DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
COMMONWEALTH OF PUERTO RICO
DEPARTMENT OF NATURAL RESOURCES

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1054

Base by Geological Survey, 1969
2000–meter grid based on Puerto Rico coordinate system

APPROXIMATE MEAN DECLINATION, 1977

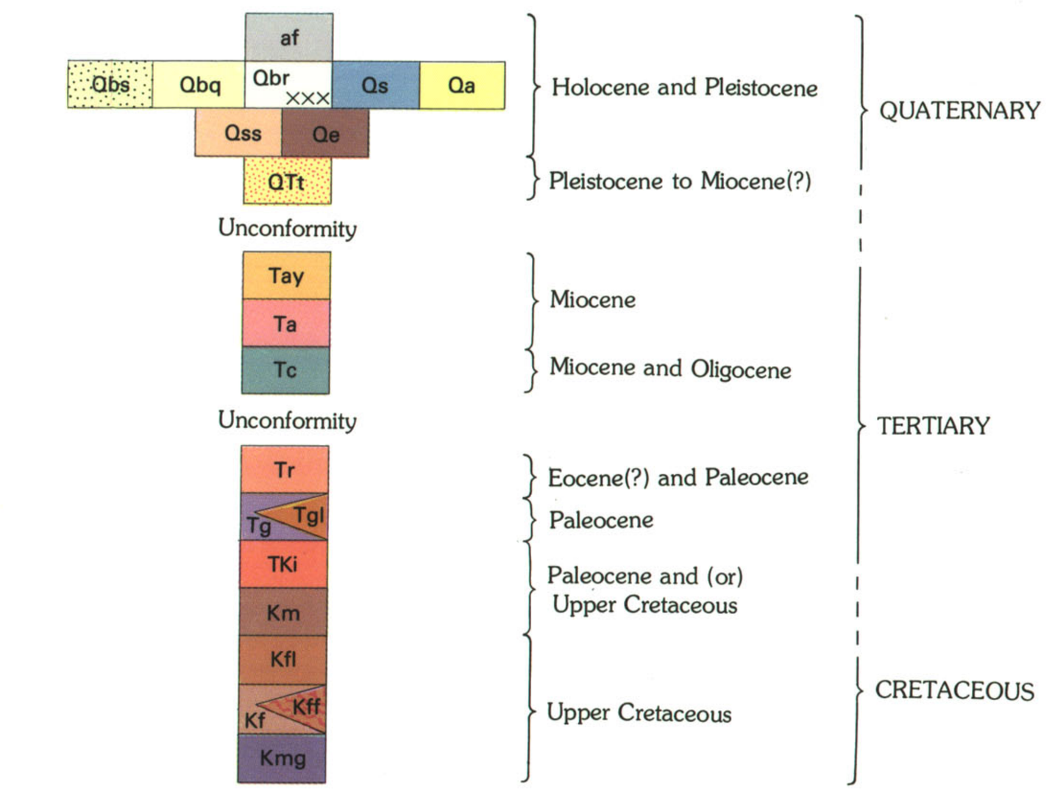
SCALE 1:20 000

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

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1977—G76408

Geology mapped in 1961–62, 1971, and 1973

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

af ARTIFICIAL FILL (HOLOCENE AND PLEISTOCENE)—Material from various sources hauled in and dumped in low, swampy places to provide foundations for housing and industrial development

Qbs BEACH DEPOSITS (HOLOCENE AND PLEISTOCENE)—Fine to medium sand on beaches and coastal dunes; composed largely of rounded shell fragments mixed with minor quantities of fine quartz grains and fine grains of volcanic rock fragments. Generally less than 10 m thick

Qbq BEACH DEPOSITS (HOLOCENE AND PLEISTOCENE)—Sand on beaches and abandoned beach ridges composed largely of fine quartz grains mixed with minor quantities of shell fragments and volcanic rock fragments. Grains of magnetite concentrated in thin lenses at the mouth of the Río Grande de Loíza (Guillou and Glass, 1957, p. 281, tables 1, 2, plate 15). Generally less than 10 m thick

Qbr BEACH ROCK (HOLOCENE AND PLEISTOCENE)—Beach sand, predominantly composed of shell fragments cemented by calcium carbonate. Generally 1 m or less thick

Qs SWAMP DEPOSITS (HOLOCENE AND PLEISTOCENE)—Sandy muck and clayey sand; some areas underlain by peat (Roberts and others, 1942). Much of the area now covered by artificial fill (af) was originally swamp deposit. Generally less than 20 m thick

Qa ALLUVIUM AND RIVER-TERRACE DEPOSITS (HOLOCENE AND PLEISTOCENE)—Sand, clay, and sandy clay; beds of sand containing gravel at sides of Río Grande de Loíza. Thickness variable, possibly as great as 100 m

Qss SILICA SAND (HOLOCENE AND PLEISTOCENE)—Very pure quartz sand, generally more than 99 percent silica (Meyerhoff and Frazier, 1945), but locally contains organic matter. Underlain near La Cerámica by Quaternary clay formerly used in the manufacture of terracotta tile (Cadilla, 1958). Thickness ranges from 1–3 m

Qe EOLIANITE (HOLOCENE AND PLEISTOCENE)—Friable to consolidated, crossbedded calcareous eolian sandstone composed of fine to coarse grains of shell fragments and quartz. Maximum thickness about 20 m

QTt HIGH TERRACE AND ALLUVIAL-FAN DEPOSITS (PLEISTOCENE TO MIOCENE?)—Mostly sandy clay and clayey sand containing a few pebbles of volcanic rock. North and south of Los Cerros del Comandante, the alluvial-fan deposits contain many angular fragments of siltstone. Generally less than 10 m thick

Tay AYMAMÓN LIMESTONE (MIOCENE)—White to very pale orange, locally pale-yellow and grayish-pink, massive to thick-bedded, very pure fossiliferous limestone; generally indurated on surface by secondary cementation into finely crystalline rather dense limestone. Contains thin lenses of calcitic dolomite on the westernmost limestone hill at Loíza Aldea. Commonly solution riddled and weathered on surface into dense limestone having abundant sharp spires many centimeters high. Exposed thickness 50–100 m

Ta AGUADA LIMESTONE (MIOCENE)—Alternating beds of indurated, slightly quartziferous, very pale orange to pink, fine calcarenite and grayish-orange to very pale orange clayey and chalky limestone; some beds of soft sandy marlstone. Thickness about 50 m

Tc CIBAO FORMATION (MIOCENE AND OLIGOCENE)—Rubbly sandy very pale orange to grayish-orange limestone interbedded with gray sandy clay and fossiliferous calcareous claystone. Composition of lower part is similar to adjacent pebbly sandy clay in high terrace deposits (QTt). Thickness about 35 m

Tr RÍO PIEDRAS SILTSTONE (EOCENE? AND PALEOCENE)—Well-stratified, thin-bedded, partly laminated, mostly tuffaceous siltstone and fine-grained sandstone. In fresh exposures the formation is medium gray, but in most outcrops it is weathered to yellowish, reddish, and greenish gray and brown. Local layers of yellowish-brown crumbly clay. Thickness 200–700 m

Tg GUARACANAL FORMATION (PALEOCENE)—Coarse purplish- or reddish-gray basaltic flow breccia, generally weathered to clayey sand containing abundant grains of hornblende. Pinches out toward east. Thickness 0–270 m

Tgl GUARACANAL FORMATION, LIMESTONE MEMBER (PALEOCENE)—Medium- to thick-bedded, medium-light-gray limestone containing abundant algal fragments. Thickness about 10–20 m

TKi INTRUSIVE ROCKS (PALEOCENE AND (OR) UPPER CRETACEOUS)—Quartz diorite, light-gray rock containing phenocrysts of plagioclase and quartz; in southeast corner of quadrangle includes coarse-grained diabase and diabase porphyry, probably a sill. May include some rock properly belonging to Martín González Lava

Km MONACILLO FORMATION (UPPER CRETACEOUS)—Volcanic mudstone and sandstone, generally reddish-gray. Outcrops in quarries 1 km northeast of St. Just are thin-bedded grayish-orange mudstone and siltstone, overlain directly by Río Piedras Siltstone. Thickness 0–100 m

Kfl FRAILES FORMATION, LEPROCOMIO MUDSTONE MEMBER (UPPER CRETACEOUS)—Thin- to thick-bedded medium-gray calcareous mudstone. Thickness 300–400 m

Kf FRAILES FORMATION (UPPER CRETACEOUS)—Grayish-green medium- to very thick bedded volcanic sandstone, in part pebbly; and fine to medium volcanic breccia. Thickness 700–800 m

Kff FRAILES FORMATION, LAVA FLOWS (UPPER CRETACEOUS)—Basaltic to andesitic pillow lava

Kmg MARTÍN GONZÁLEZ LAVA (UPPER CRETACEOUS)—Grayish-green to dusky-green porphyritic andesitic basalt containing abundant phenocrysts of plagioclase; includes some interbedded volcaniclastic rock. Some of material mapped as intrusive rock in the southeast corner of the quadrangle may actually be Martín González. Thickness 0–300 m

Contact—Approximately located

Fault—Approximately located; dotted where concealed; queried where doubtful. U, upthrown side; D, downthrown side. Arrows show direction of relative movement

Strike and dip of bedding. Dip value shown

Sand and gravel pit

Quarry

GEOMORPHOLOGIC NOTES

The boundary between the interior highlands of Puerto Rico and the northern coastal plain is just north of the southern border of the Carolina quadrangle. The rocks in the interior highlands consist largely of volcanic and intrusive rocks and associated sedimentary rocks (Pease, 1968 and Seiders, 1971); these are of Early Cretaceous to Eocene age. North of the boundary the coastal plain consists largely of alluvial deposits and limestone.

The Río Grande de Loíza, which has the largest drainage basin in Puerto Rico, flows from the hilly interior into the northern coastal plain at the southern edge of the quadrangle. The headwaters of the river are in intrusive rocks, largely quartz diorite of the San Lorenzo batholith, which have weathered to clayey quartz sand. Hence the flood plain of the river is underlain by alluvium composed largely of quartz sand, but containing cobbles of rock derived from the formations through which the river flows on its way north from the batholith.

The river has had a complex Quaternary history in the coastal plain. Apparently it first flowed northward from Carolina between the alluvial fan and terrace deposits of barrio Sabana Abajo and the limestone hills of barrio Hoyo Mulas. The river entered the sea near Boca de Cangrejos, as is shown by the deposits of fine quartz sand that form the beach toward the southwest. Eventually, deposition of the abundant sediment filled this channel, and the river was diverted to the east and flowed in a complicated series of meanders, partly through the limestone hills northwest of Santa Barbara. The old courses of the river are now marked by abandoned meanders and ox-bow lakes.

Eventually all distributaries flowing toward Boca de Cangrejos were blocked by silting and the river was again diverted eastward to the vicinity of Canóvanas and Santa Barbara, where it now flows in a remarkably straight course north to the coast at Loíza Aldea. As in the area west of Boca de Cangrejos the beach deposits near Loíza Aldea are composed of quartz sand brought in by the river. Quartz is very rare in the deposits along the Playa de las Tres Palmitas, the beach between Punta Vacía Talega and Boca de Cangrejos, which is composed largely of finely ground shell fragments.

The straight course of the river from Santa Barbara to the coast has never been satisfactorily explained. The earliest maps of Puerto Rico, made in the seventeenth century, show the river with its present course; and there is no record of straightening the channel of the river, so apparently the straight course is a natural one. Natural levees on both sides of the river rise about 3 m. Swamp deposits on both sides of the river are lagoons that have been gradually silted as the river overflowed its natural levees during floods, leaving only Laguna la Torrecilla and Laguna de Piñones as remnants.

In contrast to the Río Grande de Loíza, Quebrada Blasina flowed northward in a meandering course until it was straightened by dredging in the early 1960's in order to drain its flood plain for housing projects.

ECONOMIC AND ENGINEERING GEOLOGY

The only metalliferous deposits observed in the Carolina quadrangle are small quantities of magnetite concentrated in thin lenses in quartz beach sand at the mouth of the Río Grande de Loíza (Guillou and Glass, 1957, p. 281, tables 1, 2, plate 15). One lens contained 14 percent magnetite, and other thin lenses had as much as 10 percent. The lenses are so thin, however, that the magnetite does not constitute an exploitable resource.

Large quantities are available of such nonmetallic resources as clay, limestone, chalk, sand and gravel, and rock suitable for use as fill.

CLAY

A deposit of clay used at La Cerámica terracotta plant was described by Cadilla (1958). Another much smaller deposit, possibly suitable for bricks, crops out at the side of Puerto Rico Route 3, 1 km west-southwest of the plaza at Canóvanas.

LIMESTONE

Hard dense algal limestone of the Guaracanal Formation crops out south of Route 3 in a narrow belt from 1.5 to 2 km west of the plaza at Canóvanas and on the south side of a ridge about 2 km east of the plaza at Carolina and immediately north of the Río Grande de Loíza. This limestone will make excellent concrete aggregate and is pure enough to be used as a source of lime.

The Aymamón Limestone consists largely of soft chalk, but most of it is very pure calcium carbonate that has been dissolved at the surface and reprecipitated as a carapace of very hard dense limestone. The surface case-hardened part can be excavated and used as fill or as terrazo chips, but the softer parts, soon reached in quarries, are not suitable. The entire unit is suitable for the manufacture of high-quality lime, except for some thin lenses of calcitic dolomite present on the westernmost hill at Loíza Aldea.

FILL

The Aguada Limestone consists of 30–40 m of alternating beds of rather tough, slightly earthy limestone and of very calcareous sandy claystone. This limestone makes very good fill and has been used as road metal on many of the cane-field roads.

The thin-bedded Río Piedras Siltstone that forms the Cerros del Comandante in barrio San Antón has been extracted from several quarries for coarse fill.

SAND AND GRAVEL

Virtually unlimited supplies of sand and gravel are available in the alluvial deposits of the Río Grande de Loíza in the area bounded by Carolina, Hoyo Mulas, and Canóvanas. Sand and gravel have been excavated extensively in the valley south of Carolina.

The low dunes south of the beach between Punta Maldonado and Punta Vacía Talega have been excavated as a source of building sand, but the quantity is limited. This sand is composed principally of shell fragments.

Large quantities of quartz sand are available in the beach ridges located more than a kilometer inland in the area south of Punta Vacía Talega. Additional large quantities of somewhat carbonaceous sand are found in the long ridge about 600 m south of Punta Maldonado, in the ridges south of Piñones, and at Islote de Juan Peréz.

INUNDATIONS

All areas of the quadrangle shown as underlain by alluvium or swamp are subject to frequent floods.

The areas of alluvium at the sides of the Río Grande de Loíza between Canóvanas and Loíza Aldea are natural levees. They are higher than land farther from the river, but they are formed by the deposit of alluvium from the river waters during high floods when the velocity of the flood water drops as the river spreads beyond its channel. These strips of higher land are particularly susceptible to flooding.

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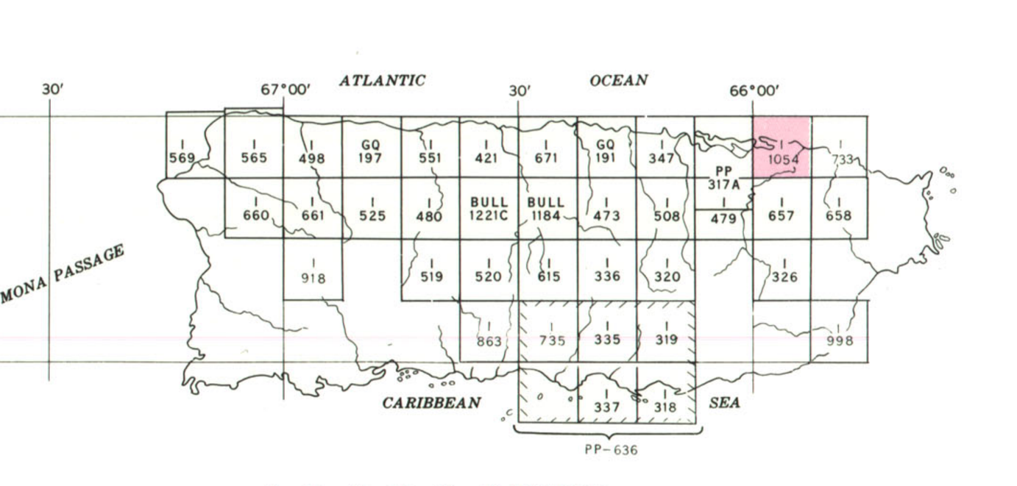

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GEOLOGIC MAP OF THE CAROLINA QUADRANGLE, PUERTO RICO

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1977

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