THE GEOGRAPHY OF CUBA.

BY

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During the spring of 1901, Dr. C. Willard Hayes was detailed by the Director of the U. S. Geological Survey to take charge of the work of making a geological reconnaissance of Cuba, in compliance with a request made by Brigadier-General Leonard Wood, Military Governor of the Island, and the authors of this paper were assigned as his assistants. Mr. Vaughan accompanied Dr. Hayes from Washington, and together they visited the Isle of Pines, made an excursion in the vicinity of Matanzas, went with pack-train from Matanzas to Cárdenas, and made a trip into the Province of Pinar del Río, going from Havana to the City of Pinar del Río, and thence northward to Viñales, in the Organos Mountains. Upon their return to Havana they found Dr. Spencer awaiting them. On April 11th he and Dr. Hayes went by rail to Cienfuegos, and thence by steamer to Santiago. Dr. Hayes remained in the Province of Santiago until April 25th, when he took a steamer for New York. Dr. Spencer continued work in that Province until June 8th. Mr. Vaughan went on April 11th from Havana to the City of Santa Clara, and spent between two and three weeks in Santa Clara Province. On May 4th he arrived in Manzanillo, in the southwestern portion of the Province of Santiago, and joined Dr. Spencer at Santiago near the end of the month. On June 8th Dr. Spencer and Mr. Vaughan left Santiago by the Havana steamer. A stop of a few hours was made at Baracoa, whence Mr. Vaughan continued on to Havana, while Dr. Spencer made an excursion in the vicinity of Holguín, and later visited Nuevitas and Puerto Principe.

Acknowledgments are due to Dr. Hayes for the contribution of his observations and for valuable suggestions in the interpretation of the natural features of the island.

The following paper is mostly taken from that portion of the report on the Geology of Cuba treating of the geography and topography of the island, portions being rewritten, others re-edited, so as to make the material suitable for publication in this journal.

One contemplating undertaking geologic or geographic work in
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Cuba meets discouragement at the outset, as there is no good map of the island. The best is the eight-sheet map published by the Adjutant-General's Office of the U. S. Army. It is a compilation from various sources, and is extremely inaccurate. The most prominent topographic features are indicated in the roughest manner. Topographic data concerning the island are in general very meagre and are scattered through numerous works, those of La Sagra, Rodriguez-Ferrer, Hill, etc.; and, as careful instrumental surveys have never been made, the information given by these authors is only approximately correct. The coast charts are very unreliable. Often a shoal may exist where moderately deep water is indicated, or the reverse may be true. There is, commercially, an imperative need for careful mapping of the Cuban coast. Under these circumstances no adequate description of the geography of the island is possible, and only an outline will be attempted here.

Although many geologists have visited Cuba, and they have produced an enormous literature, we really know very little of the geology of the island. Our ignorance of the geology prevents us from understanding the origin of much of the present topography, since topography is to so great a degree dependent upon geologic structure and rock character.

The following general remarks concerning size and location may be made:

The island of Cuba extends in longitude from 74° W. to 84° 59' W., and in latitude from 19° 49' N. to 23° 15' N. If Salt Key is included, the coast of the island reaches to 23° 43'. Its length from Cabo Maisi to Cabo San Antonio, measured along the curved axis of the island, is given by Hill as 730 miles, while its width varies from about 90 miles in the widest portion of Santiago Province to about 20 miles across the Province of Pinar del Rio, south of Mariel. The area of the island, exclusive of the outlying islands and keys, is estimated at from 40,000 to 43,000 square miles, while the Isle of Pines is given an area of 1,214 square miles, and the remaining islands and keys are calculated at 1,358 square miles, making the total area of Cuba between 42,500 and 45,500 square miles. The French geographer Reclus gives the area as 45,883 square miles, the Century Atlas as 41,655 square miles, but it is not stated in the latter whether the outlying islands and keys are included.

The surface of Cuba may be divided into five topographic provinces, three of which are essentially mountainous, while the two others are of low or moderate relief. The easternmost of these
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topographic divisions coincides approximately with the Province of Santiago, and is for the greater part mountainous. The second, corresponding closely with the Province of Puerto Principe, is made up of plains or rolling open country, broken by occasional hills or low mountains rising above the general level. The third division includes the mountainous and hilly portions of Santa Clara; the fourth comprises the western portion of Santa Clara Province, all of Matanzas and Habana Provinces, and the eastern portion of the Province of Pinar del Rio. This low region, like that of Puerto Principe, is made up of flat or rolling plains, broken by occasional hills several hundred feet in height. The fifth topographic division, comprising the greater portion of Pinar del Rio, is characterized by a prominent range of mountains with its outlying hills and mesas.

The above description of the general topographic features, calling attention to the distribution of mountainous areas at both extremities and in the central portion of the island, classifies the various topographic divisions in a striking and natural way; but since the low regions extend back into the mountainous areas in the interior, and are continued in the form of coastal platforms around the bases of the mountains, the features of the plains cannot strictly be said to be confined to any of the divisions distinguished. It is therefore more convenient to describe the topography of the island without particular regard to the natural topographic divisions.

MOUNTAINS.

Province of Santiago.—The highest mountains in Cuba are situated in the Province of Santiago, where they reach elevations higher than any in the eastern ranges of the United States, and are only slightly lower than the highest peaks in Jamaica and Haiti. The mountainous area in this province is greater than the combined mountainous area of all the other provinces of the island. Its mountains occur in several groups, composed of different kinds of rocks and having diverse structures, but all are more or less closely connected one with another.

The principal range is the Sierra Maestra, extending from Cabo Cruz to the vicinity of the Puerto de Guantánamo, 40 miles east of Santiago Bay. This range is continuous and of fairly uniform altitude, with the exception of a single break in the vicinity of Santiago, where the wide basin which is now partly occupied by Santiago Bay cuts entirely across the main trend of the range.
The hills back of Santiago Bay, separating this basin from the drainage of the Rio Cauto, correspond in structure to the northern foothills of the main Sierra east and west of this break. The slopes of the Sierra Maestra are very uniform throughout, being broken only by the cuttings of the evenly-spaced arroyos. In the western part of the range the mountains rise abruptly from the depths of the Caribbean Sea, but in the vicinity of the City of Santiago and to the eastward they are separated from the sea by a narrow coastal plain which has been locally very much dissected. The streams which traverse it occupy valleys several hundred feet in depth, while the remnants of the plain appear in the tops of the hills.

East of Guantánamo estuary there are mountains which are structurally distinct from the Sierra Maestra, and these continue to Cabo Maisí. They rise at first abruptly from the sea, but toward the eastern extremity of the island are bordered by terraced foothills. Toward the north they are continued across the island as features of bold relief connecting with the rugged Cuchillas at Baracoa and with El Yunque, which lies to the southwest of that town. Extending westward from this eastern mass there are high plateaux and mesas, forming the northern side of the great amphitheatre which drains into Guantánamo Bay.

The most prominent feature of the northern mountains of Santiago Province to the west of El Yunque is the range of mountains comprising the Sierras Cristal and Nipe. This range extends in a general east and west direction, but is separated into several distinct masses by the northward-flowing streams, such as Rio Sagua and Rio Mayarí. The high country to the south of these mountains has the character of a deeply-dissected plateau, the highest strata being massive limestone. It is supposed that all of the mountains in the eastern part of Cuba have been carved from a high plateau, indications of which are seen in the level summits of El Yunque, near Baracoa, and of other flat-topped mountains which have been observed within the drainage of the Mayarí and Sagua rivers. The broad flat summits of the Sierra Nipe are also doubtless a remnant of this old plateau.

Below this highest level several others are distinguishable as benches or broad plateaux. The two most prominent occur respectively at about 1,500 and 2,000 feet above sea-level, according to barometer readings. The highest summits rise perhaps 800 or 1,000 feet higher. The 2,000-foot plateau forms in the Sierra Nipe alone an area estimated to be not less than 40 square miles in extent.
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Considering the Province of Santiago as a whole, therefore, the various mountain groups described above form two marginal ranges, which merge in the eastern portion of the Province and diverge toward the west. The southern range is the more continuous, while the northern is composed of irregular groups separated by numerous river valleys. Between these divergent ranges is a broad, undulating plain, the famous Cauto valley, which increases in breadth westward, and opens out toward the northern coast beyond the mountain groups of the northern range. Further westward it merges with the extensive plains of Puerto Principe.

Province of Santa Clara.—The central mountainous region is situated in the Province of Santa Clara. The island is here crossed by a belt of mountains and hills, approximately bounded by northeast-southwest lines passing through the cities of Sancti Spiritus and Santa Clara. Four groups may be distinguished. One of these lies southwest of Sancti Spiritus, west of the railroad from Tunas de Zaza to Sancti Spiritus and east of the Rio Agabama or Manatí. It is a group of ridges radiating from a short axis having a direction from slightly east of north to south of west. A second group is included between the valleys of the Rio Arimao and Rio Agabama. Its highest peak, which is the highest in the central region, is Pico Potrerillo, 2,900 feet in altitude, located seven miles north of Trinidad. The mountains and hills of this group extend northward as far as Manicaragua. A third group, lying to the east and south of the city of Santa Clara, includes the Sierra del Escambray, and the Sierra Alta de Agabama. The rounded hills of this region reach an altitude of about 1,000 feet, although a few of its summits may be higher. The last of the four groups consists of a line of hills beginning at a point on the north coast about 25 miles east of Sagua la Grande and extending subparallel to the northern shore of the island into the Province of Puerto Principe. The trend of this range of hills is therefore transverse to the central mountain zone as a whole, but it conforms in direction with the geologic structure of the region. To the east of the city of Santa Clara the hills of the fourth group merge with those in the central portion of the province. The summits in the northern line of hills are not very high, and it is probable that there is none above 1,000 feet in altitude. The principal members of the group are the Sierra Morena west of Sagua la Grande, the Lomas de Santa Fé near Camajuani, the Sierra de Bamburanao near Yaguajay, and Lomas de Sabanas Nuevas south of the last-mentioned town.
PROVINCE OF PINAR DEL RIO.—The Province of Pinar del Rio, which is the westernmost political division of the island, is dominated by the Sierra de los Organos. The main sierra of this range lies just back from the north coast and extends from Mariel westward to the Ensenada Guadiana. West of this bay a line of lower mountains or hills forms the axis of the peninsula to Cabo San Antonio, the western extremity of the island. The sierra is flanked by spurs and more or less isolated foothills and buttes. Southwest of Bahia Honda is the highest peak of the range, the Pan de Guajaibón, whose altitude has been variously estimated to be from 1,920 to 2,560 feet. The former figures are probably more nearly correct. Between the city of Pinar del Rio and Viñales the range is broken up into three parallel ridges, the northernmost of which is composed of limestone, the two others being composed of slates, schists, and limestones.

SUBORDINATE MOUNTAINS AND HILLS.—The three mountain groups described above dominate the topography of the island; but in addition to these highlands there are other less prominent groups of mountains and hills rising above the generally level surfaces in the provinces of Habana, Matanzas, and Puerto Principe. These eminences of lower altitude are confined largely to the northern margin of the island, extending with frequent broad intervals of level plain from Habana eastward to Santiago Province.

A few hills rise from the level plain in the western part of Habana Province. These are the extreme eastern outliers of the Organos Range of Pinar del Rio. Other hills lie east and southeast of Habana, being closely connected with a large group northwest of Matanzas, which contains one prominent point, the Pan de Matanzas, reaching an altitude of about 1,300 feet. Some hills occur also between Matanzas and Cárdenas, and at intervals throughout the northern portion of the Province of Santa Clara. In general, these isolated hills or groups have rounded summits, but their lower slopes are frequently very steep, rising abruptly from the surrounding level plains.

The greater part of Puerto Principe is free from hills, the most prominent elevations being in the northeastern portion, where the Sierra de Cubitas contains a few points above 1,000 feet in altitude. To the eastward of this range numerous isolated elevations extend into Santiago, finally merging with the northerly range of that province.
Aside from the mountains and hills above described, the general surface of Cuba is that of a rather low, gently undulating plain.

In Pinar del Rio a piedmont plain entirely surrounds the Organos mountain range. On the south it has a maximum breadth of 20 miles, and ascends gradually from sea-level to the base of the mountains at the rate of 7 or 8 feet to the mile. Its seaward portion is extremely flat, but as the highland is approached it becomes more undulating and somewhat deeply dissected by stream channels. North of the mountain range the lowland belt is much narrower and also somewhat higher. It does not have a regular slope to sea-level, but is at least 200 feet high near the coast. It is deeply dissected, so that in places only the level hilltops mark the position of the plain.

The northern and southern piedmont plains of Pinar del Rio unite at the eastern extremity of the Organos Range and extend eastward over the greater part of Habana and Matanzas provinces and the western part of Santa Clara. Although the divide between northward and southward flowing streams is approximately on the axis of the island, the plain has a gradual southward slope from near the northern margin. In the vicinity of Havana its elevation is between 300 and 400 feet, and eastward to Cárdenas, wherever it can be recognized, it varies between those limits; that is to say, the northern edge of the island appears to have been elevated about 350 feet more than the southern edge. The northward-flowing streams have lowered their channels as the land rose, and the portion of the plain which they drain has thus been so deeply dissected that in many places only the level hilltops attest its former extent. The southward-flowing streams, on the other hand, have been scarcely at all affected by the elevation, and remain generally in very shallow channels. Eastward from Cárdenas the general elevation of the plain is less, and it slopes gradually both north and south from the axis of the island. Considerable areas of the plain are developed among the various mountain groups which occupy the eastern half of Santa Clara Province, and beyond these mountains it extends eastward over the greater part of Puerto Príncipe and into Santiago. In this province it reaches the northern coast between isolated mountain groups as far east as Nipe Bay, and to the southward merges with the Cauto Valley. From Cabo de Cruz the plain extends along the northern base of the Sierra Maestra to the head of the Cauto Valley. Its elevation near Manzanillo is about 200 feet, and it increases to about 630 feet at El
Cristo. In the central part of Santiago Province the Rio Cauto and its tributaries have cut channels in the plain from 50 to 200 feet in depth. In the lower part of the valley these channels are sometimes several miles across, and are occupied by alluvial plains. They decrease in width toward the east, and in the upper part of the valley they are narrow gorges.

Much of this plain, particularly in the central provinces, is underlain by porous limestone, through which surface waters readily find underground passages. Hence over large areas flowing surface streams are entirely absent. The rain-water sinks below the surface of the ground as soon as it falls, and, after flowing long distances in subterranean channels, often emerges in bold springs, such as those which form the Almendares River, in the vicinity of Havana.

The surface of the plain over large areas is covered by deep, residual clays, derived from the slow wasting of the underlying limestone, and forming both red and black soils of great fertility. The soils of the vast sugar plantations of the provinces of Habana, Matanzas, and Santa Clara are mostly red soils of this nature. Certain portions of the plain, such as that bordering the mountains of Pinar del Rio on the south, are covered with a layer of sand and gravel derived from the adjoining highlands, and their fertility is greatly inferior to the soil derived from the limestone. Similar superficial deposits occur in the vicinity of Cienfuegos, and doubtless in many other portions of the island where the plain forms a piedmont adjacent to highlands in which silicious rocks occur.

**TERRACES.**

Terraces form an extremely characteristic feature of a large portion of the Cuban coast. They occur along the whole of the north coast and along the south coast in Santiago Province, but west of Manzanillo, along the south coast, they are inconspicuous or are entirely absent. These terraces give very important data regarding the geographic and geologic development of the island; but no detailed description of them will be attempted here.

Westward of Havana the conditions for the preservation of the terraces have not been good. However, in the vicinity of Mariel remnants of a raised coral reef at an elevation of about 150 feet have been observed, and a lower, much more recent, terrace, about 5 feet above tide, is of general occurrence. Four terraces may be recognized at Havana at 200, 100, 10-15, and 4-5 feet. The highest level is underlain by an elevated coral reef, containing Upper Oligocene fossil corals. The lowest terrace, wherever observed, contains
species of living reef corals. At least six terraces, and probably more, can be recognized at Matanzas. The highest stands about 400 feet above sea-level. A level at 200 feet is very extensively developed, its area being miles in extent.

Along the south coast there are at Manzanillo at least three levels at 200, 100, and 5–20 feet. At Santiago there are eight, the highest being about 400 feet in elevation. Dr. Hayes distinguished at least seven levels at Cabo Maisí, three being more prominent than the others; the distance in elevation between the highest and lowest was estimated at 600 feet. These facts show a divergence in elevation of the terraces as one goes eastward, indicating greater elevation of the eastern end of the island.

Since numerous writers have spoken as if the high terraces at different localities along the Cuban coast were formed of Pleistocene or modern reef corals, we desire to state that at no point sufficiently studied by us did Pleistocene reefs occur at elevations exceeding 30 feet or 35 feet. The fossils in the higher terraces are Upper Oligocene, as fairly large collections made at Santiago and smaller collections made at other localities show. At Santiago the lowest terrace alone contains Pleistocene corals, and this rises only a few feet above the level of the sea. The higher benches are thought to be terraces cut in the Tertiary and older rocks of which the island is composed.*

DRAINAGE.

The arrangement of the streams in the greater part of Cuba is extremely simple. Excepting in the southwestern portion of Santiago Province the stream courses are practically all normal to the coast. Owing to the shape of the island, therefore, none of its streams have any considerable length or volume; they are, however, very numerous, and nearly 200 enter the sea.

The divide between the northward and southward flowing streams follows near the axis of the island, but is generally somewhat nearer the north coast. In Pinar del Rio the divide is formed by the crest of the Organos Range. Wherever this range is composite the divide is generally upon the southern crest—that is, the northern portion of the range has been more deeply eroded and the divide has been pushed to the southward of its axis. Throughout the four central provinces the divide is, for the most part, extremely indefinite, being simply a level plain, on which there is no sharp water-parting.

* Drs. Hayes and Spencer saw eastward of Santiago, over the older formations, a veneer of limestone, which they consider of possible Pleistocene age.
Owing to the southward tilting of the plain the northward-flowing streams occupy deeper channels than those flowing to the southern coast. In general, the drainage of this central portion of the island may be described as autogenous—that is, the stream courses are such as would be formed on a gently undulating plain recently raised above sea-level. No considerable subsequent adjustments are observed in the main streams, although some of the upper stream courses are closely adjusted to structure. This is particularly noticeable in the central part of Santa Clara Province, where the streams occupy the outcrops of certain soft beds between harder strata on the sides of synclinal folds. A similar adjustment upon the sides of an anti-clinal fold is seen in the Yumuri Valley, near Matanzas.

The drainage of Santiago Province affords some exception to the normal arrangement elsewhere observed. The Cauto River flows through the centre of the province in a broad westward pitching syncline. It is, therefore, a consequent stream, its position being determined by the structure of the underlying strata. Its northern tributaries head upon a low divide similar to that throughout the central provinces, but its southern tributaries head upon the northern slopes of the Sierra Maestra and flow northward directly away from the coast. To the eastward of Santiago City the streams have courses normal to the coast, although there is little regularity of arrangement, owing to the mountainous character of this region. Many of the rivers flow outward from the centre of a syncline and cut directly across the edges of upturned strata. These are doubtless antecedent streams, and it is only in their upper courses that adjustment to structure is to be expected.

HARBOURS.

Cuba is noted for its splendid harbours, and nearly every author who has written on the physical aspects of the island has devoted considerable space to their description. The best harbours, excepting that of Matanzas, are pouch-shaped, possessing a narrow entrance separating a large, nearly circumscribed inland body of water from the sea. The harbours of Havana, Cienfuegos, and Santiago are the most important, and all belong to the same type.

The entrance to the harbour of Havana, between the Morro and Castillo de la Punta, is very narrow. The harbour itself is dumb-bell-shaped, arroyos that empty into it determining its outline. The Morro and Fort Cabañas are situated on the northeastern side; Regla, with its warehouses and wharves, is on a projection on the
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eastern side; the southern end is shallow, having been filled by sediment brought down by several streams. The city of Havana is situated on the western side, extending south from the Castillo de la Punta to the southern end of the harbour. The water in its channel and central portions is deep enough for the deepest-draught vessels, but only shallow-draught vessels can be accommodated at the docks.

Careful borings which have been made across the entrance to the harbour by the Military Government, in connection with the preparations of plans for a sewerage system, point to the existence of an old channel in the middle of the present channel. This is now filled with sand, but it certainly at one time afforded a free outlet to the sea at a level considerably below the present bottom of the harbour.

Other important harbours on the northern coast are Bahia Honda, Cabañas, and Mariel, in the Province of Pinar del Rio; Matanzas and Cárdenas, in the Province of Matanzas; Nuevitas, in the Province of Puerto Principe; Gibara, Bahia de Nipe, and Baracoa, in the Province of Santiago. All of these are pouch-shaped excepting that of Matanzas, which has a broad entrance.

Good harbours are not so abundant on the south coast as on the north. The most easterly one is that of Guantánamo. It is a fairly good pouch-shaped harbour but rather shallow. The next one toward the west is at Santiago, which is one of the finest in the world. There is no noticeable indentation of the coast-line excepting immediately in front of the entrance, which is only 180 yards across and is cut in a steep seaward escarpment over 250 feet in height. On the eastern side of the entrance is the Morro, its lighthouse rising 310 feet above sea-level, or about 40 feet above the point of land on which the fort stands. On the western side of the channel the sea scarp is less abrupt and regular, the land rising from the sea in series of low hills. The island Cayo Smith lies just within the harbour, to the west of the main channel. On the eastern side are precipitous cliffs rising to a height of 200 or more feet. Cayo Smith and the high land on each side of the sinuous entrance completely conceal the broad expanse of the harbour proper from the sea. North of Fort Socapa, now in ruins, on the eastern side of the harbour, is the narrow entrance to Nispero Bay, a beautiful land-locked harbour deep enough to accommodate the largest man-of-war, and in which the Military Government has built a dock. The depth of water in the channel and in the greater part of Santiago harbour is sufficient for the largest vessels, but only light-draught vessels can come up to the docks. On the northern and northeastern sides of
the harbour the land rises less abruptly than on the eastern side, and there is a succession of terraces from sea-level to an elevation of 200 feet. It is upon these terraces that the city of Santiago is built.

The harbour of Cienfuegos is very similar to that of Santiago, except that the land on each side of the entrance is not so high.

Other harbours on the south coast, as Manzanillo and Batabanó, are merely open roadsteads, generally shallow and more or less perfectly protected by the numerous sand keys which abound along the coast from Cabo Cruz to the western end of the island.

Various explanations of the pouch-shaped Cuban harbours have been made by several writers. These need not be given here; but the explanation which appears to us most satisfactory may be briefly stated.

The depressions occupied by the water of these harbours appear to be due entirely to erosion by streams flowing into the sea during a very late geologic period, when the land stood somewhat higher than now. In other words, they are drowned drainage basins. Their peculiar shape, a narrow seaward channel and a broad landward expansion, is due to the relation of hard and soft rocks which generally prevail along the coast. Wherever the conditions are favourable for the growth of corals a fringing reef is built upon whatever rocks happen to be at sea-level, and as the land rises or sinks this reef rock forms a veneer of varying thickness upon the seaward land surface. The rocks on which this veneer rests are generally limestones and marls, much softer and more easily eroded than the coral rock. Hence several small streams, instead of each flowing directly to the sea by its own channel, are diverted to a single narrow channel through the hard coral rock, while they excavate a basin of greater or less extent in the softer rocks back from the coast.

The fact that the land has recently stood at a sufficiently higher level to enable the streams to excavate such basins is proved by the sand-filled channel in the Havana harbour entrance and by borings made near the mouth of Rio San Juan at Santiago. Doubtless similar-filled channels would be discovered in the other harbours of this class if they were explored by boring.

It is interesting to note that at various points along the Cuban coast precisely similar basins are now being excavated which would form pouch-shaped harbours if the land should be slightly depressed. Several of these were observed eastward from Santiago. If the coast at Matanzas were to sink thirty feet or more a portion of the Yumurí valley would be flooded, forming a broad land-locked basin connected with the sea by a very narrow channel in the present Yumurí gorge.