahona cars can be hired to travel all these roads in dry weather. Although the natural conditions favor the easy construction of excellent highways, few of those now existing are worthy of the name, being merely trails littered with rocks and bristling with stumps.

Travelers go by land from Barahona to Azua by saddle, generally up Rio Yaque to Quita Coraza, thence northeastward up an arroyo and across a low divide to the Azua-San Juan road at a point about 10 kilometers

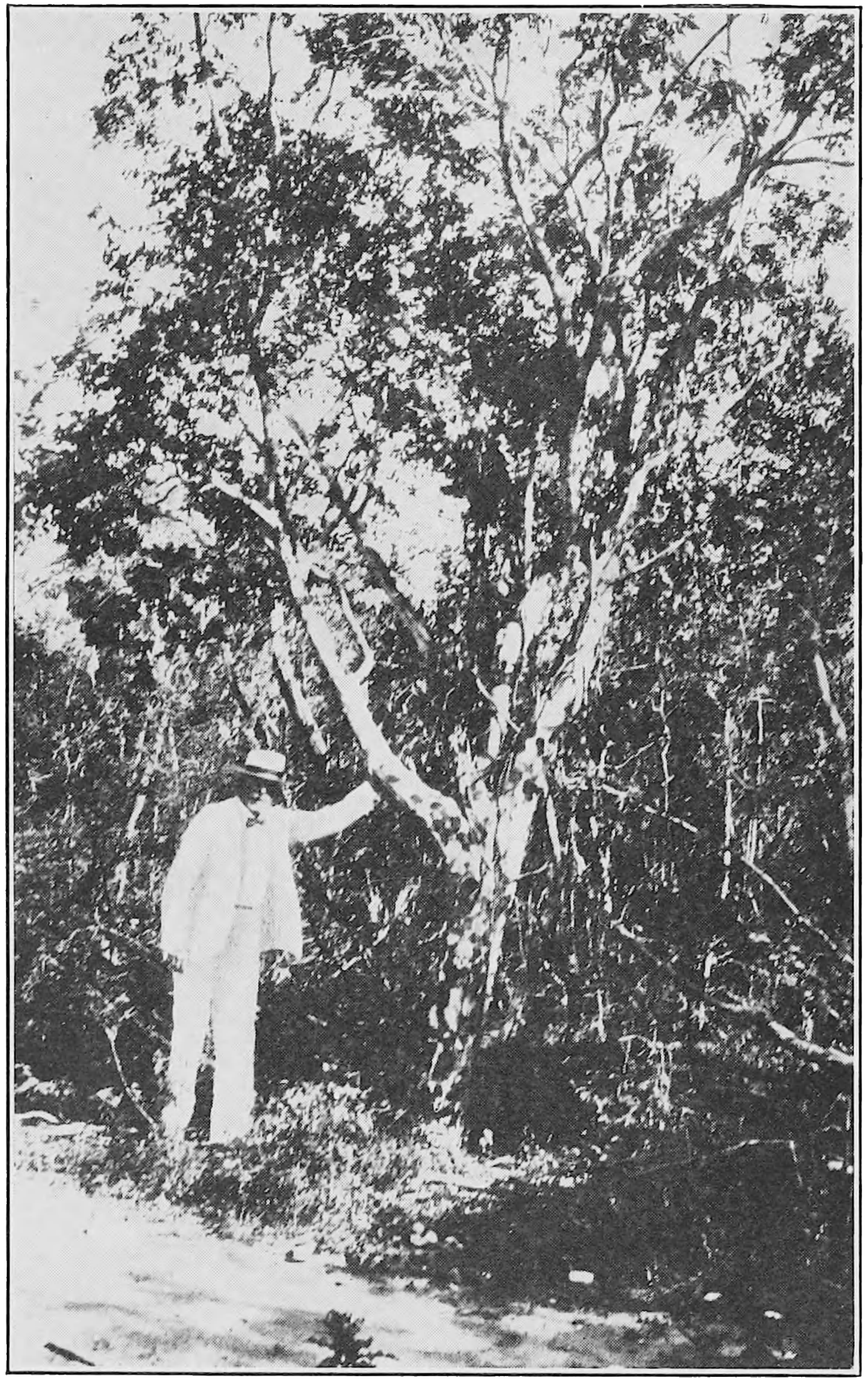
ranker growth of forest. The change is noticeable in an ascent of only a few hundred meters. Different exposures of the same mountain may not be similarly favored, however, for the clouds generally come from the northeast and lose much of their moisture on the northeastern slopes.

The vegetation of the coastal plain and low hills of the interior in the more arid part of the two provinces consists largely of a variety of mesquite (cambrón) and of logwood, together with lignum vitae (guayacân). (See Pl. XVII, *A*.) The cacti include large, branching trees of the Cereus type (cayuca) and the prickly pear type (taina); and a low, branching exceedingly troublesome cactus (guazabara) covers most of the ground and protects the scattered clumps of grass from hungry cattle. In the moist river bottoms there are many other trees, some of which grow very large, especially the ceiba. There are also the amacigo, mora, and other trees that are more or less valuable for export. Mahogany (caoba) is one of the most common woods and is used for lumber and fire wood. It generally grows in limy soil in the hills. Many of the higher mountains are timbered with pine, generally of telegraph pole size but here and there 60 to 80 centimeters in diameter. It makes an inferior lumber, rich in in resin and so heavy that it hardly floats. When placed in the river for rafting, the logs are said to absorb water and to sink after a short time.

PRODUCTS.

Coffee of excellent grade is grown in considerable quantity in the uplands near Barahona. The rice grown on the mountain slopes is nearly sufficient to supply the needs of the two provinces. Tobacco is a standard crop and is shipped in large quantities. Beans are grown in the mountain valleys north of Lake Enriquillo and as much as 1,000,000 pounds is said to have been marketed from that district alone in one year. Bananas, plantains, yams, and yuca, the food of the poor people, are plentiful in every community. The settled political conditions of the last few years have encouraged cattle raising. The Province of Azua is famous throughout the Republic for its excellent mules, and though these are small as compared with those raised in the United States, few of them being much over 14 hands high, they are as hardy and on the whole better tempered. There is no wild game, the largest animal native to the island being no larger than the woodchuck of the United States. Pigs and goats abound in every settlement, and wild pigs that have escaped from domestic stock roam in the mountains.

Many of the people are engaged in getting out mahogany, lignum-vitae, mora, dye woods, and other valuable timber for exportation, but their efforts are confined largely to small timber of inferior grade, for there are almost no roads over which the lumber can be carried to the sea for shipment.



A. YOUNG LIGNUM VITAE TREE (GUAYACÁN) ALONG ROAD NEAR RIO OCOA.
One of the most valuable woods in the region.

B. TYPICAL EXPOSURE OF REEF CORALS FORMING A BENCH ON THE SOUTH SIDE OF LAKE ENRIQUILLO NEARLY 1 KILOMETER WEST OF LAS BAITOAS.

Province of Barahona, as follows: Station 8626, limestone pebbles near Rancho Viejo; station 8627, foraminiferal limestone, Sierra de Bahoruco, west slope of Cañada de Rancho Viejo; station 8576, foraminiferal limestone from near sea beach, south side of Rio Cana, about 9 kilometers south of Barahona; station 8595, rubble on mountain slope 2.5 kilometers north of Barbacoa. The fossils obtained at these localities are listed on page 106. Sediments of probably Eocene age were seen at other places.

The mountain ridges of dense gray limestone in the southwestern part of the Dominican Republic are at least in large part composed of rocks of Eocene age. In the Republic of Haiti similar rock containing Eocene fossils forms the limestone mountains. Vaughan collected specimens of limestone containing Eocene Foraminifera at Cape Haitien and around Plaisance. The mountains around Ennery, between Ennery and Gonaïves and between Gonaïves and the Cul-de-Sac are composed largely of Eocene limestone, according to Vaughan.[2] W. F. Jones estimates that the limestones near Port-au-Prince attain a thickness of at least 8,000 feet, but he did not distinguish between Eocene and Oligocene deposits.[3]

Oligocene.

Oligocene fossils were found at five localities in the Province of Azua, as follows: Station 8617, Las Cuevas, Rio San Juan, north of San Juan; station 8618, limestone hill at Majagual, Rio San Juan, north of San Juan; station 8565, Rio San Juan, about 1.8 kilometers west of Los Bancos, upper part of exposure; station 8619, Rio Yaque del Sur, near Los Bancos; station 8567, limestone, right bank of Rio de las Cuevas, about 1.9 kilometers west of Túbano. For lists of fossils from these localities see page 109.

The stratigraphic relations of the Oligocene to the Eocene deposits were not definitely ascertained, but the exposures along Rio San Juan about 1.8 kilometers west of Los Bancos strongly suggest that the rocks belonging to the two series are separated by an unconformity. The strata at station 8565 are exposed in a bluff about 900 meters long on the south side of Rio San Juan; the dip is northeastward at an angle of 10° to 13°. The material consists of fossiliferous conglomeratic shale and argillaceous sandstone. The fossils comprise coral fragments, oysters, and gastropods. At a horizon about 100 meters stratigraphically lower poorly preserved plant remains were found in evenly bedded sandstone. Among these plants Prof. E. W. Berry has recognized a species of *Sophora*, a coastal member of the Leguminosae. The suggestion is that this area was land prior to the deposition of the marine Oligocene and that the Oligocene is separated by an erosion unconformity from the Eocene. Besides including conglomerate, shale, and sandstone, the Oligocene deposits are in large part composed of limestone.

[2] Unpublished information.
[3] Jones, William F., A geological reconnaissance in Haiti: Jour. Geology, vol. 26, p. 733, 1918.

For lack of time it was not practicable to map separately the Eocene and Oligocene deposits and they were therefore considered together, but in subsequent work the rocks belonging to the two series should be discriminated. The fossils most useful in the determination of the age of the early Tertiary beds are the Foraminifera, which appear to be equally abundant in the limestones, the sandy beds, and even the coarse conglomerates, but they are so inconspicuous that they may readily be overlooked.

Miocene.

YAQUE GROUP.

The rocks of Miocene age, besides occupying the greater part of the Cibao Valley, also occupy the principal structural basins in the Provinces of Azua and Barahona. The strata exposed along Rio Yaque del Sur are at least 1,500 meters thick. Sandy conglomeratic strata predominate, but there are also shales and limestones. The deposits are almost entirely marine but include local beds of lignite and fossil plants, which denote temporary emergence. These beds belong to the Yaque group as defined by Cooke. (See pp. 65-66, and for lists of fossils see pp. 156-162.)

CERROS DE SAL FORMATION.

Around the border of Enriquillo Basin there are Miocene strata which are obviously much younger than those found along the upper course of Rio Yaque. They comprise the gypsum and salt-bearing beds, the fossils of which indicate late Miocene age. To these strata the name Cerros de Sal is applied, from the locality of that name, near which rock salt is obtained. Until a more detailed study is made it will not be possible to define sharply the boundary between these beds and the underlying Miocene strata. As stated above, the lowest strata of the Miocene found along the upper course of Rio Yaque are largely sandstone. It is not known whether the Yaque group occurs in the Bahoruco Mountains. A great thickness of impure limestone, probably of Miocene age, underlies the Cerros de Sal formation, but its lithologic character is so different from that of the Yaque formation that there is considerable uncertainty as to their relations. (For lists of fossils, see pp. 163-164.)

Pliocene.

LAS MATAS FORMATION.

There is no positive evidence of the presence of Pliocene deposits in the Dominican Republic. In San Juan Valley and to the southeast, along and near Rio Yaque, the plicated Miocene and older strata are overlapped by thick deposits of loosely cemented gravels and clays which generally dip gently basinward or are folded to a much less extent than underlying strata. These beds are called the Las Matas formation, for they are typically exposed near the town of Las Matas. No fossils have been observed in these gravels, but it is surmised that they are of Pliocene age.

QUATERNARY SEDIMENTS.

"COAST LIMESTONE."

Along and near the coast in the Provinces of Barahona and Azua are locally flat-lying limestone and calcareous conglomerate called by Gabb the "Coast limestone." In the vicinity of Barahona village the rocks form terraced sea cliffs, and to the south, where the mountains lie near the sea, they consist largely of firmly cemented limestone conglomerate and reef-coral material. Somewhat similar deposits extend inland along the south border of Enriquillo Basin (Pl. XVII, *B*). (For lists of fossils see pp. 167-168.)

ALLUVIAL DEPOSITS.

South of Azua the material penetrated in drilling water wells appears to be in large part unconsolidated sand and gravel. Many deposits of such material are later than the "Coast limestone," including outwash gravels along the base of the mountains and sand and gravel along modern river channels and on terraces bordering the valleys. Part of the delta deposits of Rio Yaque and other streams and of the alluvium that forms the floor of Enriquillo Basin may be of Pleistocene age, but most of it is probably Recent.

IGNEOUS ROCKS.

As already stated, large parts of the Cordillera Central consist of crystalline igneous rocks ranging in composition from quartz diorite to granodiorite. Others consist of serpentine, probably altered basic igneous rock. The diversity of igneous rocks found in the gravel of almost any large river flowing from the Cordillera Central shows that the basal complex includes a wide variety of types. No adequate petrographic study of these rocks was made. Quartz diorite and granodiorite appear to compose the bulk of the larger batholithic masses. Nearly all the crystalline igneous rocks show evidence of dynamic metamorphism, and many have been changed to gneisses, but in few places has the metamorphism gone far enough to obscure the original character of the rock.

Besides the coarsely crystalline igneous rocks there is a thick series of volcanic rocks in the Cordillera Central, which are in part lavas and in part fragmental rocks, including tuffs and breccias. These are characteristically dark purple to green in color and vary in texture from fine-grained to coarse. They are metamorphosed, chloritized, and in part altered to serpentine. The more basic types of lavas are more common than the silicic types.

In San Juan Valley and here and there in the mountains of the two provinces there are small areas of volcanic rocks of Pliocene or more recent age. Some of these are fine-grained porphyritic lavas of andesitic composition but there are also basalts. In Sierra Bahoruco near the seacoast there are amygdaloidal basalts.

THE CORDILLERA CENTRAL.

The Cordillera Central was examined along the cross mountain trails through Restauración and Constanza, those being the only feasible routes of travel northward to the Cibao Valley. Only the parts south of Restauración and Constanza are described here. Plate XVI, *B*, shows a view in the Cordillera Central looking southwestward across the frontier of Haiti from a place on the Bánica-Restauración trail near La Cruz, in the Province of Monte Cristi.

The high mountains north of San Juan Valley are made up of a large variety of rocks, both igneous and sedimentary, consisting in part of quartz diorite and related crystalline rocks, which have intruded and more of less extensively metamorphosed older crystalline and sedimentary rocks. The foothills are faced with white, finely crystalline limestone, which appears in bold exposures that stand out conspicuously as seen from far out in the valley. Resting on and cutting the metamorphosed sedimentary beds and diorite are volcanic rocks of several kinds that for convenience are designated the "early volcanics." They include dikes, lavas, and volcanoclastics, generally of basic variety, well advanced in alteration to serpentine. There are in addition the "late volcanics," of andesitic to basaltic composition, probably of Pleistocene age. These occur here and there in the valley and also cover small areas in the mountians. They are easily distinguished from the "early volcanics" by their slight decomposition and their lack of deformation.

The great San Juan Valley is bordered on the north by a conspicuous ridge of gray crystalline fossiliferous limestone, which forms a facing for higher mountains opposite the town of San Juan, and thence extends westward to Bánica as a spur from the main mountain mass, 300 to 500 meters above the surrounding plain. The limestone is finely crystalline, is greatly seamed by veinlets of calcite, and contains indeterminable Foraminifera.

Back of the limestone ridge and possibly conformably underlying it is a thick series of beds of hard shaly sandstone and sandy shale, which extend northward for many kilometers and form high mountains near the border of the Republic of Haiti. The hardness of these beds is the result of regional metamorphism that appears to become increasingly pronounced toward the north. The bedding lines in the shale are in large part obscured by a slaty cleavage having a general northwest strike. In the exposures farthest north the beds of shale have been changed to phyllite and the few beds of limestone have been changed to marble. From the vicinity of Guayajayuco southward to the mouth of Rio Joca, Rio Guayajayuco flows through a sharp canyon cut in this rock, which is a dark phyllite intricately seamed with white veinlets that run at right angles to the schistosity. In passing this canyon the trail along the Dominican side of the river leads over a steeply sloping mountain side at an altitude of about 1,100 meters.

The age of this series of sedimentary rocks is not known, as no fossils were found in it. The rocks are similar in lithology to sandy beds seen near Bani, which are probably of Eocene age. The regional alteration may have been caused by the intrusion of the large masses of quartz diorite that cover much of the region east of Restauración.

The trail from Constanza southward descends the steep side of Loma Higüela or Chingüela, the top of which probably reaches an altitude of 1,500 meters above sea level, and follows the narrow gorge of Rio del Medio down to Arroyo el Gorbano, where it begins to ascend Loma la Fortuna, making a steady, steep climb to an altitude of about 1,000 meters above sea level, beyond which it follows the undulating crest of the mountain to Las Cañitas, a settlement scattered over the side of the mountain at an altitude of some 1,100 meters above sea level.

At Las Cañitas a splendid view can be had of the great bulk of Monte Culo de Maco, towering above the canyon of Rio del Medio. This mountain, which is said to be as high as the more famous Monte Tina, is probably one of the highest in the island. The mountain falls off steeply at its north end, but its southern or southwestern slope is even and gentle, appearing, as seen from a distance, like a dip slope. From the southwest side of Loma la Fortuna one can look out across the valleys of Rio Yaque del Sur and Rio de las Cuevas.

Beyond the ford of Rio del Medio at Limon the trail leads across Loma la Laguna (altitude about 950 meters above sea level) and descends gradually to Rio de las Cuevas, down the boulder-strewn bed of which it extends to Túbano.

The mountains between Constanza and Las Cañitas are carved out of a great massif of serpentine. Their slopes are steep but usually not precipitous, and they are easy to climb. They are clothed for the most part with an open pine forest and a thin carpet of grass. Near the foot of Loma las Cañitas, at an altitude of about 925 meters and about 8 kilometers from the village of Las Cañitas, a quartz vein that contains copper ore cuts the serpentine. The width of the vein is variable but where seen does not exceed 2 meters. Several of the common copper minerals, including chalcocite, chalcopyrite, and bornite and their oxidized products, were recognized.

About 1 kilometer beyond the outcrop of this vein and about 75 meters lower a bed of hard blue limestone abuts against the mountains of serpentine, from which it is evidently separated by a fault. This bed is probably a mass that has been separated from the main body of limestones of the older series, chiefly of Eocene age, by block faulting, but as no fossils were found in it, its age remains in doubt. Fragments of limestone breccia were found beside the trail a little farther down, and at La Madre Vieja, a spring about 1 kilometer beyond the outcrop of limestone, there were rolled boulders of conglomerate.

Massive red rock, weathering shaly and inclosing pebble-like lumps, forms the base of Loma la Laguna on its northern side, but higher there are large blocks of massive conglomerate, composed of many varieties of igneous rocks, and less abundant fragments of limestone. At the top of the mountain is massive blue limestone conglomerate containing large boulders of gray cherty limestone.

The bluff of Rio de las Cuevas where the Constanza trail meets it is composed of very coarse conglomerate with calcareous cement. It consists chiefly of boulders of igneous rocks, especially gray andesite, but it contains also travel-rounded boulders of limestone conglomerate similar to that at the top of Loma la Laguna. There are evidently conglomerates of two ages in this region and the limestone is older than either. The conglomerate at the river appears to dip 18° N., but its bedding is obscure.

RIO YAQUE VALLEY.

In its course from the high mountains to the sea Rio Yaque del Sur crosses weak Oligocene and Miocene sandstones and shales, which are exposed along the valley in cliffs on alternate sides almost continuously as far down as Alpargatal, where the river emerges from the hills and flows slowly through alluvial lands for the rest of its course. The opportunity for stratigraphic study is so excellent that a week was spent in examining the exposures from the vicinity of Túbano on Rio de las Cuevas down to Alpargatal. A rough compass traverse was carried the entire distance, and supplemental traverses were run to nearby points of interest along the route. An attempt was made to ascertain the stratigraphic sequence of the beds and to determine the possibility of their being oil-bearing under cover. As a result it is possible to give a section that is believed to be representative of at least the south-central part of the Province of Azua. At several places the river has cut close to the base of mountainous ridges of early Tertiary limestone. It crosses a spur of the Neiba Range just below the mouth of Rio San Juan, and farther down it runs just west of Sierra Martín García.

A good opportunity to study the character and thickness of the strata where they are but little affected by faulting was found in the vicinity of Quita Coraza, where beds of the Yaque group dip northward from the flank of Sierra Martín García into a synclinal trough. The following section is a compilation of measurements made in that vicinity:

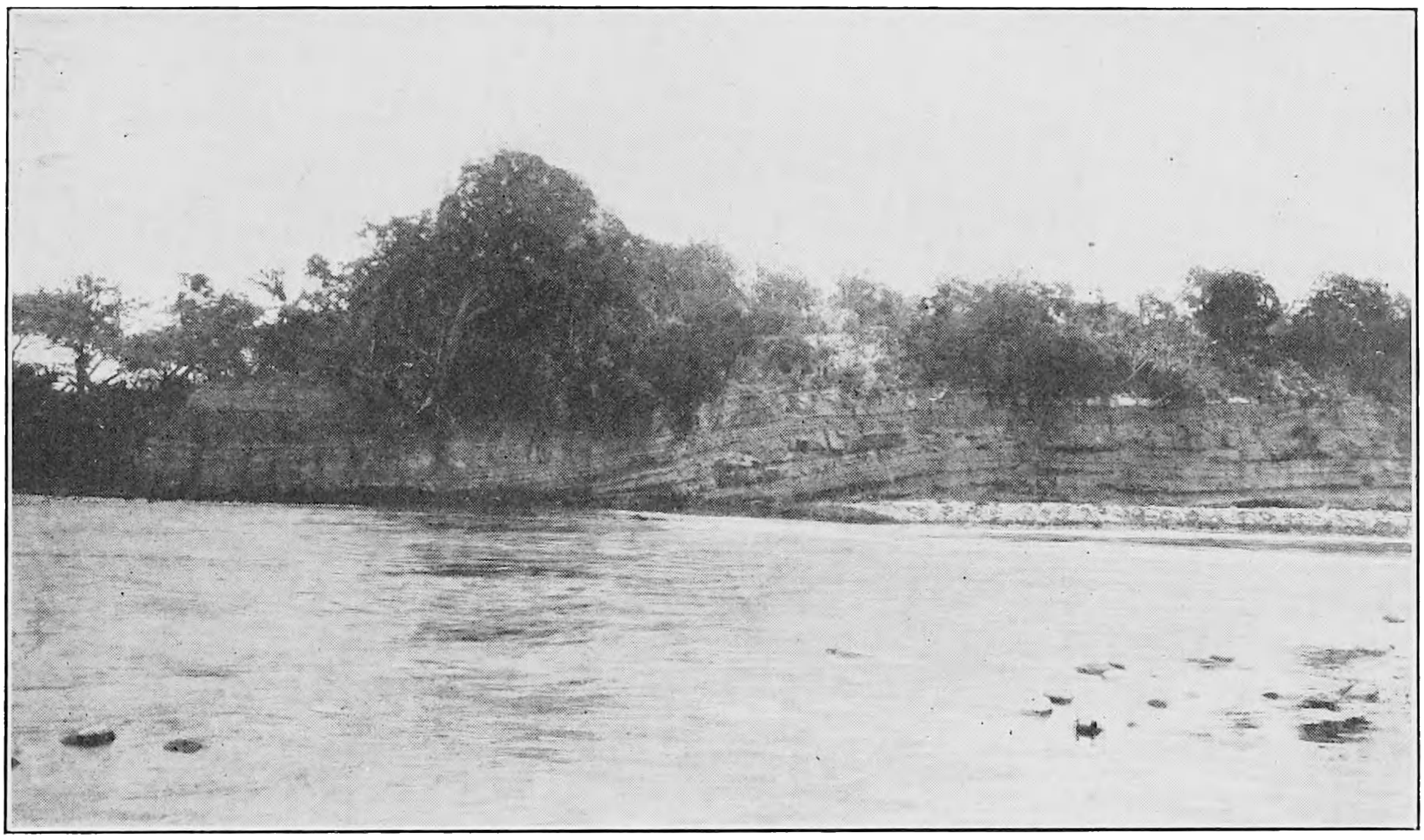
the bluish-gray to olive-green clay that constitutes the greater part of the section. Both the clay and limestone contain a large number of fossils, including corals of several species (stations 8590; for lists of fossils see pp. 157-162). The clay-limestone beds form a prominent hogback bluff along the right bank of the river opposite Quita Coraza and extend southwestward for many kilometers to the lowlands near Hatico.

This part of the section is of chief interest as a possible container of oil. The thin beds of coarse sandstone in the midst of the clay-limestone member might serve as the reservoir rock and the richly fossiliferous beds might have furnished petroliferous material. The overlying clays would serve as a cap rock, preventing the escape of the oil into the higher sandy beds.

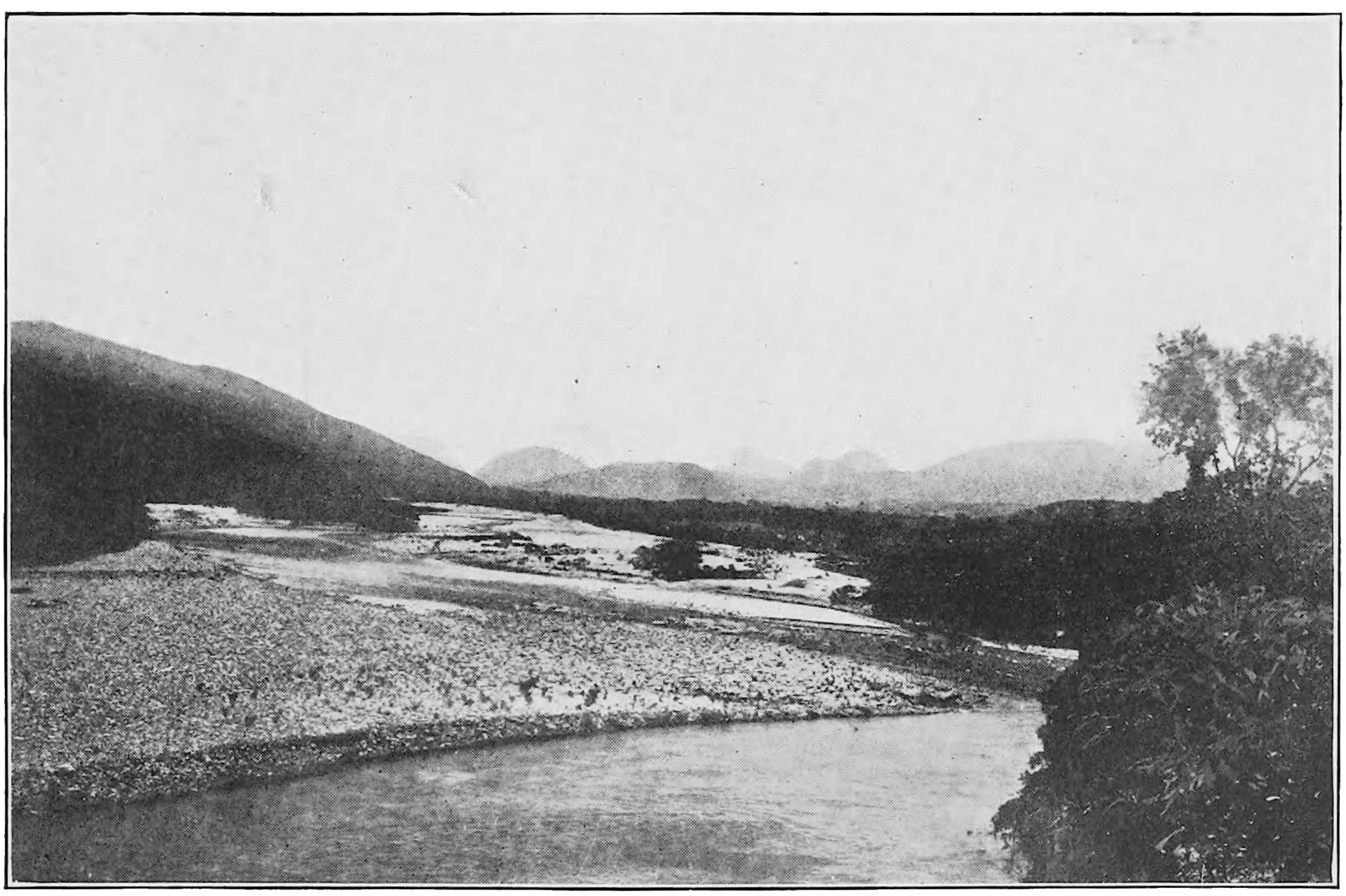
Above the calcareous beds is coarse sandstone that includes some conglomerate and some shaly and calcareous beds in its lower part. The sandy beds contain large Arcas, and some of the calcareous beds contain many corals. These strata appear on both sides of the east-west synclinal axis that lies between Los Güiros and Quita Coraza and are exposed on the south to a thickness of about 175 meters. Higher strata in this sequence are concealed by a covering of gravels of the Las Matas formation, which occupy the axis of the syncline.

The unconformable relations of the gravels of the Las Matas formation with the underlying strata is not pronounced here, the gravels agreeing rather closely in attitude with the substrata. In fact they would be taken for the same formation by one who had not become familiar with the lithologic character of the two and had not seen the decidedly unconformable relations at places up the river. The gravels of the Las Matas formation here, as usual, are less firmly consolidated than the deposits composing the Yaque group, and they contain no marine fossils. Interbedded with the gravel, which is yellowish gray, are layers of soft, marly limestone and layers of faint reddish to purplish clay, which differs strikingly in color from the bluish-gray to olive-green clays of the Yaque group. The unconformity between the two formations is plainly shown at a locality 3 kilometers upstream from Los Güiros. Here the gravel of the Las Matas formation forms a cliff on the left bank of the river, whereas a short distance farther upstream the water flows in a cataract over fossiliferous sandstone of the Yaque group. The unconformity between the two formations is very marked, for there is discordance in the strikes as well as the dips.

The general character of the strata along the upper course of Rio Yaque in the vicinity of the crossing of the Azua-San Juan road is described below. (See Pl. XVIII, *A*.) From the mouth of Rio de Las Cuevas down to the mouth of Rio San Juan there are thick deposits of sandstone and conglomerate, which are considered the basal part of the Yaque group. The same strata appear for a distance of several kilometers up Rio San Juan and com-



A. SANDY SHALE AND SANDSTONE OF THE YAQUE GROUP ON RIO YAQUE DEL SUR AT CROSSING OF AZUA-SAN JUAN ROAD.



B. VIEW NORTHWARD UP THE VALLEY OF RIO YAQUE DEL SUR FROM THE VICINITY OF BOCA MULA.

The distant hills are capped with basaltic lava.

apparently without fossils, and shale that weathers to a faint reddish-brown color. These beds slope valleyward at a low angle. They dip southward in the northern part of the valley at an angle of 10° to 15°, and dip northward at the few places where seen in the southern part. The gravel consists of pebbles of limestone, diorite, and volcanic rock in variable proportions, their character depending on the rocks in the mountains that border the basin.

The age of the gravel is not known, as no fossils were found within beds recognized with certainty as a part of the formation, but data obtained along Rio Yaque and farther south indicate that the formation is composed of terrestrial or near-shore deposits of early Pliocene age, postdating the late Miocene marine Cerros de Sal formation, which contains the beds of gypsum and rock salt found along the south side of Enriquillo Basin.

The gravel of the Las Matas formation of San Juan Valley, as has already been stated, apparently rests unconformably upon folded and faulted fossiliferous strata of Miocene age, which consist of dark-gray to bluish friable sandstone and conglomerate, shale, and a little limestone. As the Miocene rocks are largely concealed by the gravels in the valley they are exposed only in isolated hills that rise above the valley floor, for the Miocene rocks are slightly more resistant than the gravels. Sierra del Agua, a low range of hills that forms the eastern limit of the basin, is made up largely of these strata, typical exposures of which may be seen along the San Juan-Azua road near Rio Yaque.

The only other rock in San Juan Basin that is noteworthy in this connection is basaltic lava of recent age, which lies in nearly flat sheets, capping mesas and upland areas of the gravels. No attempt was made to find the vents from which the lava issued. Jones, in his report on Haiti,[1] mentions having found in the Cul de Sac district, adjacent to Azua Province, a well-defined crater from which extend basalt flows that occupy depressions in the present surface and are evidently very recent.

Local Details.

San Juan Valley was entered from the northwest by the trail leading from Bânica to Las Matas. Short trips were made southward from Las Matas and in several directions from San Juan. The mountain slopes on the south side of the valley were not visited. As viewed from Las Matas the lower slopes are seen to be white limestone resembling the limestone on the north side of the basin, which is probably of early Tertiary age. The higher mountain slopes are covered with timber that conceals the rocks.

In the vicinity of Las Matas there are low hills of the Las Matas formation, made up of clay, shale, and gravel with interbedded marly limestone.

[1] Jones, William F., A geological reconnaissance in Haiti: Jour. Geology, vol. 26, pp. 728–752, 1918.

The topography suggests a general northward dip of about 15°. About 6 kilometers southwest of Las Matas, near several large springs of sulphur water, at a locality known as El Puerto, Rio Macasía emerges from a gorge through limestone which strikes N. 75° E. and dips 10° to 30° northward. The rock is regarded as probably older than Miocene.

Extending eastward from Bânica is a mountainous limestone ridge known as Sierra de los Altos. Where crossed at a point about 6 kilometers east of Bânica the south side of this ridge consists of andesitic agglomerate and tuff resting on the limestone and possibly constituting the basal member of the Las Matas formation, which extends from here southward. Exposures in arroyos show loosely cemented, coarse conglomerate interbedded with sand and hematite-red clay beds. The dip is generally about 15° southward. About 5 kilometers south from Sierra de los Altos is a small westward-flowing stream known as Rio Caña or Tocino. Eastward along this valley outcrops of the fossiliferous Yaque group were found underlying the Las Matas formation. These strata consist of sandstone, limestone, and conglomerate striking about east-west and dipping steeply southward. In these strata certain species of characteristic Miocene fossils, belonging to the genera *Conus, Turritella,* and *Arca,* are plentiful. Probably the presence of these deposits in the midst of the valley is due to comparatively recent faulting. This view is supported by the fact that in the same vicinity the beds of the Las Matas formation are steeply inclined.

The road from Las Matas to San Juan passes over a nearly level gravelly country with numerous dry, shallow arroyos and no rock outcrops for the first 10 kilometers east of Las Matas. At a distance of about 12 kilometers, at a locality known as Punta Caña, the road ascends to a bench about 10 meters high, which is capped by a basalt flow resting on gravel of the Las Matas formation. From this bench, which forms the divide between the westward-flowing waters tributary to Rio Artibonito and the Rio Yaque drainage, the road leads over low gravel hills and thence across the extensive Sabana de San Tomé to the town of San Juan.

For a long distance up Rio San Juan the country is a gravelly plain, across which the river flows swiftly in a shallow, bouldery channel bordered by low gravel embankments. A short distance above Carpintero massive buff to white limestone appears in the river channel, and a little farther upstream it forms hills. The rock is more or less brecciated, is finely crystalline, and dips steeply northward. This limestone is in fault contact with quartzitic sandstone and hard bluish shale that dip steeply northeastward. The recent gravels along the river consist largely of huge boulders of andesite but include some boulders of diorite and limestone. The mountain slopes to the west in the same vicinity consist of limestone. No identifiable fossils were found, but it is believed that all the hard rocks seen along this part of Rio San Juan are of pre-Miocene age.

From the town of San Juan eastward beyond Rio Mijo gravels of the Las Matas formation are the only rocks encountered. At the crossing of the river is a gravel cliff with a bed of yellowish-gray marl, the strata dipping gently southward. A few kilometers east of Rio Mijo the road enters the hills known as Sierra del Agua, which form the east limit of the Gran Valle de San Juan. The rocks of the Yaque group in the Sierra del Agua are largely bluish-gray sandstone (weathering to olive green), interbedded with conglomerate. They contain many fragments of corals, plants, and other fossils. The beds dip steeply in various directions. Similar deposits may be seen in continuous exposures along Rio Yaque del Sur.

AREA EAST OF RIO YAQUE DEL SUR.

No attempt was made to cover systematically the region from Rio Yaque del Sur eastward to Azua. It was crossed by three different routes—one from Túbano southward through Las Yayas, another along the San Juan road, and another along the trail from Quita Coraza to Azua.

Most of the area east of Rio Tabara is a gravelly plain covered with a dense growth of mesquite, and bed rock is exposed only in the few hills that project above the plain. West of the Tábara there are fairly plentiful outcrops of gravel of the Las Matas formation, which unconformably overlies the folded beds of the Yaque group. Farther north, where the surface is more hilly, there are extensive areas of the Yaque group and volcanic rock and a small area of early Tertiary limestone.

The trail from Túbano southward through Las Yayas leads first over a series of steeply tilted and probably faulted calcareous shales interbedded with limestone (strike N. 80° E.) and next over hard, brittle yellowish limestone of upper Eocene age. Rock of Oligocene age is exposed on Rio de las Cuevas below Túbano. In the vicinity of Higuero Largo fragments of white coraliferous limestone (station 8608, mixed Eocene and Miocene; for lists see pp. 106, 157–162), probably much younger than the distorted limestone that crops out in Arroyo Salado nearby, were found. The trail then crosses a series of massive, steeply tilted conglomerate.

About 3 miles south of Higuero Largo, in a branch of Arroyo Salado, a collection of corals (station 8610; for list see pp. 157–158), including *Stylophora* sp. and other branching forms, was made from a vertical bed of conglomerate striking north and south and interbedded with shale. This formation is of Miocene age. Non-fossiliferous conglomerate with the same strike but dipping eastward is exposed at Las Charcas.

Several dikes of hard, dark trap that cut Eocene rocks were seen in the vicinity of Túbano. The contact of the trap with limestone is well exposed in a small hillock known as La Cerrita, on the northern edge of Túbano. Other exposures of the intrusive rock were noted in the Cerro de las Chivas, northeast of the village, and in the upper course of Arroyo Lima.

Such faulting appears to have occurred near Lake Rincón, where the gypsum and salt-bearing beds crop out as ridges in the midst of the valley.

Vicinity of Barbacoa and Eastward.

Both Barbacoa and Neiba stand on a terrace of coralliferous limestone that is about 80 meters above the level of Lake Enriquillo. At Barbacoa this terrace, which is only a few hundred meters wide, has a back slope of limestone rubble, which we ascended for more than 2 kilometers without reaching any outcrops. In a deep ravine well up the slope, where cliffs 50 meters high are exposed, the rubble is stratified as though waterlain and dips southward at an angle of 15°. The rubble consists entirely of gray semicrystalline limestone containing many orbitoid Foraminifera of Eocene age (station 8595, list of fossils on p. 106). The mountain top in the rear as seen from the valley is made up of limestone. The altitude is estimated at 1,300 meters. Several kilometers west of Barbacoa outcrops of limestone appear to extend down to the shore. The mountain front is probably a fault escarpment and may extend eastward to the vicinity of Boca Mula, on Rio Yaque.

The rocks exposed in the few outcrops northward from Neiba for a distance of several kilometers show great variation in strike and are steeply inclined. The strata exposed nearer Neiba are probably of the same age as the Cerros de Sal formation on the south side of the basin and are doubtless in fault contact with the pre-Miocene limestone on the north. The results of observations by A. F. Dixon, who made a geological investigation in this area,[1] indicate that from Neiba eastward to Rio Yaque the structure is synclinal and that the rocks consist in large part of beds of late Miocene age, which are in places covered by nearly flat strata supposed by Mr. Dixon to be the "coast limestone." Elsewhere the "coast limestone" extends up to an altitude of little more than 70 meters above sea level. In this region there are probably also areas of gravels of the Las Matas formation, which elsewhere unconformably overlie the Miocene strata.

Cerros De Sal.

The Cerros de Sal were named from beds of rock salt, which are there exploited on a small scale to supply local demand. The rock salt occurs also in the ridge near Las Salinas and for several kilometers westward. The associated gypsum beds extend eastward along the south side of Lake Rincón and upfaulted blocks of these beds also appear on the north side of that lake as far east as Rio Yaque. The beds can be traced westward nearly to Duvergé. Throughout their extent they generally dip steeply northward but in places they stand vertical or are even slightly overturned.

The stratigraphic sequence as studied about 3 kilometers west of Las Salinas, in the vicinity of the Manuel Pérez excavations, is shown in the

[1] Report furnished by Mr. R. D. Upham, of the Interocean Oil Co.

accompanying section. Higher beds of the same formation outcrop in the lowlands and hills north of Cerros de Sal. Thick beds of clay and sandstone were also noted, but they are not listed in the section. Beds of bituminous limestone occur in the series near Angostura.

Condensed stratigraphic section of Cerros de Sal formation.

	Thickness in meters.
7. Sandy shale, poorly exposed, alternating with calcareous, fossiliferous sandstone that forms low ridges north of Cerros de Sal	300
6. Cross-bedded sandstone, unconsolidated, alternating with gypseous shale; strike N. 70° NE.	150
5. Sandy clay beds, light-olive color, with embedded corals at two horizons (station 8574, list of fossils on pp. 163–164); strike about N. 70° W., dip vertical	400
4. Sandy clay beds of various colors, with several shell beds, composed of oysters, arcas, and other fossils (station 8572, list of fossils on pp. 163–164); also with thin layers of impure earthy lignite	170
3. Sandstone, sandy shale, and thin layers of pinkish fossiliferous limestone, which form the north face of the high ridge	150
2. Gypsum in thick, massive, white, finely crystalline layers, alternating with thinner layers of green gypseous shales and with beds of coarsely crystalline salt; gypseous shales in upper part	700
1. Red and yellow sandy clay and sandstone	100+

Gypsum interstratified with beds of salt and shale forms the upper part of the high ridge of the Cerros de Sal (altitude about 200 meters). These beds are underlain on the southwest side of the ridge by shaly reddish-brown clays. In the valley on the northeast side of the ridge the gypseous strata are overlain by a few thin beds of pink limestone, above which lie shale and sandstone alternating with variegated clays, the whole loosely cemented or with only a few beds of calcareous sandstone, which is sufficiently indurated to form low hogback ridges. The mollusks and corals, which are abundant in the strata, indicate that the formation is late Miocene.

THE SALT DEPOSITS.

The salt deposits occur on the north side of Cerros de Sal near the top. They are the property of the communes of Las Salinas and Angostura. The people of Las Salinas work in the excavations known as the Carrera del Potro, Manuel Perez, and La Partilla and several smaller excavations. Work is usually done at only one locality at a time. The workings of the inhabitants of Angostura near the western end of Cerros de Sal were not examined.

The salt deposits are in the upper part of the gypseous beds of the Cerros de Sal formation. The thickness assigned to this member—700 meters—is a minimum one, and more detailed work may show that it is much greater. The upper part of the member contains a larger proportion of shale than the lower part. The thickness of the part of the gypseous strata that contains the salt is about 50 meters, but further development would perhaps show a greater thickness and the presence of other salt-bearing strata.

The salt is found in lenticular masses. The pits have been dug to shallow depths in an unsystematic way and no lenses have been completely exposed. The thickness of the lenses ranges from a few centimeters to 6 meters and perhaps more, but in none of the excavations has any attempt been made to discover their length. Probably few of the lenses are much over 20 to 30 meters long and most of them are shorter. The three principal sets of workings of the Commune of La Salina are rather far apart but were probably located in a haphazard way, for salt is found at several places between these workings. Although individual lenses are short, the deposits probably are fairly continuous throughout the length of the Cerros de Sal. The salt in the lenses is massive, and nearly all of it is white. Layers of red and of black or nearly black salt are reported but are not common. Large, white, semitransparent crystals of halite, some of which are nearly a meter long, are found rather frequently. The green, soft shale associated with the lenses is distinctly saline in taste for considerable distances from the masses of salt.

The easternmost of the principal workings is Carrera del Potro, where only one opening has been made. The salt exposed is a lens nearly 6 meters thick, banded with ribbons of green shale, most of which are only one or two centimeters thick. These ribbons are somewhat wavy but are in general vertical, thus agreeing in dip with the lens. The strike is N. 85° W. East of this opening, on the line of strike, is an outcrop of gypsum and west of it is shale.

The Manuel Pérez excavations are more than a kilometer west of Carrera del Potro. Here a number of pits are scattered over an area roughly 50 meters wide by 300 to 400 meters long. There are nearly a score of excavations in this area, all of which are small and shallow. The lenses of salt range in thickness from a few centimeters to more than a meter. Some are close together and even merge into one another. They lie in the usual green to yellow shale. At this locality work was in progress at the time of the visit.

The Partilla workings, which are about as far west of the Manuel Pérez locality as Carrera del Potro is east of it, are similar to those at the Manuel Pérez. The excavations are perhaps fewer, but are deeper, and the average thickness of the salt lens exposed is a little greater. The salt here has a more greenish cast than elsewhere, probably due to admixed clay.

The rock salt in Cerros de Sal is so good that it is used for some purposes without refining. Salt picked clean of shale will probably average about 90 per cent of sodium chloride. The results of analyses of 12 samples from Cerros de Sal are given in the accompanying table. The impuri-

general average of K_2O in the deposits mined at Stassfurt, Germany, is 10 per cent.

The present methods of mining in the Cerros de Sal are very crude. No explosives are used. The tools used are axes, crowbars, and wedges. There is almost no timbering, although mesquite bushes of ample size grow on the hills close at hand. The soft shale that surrounds the salt lenses slacks and does not stand well, so that all the pits are shallow. Hillside locations that can be worked tunnel-fashion are sought, but, as the roofs will not stand without timbering the tunnels are very short. It is the present practice to work in one locality for a few months and then shift to another. Probably the pits at one place are pushed as far as is deemed safe and then temporarily abandoned. When erosion and weathering have removed the dangerous overhanging rock the miners return, clear out the debris, and resume work.

It is said that about 15 or 20 miners are usually employed in the workings of the Commune of Las Salinas. When we visited the mines work was in progress at only the Manuel Pérez excavations. Wages were $1 a day when powder was used, but now that it is not used the average is reported to be $1.20 a day. It is said that under favorable conditions one man can mine as much as 10 mule loads of salt in a day (say 750 kilograms), but the average daily production per man is probably not half that amount. The salt is sold for $1.25 a mule load (70 to 80 kilograms) at the mine and for $1.50 a mule load at the town of Las Salinas. Probably more salt is sold at the mine than in town. People come for long distances to get this salt, as it has a reputation for being superior to that obtained by the evaporation of sea water at the coast. The quantity sold daily is reported to range from 20 mule loads to 100 mule loads, but 20 mule loads is probably above the average.

Crude as the methods of operation are they may be the best that is possible under the present conditions. The rock is too firm for steam shoveling without blasting and the salt lenses are probably too small and too discontinuous to be worked by steam shovel or large-scale quarrying, yet more intelligent and systematic work, with the use of explosives and timbering, would no doubt materially lower the cost of mining. Transportation is not very difficult. There is already an automobile road between Barahona and Las Salinas, a distance of about 26 kilometers, and though it is poor it could be greatly improved at slight expense. There is now only a winding pack-mule trail from Las Salinas to the mines, and the slopes are so steep that the construction of a road which could be used for motor trucks would be somewhat expensive, but there would be no great difficulty in building a tramway. Whether the financial returns to be expected would warrant the outlay necessary to equip these mines with modern appliances could be determined only by field examination and careful calculation by a competent engineer. The output under present management is sufficient to supply the local demand, and the profit appears to satisfy the owners.

Petroleum Possibilities in Enriquillo Basin.

There are rumors that indications of petroleum have been seen at many places in and near Enriquillo Basin. Some of the places mentioned are east of Neiba, others are north and west of the Cerros de Sal, and still others are near Tierra Nueva and Jimaní. The indications reported are asphalt seeps, salt springs, limestone having the odor of "burned gasoline," and lignite.

E. I. Kilborne, an engineer in the employ of the Barahona Company, reports that he found asphaltic material which had the odor of petroleum on a branch of Arroyo Palma Dulce, about 6 kilometers east of Duvergé. Salt springs, which are regarded by the natives as indicating the presence of oil, are reported to exist at several places east of Neiba. Bituminous limestone that gives off a fetid odor when struck occurs near Angostura, at the west end of Cerros de Sal. There are small fragments of woody material at the same locality and elsewhere in the rocks of the Cerros de Sal formation.

The strata that overlie the gypsum beds in the Cerros de Sal appear to have been a possible source of petroliferous material, as they are rich in marine fossils and contain layers of lignite. The same beds under suitable cover might contain pools of oil. Any search for favorable structure in Enriquillo Basin should be preceded by a thorough study of the stratigraphic sequence along the Cerros de Sal, where the steep tilting of the beds furnish excellent exposures. The area from Neiba eastward to Rio Yaque is regarded as sufficiently promising to warrant a careful study of the structure and detailed investigation.

Sierra Bahoruco South of Duvergé.

Sierra Bahoruco is a rugged range that rises to an altitude of 1,700 meters on the south side of Enriquillo Basin, in the south-central part of the Province of Barahona. (See Pl. XIX.) Trips were made along the foothills of this range and southward from Duvergé through Puerto Escondido to Rancho Viejo, on the trail to Pedernales.

A bench of coralliferous limestone, which is mentioned elsewhere in this report (p. 213), is especially well developed between Duvergé and a point a few kilometers west of Las Baitoas. (See Pl. XVII, *B*.) Close to the road that skirts the base of the mountains there are cliffs, 3 to 12 meters high, composed almost entirely of branching corals, some of which are so fresh as to retain their original colors. Somewhat farther north in the basin there are more massive corals, which commonly occur as detached heads lying on or partly buried in the silty soil. Many of the mountain spurs are terminated by small cliffs, probably due to wave action in the sea that once filled Enriquillo Basin.

Along the border of the mountains, yet semi-detached from them, there are foothills, 40 to 100 meters high, composed of clayey sandstone, clays, and conglomerate, and probably some limestone. No fossils were collected from these beds, but it is believed that they form a part of the Cerros de Sal formation, because they are lithologically similar to some of the lower beds of that formation and lie stratigraphically above beds that make up the mass of the higher mountains in the northern part of Sierra Bahoruco. Near Duvergé the strike of these beds ranges from east-west to N. 50° W. and the dip ranges from 20° to 50° NE.

From Duvergé southward through Sierra Bahoruco past Puerto Escoudido to Cañada Diablo there is a single series of sedimentary beds. As indicated in the stratigraphic section given on page 215, this series consists of several distinct parts, but there appear to be no great stratigraphic breaks between them. Nearly all the beds are calcareous and most of them are impure limestones. Many are fossiliferous, but the fossils are poorly preserved. There are corals, casts of pelecypods, and some Foraminifera. The beds are probably early Miocene or late Oligocene. At their base is a well-defined conglomerate with oval pebbles of hard limestone 5 to 6 centimeters and more in diameter. Many of the pebbles contain abundant orbitoidal Foraminifera.

A striking feature of this region of calcareous rocks is the intensely red color of a very large part of the clayey soil, which is apparently a product of the weathering of the limestone. A thickness of some 130 meters of the rock series is made up of red and yellow highly ferruginous clay-stones, but these are subordinate in amount to the limestone. The red color of the soil is most noticeable where limestone strata form the bed rock.

The average strike of the beds is N. 70° W., although variations of 10° or more from this were noted. The rocks are folded into open anticlines and synclines, but no considerable faults were observed. Over most of the area between Duvergé and Cañada Diablo the dips are as high as 60°, but dips of 15° to 25° are more common. Near Cañada Diablo and Rancho Viejo, however, there is a change. Here the beds are bent sharply upward. Dips of 70° N. to vertical are common, and at some places, as in the basal beds near Rancho Viejo, steep southerly dips were observed, indicating that the beds here are actually overturned.

The basal conglomerate containing foraminiferal limestone pebbles is found in the vicinity of Rancho Viejo on both sides of Cañada Rancho Viejo, a few kilometers above the point where it joins Cañada Diablo. This conglomerate rests directly upon the limestone from which its pebbles are derived. There is clearly an unconformity here, and probably a large one. The limestone is hard, fine-grained, semicrystalline, and massive. No

indication of bedding was observed. As the investigation was not carried farther south, no data as to the probable thickness of this formation were obtained. The Foraminifera collected include *Nummulites* and other forms of Eocene age (stations 8626, 8627; lists of fossils on p. 106).

The following generalized section summarizes the stratigraphy of the northern part of Sierra Bahoruco. It is based on a hasty reconnaissance examination, and the thicknesses given are therefore only approximate, but the general relations are believed to be correctly shown.

Generalized section in Sierra Bahoruco south of Duvergé.

	Thickness in meters.
Pleistocene:	
Coral limestone and limestone conglomerate, forming terrace deposits near the border of Lake Enriquillo	12
Unconformity.	
Miocene (?):	
Conglomerate, variegated clay, and clayey sandstone; probably some limestone	50–75
Unconformity ?	
Early Miocene or late Oligocene:	
Rudely bedded marly limestone, with interbedded limestone conglomerate; fossiliferous, especially in the lower part, but the fossils are poorly preserved	300–500
Thin-bedded impure limestone; few fossils	100
Brick red, and yellow tuffaceous claystone and conglomerate; no fossils observed	130
Rudely bedded sandy limestone; no fossils observed	300–500
Basal conglomerate composed of pebbles of foraminiferal limestone	230
Unconformity.	
Eocene:	
Hard semicrystalline limestone with Foraminifera	Not known.

BARAHONA-BAHORUCO COAST.

The village of Barahona stands on a terrace of "coast limestone" which extends from the beach inland for a few kilometers. South of Barahona, along the coast, this limestone forms a sea cliff, 15 to 20 meters high, the top of which is a narrow terrace strewn with modern shells. Back of this terrace is a higher one at an altitude of about 50 meters, consisting of coarse limestone rubble derived from the mountains in the rear. The "coast limestone" throughout this area is made up chiefly of firmly cemented limestone conglomerate containing a few corals. In the southern part of this area, beyond Rio Bahoruco, the adjacent mountains consist in part of basaltic flows and the conglomerate contains pebbles of basalt. About 5 kilometers south of Rio Bahoruco is El Derrumbado, a precipitous promontory of limestone that rises about 500 meters above the sea. This limestone probably rests in fault contact against the basalt, extending from this point northward to the vicinity of Rio Bahoruco.

The limestone along this coast is at least in part Eocene, as indicated by *Nummulites* and other Foraminifera found near the sea beach on the south side of Rio Cana (station 8576; for list of fossils see p. 106). The only fossils found at El Derrumbado were a few fragments of shells and some corals, probably of Eocene age.

The basalt is evidently extrusive, for it is vesicular and its structure indicates flowage, but some of it is very compact and finely crystalline. The bed of Rio Bahoruco contains boulders of more coarsely crystalline rocks, almost of gabbroid appearance, which may have been derived from an igneous mass farther inland.

Copper stains are common in the basaltic lava, especially in its vesicular part, where thin films of chalcocite fill irregular cracks that traverse the mass and occur also as impregnations of the tufflike part. The amygdular spaces are generally filled with zeolite materials. At Bahoruco the conspicuous green malachite stain in the weathered rock has attracted the attention of local prospectors, who have dug trenches and pits over a considerable part of the hillside and have done sufficient work to show the futility of further search in this vicinity. Chalcocite occurs in insignificant amounts in the body of the rock and in films, 1 to 3 centimeters thick, that follow irregular, widely separated cracks in the rock.

Specimens from other prospect pits, farther south along the coast, near Paradís, indicate the occurrence of similar copper deposits there. The owner of the prospect near Paradís reports that his locality is the more promising of the two. One specimen found near Paradís showed a vein, about 5 centimeters thick, composed in part of chalcocite.

So far as known these are the only places in the Bahoruco Mountains where prospecting has been done for copper. On the strength of these discoveries the concession "Bahoruco" was obtained from the Dominican Government.

AZUA AND VICINITY.

Outline of Geology.

The town of Azua lies on a gravelly plain that slopes southeastward toward Ocoa Bay. A short distance to the north there are low hills of conglomeratic sandstone and shale, of Miocene age, beyond which lie mountainous slopes of early Tertiary limestone. In the foothills at a place known as Higuerito there is a seepage of oil that has been the chief center of interest for the oil prospectors in the Republic. The fertile plain south of Azua consists of sand and gravel, which is possibly in part contemporaneous with the Las Matas formation of the region to the west. The strata found in drilling for artesian water to a depth of about 100 meters at the Ansonia sugar plantation are said to consist of unconsolidated clay, sand, and gravel. Between the plain and the coast to the south is

hilly. Bed rock lies near the surface and crops out at many places along the ravines, though at others it is covered with a mantle of gravel in which pebbles of limestone from the adjacent mountains predominate. The rocks of the slopes of these mountains, which lie about 2 kilometers to the northeast, consist of white limestone containing abundant orbitoidal Foraminifera that are probably of Eocene age. The boundary between the older limestone of the mountain slope and the sandstone and conglomerate at Higuerito may be a fault. Beds near the contact can be seen plainly along Rio Vía, where the Miocene conglomerate apparently dips under the older limestone.

HISTORY OF DEVELOPMENT.

Of the six wells said to have been drilled before the advent of the present holders of the concession all but one were put down within a few hundred meters of the principal oil seepage. More or less oil is said to have been found in each at depths ranging from 180 to about 290 meters. The deepest well is said to have reached a depth of 400 meters. The earlier wells, which gave the best promise of becoming good producers, yielded oil in quantities that are variously estimated from a dozen up to several hundred barrels a day. Most of the oil was found at depths of less than 220 meters, and drilling to greater depths almost invariably resulted in a strong flow of salt water, which was left uncontrolled and destroyed the well. One well was drilled about four kilometers north of Higuerito, in a narrow valley at the base of the mountains. A depth of 200 meters is said to have been reached. The material for the first 125 meters was recorded as "sand and gravel," beneath which was "dark, hard rock with much spar."

Drilling is now being done on the recommendation of a geologist, who has obtained data that suggest the presence of an elongated dome, which trends nearly north-south and has steeply dipping flanks. The beds to the southeast, along Rio Vía, are so greatly crumpled and faulted that a geologist should do much very careful detailed work before he makes recommendations for drilling in this region. If the next two or three holes are drilled without obtaining oil it would seem to be advisable to abandon drilling here and to look for another field to the west, where the rocks are less disturbed.

QUALITY OF OIL.

The oil from the Azua field is dark brown, very liquid, and of high gravity, the results of various tests showing a gravity of 19° to 21° Baumé. It is said to yield no gasoline. The following are the results of tests of a sample taken from well No. 1 at a depth of 960 feet. The tests were made by Leroy M. Law for the Interocean Oil Co.

Tests of sample of oil from well No. 1.

Specific gravity at 60° F.	0.9309
Gravity (Baumé)	20.4°
Pounds per gallon	7.752
Flash point, open cup	185° F.
Fire test	220° F.
Distillation test:	
Initial boiling point	160° C. (320° F.)
10 per cent distills at	224° C. (435° F.)
20 per cent distills at	225° C. (491° F.)
30 per cent distills at	277° C. (531° F.)
40 per cent distills at	296° C. (565° F.)
44 per cent distills at	300° C. (572° F.)
56 per cent residue above	300° C.
Moisture	Trace.

Gas also issues from the ground in the vicinity of the oil seepage but none of it appears to be inflammable. A sample taken from one of the wells was analyzed by the chief chemist of the Bessemer Gas Engine Co., Grove City, Pa., whose report states that the sample "consists of carbon dioxide and air to 94.6 per cent of the total sample." The presence of air indicates that the sample was not carefully taken. His analysis is given below.

Analysis of sample of gas from well near Azua.

Heavy hydrocarbons by clarioline oils	4.00
Heavy hydrocarbons as calculated, less 55.5 air	9.00
Carbon dioxide	39.10
Oxygen	11.60
Specific gravity (air equals 1)	1.18

Reported Oil Seepages East of Azua.

The seepages of oil at Higuerito are the only ones found in the region, though there are numerous reports of others, some of which were visited and found to be merely salt springs or the carbonaceous material of fossilized plants. Mr. E. E. Dreyfus, of Santo Domingo City, who has resided for many years in the Province of Azua, reports that he has several times seen films of oil on the surface of the water near the beach along the east side of Ocoa Bay. No attempt was made to verify this report.

Another place at which oil is reported to occur is on Arroyo Salado, about one-half kilometer above its confluence with Arroyo Escondido, a branch of Rio Ocoa, about 16 kilometers northwest of Baní, in the Province of Santo Domingo. Dr. P. V. Logroño Cohen of Santo Domingo and Señor Marciel Soto of Galion state that they have collected samples of oil at this place. The place was visited by Doctor Cooke, who makes the statement that the supposed seep is near a fault contact of purplish-red limestone with shale. (See Pl. XX, *B; A* shows an exposure of similar rocks on Rio Ocoa below San José de Ocoa.) There were dark stains on the rock, but no trace of petroliferous material was found. The mud in the stream bed had an odor of hydrogen sulphide. At the time of the visit much rain had recently fallen, and with the rise of the creek the indications may have been obscured. The rocks in this vicinity are all early Tertiary or older and are so greatly sheared, twisted, and faulted that oil could hardly be trapped in them except in small quantities. The discovery of any petroliferous material here, however, would indicate that the "older series" may possibly contain oil elsewhere at places where the beds are not so greatly folded and faulted.

Practically all the rocks that form the hills from Ocoa Bay eastward to Rio Nizao are of Oligocene age or older (Eocene at station 8614, 5.2 kilometers east of Baní), the principal exception being the Pliocene or more recent conglomerates that lie nearly flat and form terraces that reach altitudes of a few hundred meters. The early Tertiary or Cretaceous strata consist of gray to dark limestone, purplish to reddish slaty shales or shaly limestone, sandstone, and calcareous sandy shale, all of which are greatly distorted and broken by faulting. Rio Ocoa, in its course from San José de Ocoa to Arenoso, follows one of these faults, the uplifted side of which is preserved in El Número, a southward-trending ridge west of Rio Ocoa.

SUMMARY OF ECONOMIC GEOLOGY.

Oil and gas.—The locality at Higuerito, near Azua, has been the principal center of interest as a possible commercial oil field and is the only place where wells have been drilled for oil. The results have not been very encouraging, but drilling has been resumed in the belief that some of the earlier wells might have been valuable but were lost through the encroachment of salt water, due to mismanagement.

There are large areas in the provinces of Barahona and Azua that are of sufficient interest as possible oil fields to warrant detailed geologic investigation. The investigation should cover all the region from Azua westward to Sierra Martín García and northwestward to the hills around Las Yayas, and structural studies should be made where outcrops are sufficiently numerous. All of Enriquillo Basin is worthy of careful attention. Search for oil seepages should be made east of Duvergé and also from Neiba eastward. The triangular area southeast of the limestone slopes of the Sierra de Neiba, north of Laguna Rincón, and west of Rio Yaque appears to deserve most careful attention.

San Juan Valley is so largely covered with the gravel of the Las Matas formation that the folded beds beneath it can be studied at only a few places. The exposure along Rio Yaque, near the east end of the San Juan Valley, consist almost entirely of coarse sandy materials of no promise as possible containers of oil. An examination should be made of the western part of this valley, near the Haitian border, where there are outcrops of lignite, possibly of Miocene age.

Salines.—Chemical analyses of the water of Lake Enriquillo and of two salt springs showed that the waters are of no economic value. The Cerros de Sal was examined in the hope that the beds of rock salt might contain potash. The results were disappointing, as no analysis showed potash in commercial quantity. (See analyses on p. 217.) The salt beds consist almost entirely of sodium chloride, with small admixture of clayey material or other salts. The deposits will probably continue to be the chief source of salt for the inhabitants of the interior, although the salt is far from pure, generally containing at least 10 per cent of impurities. If it is mined for export it must be refined, and it could probably not compete in the export market with the salt derived by evaporation in the many "salt pans" along the coast of this country and other islands of the West Indies.

Gypsum.—The Cerros de Sal contains enormous quantites of gypsum, which varies from a coarsely crystalline substance to fine-textured snowy white alabaster and can be obtained in layers of almost any thickness desired. It may be used chiefly for making plaster of Paris and possibly for statuary, so that the beds have little prospective value.

Metalliferous deposits.—Little is known concerning the metalliferous deposits in this part of the Republic, though gold, silver, nickel, copper, pyrites, and iron are mentioned in the several mining concessions now in force in the Province of Azua. Almost all the rivers that flow from areas of crystalline rocks in the Cordillera Central contain gold-bearing gravels, and some of these were mined by the Spanish in early Colonial days. Small quantities of placer gold have been obtained in the beds of several rivers from time to time.

Copper stains are plentiful in the area of volcanic rock in the Bahoruco Range south of Barahona, and they have attracted the attention of prospectors, who have done a little work near Paradis and at the mouth of Rio Bahoruco. The results do not encourage the hope of finding deposits of any value in this area. Copper sulphides and their oxidation products were noticed along the trail from Constanza to Túbano at a point about 10 kilometers northeast of Túbano.

Iron deposits in the form of limonite are reported to occur near Paradís and in the Bahoruco Range south of Duvergé, where float siderite was also noted. Reports concerning the deposit at Paradis indicate that it is probably surficial and of slight extent. It is probably derived from the decomposition of basic volcanic rock.

CHAPTER X.

ECONOMIC GEOLOGY.

By D. Dale Condit and Clyde P. Ross.

MINING CONCESSIONS IN FORCE IN JULY, 1919.

The notes of all the members of the expedition, as well as published accounts of some of the deposits, have been used in the preparation of this chapter, but the limitations of time made it impossible to study or even to visit many of the localities where mineral deposits have been reported to occur.

As will be seen by a glance at the accompanying index map (Plate XXI), the greater part of the Republic is covered by concessions granted by the government for mining minerals of diverse sorts. A list of the concessions in force in July, 1919, is given below.

Mining concessions in force in the Dominican Republic in July, 1919.

[See numbers on index map, Pl. XXI.]

No. and name of concession.	Concessionaire.	Approximate area in square kilometers.	Minerals designated.
1. Union	Manuel del Monte	2099	Gold, silver, manganese.
2. Boya	do	938	Gold, silver, copper.
3. Hatillo Maimón	F. L. Vásquez	138	Magnetite, copper.
4. Peguera	Eugenio Álvarez	88	Iron, nickel, manganese.
5. Altar Jayaco	Manuel del Monte	545	Do.
6. Miranda	Eugenio Álvarez	95	Do.
7. Yami	Bobea y del Monte	23	Nickel, iron.
8. Bulla	M. H. Telleria		Copper and gold.
9. Zarzuela	F. Zarzuela		Gold and other metals.
10. San Juan	González & Álvarez		Gold, nickel, copper.
11. Yaque del Sur	do		Do.
12. Guanarate	Esteven Nivar		Petroleum.
13. Santa Ana	A. J. Montolio	508	Iron, other metals.
14. Bahoruco	do	346	Copper, iron.
15. Higuerito	S. D. Inv. & Dev. Co	900	Petroleum.
16. Los Pinos	Ernesto Rodriguez & Co	615	Copper, silver, pyrites.
17. Perseverancia	Dr. Diaz Pardo	647	Nickel, iron, copper.
18. El Cobre	Del Monte & Sánchez		Copper, placer gold.

MINERAL DEPOSITS NEAR HATILLO AND MAIMÓN, PROVINCE OF LA VEGA.

By Clyde P. Ross.

Deposits of ores of copper and iron south of Cotuí, on and near Rio Yuna, have been known for many years. Much prospecting has been carried on intermittently, but the results have been discouraging. The deposits lie along the northern border of the Cordillera Central at some distance from

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EOLOGY.

ɪd Clyde P. Ross.

FORCE IN JULY, 1919.

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938	Gld silver, copper.
138	Magn te copper
88	Iron, nicel manganese.
545	Do.
95	Do
23	Nickel, iron.
	Copper and gold
	Gold and other meta
	Gd nickel, copp
	Do
	Petroleum
508	Iron other metals.
346	Copper, iron
900	P troleum.
615	Copper, silver, pyrites
647	Nickel, iron, copper.
	Copper, placer gold.

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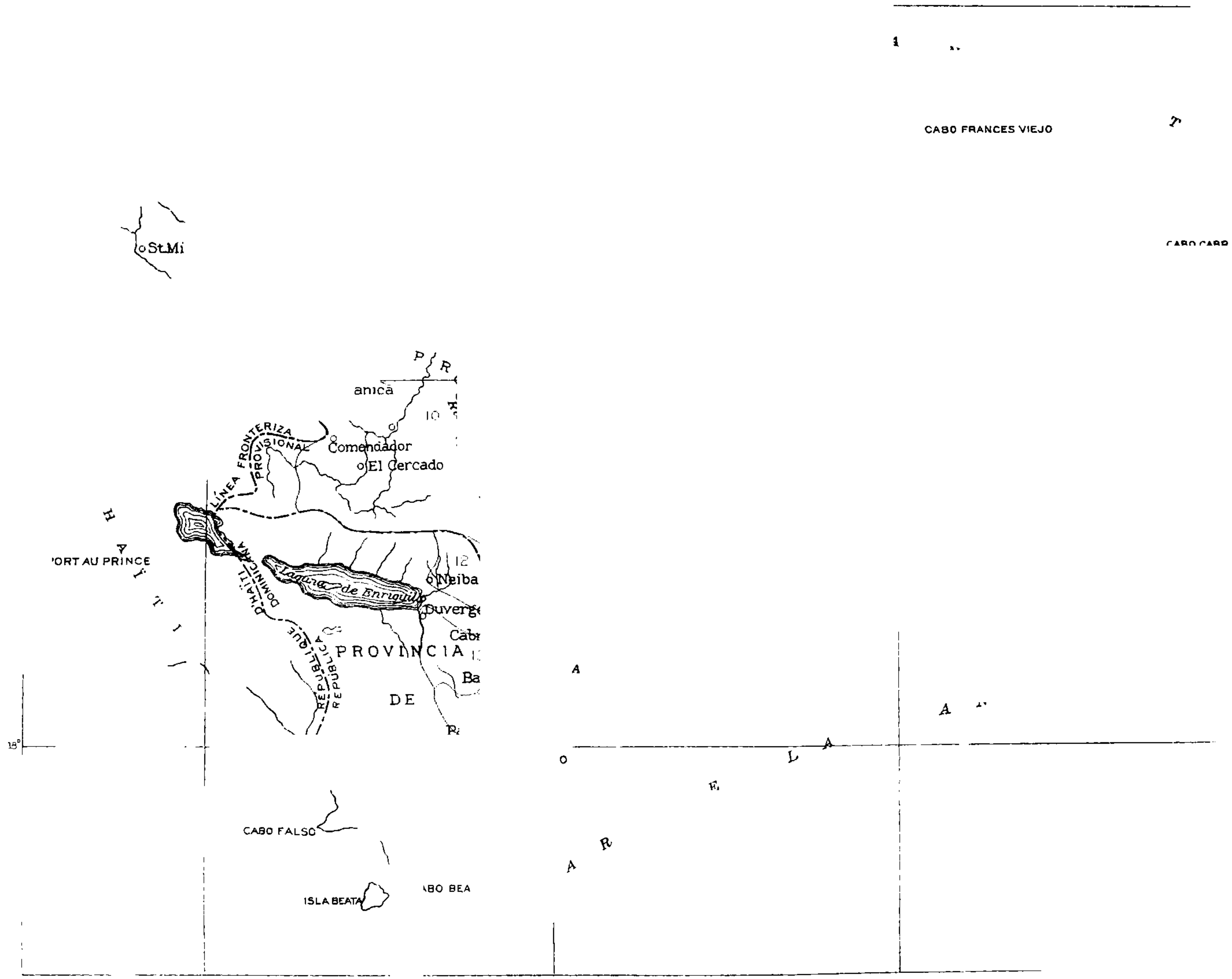

MAPA DE LA REPÚBLICA DOMINICANA QUE INDICA LAS CONCESIONES MINERAS VIGENTES, JULIO DE 1919

INDEX MAP OF DOMINICAN REPUBLIC SHOWING MINING CONCESSIONS IN FORCE IN JULY, 1919.

Brinsmade,[1] in his report on this district, mentions four localities at which he found similar magnetite deposits besides the one here described. He gives six analyses, which show that the magnetite is of high quality and that the ore is a mixture of hematite and magnetite, with a larger percentage of the hematite than is evident from field examination. He thinks that the material in which the magnetite is embedded is decomposed porphyry.

The magnetite deposits of this district have no present commercial value, for the amount exposed in the pits is entirely too small to warrant exploitation. A magnetic survey of all areas in this district where limestone outcrops or is supposed to occur is desirable to ascertain whether there are larger lenses of magentite.

COPPER DEPOSITS NEAR HATILLO.

Copper prospecting has been carried on intermittently for many years in the vicinity of Hatillo. The known indications of copper are on Loma de la Mina, about 4 kilometers southeast of Hatillo. Many small prospect pits have been sunk on this mountain and at one place, near the summit, there are large workings consisting of shallow trenches and pits. The main dump, which is on the side of the mountain, is about 75 meters in diameter and has a maximum depth of about 25 meters. A little ore was evidently smelted by some of the prospectors. Several hundred meters south of the main workings there are some small pits, and on the surface of the ground nearby there are pieces of slag, some of which contain blebs of metallic copper.

In the pits where the ore was smelted there is a small quantity of bog iron ore mixed with lignitic material consisting of partly carbonized seeds and other vegetable matter. The bog iron ore has formed since the pits were dug. These deposits are of no commercial value, but they are of interest as showing the rapidity with which bog iron ore can be formed.

Loma de la Mina is composed principally of chloritic schist. Near its base gneissic igneous rock, probably dioritic, was observed in places. The mountain is covered with a rather thick mantle of soil and outcrops are not abundant.

The principal workings are on a shear zone in chloritic schist, which has been much crushed and sericitized. The schist is locally stained with iron and bears scattered copper stains. It contains a few small quartz stringers, but most of them are only a centimeter or two wide. Some of the stringers contain a little azurite, but most of them are barren. A few fragments of hard gossan were seen. A small amount of a mineral that is believed to be alunite and a little chalcanthite were found in the schist.

These deposits are so inaccessible and the quantity of copper they contain in so small that they are of no present commercial value.

[1] Brinsmade, Robert B., Iron in Santo Domingo: Mining and Scientific Press, vol. 117, pp. 356-358, Sept. 4, 1918.

THE MAIMÓN IRON DEPOSITS.

Señor León Sánchez, of Maimón, guided us to his iron prospects on Loma Pegado, a hill about 4 kilometers southwest of Maimón. This hill is composed of serpentine, which is an alteration product of some basic igneous rock. All the hills near Maimón are apparently composed of similar rock, but none except Loma Pegado was examined. Near the top of Loma Pegado a black trap rock, hornblende diabase, which is probably part of a dike intruded into the serpentine, is exposed in a prospect pit.

There are numerous prospect trenches and pits on the flank of Loma Pegado. They expose serpentine cut by plates and banded, botryoidal, and drusy veinlets of quartz. The serpentine has weathered for a depth of more than a meter below the surface, and the upper 30 to 50 centimeters is changed to a red, very highly ferruginous residual soil.

The conditions here are similar to those in the Mayari district of Cuba, with the important difference that the deposits in the vicinity of Loma Pegado are on steep hillsides, so that the amount of residual soil of possible value as iron ore is very small, but commercial quantities of ore may be found in the vicinity of Maimón in a more favorable topographic position.

Apparently the prospecting on Loma Pegado was originally undertaken in the hope of finding deposits of nickel. H. G. Ferguson made a hasty examination at this locality and reports that small amounts of garnierite, a silicate of nickel, occur in places in the serpentine but not in commercial quantities.

LA PERSEVERANCIA NICKEL DEPOSIT, PROVINCE OF SANTO DOMINGO.

By D. Dale Condit.

Sierra Prieta, a part of the property known as "La Perseverancia" concession, was visited on June 10 and July 6, 1918, by H. G. Ferguson, of the United States Geological Survey, and on June 16, 1919, by the writer, while he was in the service of the Dominican Government.

HISTORY OF CONCESSIONS.

The "Perseverancia" concession was granted to Señor Manuel Delmonte on January 13, 1915. The "denouncement" which went with this concession mentioned iron, chrome, manganese, cobalt, nickel, copper, and gold in both quartz and placers. The localities included El Cerro Pelada, El Mongote, Mirador, Leonora, Guamuna, Isabela, Matiguelo, Sierra Prieta, Higuero and Maimón, parts of Communes Villa Mella, Yamasá, and La Victoria, Santo Domingo Province. The ownership of the concession was transferred from Señor Delmonte to Doctor Rogelio Díaz Pardo of Havana, Cuba, in February, 1918. All the exploratory work since the advent of Dr. Pardo has been done at a locality known as Sierra Prieta. The accompanying map of Sierra Prieta (Pl. XXII) is a reduction, after redrafting, of the map filed in the office of the Secretario de Fomento y Comunicaciones.

GEOGRAPHY.

Sierra Prieta is an isolated outlier of the main mountain range about 30 kilometers north of the city of Santo Domingo and about 12 kilometers northeast of Los Alcarrizos, the nearest point on the automobile road (Carretera Duarte) now being constructed from the capital city northwestward across the island. A direct trail, passable by light automobiles in dry weather, leads from Santo Domingo City northward through Villa Mella. It is an easy, natural route, which with little work could be made into a good wagon road, following as it does the nearly level upland surface of the "coast limestone," with only the valleys of Rio Isabela and Rio Yuca offering serious obstacles. Mr. Leslie, agent for the company, reports that a railroad route to the mine, extending in part up Rio Ozama, has already been surveyed. The altitude of the plain near the foothills of the mountain range is 70 to 80 meters. Sierra Prieta, the hill containing the nickel deposits, rises abruptly from this plain to an altitude of 241 meters and about 170 meters above the plain to the south. The rugged upland country of which this hill is an outlier extends northward to the Vega Real.

GEOLOGY.

The coast at Santo Domingo consists of a coral reef that has been elevated about 15 meters above sea level. Landward of this reef is a nearly level surface, which rises toward the north as a plain that extends to the mountains. This plain is made up of strata that slope gently seaward. The beds farthest from the coast are the oldest and are overlapped by successively younger rocks seaward. Coralliferous limestone, probably not all of the same age as that at the sea front, extends a few kilometers north of Santo Domingo, but beyond this limit the sections in the arroyos show chiefly gravel, sand, and fossiliferous nodules of limestone. Nearer the mountains the plain has a thin covering of limonitic conglomerate, which toward the foothills thickens and becomes increasingly ferruginous and might be of possible value as iron ore. The mountains in this vicinity consist of serpentine, which forms part of a large belt that extends northwestward across to the vicinity of La Vega. The stream pebbles are of slate and limestone and of many varieties of intrusive rock. The hill containing the nickel deposit is entirely serpentine, as is also the neighboring hill to the north, and no other rocks were found in place except a small basic dike that cuts the serpentine.

Gold has been washed by the natives from the stream gravels of the region and it is said that small quantities of platinum have been found in the placers, but probably not in quantities sufficient to encourage hopes of profitable working. A sample of black sand washed from a small brook near the camp at the east base of the hill was found on examination to contain chromite in addition to considerable magnetite.

MINING OPERATIONS.

Nickel ore is said to have been discovered at Sierra Prieta by Señor Manuel Delmonte, who obtained a concession and held it through several revolutions. The disturbed state of the country prior to American occupation prevented development. Señor Delmonte sold the concession to the syndicate of which Dr. Rogelio Díaz Pardo of Havana is the principal owner, and a small amount of shafting and trenching has been done for the syndicate under the supervision of a mining engineer named Pagliuchi. The work done includes a shelf excavation wide enough for a cart road extending around the east and north sides of the hill at about the 195 meter contour. A shaft having a depth of about 25 meters and about 15 meters of cross cuts have been dug near the highest part of the hill. The underground work has been discontinued and a tunnel is being started on the southeast side, opposite the shaft and about 50 meters below its mouth. Samples of "picked ore" sent to Havana from time to time are said to have yielded very favorable assays. The mine foreman who selected these samples assisted in the sampling in the shaft and also selected samples of "picked ore," the assays of which are given on pages 234-235.

The exploratory work done prior to 1918 consisted of digging trenches and pits at irregular intervals over the most promising part of the deposit. On the assumption that the entire hill consisted of ore, a civil engineer named Henderson was engaged to make a survey and estimate the quantity of minable ore. His report showed that 95,000,000 tons lay above the level of the plain. The same engineer was then engaged to survey a railroad route from the mine to the harbor of Santo Domingo.

MODE OF OCCURRENCE OF NICKEL.

The nickel in the outcrop occurs as the mineral garnierite (genthite), a hydrated silicate of nickel and magnesium of pale apple-green color, which is associated with a fine network of quartz veins. The mineral is probably a product of weathering, the nickel being in the form of another silicate a few meters below the surface. The mineralization appears at widely separated points over the upper part of the hill, and the weathered outcrops appear as spongy, honeycombed rock of rusty brown to greenish color, showing the garnierite stain when freshly broken. Below the surface the garnierite green becomes less and less noticeable, and at a depth of about 15 meters the vein material is almost entirely white and consists of a soft, amorphous mineral, possibly magnesite, with dark stains and a few quartz veins. The analyses of samples from a depth of over 15 meters below the surface indicate that the nickel is disseminated through the vein material and country rock, forming an "ore" of lower grade than that nearer the surface, where enrichment has more or less localized the mineral.

RESULTS OF SAMPLING.

Samples were taken from all accessible parts of the hill (see Nos. 1–14 inclusive, on Pl. XXII), and particularly from the parts that showed best evidence of valuable mineralization, so that the mean of the samples probably shows a considerably higher tenor than the average. The following notes describe the samples taken:

Prospect pits sampled by Ferguson.

Sample 1. Grab sample from outcrops extending N. 45° W. across small outlying hill for a distance of 360 meters. Practically unaltered serpentine at the base; cut at the summit by small quartz veinlets containing traces of garnierite. Assay result: Nickel, 0.65 per cent.

Sample 2. Grab sample from outcrops extending N. 45° W. up main hill to 104-meter contour for a distance 120 meters. In serpentine, slightly veined. Assay result: Nickel, 0.29 per cent.

Sample 3. Grab sample from outcrops extending 190 meters to crest of ridge. Serpentine with rare quartz veinlets. Assay result: Nickel, 0.29 per cent.

Sample 4. Grab sample from outcrops extending 270 meters along crest of ridge. Same type of materials as No. 3. Assay result: Nickel, 0.41 per cent.

Sample 5. Continuation of No. 4 for a distance of 140 meters. Type of material similar. Assay result: Nickel, 0.43 per cent.

Sample 6. Open cut at base of hill near camp. Sample along sides of cut for 6 meters N. 85° W. No visible garnierite, but slight quartz veining and weathered serpentine. Assay result: Nickel, 0.36 per cent.

Sample 7. Small open cut on trail at 124-meter contour, 6 meter face. Weathered serpentine. Assay result: Nickel, 1.13 per cent.

Sample 8. Shallow cut along 198-meter contour for distance of 195 meters. Weathered serpentine with rare quartz and garnierite. Assay result: Nickel, 1.05 per cent.

Sample 9. Open cut 50 meters long from south end of No. 8 to crest of ridge. Serpentime with many small quartz stringers and a little garnierite. Assay result: Nickel, 0.55 per cent.

Sample 10. Small open cut just below crest of ridge on east side, 18 meters long. Serpentine with quartz and garnierite. Assay result: Nickel, 1.75 per cent.

Sample 11. Open cut across top of ridge, 25 meters long. Serpentine honeycombed with small quartz veins in places, with good showing of garnierite. Assay result: Nickel, 2.09 per cent.

Sample 12. Small pits along crest of hill, in two lines, 5 meters apart and 1 meter deep, many not reaching bedrock. Samples taken from material on dumps, consisting of weathering serpentine and quartz, for a distance of 80 meters. Assay result: Nickel, 3.01 per cent.

Sample 13. Northward continuation of same line of pits, most of them, however, not reaching bedrock. Distance, 240 meters. Similar material. Assay result: Nickel, 1.24 per cent.

Sample 14. Line of similar pits southward from No. 11, most of them reaching bedrock. Distance, 220 meters. Similar material. Assay result: Nickel, 1.29 per cent.

Samples from shaft on summit of hill taken by Condit.

Samples 15 to 22. The samples taken below the surface include Nos. 15 to 19, selected from the ore dump, and Nos. 20 to 22, taken from the deeper part of the shaft. The material from the deepest part of the shaft consists of dark-green serpentine, veined by white, soft, amorphous material, which is regarded by the mine foreman as the

in the United States, even if situated at a locality convenient to a supply of acid, could not be profitably worked unless it contained at least 1 per cent of nickel and included at least a million tons. In a region such as the Dominican Republic, with its transportation difficulties, the ore must be much richer in order to be profitably extracted. The evidence at hand gives but little encouragement to the hope that the nickel deposit at Sierra Prieta can be profitably mined while nickel is at its present price.

Further exploration of neighboring areas of the serpentine rock may possibly disclose a richer deposit. Nickel in disseminated form is a usual constituent of serpentine, and the deposit at Sierra Prieta is therefore not unique. The disappointing results of prospecting there need not discourage search in other parts of the Republic that are covered by extensive tracts of serpentine.

SAN CRISTOBAL MINING DISTRICT, PROVINCE OF SANTO DOMINGO.

By Clyde P. Ross.

LOCATION AND ACCESS.

The copper deposits in the old San Francisco concession, north of San Cristóbal, were examined by the writer during four days early in June, 1919. The accompanying map (Pl. XXIII), which is a reduction of a map made by the engineer of the Blanton Syndicate, shows the area occupied by the deposits. The office of the operators was at Naranja Dulce, on the west side of Rio Nigua, about 13 kilometers north of the town of San Cristobal. The principal workings on San Francisco Hill are directly across the river from Naranja Dulce. Carts are said to have traveled the trail from San Cristóbal to the mines to carry ore when the mines were shipping—a journey that would be possible only in the dry season, and much work would now be necessary to put the trail in shape for the use of carts even then. In the rainy season the trail is at times impassable. It would be difficult but by no means impossible to build a wagon road from some point on the Santo Domingo-San Cristóbal Carretera to Naranja Dulce and Búcaro Hill.

In addition to the openings on Búcaro and San Francisco hills a number of others are scattered over the district, but the only important ones are those recently made by Dr. Jacob Harootian near the crest of the divide between Rio Nigua and Rio Jaina, not far from the source of Arroyo Platanito, at a locality called La Rama, which has been approximately plotted on the map (Pl. XXIII). It can be reached by a rather steep mountain trail from Naranja Dulce. A trail or even a wagon road could probably be constructed from this prospect to Jaina or to some point on the carretera between Jaina and San Cristóbal, and thus shorten considerably the distance to Santo Domingo City.

END

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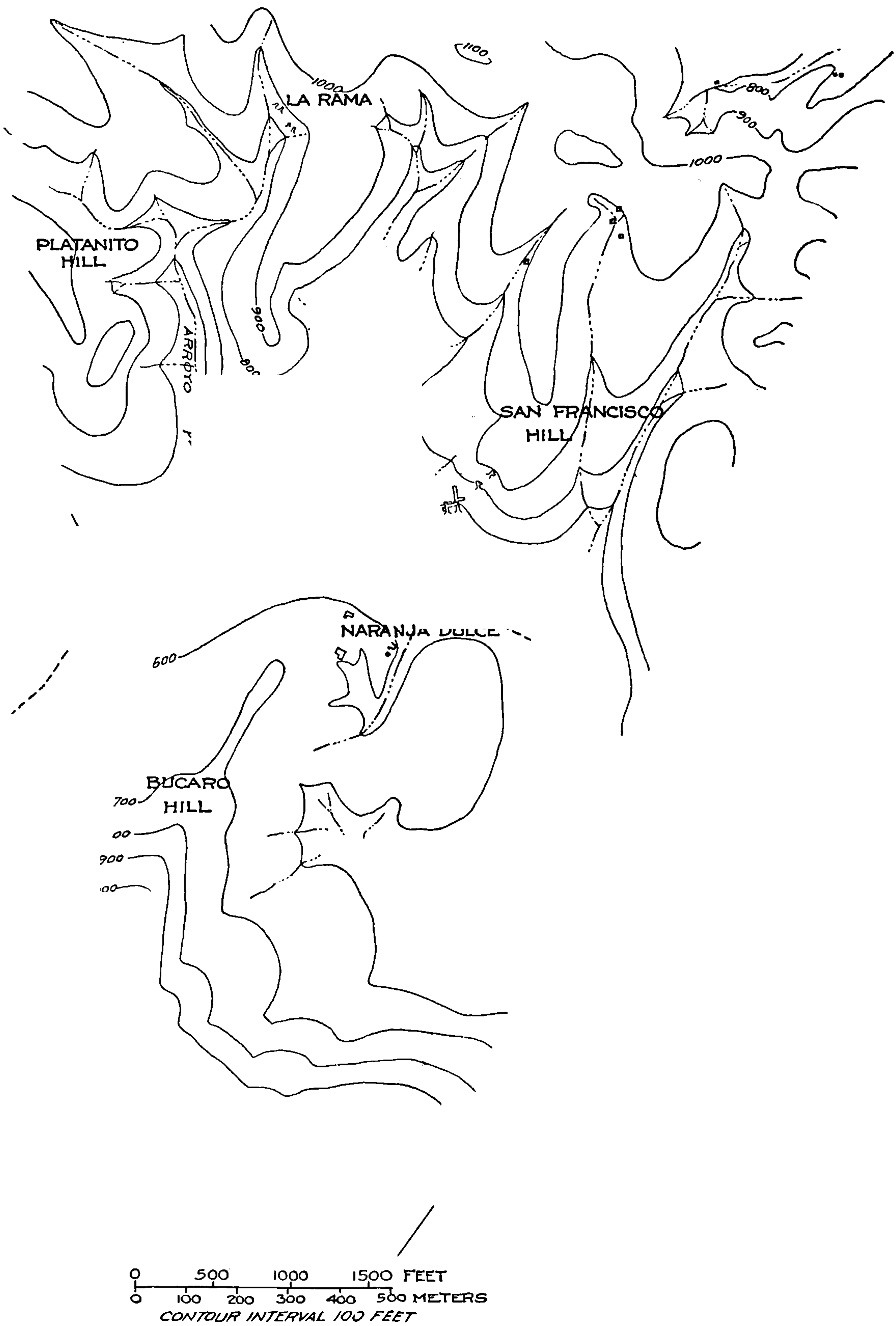

P OF PART OF THE SAN FRANCISCO CONCESSION, SAN CRISTÓBAL MINING DISTRICT.

by the Blanton Copper Mining Syndicate between October 1, 1915, and July 5, 1917, inclusive. The ore, which is reported to have come principally from Búcaro Hill, was picked ore. About 10 tons were mined for each ton shipped. The average value of the ore shipped was $57.70 per ton. The highest assay for copper in the ore shipped was 16.9 per cent; the lowest was 8.6 per cent. The highest silver assay was 2.80 ounces per ton; the lowest was 1.30 ounces per ton. The highest gold assay was 0.10 ounces per ton. None of the shipments contained valuable quantities of silver or gold.

Ore shipped from the San Francisco concession by Blanton Copper Mining Syndicate.

Approximate date of shipment.	Approximate gross tons.	Per cent of copper.	Ounces per ton of 2,000 pounds.	
			Silver.	Gold.
October 1, 1915	133	8.6	1.70	0.035
November 5, 1915	128	9.78	2.20	0.028
December 9, 1915	92	11.03	2.00	0.04
January 2, 1916	43	11.23	1.80	0.10
January 15, 1916	47	13.91	2.30	0.06
January, 1916	16	12.36	1.90	0.05
February 1, 1916	50	13.94	1.30	0.01
March 2, 1916	39	14.13	2.50	0.005
March 9, 1916	59	16.9	2.80	0.01
March 28, 1916	69	13.35	2.10	0.024
April 10, 1916	57	13.35	2.10	0.024
April 22, 1916	45	11.93	1.70	0.02
June 10, 1916	37	11.61	2.10	0.04
July 5, 1916	22	10.80	1.30	0.06
January 6, 1917	79	12.69	1.60	0.048
March 13, 1917	40	13.13	1.50	0.01
April 13, 1917	65	11.83	1.40	0.005
July, 1917	40	11.92	1.60	....

Less than 500 tons—according to one report only 50 to 60 tons—was shipped from San Francisco Hill, but no records of the shipments are at hand, and the amounts and values are not known unless some of the above mentioned shipments were made from the San Francisco workings. Two tunnels were entered, and several caved workings on San Francisco Hill were examined. Several hundred meters of tunneling and drifting has been done here, and one small stope in the uppermost tunnel is still accessible. Much of the drifting, both here and on Búcaro Hill, was done along barren slips and appears to have been of no value in developing the property.

Doctor Harootian's La Rama prospect, near the head of Arroyo Platanito, has been just developed by four openings in the hill, the largest about 6 meters long.

GEOLOGY.

The mineralized area consists of volcanic rocks, principally tuffs and breccias. Limestone crops out along the crest of the hills on the southwest side of Rio Nigua.

The volcanic rocks are a series of altered tuffs, breccias, and lavas, cut by a few small porphyritic dikes. The tuffs and breccias appear to predominate, but the rocks are so much metamorphosed that their identification is difficult. They appear to be finely fragmental, and most of them are green to purple. The coloring is in streaks and blotches and usually is extremely variable. Some of the rocks are uniform in color, green or black, and aphanitic or nearly so. The volcanic rocks are everywhere much jointed and fractured and in places are sheeted.

The contact between the limestone that forms the upper part of the ridge on the southwest side of Rio Nigua and the volcanic rocks is probably a normal fault. The fault plane apparently strikes about N. 55° W. and dips to the northeast. The limestone is gray to cream-white, granular near the contact, and fine-grained and thin-bedded farther up hill. The beds strike approximately east and dip southward 20°–30°.

In the bed of Rio Nigua there are many boulders of a coarse pink granitic rock, but this rock was not found in place. The first outcrop is reported to be about 5 kilometers upstream from Naranja Dulce.

BÚCARO HILL ORE DEPOSITS.

The volcanic rock in and near the workings on Búcaro Hill is full of small slips. Some of the slips in the tunnels that were examined strike northwestward and have copper stains along them, but no ore. The dumps of several of the caved tunnels, however, show ore, some of it of good grade. The ore is of two types— (1) malachite, with some quartz, hematite, and usually some sulphide, in chloritized volcanic rock; (2) chalcopyrite, pyrite, bornite, and specular hematite in quartz, with limonite as an alteration product of the sulphides. The quartz seen on the dump appears to have been in narrow stringers or veinlets in chloritized tuff. There are fragments of calcite veins 30 centimeters wide, but these are barren. No chalcocite was noted in the ore on any of the dumps in the district, but a specimen of high-grade massive chalcocite, reported to have come from one of the workings on Búcaro Hill, was shown to the writer by a former employee of the Blanton syndicate. At the end of a drift in the Francis Chini tunnel there is an infaulted block of black, hard slate full of small cubes of pyrite. This is the only sedimentary rock found in the volcanic series.

Mr. F. Lynwood Garrison[1] considers the deposits of Búcaro Hill segregations in tuff rather than veins, but states that in the lower part of the hill, where erosion has exposed fresher rock, the deposits have the appearance of discontinuous veins.

The mineralization appears to occur along slips or shear zones and the deposits are therefore veins rather than segregations. The slips seem to be small, and the mineralization is nowhere great. It is extremely doubtful

[1] Garrison, F. L., Mining and Scientific Press., vol. 95, p. 308, 1907.

whether any large, persistent vein exists in so shattered a volcanic rock. Although a considerable amount of copper ore occurs here and although some of it may be of high grade, the existence of enough ore to be profitably worked is doubtful.

ORE DEPOSITS ON SAN FRANCISCO HILL.

The general geology and the character of the mineralization on San Francisco Hill are very similar to that on Búcaro Hill. The accessible openings and outcrops, however, show ore as much as a meter wide along a few of the numerous slips. Sample No. 86 is a channel sample of a meter vein running N. 45° E., and dipping 40° S., and the result of its assay is given in the table on page 241. It is possible that ore running 10 per cent or more can be readily picked from some of these veins, as is reported to have been done. Probably much richer ore than this can be found occasionally in small quantities. Garrison[1] states that on the crest of this hill is the beginning of a mineralized shear zone that extends north-northeast for several miles. According to Garrison the zone is more or less regular, but the mineralization along it is uncertain and discontinuous. During the present investigation, no time was available to trace this zone through the dense vegetation of the hill.

Some of the veins on San Francisco Hill may be large enough and rich enough to be worked profitably on a small scale under favorable conditions, but it is virtually certain that the ore bodies are discontinuous and irregular.

LA RAMA PROSPECT.

The new prospect of Doctor Harootian in the Platanito district differs somewhat from those described above. The most important difference is that the ore contains more gold. Galena occurs in one of the openings here but is not found elsewhere in the district. The specular hematite found at the Búcaro and San Francisco workings was not seen here. The quartz contains a little gold in blebs visible to the eye and some chalcopyrite, pyrite, and galena. Doctor Harootian states that his assays made at Naranja Dulce indicate a value of more than 5 ounces per ton in gold and negligible amounts of silver. Assays, made by Ledoux & Co. (see table on p. 241), of samples collected during this investigation indicate a lower content of gold. As the gold occurs in part in large blebs that are easily visible to the eye, no two small grab samples are likely to agree closely on assay. The gold in the three samples from the principal opening at La Rama varies directly with the copper. On the other hand, sample No. 85, from the dump of one of the other openings at La Rama, is very high in copper and low in gold. The sample carrying lead carries more silver than any of the others.

[1] Garrison, F. L., op. cit., p. 308.

possibilities. The results of the development so far made are sufficiently favorable to warrant further work in order to determine whether the deposit can be profitably worked.

SUMMARY STATEMENT ON ECONOMIC GEOLOGY.

In spite of the numerous concessions granted and the even more numerous rumors of "minas" which are common in almost every part of the Republic, very little actual mining is in progress. The country people call every occurrence of unusual or peculiar rock a "mina," often without themselves supposing that the "mina" has any actual or potential value. The multiplicity of rumors of mineral wealth is in part due to this practice. Many actual deposits of valuable mineral do exist. Intelligently directed exploration backed by sufficient capital may discover valuable deposits or profitably develop those already known. The mining industry of the Dominican Republic has suffered from the operations of many irresponsible promoters. The large scale salting of gold placers, among other things, has done much to weaken the confidence of investors and has caused them to hesitate to put any money into mining enterprises. With the passing of new laws and the enforcing of old ones, the confidence of the investing public should soon be restored.

GOLD.

Large quantities of gold are supposed to have been obtained by the Spaniards from the streams of the Dominican Republic. Ancient pits are reported to be still visible in the mountains near La Vega, near Cotuí, along Rio Jaina, and elsewhere. Gold is reported to exist in the gravels of many streams in the Cordillera Central, and the native women wash out small amounts by hand from the gravel and sand in some places. Several attempts have been made to form companies to finance the working of the placer deposits by modern methods, but none have been successful, and none of these companies are now operating.

Veins carrying gold are reported to exist at several places in the Cordillera Central. None of these is now being developed except one in the Platanito district near San Cristobal, at a prospect on which development has just begun. The copper deposits in the San Cristobal district, which have long been known and intermittently worked, contain gold, but not in large amount, and there is no record of successful vein mining anywhere for gold.

SILVER.

No silver mines are now in operation in Santo Domingo nor is there any available record that any have ever been successfully worked. The veins in the San Cristóbal district and the placer gold doubtless contain some silver.

PLATINUM.

Platinum is reported to have been found in the gravel of Rio Mao, on the northern slope of the Cordillera Central, southwest of Santiago.

NICKEL.

The property known as La Perseverancia, on Sierra Prieta about 30 kilometers north of Santo Domingo City, is being prospected for nickel. This mine has been visited by H. G. Ferguson and D. D. Condit, both of the United States Geological Survey, whose report on it is given on pages 231–236.

COPPER.

The copper deposits of the San Cristóbal district have been worked intermittently for a long time, and some ore has been shipped. An examination of these deposits and of the gold prospect in the same district was made during the present examination of the Republic and a report on them is given on pages 236–242. Copper ore is reported to occur in many other parts of the Republic, but none of it has yet been mined except in the San Cristobal district. The prospect on Loma de la Mina near Hatillo, south of Cotuí, and the indications of copper noted on Loma Miranda, near Bánica, and near Baní are mentioned in the descriptions of those parts of the Republic.

IRON.

No iron mines are in operation in the Dominican Republic, although prospecting for iron ore has been undertaken at several places. The lateritic deposits near Maimón and the magnetite near Hatillo, both in the Cordillera Central south of Cotuí, are described on pages 228–231. The known deposits in these localities are small and are of no commercial value. Deposits of limonite are reported near Paradis and in Sierra de Bahoruco, in the southwestern part of the Republic.

MANGANESE AND LEAD.

Deposits of manganese ore are mentioned in several consular reports as occurring in different parts of the Republic, but none of them are now being mined. There is a deposit in the Province of Seibo, but it was not visited. Specimens of the ore have been examined by D. F. Hewett, of the United States Geological Survey, who states that they show nodules of manganese oxides replacing red tuff and therefore resemble the ores from several districts in eastern Cuba.

Galena in very small quantities is present in some of the ore in the San Cristóbal district.

OIL.

Oil has been found near Azua, in the southwestern part of the Republic, but the quantity so far obtained is small. This area is described in this report by D. D. Condit and C. P. Ross (pp. 223–225), who also consider the possibility of finding oil elsewhere in Santo Domingo. There are rumors of indications of oil in many parts of the Republic, but no such indications were found except near Azua. The oil there has an asphalt base, contains no gasoline, and is unsuitable for refining into the lighter grades of petroleum.

COAL.

Lignite occurs at many places in the Republic. All outcrops seen during the present investigation were small lenses and irregular masses in the Tertiary sedimentary rocks. The age of the rock, where it was possible to determine it, was Miocene, but the lack of suitable fossils made the determination of the age of some of the beds impossible. None of the outcrops seen contained nearly enough lignite to be of any commercial value. Most of the lenses are only a few inches thick and in many the lignite is mixed with clay. Specimens of clean lignite ranging from material which has the appearance of charcoal to hard, dense, black pieces with conchoidal fracture and vitreous luster can be found, but all these specimens are very small. No deposit of coal is known in the Republic, although some of the lignite has been in places so much altered that specimens having the appearance of coal can be obtained from it. The mode of formation of this coal from the lignite is not definitely known.

The lignite or coal does not appear to be mined or used as fuel anywhere in the Republic. The lignitic streaks near Sânchez, Samanâ Peninsula, are of no commercial value.

AMBER.

Pieces of amber have been found in stream gravels on the northwestern border of the Cordillera Central, and there are rumors that some of it was found in place. Very little has been done to work either the gravel or bedrock deposits for amber. In the vicinity of Tamboril, in the Cordillera Septentrional, there are beds of sandy shale containing seams of lignite and lumps of amber. The amber is of good quality, and the natives have for many years shipped small quantities of it from this district, but most of that shipped is obtained from the stream gravels. Exploratory work for amber has been done by an American company,[1] which is reported to have found natural gas in some of the holes.

COMMON SALT.

Common salt (sodium chloride) is obtained in the Dominican Republic both by evaporation from sea water and by mining rock salt deposits. Neither industry is large. The deposits of rock salt in Cerros de Sal northwest of Barahona are described on pages 214–219. There is sufficient local demand for the salt from these deposits to satisfy the present owners. Larger and more efficient production could be made by installing modern methods, but it is doubtful whether the returns would justify the outlay of capital.

GYPSUM.

In the Cerros de Sal, associated with the salt deposits mentioned above, there are thick deposits of gypsum. Plates of almost transparent selenite are abundant, and masses of fine, snowy white alabaster occur in many

[1] Sample, C. C., Engineering and Mining Jour., vol. 80, pp. 250–251, 1905.

unlimited supplies of such material, awaiting only adequate transportation facilities to be utilized. Similar rock has been described in the Sierra de Monte Cristi, at the west end of the Cordillera Septentrional. Some of it occurs near Puerto Plata and doubtless in other parts of the Cordillera Septentrional. Large areas of limestone of this general type are found in the provinces of Barahona and Azua. These areas have been partly mapped on the geologic map of that region. Other sources of concrete material are to be found in the great batholithic masses of granitic and dioritic rocks in the Cordillera Central. Most of these are remote from large towns, but almost every stream that emerges from the Cordillera carries large quantities of these rocks in the form of gravel and boulders. Where such stream gravels are found close to places where concrete is needed they can be crushed so as to produce sharp edges and successfully used. Uncrushed stream gravel is often used in concrete, but the rounded smooth pebbles do not produce so strong a concrete as angular, sharp-edged rock.

ROAD METAL.

The discovery of rock suitable for road metal is one of the great problems before the engineers of the Republic, for the construction of good roads is one of the improvements most needed in the island. After a system of good roads is once established and adequately maintained many of the other desirable improvements in industry and in the condition of the people will naturally follow. The limestone and igneous rock mentioned above as suitable for concrete construction would also make excellent road metal if it could be economically quarried and transported to the places where it is needed. The schistose limestone of Samaná Peninsula and some of the metamorphosed ferromagnesian rocks and of the harder sedimentary rocks of the basal complex might well be utilized as road metal, but most of these are far from the places where roads seem to be most urgently needed, and the soft marly limestone of the coastal plains is therefore extensively used as road metal. It is cheaply and easily obtained and has fairly good binding power, but it is too soft to make really permanent roads. Some of the rocks that would make excellent road metal are not very far from the line of roads now under construction and are quite close to places where roads will eventually have to be constructed. Perhaps some plan by which these rocks could be used might be devised. If quarries were established at suitable places and roads built from the quarries by using the good road metal obtained there many of the difficulties now encountered in road construction would be eliminated. With good material at hand the construction should proceed at a faster rate than at present. The Telford type of road, so extensively used in France, has certain advantages where labor is cheap and the rock is soft and breaks into slabs, and it might be advantageously used in some parts of the Dominican Republic.

Tests of samples of rock and sand-clay were made by the Bureau of Public Roads, United States Department of Agriculture, with the results stated below.

A sample of crystalline limestone found in large quantity at a quarry 14 kilometers from Santo Domingo City, near Los Alcarrizos, Santo Domingo Province, tested for use in water-bound macadam road construction yielded the following results:

Specific gravity	2.29
Weight per cubic foot (pounds)	143
Percentage of water absorbed per cubic foot (5.01 pounds)	3.50
Percentage of wear	24.0
French coefficient of wear	1.7

A specimen of brecciated augite andesite from road cut on Carretera Duarte, about 19 kilometers north of Los Alcarrizos, Santo Domingo Province, tested for road metal, gave the following results:

Specific gravity	2.85
Weight per cubic foot (pounds)	177
Percentage of water absorbed per cubic foot	0.55
Percentage of wear	3.5
French coefficient of wear	11.4
Hardness	18.7
Toughness	11

Mineral analysis of specimen mentioned above.

Essential minerals:
- Plagioclase (silicate of alumina, lime and soda).
- Augite (silicate of lime, magnesia, iron and alumina).
- Rock glass.

Accessory minerals:
- Pyrite (disulphide of iron).

Secondary minerals:
- Calcite (carbonate of lime).

The specimen is not suitable for quantitative microscopic analysis. It is a very dense, fine-grained, gray-black basaltic rock, composed essentially of angular fragments of vitreous basalt firmly embedded in a greenish-gray glass base.

A specimen of crystalline limestone from a large deposit of gravel in the bed of Rio del Rancho Español at the crossing of the Sánchez and Samaná road, Samaná Peninsula and Province, was tested for use in waterbound macadam road construction and concrete mixture with the following results:

Specific gravity	2.74
Weight per cubic foot, in pounds	170
Percentage of water absorbed per cubic foot (pounds)	0.16
Hardness	8.5
Toughness	6

A specimen of tuffaceous limestone from an unlimited source on the south shore of Samaná Bay near Punta de la Boca del Infierno, Samaná Province, was tested for use in waterbound macadam road and concrete construction with the following results:

Specific gravity	3.49
Weight per cubic foot, in pounds	155
Percentage of water absorbed per cubic foot	1.94
Percentage of wear	11.2
French coefficient of wear	3.6

A specimen of sand-clay found in large quantity on the beach 3 kilometers east of Sánchez, Samaná Peninsula and Province, was examined for use in concrete with the results shown below. The sample consisted essentially of angular grains of quartz and kaolinized orthoclase with some ferruginous clay.

Mechanical analysis of sand.	*Per cent.*
Retained on one-fourth-inch screen	0.0
Passing one-fourth inch, retained on 10-inch mesh	0.5
Passing 10, retained on 20-inch mesh	0.5
Passing 20, retained on 30-inch mesh	3.0
Passing 30, retained on 40-inch mesh	11.0
Passing 40, retained on 50-inch mesh	17.0
Passing 50, retained on 80-inch mesh	36.5
Passing 80, retained on 100-inch mesh	7.0
Passing 100, retained on 200-inch mesh	0.5
Passing 200	24.0
	100.0

Loss by washing (silt and clay) 12.5 per cent.

The value of the sand for use in cement was compared with that of standard Ottawa sand by tests of the tensile strength of three specimens of cement-sand briquets made of each of these two sands. The briquets consisted of three parts of sand and 1 part of cement and weighed less than 10 pounds each. They were tested 28 days after manufacture, with the following results:

Tensile strength, in pounds, per square inch of sample briquets.

Sample.	Standard Ottawa sand.	Sánchez sand.
1	345	225
2	333	210
3	328	225

Ratio of strength of Sánchez sand to Ottawa sand, 65.7 per cent.

Classification.

Quality for boiler use	Poor.
Quality for domestic use	Poor.
Quality for irrigation	Good.
Chemical character	$CaCO_3$
Mineral content	Moderate.

Mineral analysis and classification of surface water from Arroyo la Sulsa, 14 kilometers north of Santo Domingo City.

[Sample collected by C. P. Ross April 7, 1919. Analyst, Addie T. Geiger.]

Constituents.	Parts per million.
Silica (SiO_2)	31
Iron (Fe)	.31
Calcium (Ca)	121
Magnesium (Mg)	12
Sodium and potassium (Na+K), calculated	14
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	428
Sulphate radicle (SO_4)	9.9
Chloride radicle (Cl)	14
Nitrate radicle (NO_3)	Tr.
Total dissolved solids	410
Organic matter	4.8

Classification.

Quality for boiler use	Poor.
Quality for domestic use	Poor.
Quality for irrigation	Good.
Chemical character	$CaCO_3$
Mineral content	Moderate.

Mineral analysis and classification of water from dug well of Gregorio Valois, 13 kilometers north of Santo Domingo City.

Well 30 meters deep; altitude of mouth about 72 meters. Sample collected by C. P. Ross April 7, 1919. Analyst, Addie T. Geiger.]

Constituents.	Parts per million.
Silica (SiO_2)	38
Iron (Fe)	.34
Calcium (Ca)	91
Magnesium (Mg)	28
Sodium and potassium (Na+K), calculated	29
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	446
Sulphate radicle (SO_4)	11
Chloride radicle (Cl)	19
Nitrate radicle (NO_3)	1.4
Total dissolved solids	426
Organic matter	6.0

Classification.

Quality for boiler use	Poor.
Quality for domestic use	Poor.
Quality for irrigation	Good.
Chemical character	$CaCO_3$.
Mineral content	Moderate.

Mineral analysis and classification of water from dug well of Ibarra & Gosling, 4 kilometers north of Santo Domingo City.

[Well 40 meters deep; altitude of mouth about 60 meters. Sample collected by C. P. Ross April 7, 1919. Analyst, Addie T. Geiger.]

Constituents.	Parts per million.
Silica (SiO_2)	14
Iron (Fe)	.42
Calcium (Ca)	108
Magnesium (Mg)	34
Sodium and potassium (Na+K), calculated	126
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	352
Sulphate radicle (SO_4)	47
Chloride radicle (Cl)	233
Nitrate radicle (NO_3)	19
Total dissolved solids	758
Organic matter	18
Classification.	
Quality for boiler use	Bad.
Quality for domestic use	Poor.
Quality for irrigation	Fair.
Chemical character	NaCl.
Mineral content	High.

Mineral analysis and classification of water from Bombita Spring, on bank of Rio Isabela about 3 kilometers west of north of Santo Domingo City.

[Sample collected by C. P. Ross April 7, 1919. Analyst, Addie T. Geiger.]

Constituents.	Parts per million.
Silica (SiO_2)	20.
Iron (Fe)	.41
Calcium (Ca)	118
Magnesium (Mg)	.42
Sodium and potassium (Na+K)	308
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	338
Sulphate radicle (SO_4)	98
Chloride radicle (Cl)	504
Nitrate radicle (NO_3)	8.7
Total dissolved solids	1273
Organic matter	67
Classification.	
Quality for boiler use	Very bad.
Quality for domestic use	Poor.
Quality for irrigation	Poor.
Mineral content	High.
Chemical character	NaCl.

Mineral analysis and classification of water from dug well of Ibarra & Gosling, 3 kilometers from Santo Domingo City, on Santa Cruz road.

[Well 56 meters deep; altitude of mouth about 36 meters. Sample collected by C. P. Ross April 7, 1919 Analyst, M. D. Foster.]

Constituents.	Parts per million.
Silica (SiO_2)	12
Iron (Fe)	.35
Calcium (Ca)	119
Magnesium (Mg)	9.3
Sodium and potassium (Na+K)	17
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	328
Sulphate radicle (SO_4)	32
Chloride radicle (Cl)	48
Nitrate radicle (NO_3)	7.2
Total dissolved solids	434
Organic matter	13
Classification.	
Quality for boiler use	Poor
Quality for domestic use	Poor.
Quality for irrigation	Good.
Chemical character	$CaCO_3$.
Mineral content	Moderate.

The water supplies of the Monte Cristi district are discussed by C. P. Ross on pages 177–180. Water can certainly be obtained from wells there, and in favorable situations artesian flows may be possible, but some of the water may be rather strongly mineralized.

In the parts of the Samaná Peninsula that were examined the conditions are favorable for obtaining only small quantities of water from wells. Analyses of some waters on the peninsula are appended.

Mineral analysis and classification of water from spring just below head of Arroyo Salado, Samaná Peninsula, Samaná Province.

[Sample collected by C. P. Ross June 30, 1919. Analyst, M. D. Foster.]

Constituents.	Parts per million.
Silica (SiO_2)	13
Iron (Fe)	.13
Calcium (Ca)	94
Magnesium (Mg)	20
Sodium and potassium (Na+K), calculated	235
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	298
Sulphate radicle (SO_4)	40
Chloride radicle (Cl)	370
Nitrate radicle (NO_3)	.61
Organic matter	14
Total dissolved solids	957
Classification.	
Quality for boiler use	Fair.
Quality for domestic use	Fair.
Quality for irrigation	Good.
Chemical character	$CaCO_3$.
Mineral content	Moderate.

Mineral analysis and classification of water from Rio de los Cocos, Campo Arenoso Samaná, Samaná Peninsula, Samaná Province.

[Sample collected by C. P. Ross June 25, 1919. Analyst, M. D. Foster.]

Constituents.	Parts per million.
Silica (SiO_2)	17
Iron (Fe)	1.1
Calcium (Ca)	64
Magnesium (Mg)	6.0
Sodium and potassium (Na+K), calculated	8.9
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	214
Sulphate radicle (SO_4)	6.7
Chloride radicle (Cl)	15
Nitrate radicle (NO_3)	Trace.
Organic matter	4.2
Total dissolved solids	242
Classification.	
Quality for boiler use	Poor.
Quality for domestic use	Good.
Quality for irrigation	Good.
Chemical character	$CaCO_3$.
Mineral content	Moderate.

Mineral analysis and classification of water of Rio San Juan at mouth of Arroyo Santa María Luisa, Samaná Peninsula, Samaná Province.

[Sample collected by C. P. Ross June 24, 1919. Analyst, M. D. Foster.]

Constituents.	Parts per million.
Silica (SiO_2)	39
Iron (Fe)	.42
Calcium (Ca)	58
Magnesium (Mg)	11
Sodium and potassium (Na+K), calculated	13
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	224
Sulphate radicle (SO_4)	9.0
Chloride radicle (Cl)	16
Nitrate radicle (NO_3)	2.3
Organic matter	3.6
Total dissolved solids	264
Classification.	
Quality for boiler use	Poor.
Quality for domestic use	Good.
Quality for irrigation	Good.
Chemical character	$CaCO_3$.
Mineral content	Moderate.

At many places in the Ciboa Valley ground water could be used to a much greater extent than it is now. In this valley very few wells are in use, but water can be obtained at moderate depths nearly everywhere in it. The outwash deposits from the mountains on both sides of the valley contain gravel beds which should be excellent reservoirs for ground water. The outwash deposits on the north slope of the Cordillera Septentrional have in places a distinct slope valleyward. Suitable locations for artesian wells might possibly be found here. In the vicinity of Azua there are artesian wells of considerable flow.

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