DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I-671

DESCRIPTIONS OF MAP UNITS

Qb *Beach deposits,* medium- to coarse-grained, pale grayish-orange sand composed chiefly of calcium carbonate in the form of polished shell fragments; contains small to moderate quantities of quartz and volcanic rock; indurated into beach rock in patches along entire coast line. Includes low beach dunes north of Laguna Tortuguero and wind-blown beach sand in the valley west of Marchiquita. 0–5± m thick.

Qs *Swamp deposits,* clay, sandy clay, and muck, commonly underlain by peat. Includes some mangrove swamps. Some areas that have been drained consist of carbonaceous sandy clay. 0–5± m thick.

Qa *Alluvium,* stratified clay, silt, sand, and cobbles. In the valleys of Río Grande de Manatí and Río Indio the alluvium consists largely of sand and clay derived from weathering of the middle Tertiary limestone formations and sand and cobbles derived from volcanic rocks farther south. From 1 to 2½ km north of the southern edge of the quadrangle several small areas of alluvium consist predominantly of sand and clay that has been deposited by short streams originating in the upper part of the Cibao Formation and ending in sinks in the Aguada Limestone. A wide exposure of alluvium north of Vega Baja is composed of sand and clay and apparently represents an emerged delta of the Río Cibuco. Many of the closed depressions resulting from solution of limestone contain small patches of alluvium; this material has generally been mapped with the blanket deposits. 0–50(?) m thick.

Ql *Landslide deposits,* blocks of limestone and of sandy clay as long as 20 m in a mass of sandy clay (Monroe, 1964). 0–20± m thick.

Qt *River terrace deposits,* cobbles of igneous and volcanic rocks as much as 27 cm long in a matrix of clay, silt and sand. A small deposit on Río Indio is mostly sand but contains cobbles of limestone derived from the Cibao Formation. 0–5± m thick.

Qe *Eolianite,* friable to consolidated, highly crossbedded, calcareous eolian sandstone composed of fine to coarse grains of shell fragments and quartz. At Los Molinos includes a paleosol a few centimeters thick (Kaye, 1959). 0–30 m thick.

Qts *Marine terrace deposits,* white to red, fine to medium sand, mostly quartz, but in a few places containing grains of shell fragments. Cemented into beach rock at an altitude of about 4 m at several places near Punta Chivato and at places (marked by crosses) near Laguna Tortuguero and east of Puerto Nuevo. Includes some sand blown inland from the coastal beaches and dunes. Some of the sand included in this category may have been lowered by solution of the underlying limestone and may be properly classified with the blanket deposits. 0–10(?) m thick.

Qss *Silica sand,* very pure quartz sand derived by leaching from the marine terrace deposits and the blanket deposits. The composition is generally more than 99 percent silica (Meyerhoff and Frazier, 1945), but locally the deposits contain some organic matter. Most deposits grade downward into ferruginous sand mapped as marine terrace deposit or blanket deposit. The surface is characterized by low dunes and shallow deflation hollows. Thickness ranges from 1 to 4 m.

QTbs *Blanket deposits, sand,* clayey, ferruginous, fine to medium sand found between ridges of limestone; a surficial sand that has been lowered by solution of underlying limestone (Briggs, 1966). 0–30(?) m thick.

QTbc *Blanket deposits, clay,* sandy clay found between limestone ridges and believed to have been lowered by solution of the underlying limestone (Briggs, 1966). 0–30(?) m thick.

UNCONFORMITY

Tca *Camuy Formation,* ferruginous, clayey, locally sandy limestone and chalk. May include some of rock near Punta Chivato referred to the Aymamón Limestone. None of the rocks mapped as Camuy Limestone are typical of the Camuy in its type locality farther west. 10–20 m thick.

Tay *Aymamón Limestone,* white to very pale orange, locally pale yellow and grayish pink, massive to thick-bedded very pure fossiliferous limestone generally indurated by secondary cementation into finely crystalline rather dense limestone (Monroe, 1966), locally a rubble of recemented solution breccia. Near coast surface of limestone has been locally dolomitized (xd). Commonly solution riddled and indurated on surface into hard limestone having abundant sharp spires as much as 30 cm high. Rests with sharp contact on underlying Aguada Limestone. 190–200 m thick.

Ta *Aguada Limestone,* thick layers of very pale-orange to pink hard calcarenite alternating with chalky and rubbly limestone; locally fossiliferous; at top 1 to 3 m of thin-bedded and cross-laminated coarse calcarenite in which individual beds range from 1 to 6 cm. Basal bed is hard calcarenite 30 cm to a meter thick that locally contains grains of quartz, limonite, or volcanic rock fragments. Quartz grains are much more common in the eastern part of the quadrangle. Most of the outcrop belt is characterized by closely spaced closed depressions, many of which are deeper than 30 m, separated by narrow winding ridges of limestone—a typical doline karst. 90–110 m thick.

Tcu *Cibao Formation, upper member,* soft chalky limestone and clayey chalk. 50 m thick.

Tcn *Cibao Formation, Miranda Sand Member,* angular to subangular coarse quartz sand in a noncalcareous silty clay matrix; apparently fills channels eroded during Cibao time in the Quebrada Arenas Limestone Member. 0–20 m thick.

Tcq *Cibao Formation, Quebrada Arenas Limestone Member,* very finely crystalline to dense, very pale-orange to pale grayish-orange limestone that locally contains scattered grains of quartz sand and abundant molds of fossils. About 10 m thick in western part of quadrangle, but not seen and possibly absent on east wall of valley of Río Grande de Manatí; thickens to about 40 m at east edge of quadrangle.

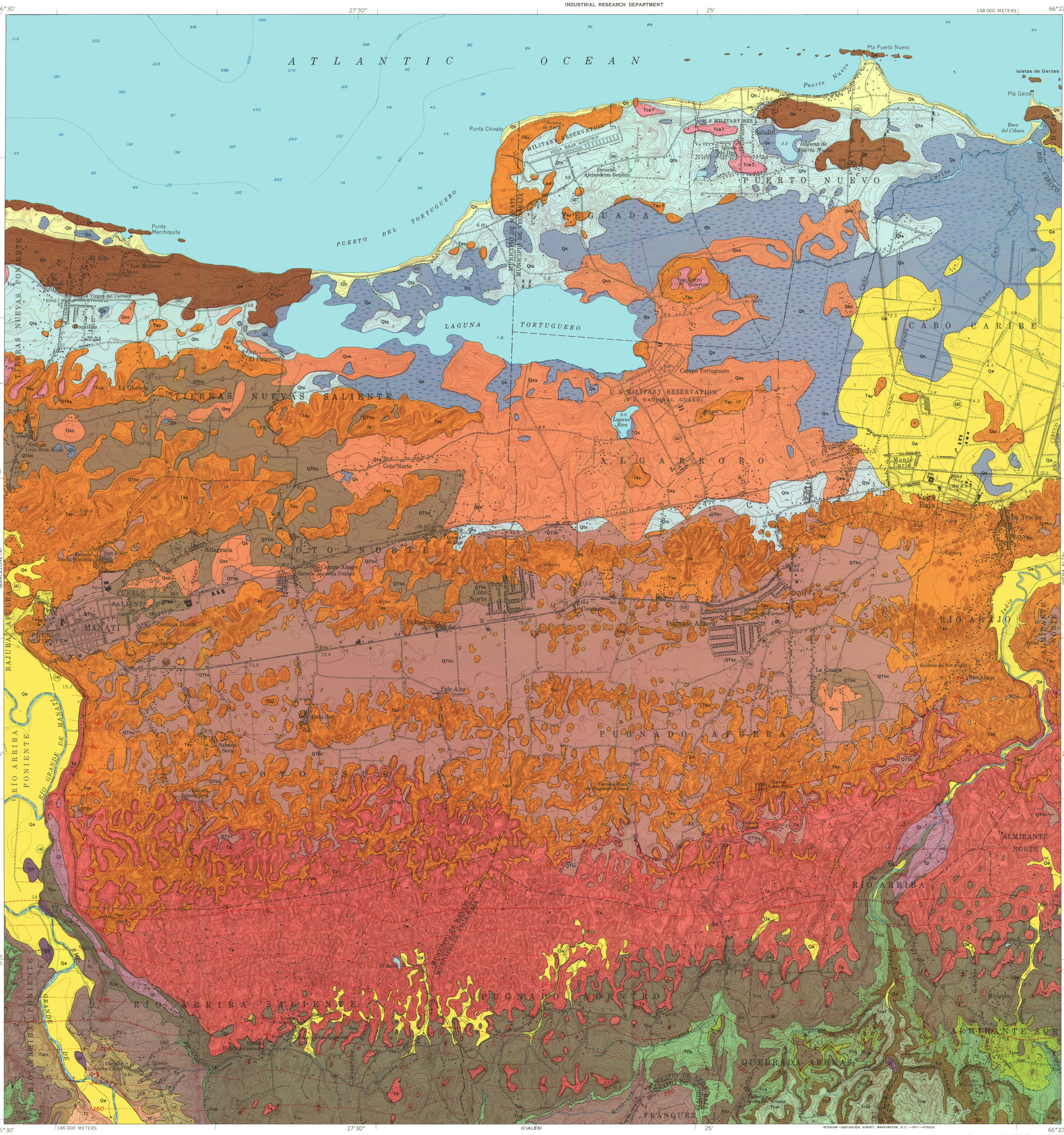
Tc *Cibao Formation, typical chalk or marl member,* sandy and silty slightly clayey chalk or marl. In western part of quadrangle rests gradationally on an eastward-thinning wedge of the Montebello Limestone Member, into which most of the Cibao grades in the Florida quadrangle to the southwest. In the eastern part of the quadrangle grades laterally into intertonguing members below the Quebrada Arenas Limestone member. 100–140 m thick.

Tcr *Cibao Formation, Río Indio Limestone Member,* compact but chalky fragmental limestone, averaging pale yellowish orange, weakly bedded to massive, locally slightly glauconitic; broad scale crossbedding notable in valley of Río Indio. Divided into upper and lower parts on both sides of Río Indio by the Almirante Sur Sand Lentil. Present only in the eastern part of quadrangle; in western part represented by the typical beds of the Cibao. About 90 m thick, including the Almirante Sur Sand Lentil.

Tcal *Cibao Formation, Almirante Sur Sand Lentil,* subrounded to subangular, crossbedded pebbly fine to coarse sand consisting of quartz grains and volcanic rock debris. Forms a lens from 35 to 40 m thick in the Río Indio Limestone Member.

Tcm *Cibao Formation, Montebello Limestone Member,* friable chalky coarse calcarenite composed largely of medium to coarse grains, many of which are Foraminifera and shell fragments. The Montebello is typically exposed farther southwest in the Florida quadrangle where it represents nearly all of the Cibao Formation. About 30 m thick west of the Río Grande de Manatí; thins eastward by grading laterally into typical beds of the Cibao.

Tl *Lares Limestone,* hard finely crystalline very pure limestone in beds 10 to 30 cm thick; color ranges from nearly white to very pale orange. 40 m of upper part exposed in valley of Río Grande de Manatí.



SCALE 1:20 000

1 .5 0 1 2 KILOMETERS

1 ½ 0 1 MILE

CONTOUR INTERVAL 5 METERS
DOTTED LINES REPRESENT 1-METER CONTOURS
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 0.3 METERS

EXPLANATION

QUATERNARY

Holocene
- Qb — Beach deposits
- Qs — Swamp deposits
- Qa — Alluvium
- Ql — Landslide deposits

Pleistocene
- Qt — River terrace deposits
- Qe — Eolianite
- Qts x — Marine terrace deposits (*x, outcrop of calcarenite*)
- Qss — Silica sand
- QTbs — Blanket deposits, sand
- QTbc — Blanket deposits, clay

UNCONFORMITY

TERTIARY

Miocene
- Tca — Camuy Formation
- Tay xd — Aymamón Limestone (*xd, outcrop of dolomite*)
- Ta — Aguada Limestone

Oligocene and Miocene — Río Guatemala Group

Cibao Formation
- Tcu, *upper member*
- Tcn, *Miranda Sand Member*
- Tcq, *Quebrada Arenas Limestone Member*
- Tc, *typical chalk or marl member*
- Tcal, *Almirante Sur Sand Lentil*
- Tcr, *Río Indio Limestone Member*
- Tcm, *Montebello Limestone Member*

Oligocene
- Tl — Lares Limestone

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

8
Strike and dip of bedding

100
Structure contour
Drawn on top of Aguada Limestone. Dashed where approximately located or inferred; short dashed where reference plane is above ground surface. Contour interval 20 meters; datum is mean sea level

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

Quarry

INTRODUCTION

The Manatí quadrangle is the first area of rocks of the northern coastal plain of Puerto Rico that was studied under a cooperative agreement begun in 1952 between the Geological Survey and the Department of Industrial Research of the Puerto Rico Economic Development Administration; a preliminary geologic map (Monroe, 1962) was published. Studies of the geology of other areas of similar rocks (Briggs, 1965; Monroe 1963a, 1963b), have resulted in refinements in the stratigraphy that are worth recording. The principal differences between the present map and that of 1962 are (1) the Camuy Formation is now separated from the Aymamón Limestone—on the 1962 map it was included in part with the Aymamón Limestone and in part with a unit designated "Undifferentiated dune and marine deposits"; (2) the contact between the Aguada Limestone and the Aymamón Limestone is now placed 10 to 30 meters higher than in 1962; (3) the Miranda Sand Member of the Cibao Formation is known to be much more extensive than formerly believed—much of it was mapped as colluvium in 1962; and (4) the Montebello Limestone Member of the Cibao Formation, defined in the Florida quadrangle (Nelson and Monroe, 1966, p. C16, C17) has been extended into the Manatí quadrangle—on the 1962 map these beds were mostly included in the Lares Limestone. The preliminary map is still useful, however, as it includes original definitions of many of the members of the Cibao Formation and the descriptions of the rock units are more complete than space permits in the present format.

KARST TOPOGRAPHY

The Manatí quadrangle contains abundant closed depressions, mostly in the outcrop belt of the Aguada Limestone. The depressions are mostly subcircular in plan and are commonly about 30 meters deep. They form one of the best examples of doline karst in Puerto Rico.

Farther north the belt of dolines grades gently into a belt of subconical hills of Aymamón Limestone separated by broad lowlands underlain by sand or sandy clay—the so-called blanket deposits. The hills range in height above the nearly flat plains from a very few meters to as much as 50 meters and they form a characteristic mogote karst.

STRUCTURAL AND ECONOMIC GEOLOGY

The rocks in the Manatí quadrangle dip generally north. In the southern part of the quadrangle the dip is about 5 degrees; near the coast stratification is so poor that attitudes could not be observed, but from adjacent areas the attitudes are believed to be nearly horizontal. The generally northerly dip is interrupted by several small flexures having a generally north-south trend, as shown by the structure contours. An anticline trending northeast along Quebrada Arenas, described earlier (Monroe, 1962), seems to be less pronounced than formerly thought.

The principal known economic mineral deposit in the quadrangle is limestone, which is quarried extensively, especially from the Aymamón Limestone between Highways 2 and 670. The limestone is used for terrazo chips, as concrete aggregate, and as fill. An area several hundred meters south of Punta Chivato is underlain by dolomite containing about 18.5 percent MgO, but the thickness is not known. If a demand for dolomite develops, the area should be explored by drilling to determine the volume of dolomite.

The silica sand is extracted from shallow pits and used in the manufacture of glass (Meyerhoff and Frazier, 1945; Vázquez, 1955).

LANDSLIDES

The landslide deposits on the sides of the Río Grande de Manatí and the Río Indio consist mainly of blocks of Aguada Limestone that have broken from cliffs and have slid downhill on clay of the upper member of the Cibao Formation (Monroe, 1964). Although lower parts of the landslide deposits are fairly stable, some movement of material in their headward parts may be expected in the future as new blocks of Aguada Limestone break away from the cliffs and are added to the landslide area.

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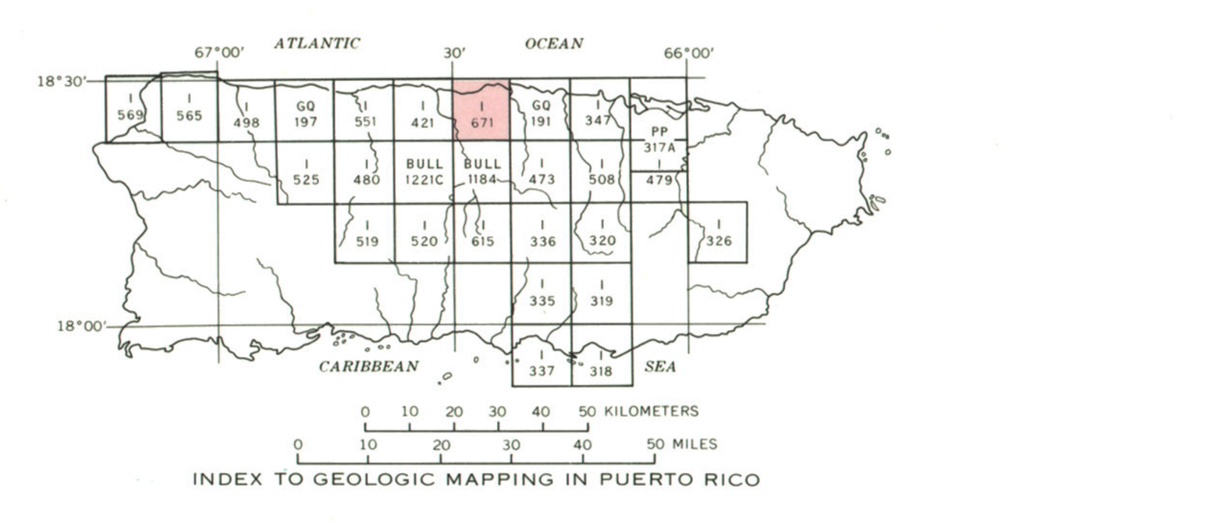

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GEOLOGIC MAP OF THE MANATÍ QUADRANGLE, PUERTO RICO

By
Watson H. Monroe
1971

For sale by U.S. Geological Survey, price $1.00