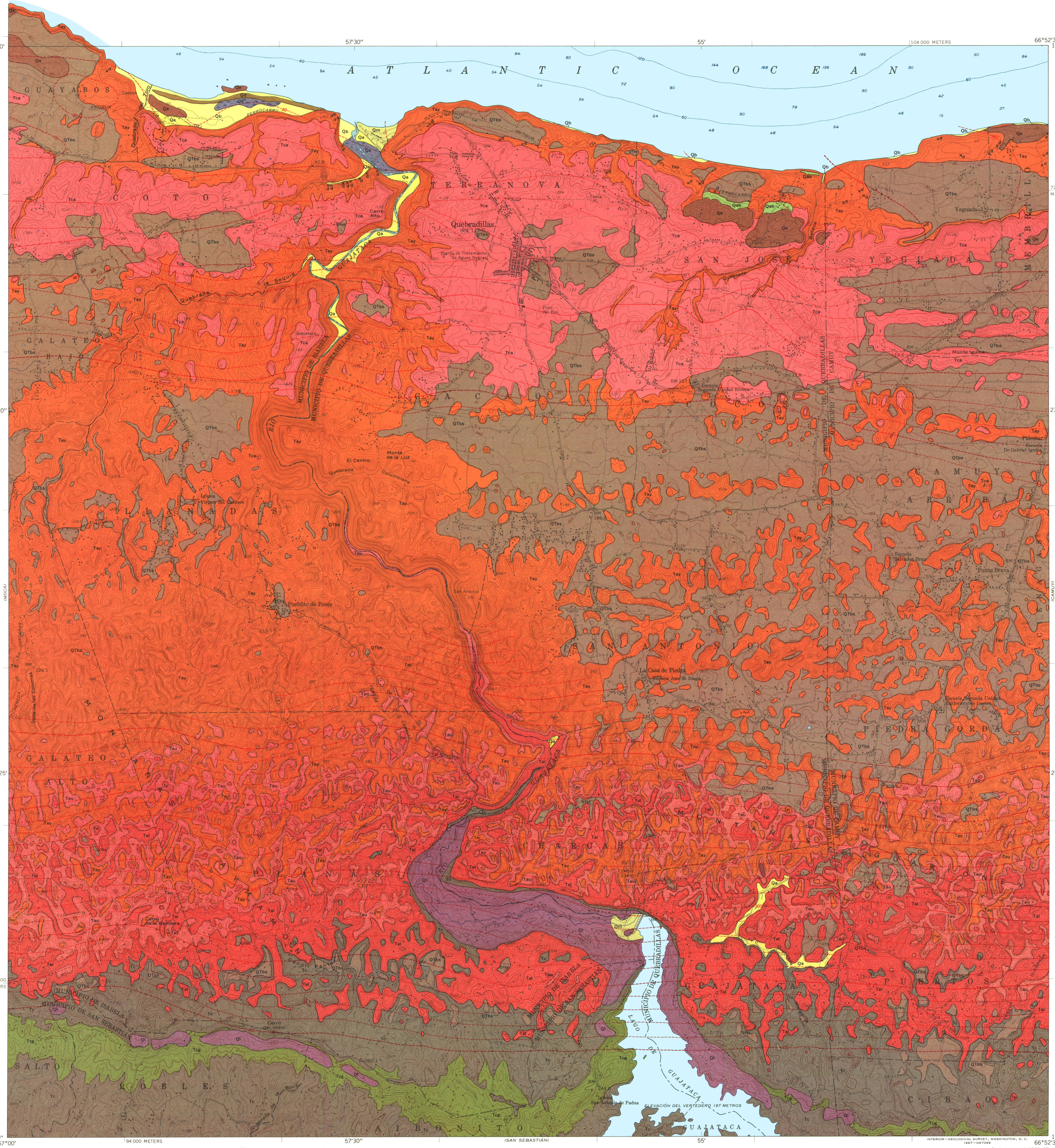
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE DEPARTMENT OF INDUSTRIAL RESEARCH
PUERTO RICO ECONOMIC DEVELOPMENT ADMINISTRATION

MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I–498



Base by U.S. Geological Survey, 1957

APPROXIMATE MEAN DECLINATION, 1967

SCALE 1:20 000
1 ½ 0 1 MILE
1 .5 0 1 KILOMETER
CONTOUR INTERVAL 10 METERS
DATUM IS MEAN SEA LEVEL

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.
1967—G67069

Geology mapped, 1964–65

GEOLOGIC MAP OF THE QUEBRADILLAS QUADRANGLE, PUERTO RICO

By
Watson H. Monroe
1967

E X P L A N A T I O N

QUATERNARY

Recent

Qb — Beach deposits
Quartz sand, shell fragments, and scattered grains of other minerals resistant to weathering; cementation to beach rock discontinuously present at all beaches; older deposits covered by thin blanket of sand blown from present beaches and dunes. Thickness is 0–5± m

Qs — Swamp deposits
Sandy, organic muck and peat associated with mangrove swamps. Thickness is 0–5± m

Qd — Sand dunes
Unconsolidated quartz and shell sand, fine to medium grained. Thickness is 0–15 m

Qa — Alluvium
Clayey sand and sandy clay, locally containing blocks of limestone. Thickness is 0–5± m

Ql — Landslide deposits
Blocks of limestone and of sandy clay as much as 10 m long in a mass of sandy clay; generally underlain by wet calcareous clay. Thickness is 0–20± m

Pleistocene

Qm — Miscellaneous surficial deposits
Largely eolianite, but including broken blocks of eolianite, cobbles and boulders of Aymamón Limestone, and some alluvium. Thickness is 0–20 m. Includes earth fill at dam on Lago de Guajataca

Qab — Ancient beach deposits
Crossbedded quartz and shell sand and gravel at altitude of 50 to 70 m; small patches of beach rock and sand on wave-cut bench at altitude of 12 m. Thickness is 0–20 m

Qe — Eolianite
Friable to consolidated highly crossbedded calcareous eolian sandstone composed of a mixture of shell fragments and quartz grains. Thickness is 0–20 m

TERTIARY(?) OR QUATERNARY

Pliocene(?) or Pleistocene

QTbs — Blanket sand deposits
Mixtures of fine to medium quartz sand and light-brown to moderate-brown clay; all material mapped in this category has been lowered in altitude subsequent to deposition by solution of underlying limestone. Thickness is 0–30? m

UNCONFORMITY

TERTIARY

Miocene

Tca — Camuy Formation
Heterogeneous reddish-brown crossbedded and thin-bedded very ferruginous limestone, pale-yellowish-orange silty chalk, and very pale orange chalky or earthy limestone; locally contains scattered quartz grains; local beds of very pure finely crystalline, rather porous pure limestone closely resembling underlying Aymamón Limestone and probably of similar origin. Thickness is 0–60 m

DISCONFORMITY

Tay xd — Aymamón Limestone
White to very pale orange, locally pale yellow and grayish-pink very pure limestone; lower part generally indurated into finely crystalline rather dense limestone, locally a rubble of recemented solution fragments generally of cobble size; upper part compact very finely crystalline chalk; on surface both parts weathered and recemented into irregular, solution sculptured dense limestone having abundant sharp spires a few centimeters high; near coast upper part dolomitized at many places to calcitic dolomite of distinctive sugary texture; beds directly beneath the Camuy Formation commonly pink to red because of strong impregnation by ferric oxides. Thickness is 200± m
d, *outcrop of dolomite*

Tau / Tal — Aguada Limestone
Tau, *upper member, thick layers of very pale orange to pink hard limestone alternating with chalky and rubbly limestone; at top and locally at base 1 to 5 m of pink granular thin-bedded and locally cross-laminated limestone in which individual beds range in thickness from 1 to 3 cm. Thickness is 30–40 m*
Tal, *lower member, at base a bed of hard granular limestone or calcarenite from 50 cm to a meter thick, overlain by granular chalky marl containing discontinuous beds of fine to medium grained fossiliferous limestone; contains much less clay than underlying Cibao Formation. Thickness is 50–60 m*

Oligocene and Miocene

Tc / Tcg / Tc — Cibao Formation
Calcareous clay, marl, and marlstone interbedded with soft limestone; 60 m thick below Guajataca Member and about 80 m thick above that member; in upper part a few beds as thick as 20 cm of hard, very fine grained limestone or calcilutite. 200 m exposed in quadrangle
Tcg, *Guajataca Member, calcareous clay like rest of Cibao but containing lenses as thick as 5 m of sand and gravel derived from volcanic rocks including cobbles of silicified rock as much as 10 cm in diameter. Thickness is 25–80 m*

Contact
Dashed where approximately located; short dashed where gradational or inferred

Strike and dip of beds

Control point
Showing outcrop of key horizon used in locating structure contour lines

Structure contours
In southern part of map drawn on top of Aguada Limestone. In northern part of map drawn on top of Aymamón Limestone. Dashed where approximately located or inferred from overlying structure; short dashed where reference plane is above ground surface. Contour interval 10 meters, datum is mean sea level

NOTES ON PHYSIOGRAPHY

The principal physiographic elements of the Quebradillas quadrangle are two south-facing escarpments that bound belts of rolling hills near the southern edge of the quadrangle, a wide central belt exhibiting a variety of karst phenomena, and a northern belt consisting predominantly of east-trending strike ridges. Cutting across all these elements is the deep steep-sided gorge of the Río Guajataca. Each of the outcropping formations has its own distinctive topographic form: The Cibao Formation gives rise to low rolling hills that are interrupted by the south-facing escarpment on which the Guajataca Member crops out; the Aguada Limestone is a ridge-forming limestone unit that is characterized by a notable south-facing escarpment and by hundreds of dolines or sinkholes; the Aymamón Limestone characteristically weathers to steep-sided subconical hills called mogotes; and the Camuy Formation, although dominantly limestone, weathers to low rolling ridges alined along the strike—it contains neither mogotes nor deep sinkholes.

Deep dolines are common throughout the belt of outcrop of the Aguada Limestone and in the southern half of the belt of outcrop of the Aymamón. Some of these dolines are deeper than 70 meters and are at the sides of hills of Aymamón Limestone that rise some 50 meters higher than the edge of the dolines. At the southern edge of the Aguada Limestone, spurs and outliers of the Aguada extend southward from the main escarpment, producing blind valleys underlain by the upper part of the Cibao Formation. The water that flows into these valleys drains out in ponors and small caverns that have been dissolved in thin limestone beds in the upper part of the Cibao. Caves are common in the Aguada, and a small natural bridge is present near the northeast corner of barrio Planas.

The effect of sheet solution of limestone under soil is well shown on the two sides of the Río Guajataca in barrios Llanadas and Cacao, particularly on the west side of the river. A nearly flat plain of "blanket sand" (Briggs, 1966) at an altitude of 135 to 140 meters extends east from Highway 446 to a limestone barrier that rises to an altitude of 165 meters, about 25 meters above the plain. East of the ridge the valley of the Río Guajataca drops precipitously to a V-shaped canyon only 10 meters above sea level at the bottom. The opposite wall of the canyon rises steeply to another ridge crest that has peaks on it higher than 180 meters; from these the limestone slopes off to another sand-covered plain that has an altitude of about 140 meters. The sandy clay of the plains, mapped as blanket sand deposits, was once continuous across the area before the river cut its channel. Since then, the plain has been lowered at least 25 meters by solution of the limestone beneath it, except at the sides of the river where the limestone forms a casehardened rampart. Similar ramparts are well known in Okinawa (Flint and others, 1953) and Guam (Tracey and others, 1964, p. 62) and are generally ascribed to solution of soft, porous limestone by water containing a little carbon dioxide, followed by reprecipitation of the limestone after evaporation of water. The Río Guajataca rampart was noted by Kaye (1957, p. 112) who apparently attributed it to casehardening at the sides of joints.

NOTES ON ECONOMIC AND ENGINEERING GEOLOGY

Limestone.—Very large supplies of calcium carbonate that can be used as agricultural limestone, as a raw material for cement, and as "marble" for terrazzo chips are available in the Aymamón and Aguada Limestones. Some parts of the Aymamón Limestone are sufficiently pure to be chemical-grade limestone.

Dolomite.—Calcitic dolomite, recognizable by its sugary texture, containing as much as 18.5 percent MgO is present in the Aymamón Limestone near the coast. Deposits near the bridge of Highway 2 over Río Guajataca have been described by Vázquez and others (1957), but similar calcitic dolomite is also present on Highway 2 east of the river, where 10 meters of dolomite is exposed from an altitude of 60 to 70 meters. Abundant outcrops have been observed in the hills near the coast, particularly east of Quebrada Bellaca and north of Yeguada.

As the dolomite has not been seen very far inland from the sea and as it does not seem to occupy a definite stratigraphic position, it probably forms a thick surficial replacement of limestone and chalk. In order to determine the quality, the local thickness, and the total tonnage, a number of vertical and horizontal holes should be drilled, preferably with a core drill. Horizontal holes should be drilled in the walls of the roadcuts near Río Guajataca, and vertical holes should be drilled on several hills east of Quebrada Bellaca.

Sand and gravel.—The dunes east of Quebrada del Toro can provide a small quantity of calcite beach sand suitable for concrete. A virtually unused supply of sand and gravel is provided by the Guajataca Member of the Cibao Formation near the southern edge of the quadrangle, especially east of Lago Guajataca. This sand and gravel may require washing before it can be used in concrete. It should be tested to be sure it does not contain constituents deleterious to concrete.

Oil and gas possibilities.—Neither oil nor gas has been reported from northern Puerto Rico (Briggs, 1961), but possible source beds and reservoir rocks were observed in samples collected from a stratigraphic test well drilled in the northern coastal area, about 33 kilometers east of Quebradillas. The anticline north of Quebradillas and the small dome near the northwestern corner of the quadrangle are structures that in an oil-producing region would be considered favorable for testing. Holes should be drilled through the entire Miocene and Oligocene sequence to the top of the volcanic basement rocks, a depth of about 1,500 meters (5,000 feet).

The small dome is especially interesting because it coincides with a magnetic maximum shown on an aeromagnetic survey made for A. D. Fraser (Briggs, 1961), suggesting that the nose is a reflection of topography on the surface of deeply buried volcanic basement rocks. The aeromagnetic survey does not show any features that parallel the syncline and anticline through Quebradillas.

Landslides.—The most extensive landslides in the quadrangle are in the valley of the Río Guajataca, where large masses of Aguada Limestone have slipped downslope on the clay at the top of the Cibao Formation; these landslides have an origin similar to that of the slides near Corozal (Monroe, 1964). The Guajataca dam is built in part on a landslide; south of the dam, recent movements of parts of the slide have cracked the pavement of Highway 119. Less extensive landslides have developed at several places on the escarpment formed by the Guajataca Member of the Cibao Formation. So far as can be determined these latter slides are now stable.

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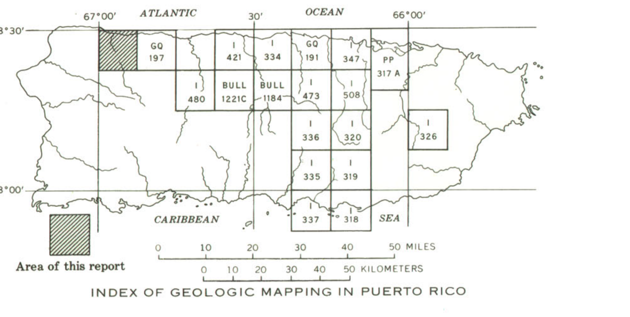

INDEX OF GEOLOGIC MAPPING IN PUERTO RICO

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