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PREPARED IN COOPERATION WITH
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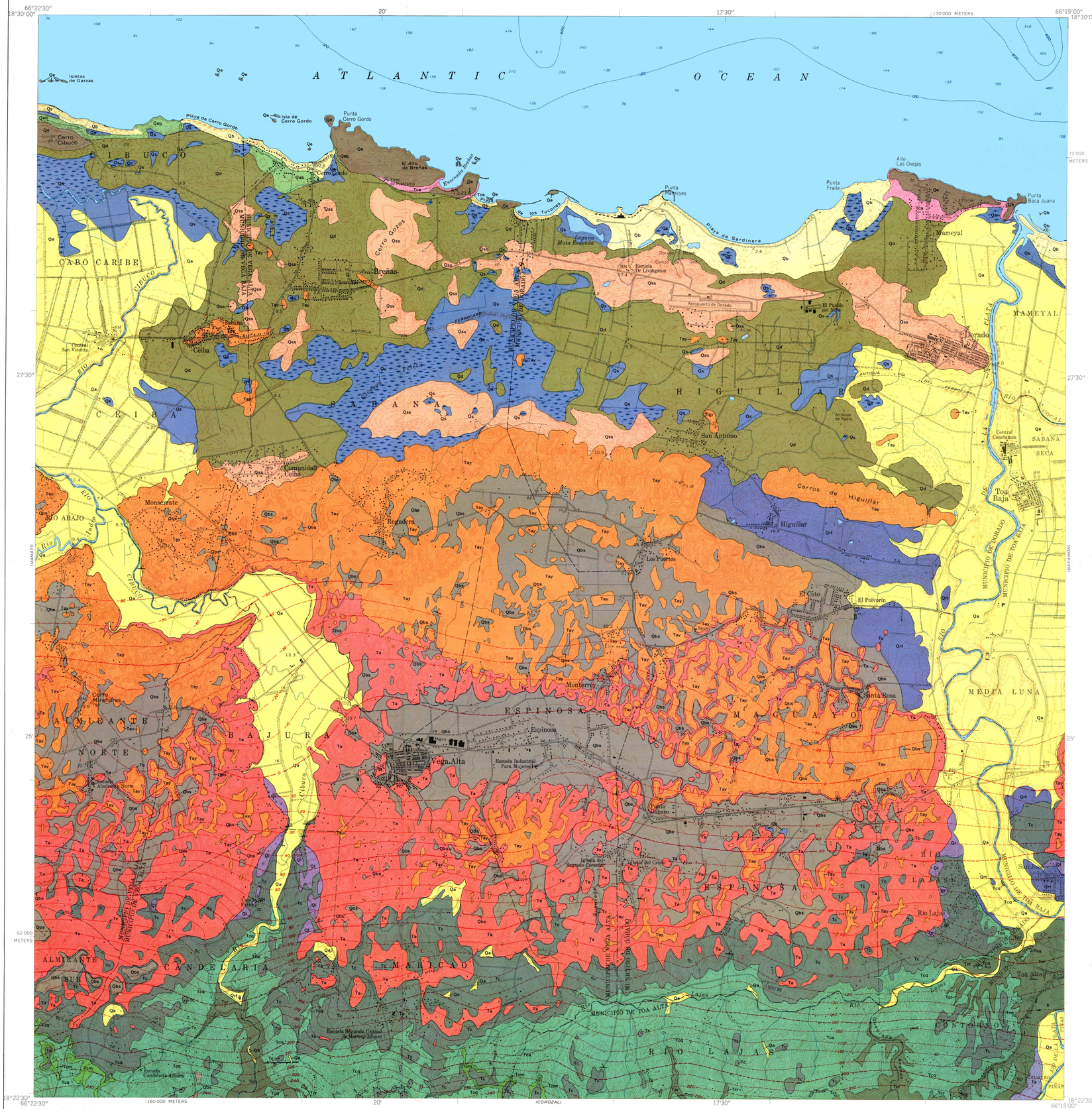
ECONOMIC DEVELOPMENT ADMINISTRATION
INDUSTRIAL RESEARCH DEPARTMENT

GEOLOGY OF THE
VEGA ALTA QUADRANGLE
PUERTO RICO
GQ–191



EXPLANATION

- Qb — Beach deposits. *Triangles show areas of beach rock*
- Qs — Swamp deposits
- Qa — Alluvium
- Ql — Landslides
- Qss — Silica sand
- Qbs — Blanket sand deposits
- Qe — Eolianite
- Qab — Ancient beach deposits. *Triangles show areas of ancient beach rock*
- Qd — Ancient deltaic and mud flat deposits
- Qrt — River terrace deposits

Recent / Pleistocene — QUATERNARY

UNCONFORMITY

- Tca — Camuy(?) Formation
- Tay — Aymamón Limestone
- Ta — Aguada Limestone
- Tc / Tcm / Tcq / Tcr — Cibao Formation
  - Tc, *Upper member*
  - Tcm, *Miranda Sand Member*
  - Tcq, *Quebrada Arenas Limestone Member*
  - Tcr, *Rio Indio Limestone Member*
- Ts — San Sebastián Formation

Miocene / Oligocene — TERTIARY

- Geologic contact. *Dashed where approximately located; short dashes where gradational or indefinite*
- Lateral gradation between two units
- Fault. *Dashed where approximately located*
- Strike and dip of beds
- Structure contours. *Drawn on top of Cibao Formation. Dashed where approximately located; short dashes where datum is above ground surface. Contour interval 10 meters, datum mean sea level*

The Vega Alta quadrangle is on the northern coast of Puerto Rico; the eastern edge of the area is about 15 kilometers west of San Juan, the capital city. All rocks exposed in the quadrangle are of sedimentary origin and range in age from late Oligocene to Recent.

TERTIARY SYSTEM
OLIGOCENE SERIES

San Sebastián Formation

The San Sebastián Formation, the oldest Oligocene formation present in northern Puerto Rico, crops out only near the southeast corner of the Vega Alta quadrangle. It consists of about 70 meters of sandy clay interbedded with slightly glauconitic calcareous clay that contains a few fossils. The upper 20 meters consists of friable fine-grained calcareous sandstone, locally glauconitic. In the adjacent Corozal quadrangle the San Sebastián is overlain by the Lares Limestone, which grades laterally eastward into material that is indistinguishable from the San Sebastián. Thus in the Vega Alta quadrangle it is entirely likely that the rocks mapped as San Sebastián are equivalent in age to the Lares Limestone farther west. The San Sebastián Formation is overlain conformably in the Vega Alta quadrangle by the Cibao Formation.

OLIGOCENE AND MIOCENE SERIES

Cibao Formation

The Cibao Formation is divided into four members in the Vega Alta quadrangle: the Rio Indio Limestone Member, the Quebrada Arenas Limestone Member, the Miranda Sand Member, and an upper unnamed member of calcareous clay-stone and chalk typical of the Cibao. The Cibao is about 200 meters thick in the western part of the quadrangle, but thins to about 135 meters at the eastern edge.

Fossils collected by C. Wythe Cooke (written communication, June 21, 1956) from the Rio Indio Limestone Member include *Lepidocyclina gigas* Cushman and other upper Oligocene fossils; collections made by him and by H. R. Bergquist (written communication, June 1945) from the Quebrada Arenas and the upper member consists of assemblages generally considered of early Miocene age.

Río Indio Limestone Member.—The Río Indio Limestone Member is characteristically dark yellowish orange in contrast to the pale-orange tints of adjacent limestone units. The member consists of earthy, generally thick bedded limestone that in this area commonly contains no quartz sand; an exception is near Toa Alta where the upper part is a very fragmental yellowish-orange limestone that contains scattered quartz grains and many pelecypods. At several places the member includes lenses of soft marly clay rich in large *Lepidocyclina*. The Río Indio Limestone Member is about 100 meters thick in the valley of the Río Cibuco, but in the eastern half of the quadrangle, the member thins rapidly to a total thickness of only 65 meters near Toa Alta.

Quebrada Arenas Limestone Member.—The Río Indio Member is overlain conformably by finely crystalline to granular, very hard, very pale orange to grayish-orange limestone, the Quebrada Arenas Limestone Member. The hard limestone of the member is in beds ranging from ½ meter to 2 meters in thickness that are separated by soft chalky grayish-orange limestone beds averaging half a meter in thickness. Corals are present locally, but in general the member is only sparsely fossiliferous. The outcrop area of the member is characterized by sinkholes as deep as 35 meters interspersed with rounded hills that are covered with large angular fragments of limestone. The member is about 60 meters thick in the western part of the quadrangle, but near Toa Alta, where the lower part grades laterally into beds included with the Río Indio Member, it is only about 20 meters thick.

Miranda Sand Member.—At the southwestern corner of the quadrangle and near the middle of the southern border, channels that were eroded in the Quebrada Arenas Limestone Member by late Oligocene or early Miocene streams are filled with sand and gravel that is mapped as the Miranda Sand Member. The Miranda consists of medium to coarse quartz sand in a matrix of mottled dusky-red, dark yellowish orange, and very pale orange clay; in the central area the member contains subrounded to subangular pebbles of chert, quartz, and bleached tuff; some of the pebbles are as long as 10 centimeters. In the central area the upper part of the member contains oyster reefs and a few sirenian bones. The basal contact of the member is sharp and disconformable on the Quebrada Arenas; the upper contact is gradational. The maximum thickness of the member is 10 meters.

Upper member.—The upper 50 meters of the Cibao Formation consists of white to yellow chalk and calcareous clay-stone, generally massive, but locally in layers ½ to 1 centimeter thick. Locally it also contains beds of semi-indurated, compact, clayey, generally rubbly limestone. At a few places, beds 30 to 50 centimeters thick of white or yellow fine quartz sand and greenish-gray very sandy clay occur near the top of the member. The outcrop area is marked by gently rolling hills and by gentle slopes leading up to cliff faces where the Aguada Limestone crops out.

MIOCENE SERIES

Aguada Limestone

The Cibao Formation is overlain conformably by the Aguada Limestone, which consists of rubbly to finely crystalline limestone alternating with beds of clayey limestone, chalk, and rubbly calcareous claystone. The harder beds are generally very pale orange, but some are pink and pale yellowish gray; the softer beds are yellowish gray to white. The beds range in thickness from 25 centimeters to a meter; at a few places the top of the Aguada consists of limestone in strata a few centimeters thick. Quartz grains are common throughout the Aguada, and at one place 1.4 kilometer due northeast of Punto Cubano, the top is made up of 2 meters of thin-bedded and crossbedded calcareous quartz sandstone.

The outcrop area of the Aguada Limestone is marked by closely spaced sinkholes, some as deep as 40 meters, surrounded by low rolling hills. Several intermittent streams that head in the rolling topography underlain by the Cibao Formation flow northward into blind valleys that end against the cliffs of the Aguada Limestone.

The Aguada Limestone is 90 meters thick on the western border of the quadrangle, but it thins to 60 meters on the eastern border.

Aymamón Limestone

The Aguada Limestone is overlain conformably by the Aymamón Limestone, a very pure, tightly cemented, dense to very finely crystalline thick-bedded fossiliferous limestone. Most of the limestone is white, but some beds are pale yellowish gray to pink. In deep excavations the middle and upper parts of the Aymamón consist of white chalk, but at the surface all outcrops are tightly cemented, probably because of partial solution and recementation. At most fresh exposures, even in the chalk facies, the limestone is riddled with small solution channels a few centimeters in diameter, and in many outcrops it consists of a breccia of limestone pieces, 1 to 10 centimeters long, in a matrix of white chalk or reddish-brown clay.

The Aymamón Limestone weathers to steep-sided conical hills and ridges that contain many wide shallow caves. In contrast to the abundant deep sinkholes in the adjacent Aguada Limestone, the few sinks in the Aymamón all are gentle depressions.

The contact of the Aymamón Limestone with overlying Miocene rocks has not been seen in the Vega Alta quadrangle, but recent studies show that elsewhere the Aymamón is about 200 meters thick.

Camuy(?) Formation

At two places along the Atlantic coast are small outcrops of fossiliferous sandy limestone interbedded with fine sand and gravel that are tentatively correlated with the Camuy Formation, the youngest Miocene formation recognized in Puerto Rico. The best outcrop of the formation is 230 meters southwest of La Plata triangulation station in a small quarry where about 3 meters of fossiliferous coralline granular limestone is exposed.

QUATERNARY SYSTEM
PLEISTOCENE SERIES

River-terrace deposits.—Discontinuous deposits of sandy clay containing cobbles of quartz and silicified volcanic rock as large as 20 centimeters in diameter are present on the sides of the alluvial plain of the Río de la Plata, and in the abandoned valley of the river that trends west from the main valley through Higuillar to the gap at the west end of Cerros de Higuillar.

Ancient deltaic and mud-flat deposits.—In the northern third of the quadrangle extensive deposits of carbonaceous sandy clay seemingly are parts of an ancient delta and related mud flats deposited by the Río de la Plata at the time the river flowed through the Higuillar gap.

Ancient beach deposits.—At intervals along the shore in the western part of the quadrangle, thin beds about 4 meters above sea level dip to the north. They are made up of tightly cemented fine- to medium-grained calcareous sandstone composed of calcite and subsidiary quartz grains; these outcrops are interpreted as ancient beach rock. Elsewhere small outcrops of coral-bearing calcareous sandstone, possibly of the same age, have been mapped with Camuy Formation.

Eolianite.—Many of the hills along the coast and most of the small off-shore islands are composed of highly crossbedded calcareous sandstone composed predominantly of calcite, but with some quartz grains.

Blanket sand deposits.—Most of the valleys between limestone ridges of the Aymamón Limestone and many of the sinkholes in the Aguada Limestone are covered by a thick deposit of orange to red sandy clay and, locally, red clayey sand. Although much of the clay may be derived from the nearby limestone, the sand has been transported by wind, streams, and possibly coastal currents..

Silica sand.—In the northern third of the quadrangle are extensive deposits of white, nearly pure, fine- to very fine-grained quartz sand. At a few outcrops this sand rests on quartz sand that is loosely cemented by yellow clay, from which it may have been derived. Because the silica sand is loose and easily blown by the wind, at most places its surface is a succession of low dunes and blow-out depressions.

RECENT SERIES

Landslides.—On the valley sides of the Río Cibuco and the Río de la Plata, large masses of Aguada Limestone have slid down the clayey hillsides to form hummocky rubble-strewn slopes. The material in these slides ranges from large blocks several meters long to small cobbles, in a matrix of soil derived from the Cibao. The slides are not actively moving, except near the cliffs of Aguada, for roads built on the slides show no signs of cracking or slumping.

Alluvium.—Nearly flat floodplains of the Río Cibuco and Río de la Plata are underlain by stratified clay, sand, gravel, and boulders, largely derived from the volcanic rocks of the mountains farther south. Notable natural levees of fine-grained alluvium flank the banks of the Río de la Plata. In times of flood the entire width of the alluvial plains of both rivers, including the natural levees of the Río de la Plata, are submerged. Small patches of slightly sandy clay cover the floors of the lower reaches of the blind valleys at the northern edge of the outcrop of the Cibao Formation.

Swamps and swamp deposits.—In the coastal area of the quadrangle extensive deposits of carbonaceous sandy clay and muck fill depressions between ancient and recent deltaic deposits and areas that until recently were lagoons. Some of the swamps are underlain by thin beds of peat, derived largely from mangrove and grasses.

Beach deposits.—A strip of sand beach occurs along the Atlantic Coast, except at headlands where waves beat against hills of eolianite. At most places on the present shore the sand is composed predominantly of highly polished medium-sized grains derived from broken shells. At Cerro Gordo beach, however, the sand is nearly pure fine- to very fine-grained quartz; near the eastern edge of the quadrangle 300 meters west of Punta Boca Juana the sand is two-thirds shell fragments and one-third quartz,epidote, and dark volcanic rock fragments carried to the sea by the Río de la Plata. At many places along the shore the beach sand has been cemented by calcium carbonate into beach rock.

STRUCTURE

The Tertiary rocks dip 5° in a general northerly direction throughout most of the quadrangle. This northerly dip is interrupted by a small anticline and a structural terrace. The anticline plunges northwest near Cerro Miraflores; it can be seen in the valley of the Río Indio in the Manatí quadrangle. At Vega Alta the wide spreading of the structure contours that define the structural terrace may actually be a gentle anticline, but control data to determine its crest are lacking.

ECONOMIC GEOLOGY

Very large quantities of high grade calcium carbonate are available in the Aymamón Limestone. Analyses of similar rock in the adjacent Manatí quadrangle (Monroe, 1962) show 95 to 99.5 percent $CaCO_3$. Limestone suitable for cement and for fill are available throughout the outcrop belt of the Aguada Limestone; several small quarries near Vega Alta have been opened for fill at various times in the past.

Silica sand has been mined sporadically for several years and used as glass sand. The largest unexploited area is in the low hills south of Ciénaga Prieta, where the sand is from 1 to 3 meters thick; at least 3 million cubic meters of glass sand is available in these hills alone.

Sand and gravel used for concrete aggregate are extracted from the floodplain of the Río de la Plata south of Toa Alta. Large quantities are available at other places in the valley and in the terrace deposits of the river.

Little can be said about the oil and gas possibilities of the area, for to date (1961) only one test well has been drilled in northern Puerto Rico, Kewanee Interamerican Oil Company's No. 4 Commonwealth of Puerto Rico. This well, drilled nearly 30 kilometers west of the Vega Alta quadrangle, had no shows of oil or gas, but it penetrated porous potential reservoir rocks in the Lares Limestone at a depth of about 3,700 feet (Briggs, 1961). When additional prospecting is done in Puerto Rico, geophysical work and probably shallow core drilling should be done in the Vega Alta quadrangle to determine whether the anticlinal areas are accentuated at depth to provide structural traps for petroleum. Both the anticline and the structural terrace coincide with positive magnetic anomalies (Briggs, 1961).

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