U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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Base from U.S. Geological Survey, 1951, 1:120,000
Polyconic projection
1983 North American Datum

APPROXIMATE MEAN DECLINATION, 2009 (TRUE NORTH; MAGNETIC NORTH; 11½°)

SCALE 1:140 000

5 0 5 10 15 20 KILOMETERS

5 0 5 10 MILES

CONTOUR INTERVAL 50 METERS

INTRODUCTION

This map is a digital compilation, combining plate 1 of Monroe (1976) with mapping of karst areas on Isla de Mona and Isla Monito (Briggs and Seiders, 1972); these references contain more detailed descriptions of karst areas and landforms. This map is the basis for the Puerto Rico part of a new national karst map currently being compiled by the U.S. Geological Survey. In addition, this product is a standalone, citable source of digital karst data for Puerto Rico. Nearly 25 percent of the United States is underlain by karst terrain, and a large part of that area is undergoing urban and industrial development. Accurate delineations of karstic rocks are needed at scales suitable for national, State, and local maps. The data on this map contribute to a better understanding of subsidence hazards, groundwater contamination potential, and cave resources as well as serve as a guide to topical research on karst. Because the karst data were digitized from maps having a different scale and projection from those on the base map used for this publication, some karst features may not coincide perfectly with physiographic features portrayed on the base map.

DESCRIPTION OF MAP UNITS ON PUERTO RICO

(Modified from Monroe, 1976)

CENOZOIC DEPOSITS RESTING ON THE LIMESTONE FORMATIONS

The limestone formations described below are overlain in different parts of the island by surficial deposits of blanket, alluvial, coastal, or eolian sediments. Most of these surficial units are composed of noncalcareous material and show no karst development; for this reason they are discussed but not shown on this map. Water percolating through some of these units is acidified, however, so that solution may take place in the underlying limestone. This solution can result in local subsidence.

Blanket sands (not shown on map)—Blanket sands fill the depressions between mogotes and the ridges of mogotes in the northern karst belt between Bayamón and Aguadilla, especially in the northern part of the belt in the outcrop area of the Aymamón Limestone and the Camuy Formation. Mogotes are isolated karst towers or hills that range from 1 meter (m) to over 50 m in height. Blanket sands were named and described in 1962 by Briggs (1966, p. 62), and the reader is referred to his paper for details. Briggs described the sands as being composed of quartz sand, clayey sand, sandy clay, and clay. He stated, "the dominant constituents are angular, subangular, and subround, medium to fine grains of clear quartz, and reddish-brown to moderate-brown, dark-yellowish-orange, light-gray, and white, commonly ferruginous kaolinitic clay. Quartz and clay together make up almost all of the blanket sands at most outcrops, but their relative proportions vary greatly." Briggs (1966) interpreted these deposits to be residuum of detrital volcaniclastic sediments transported to coastal areas as alluvium and subsequently redistributed by longshore currents during a time of transgression

Alluvial deposits (not shown on map)—Very thick alluvium fills valleys in both northern and southern Puerto Rico; some of these valleys may contain more than 100 m of alluvium. In some places the valley fills may have buried the karst topography and filled large caves, but the deposits are so thick that this cannot be verified

Coastal deposits (not shown on map)—Much of the beach sand in Puerto Rico contains abundant shell fragments; this sand is cemented in many places into a coarse calcarenite beachrock, particularly in the intertidal zone. In places, a combination of solution and marine erosion has left low arches and pedestals in exposed beachrock

Q **Crossbedded calcarenite (eolianite) (Holocene)**—Karstification has occurred at many places in the calcarenite formed by induration of sand dunes that accumulated during Quaternary time near the Atlantic coast of Puerto Rico. Kaye (1959a) described ridges of indurated sand dunes at various altitudes above and below sea level, and also described the solution pans and small karren spikes that have formed on the crests and sides of these features

LIMESTONE OF MIOCENE AND OLIGOCENE AGE

By far, the most important limestone units in the karst terrain of Puerto Rico are the formations of Oligocene and Miocene age in northern and southern Puerto Rico. These carbonate rocks are subdivided into penecontemporaneous map units (Tl and Tcm) based on lithology. Deposits of chalk and calcareous clay (map unit Tcm) are shown on the map if they contain sufficient thin beds of limestone to provide subterranean drainage in some places, although karst phenomena are not common in these deposits

Tl **Limestone (Pliocene to Oligocene)**—

Northern Puerto Rico

Camuy Formation (Pliocene)—Sandstone, limestone, and sandy ferruginous chalk
Aymamón Limestone (in northwestern Puerto Rico) (Miocene)—Very pure chalk, indurated on the surface to hard limestone; slightly ferruginous in upper part
Aguada Limestone (Miocene)—Hard stratified limestone grading downward into chalk; locally sandy
Cibao Formation (Miocene and Oligocene)—
Montebello Limestone Member (in north-central Puerto Rico only)—Friable pure calcarenite, indurated to an erosion-resistant limestone upon exposure to air
Quebrada Arenas Limestone Member (in eastern Puerto Rico only)—Finely crystalline stratified limestone
Lares Limestone (Oligocene)—Thin-bedded to thick-bedded fairly pure limestone; lower part locally contains grains of quartz and limonite sand, and intertongues to west with sand and gravel
San Sebastián Formation (Oligocene)—Mostly thin-bedded sand and clay with some sandy limestone locally, especially in northwestern Puerto Rico. Also contains sand and gravel

Southern Puerto Rico

Ponce Limestone (Miocene and Pliocene)—Very hard, generally light-grayish-orange calcarenite containing abundant molds of mollusks, solitary corals, echinoids, and Foraminifera. The Ponce Limestone was deposited as a fringing reef of fairly pure limestone, but in some places near the present coast it has been slightly dolomitized

Tcm **Chalk and marl (Miocene and Oligocene)**—

Northern Puerto Rico

Cibao Formation (Miocene and Oligocene)—
Upper member—Chalk and soft limestone
Guajataca Member (in northwestern Puerto Rico only)—Fossiliferous calcareous clay and limestone containing lenses of sand and gravel as much as 15 m thick
Miranda Sand Member (in northeastern Puerto Rico only)—Sand and gravel; sand and sandy clay
Rio Indio Limestone Member (in northeastern Puerto Rico only)—Compact, chalky yellowish-orange weakly bedded limestone
Typical chalk or marl (in northeastern and northwestern Puerto Rico only)—Sandy and silty clayey chalk

Southern Puerto Rico

Juana Díaz Formation (Miocene and Oligocene)—Consists of lenticular and intertonguing beds of sand, gravel, clay, mudstone, chalk, and limestone. Most of the limestone is very chalky, except for a thick organic reef complex 8 to 14 kilometers (km) west-northwest of Ponce. The only part of the Juana Díaz Formation that shows any karst development is the reef complex south and west of Peñuelas, which contains several rather large caves

LIMESTONE OF EARLY TERTIARY AGE

Tls **Limestone, undivided (lower Tertiary)**—Limestone formations of Paleocene and Eocene age are present in several parts of Puerto Rico, but the most significant is the Eocene Cuevas Limestone (Glover, 1971), which crops out over a wide belt in southern Puerto Rico between the towns of Salinas and Villalba. The width of the outcrop belt is deceptive. The formation is only about 35 m thick, but the outcrop pattern is wide because of repeated faulting. Several caves are known in this limestone and probably many more are present

LIMESTONE OF CRETACEOUS AGE

K **Limestone, undivided (Cretaceous)**—The oldest limestone known in Puerto Rico is exposed in the east-central part of the island, just west of the town of Caguas, and is of Early Cretaceous age, probably Albian or Aptian. This limestone, the Aguas Buenas Limestone Member of the Torrecilla Breccia (Briggs, 1969), contains the Aguas Buenas, probably the best-known cave system in Puerto Rico. The limestone, ranging in thickness from 0 to 60 m, is lenticular and present in several places at the base of the Torrecilla Breccia. It consists of light- to dark-gray, thick-bedded (30–100 cm) to very thick bedded (>100 cm) finely crystalline limestone, bearing an extensive rudist and gastropod fauna. The limestone was deposited as a reef that formed on the flanks of volcanic islands. Limestone is more common in the Upper Cretaceous rocks than in the Lower Cretaceous rocks, but in eastern and central Puerto Rico it is present only locally, and commonly in relatively thin units. Upper Cretaceous limestone is most extensive in southwestern Puerto Rico, where it is present at several horizons on units as thick as several hundred meters. The most extensive and thickest limestone is the Cretaceous Parguera Limestone of Almy (1965), which is present in typical form from the town of Guanica westward to the coast. The Parguera consists largely of medium-bedded to massive limestone. It varies greatly in thickness along strike, reaching a maximum of more than 300 m. The other Upper Cretaceous limestone formations are similar to the Parguera Limestone, but are generally thinner. Caves are present in some, and in southwestern Puerto Rico, surface solutional features such as karren are well developed on many of these units

BLUE HOLE OR HOYO PRIETO

The Blue Hole or Hoyo Prieto is a blind valley 100 m deep in west-central Puerto Rico where the Camuy River flows northward from volcanic rocks onto the Lares Limestone (map unit Tl). The river flows through a large cave system and eventually emerges as a surface stream about 6 km (3.7 miles (mi)) to the north

DESCRIPTION OF MAP UNITS ON ISLA DE MONA AND ISLA MONITO

(Modified from Briggs and Seiders, 1972)

Qb **Beach deposits (Holocene)**—Grayish-pink, fine- to medium-grained calcite and aragonite sand; contains no quartz or heavy-mineral grains; locally includes rubble from raised reef deposits and beachrock. Thickness ranges from 0 to at least 3 m

Qbo **Boulder deposits (Holocene)**—Deposits of boulders of Isla de Mona Dolomite and Lirio Limestone. Includes boulders as large as 50 m in length

Qr **Raised reef platform (Holocene)**—Fragmental grayish-orange-pink limestone composed chiefly of fossils and fossil fragments; commonly case hardened, locally somewhat chalky. Thickness ranges from 0 to at least 3 m; locally may be as thick as 10 m

Tli **Lirio Limestone (Miocene)**—Very pale orange to grayish-orange-pink fine-grained limestone, thick-bedded and very thick bedded, locally crossbedded; commonly very well indurated, perhaps as a result of surficial solution and reprecipitation; locally chalky; cavernous, most notably in lower 10 m at the periphery of Isla de Mona. Maximum exposed thickeness is about 40 m

Tm **Isla de Mona Dolomite (Miocene)**—Very pale to moderate-orange-pink finely crystalline calcitic dolomite, very thick bedded, locally crossbedded; well indurated. Zones of limestone about 5 m thick occur locally at the top and about 15 m and 50 m stratigraphically below the upper contact. Base concealed by the sea. Maximum exposed thickness is about 80 m

ISLA DE MONA AND ISLA MONITO

(Modified from Kaye, 1959b, and Briggs and Seiders, 1972)

Isla de Mona is an uplifted carbonate platform located in the Mona Passage, 44 miles (mi) (71 km) west of Mayaguez, Puerto Rico, and 37 mi (60 km) southeast of Punta Espada, Dominican Republic. The island measures about 6.5 mi (10.4 km) from east to west and 4.5 mi (7.2 km) from north to south, and it has an area of about 23.3 mi^2 (60.3 km^2). Isla Monito is located 3.5 mi (5.6 km) northwest of Isla de Mona and is less than a quarter of a square mile in area. Isla de Mona attains its maximum altitude of 295 feet (ft) (90 m) on the north, and an altitude of 82 ft (25 m) on the south; therefore its surface dips 3.5°, gently, to the south. The island was discovered by Christopher Columbus in 1494 during his second voyage. In early colonial times the island was a watering and provisioning station and in the late 19th century its caverns were extensively worked for their deposits of leached guano. The limestone surface is weathered by solution into a karrenfels type of microrelief with sharp points, ridges, and pinnacles. In some places these solution features show a defined lineation pattern. Dark-reddish-brown lateritic soil is scattered as thin patches in depressions and fractures in the limestone, probably formed as a residual deposit left from the dissolution of the Isla de Mona Dolomite and the Lirio Limestone. Except for this lateritic soil, Isla de Mona consists entirely of limestone and dolomite. The Lirio Limestone overlies the Isla de Mona Dolomite. This carbonate platform is bounded by steep cliffs on the south and by vertical sea cliffs on the north. The cliffs on the south side of the island are fringed by a narrow coastal plain. This coastal plain is underlain by reef limestone and represents a recently "raised" reef platform that doesn't exceed 12 ft (3.7 m) in altitude. Isla de Mona is renowned for its great number of caves, and many people believe they can be traveled underground for great distances inland. Briggs and Seiders discovered, however, in the course of mapping the geology, that from the cliffs surrounding the island one can travel not more than 240 m inland. Extensive cave development, primarily flank margin caves, is limited to a zone on the island edges (Mylroie and Carew, 1990). Caves in the Isla de Mona Dolomite are few and tend to be very small. These caves tend to form at the contact between the Lirio Limestone and the Isla de Mona Dolomite.

EXPLANATION OF MAP SYMBOLS

- Area in which closed depressions deeper than 5 m are common
- Areas in which closed depressions deeper than 30 m are common
- Blue Hole or Hoyo Prieto

CORRELATION OF MAP UNITS

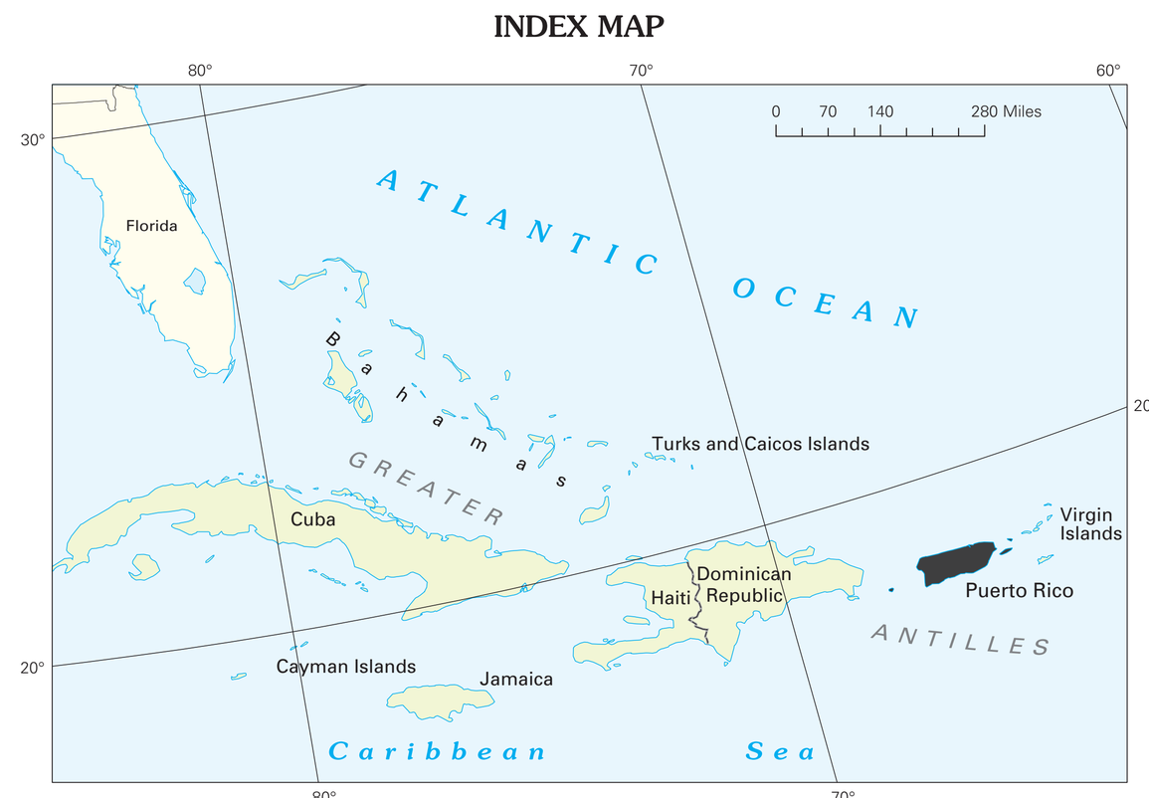
Epoch	Stage	Northern Puerto Rico	Southern Puerto Rico	Isla de Mona and Isla Monito
QUATERNARY	Holocene	Crossbedded Calcarenite		Beach Deposits; Boulder Deposits; Raised Reef Platform
	Pleistocene			
TERTIARY	Pliocene	Camuy Fm.	Ponce Fm.	
	Miocene	Aymamón Ls.; Aguada Ls.; Cibao Fm. Ls.; Cibao Fm. Chalk	Ponce Fm.; Juana Díaz Fm.	Lirio Ls.; Isla de Mona Dolomite
	Oligocene	Cibao Fm. Ls.; Cibao Fm. Chalk; Lares Ls.; San Sebastián Fm.	Juana Díaz Fm.	
	Eocene		Cuevas Ls.	
	Paleocene			
CRETACEOUS	Maastrichtian		Parguera Ls.	
	Campanian		Parguera Ls.	
	Santonian		Parguera Ls.	
	Coniacian			
	Turonian			
	Cenomanian			
	Albian	Aguas Buenas Ls. Mbr.	Aguas Buenas Ls. Mbr.	

Modified from Ogg and others (2004), Jolly and others (1998), Schweitzer and others (2006), and Edinger and Risk (1994). Abbreviations used: Fm., Formation; Ls., Limestone; Mbr., Member.

Rio Tanamá cutting through karstic limestone near Arecibo, Puerto Rico.

Flank margin caves, Playa de Pajaros, Isla de Mona, Puerto Rico.

INDEX MAP



Uplifted carbonate platform of Isla de Mona, Puerto Rico.

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KARST MAP OF PUERTO RICO

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