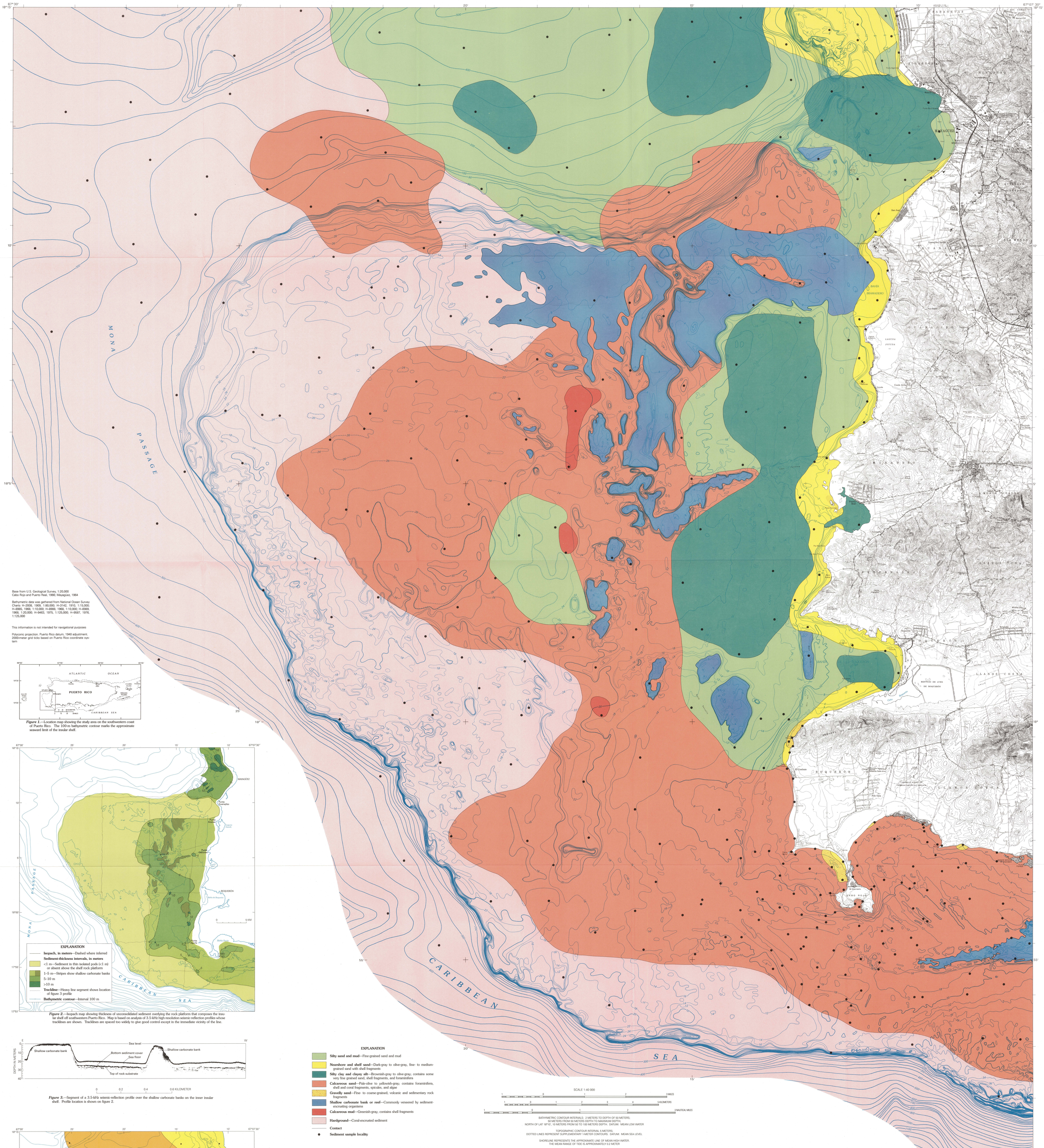
Prepared in cooperation with the
COMMONWEALTH OF PUERTO RICO
DEPARTMENT OF NATURAL RESOURCES



Base from U.S. Geological Survey, 1:20,000
Cabo Rojo and Puerto Real, 1966; Mayagüez, 1964

Bathymetric data was gathered from National Ocean Survey Charts H–2838, 1909, 1:80,000; H–3142, 1910, 1:15,000; H–8985, 1968, 1:10,000; H–8988, 1968, 1:10,000; H–8989, 1968, 1:20,000; H–9463, 1975, 1:125,000; H–9687, 1976, 1:125,000

This information is not intended for navigational purposes

Polyconic projection. Puerto Rico datum, 1940 adjustment. 2000-meter grid ticks based on Puerto Rico coordinate system

Figure 1.—Location map showing the study area on the southwestern coast of Puerto Rico. The 100-m bathymetric contour marks the approximate seaward limit of the insular shelf.

Figure 2.—Isopach map showing thickness of unconsolidated sediment overlying the rock platform that composes the insular shelf off southwestern Puerto Rico. Map is based on analysis of 3.5-kHz high-resolution seismic-reflection profiles whose tracklines are shown. Tracklines are spaced too widely to give good control except in the immediate vicinity of the line.

Figure 3.—Segment of a 3.5-kHz seismic-reflection profile over the shallow carbonate banks on the inner insular shelf. Profile location is shown on figure 2.

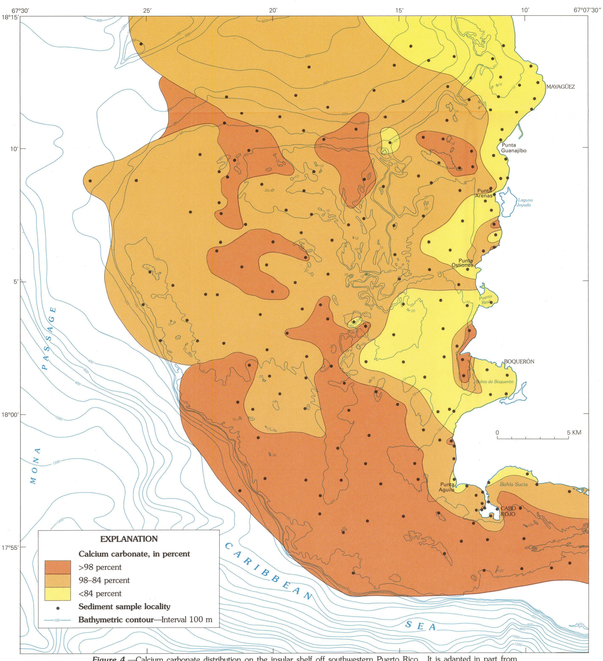


Figure 4.—Calcium carbonate distribution on the insular shelf off southwestern Puerto Rico. It is adapted in part from Shideler (1980), Trumbull and Trias (1982), and Schneidermann and others (1976). For most of the map, values have been taken from the references given above. All sediment sample localities are shown on the map.

DISCUSSION

INTRODUCTION

This map shows the thickness and composition of unconsolidated sediment cover on the insular shelf off southwestern Puerto Rico, from Mayagüez to Cabo Rojo (fig. 1). The area was examined as part of a larger project conducted by the U.S. Geological Survey (USGS) to map the entire insular shelf surrounding Puerto Rico, at a scale of 1:40,000. Our purpose in this study was to characterize and map the distribution of surficial sediment from lat 18°15′ N. (north of Mayagüez), southward to lat 17°51′ N. (south of Cabo Rojo), eastward to long 67°07′30″ W. (seaward to Bahía Sucia), and westward to long 67°30′ W.

PREVIOUS WORK

Bottom-sediment properties off the Cabo Rojo area have been studied by Grove and Trumbull (1978), Shideler (1980), Trumbull and Trias (1982), and Fernandez (1978). We used these earlier studies as well as our own profiles and samples to learn about the southwestern Puerto Rico shelf. Shideler (1980), mapping the bottom-sediment texture off southwestern Puerto Rico, showed that the shelf is covered mainly by moderately sorted calcareous sand. Grove and Trumbull (1978) mapped sediment types of Bahía Sucia east of Cabo Rojo and related them to the bathymetry of that bay. Trumbull and Trias (1982) mapped the thickness and distribution of a calcareous sand deposit west of Cabo Rojo. Fernandez (1978) mapped the sedimentary facies on the insular shelf around Cabo Rojo and attempted to estimate the amount of calcareous sand cover southwest of Cabo Rojo.

COASTLINE

The southwestern coast of Puerto Rico is characterized by low wave-energy conditions. The coast is on the lee of westward-directed trade winds, and the insular shelf is a broad and shallow platform, as much as 26 km wide and 10 to 20 m deep, that offers protection from storm swells. As a result, the coast is mostly low lying and swampy. Rocky headlands commonly separate small embayments that are fringed with mangroves.

Two major rivers drain southwestern Puerto Rico. The Río Grande de Añasco, located 7 km north of Mayagüez (just off the northern boundary of the map area), and the Río Guanajibo (about 4 km south of Mayagüez) are commonly laden with sediment due to the large amount of rainfall of the region (about 180 cm per yr; see Calversbert, 1970). Dark-colored terrigenous grains dominate the sediment of the beaches adjacent to these rivers. The southern part of the study area receives much less rainfall (about 90 cm per yr; see Calversbert, 1970) and has no major rivers or streams.

Many commercial establishments and private homes have been constructed practically at the water's edge, so that beach stabilization measures are a common feature. In Bahía de Mayagüez most of the shoreline is stabilized by revetments. Prior to their emplacement, a highway running parallel to the shore had been eroded extensively. Although the revetments have slowed erosion, buildings between the road and shore are less than 2 m above sea level.

A narrow beach fronts the shore between Punta Guanajibo and Punta Arenas. Commercial establishments, summer homes, and condominiums have been constructed between the highway and the beach. Although most of the beach area is unstabilized, a few property owners have built seawalls and revetments. The shoreline immediately south of Punta Guanajibo accreted about 1 m per yr from 1951 to 1987 (Thieler and Danforth, 1993, p. 37). Accretion rates decrease progressively south of here, becoming erosional near Punta Arenas; there the shoreline is receding because of more direct wave approach.

South of Punta Arenas lies the town of Joyuda, where commercial establishments have been constructed to the water's edge; the beach is absent. Mangrove swamps fringe the shoreline south of Joyuda. The fishing village of Puerto Real lies inside a mangrove-covered bay. Because of the low-energy environment inside the bay, the shoreline has remained stable in the last half-century (Thieler and Danforth 1993, p. 37).

To the south of Puerto Real is Bahía de Boquerón, a bay that is bounded by the rocky headlands of Punta Guaniquilla on the north and Punta Melones on the south. Mangrove swamps fringe the northern shore, whereas a narrow sandy beach extends the length of the southern shore. The town of Boquerón has several buildings at the water's edge, and the shore has been stabilized extensively.

South of the rocky headland at Punta Melones is the sandy shoreline of Punta Moja Casabe. Between 1968 and 1993, the northern end of Punta Moja Casabe eroded more than 2 m per yr, whereas the southern shore, extending south of the town of El Combate, accreted about 1 m per yr (Thieler and Danforth, 1993, p. 37). Stabilization structures at Punta Moja Casabe and El Combate have probably influenced these changes.

The white sandy beach from El Combate to Punta Aguila has been developed very little, and the shoreline appears to be stable. The rocky shoreline of Punta Aguila and Punta Jagüey encloses Bahía Salinas. The coastline here is the western side of a narrow tombolo, Cabo Rojo. The coast is low, and commercial salt ponds have been dug a few meters from the shore. Mangroves dot the shoreline north of Punta Jagüey.

On the eastern side of the spit is Bahía Sucia, a sandy beach so named because it serves as a depository of trash and surface debris transported west by currents and longshore transport along the southern coast of Puerto Rico. Westward-directed currents have also transported sand past Cabo Rojo to form a sand deposit (80 million m^3, Trumbull and Trias, 1982). From Punta Molino to Punta Pitahaya, the undeveloped shore is made up of small cliffs interspersed with pocket beaches and mangrove swamps.

METHODS

During a two-week interval in November 1990, utilizing the research vessel (RV) *Jean A* (contracted by the USGS from the Puerto Rico Department of Natural Resources), we ran 256 km of high-resolution seismic-reflection profiles off the southwestern coast of Puerto Rico. The profiles were run as 15 lines ranging in length from 15 to 50 km in a north-south, east-west grid (fig. 2). We followed the tracklines of a single-channel seismic-reflection survey, the results of which are unavailable, that was conducted by Western Geophysical Company of America for the Puerto Rico Electrical Power Authority in 1975. We towed a 3.5-kHz "fish" and a Huntec Sea Otter sled (boomer-type sound source) to profile the bottom (fig. 3); in addition, 22 bottom samples were collected (fig. 4). At least twice this number were attempted, but no samples were recovered by the Shipek bottom grab sampler, because much of the offshore area is carbonate hardground. At many stations, the sample collected was commonly less than 0.05 liter, a surficial dusting of the outcrop and a few encrusting organisms. The samples obtained from the sediment that veneers the shelf were analyzed for grain size and for composition in an effort to build upon the earlier works of Grove and Trumbull (1978), Shideler (1980), and Trumbull and Trias (1982). Navigation was facilitated by a shore-based Miniranger Positioning System with an accuracy to within 4 m.

We submitted the 22 samples to the USGS in Reston, Va., for carbonate analysis. In the analyses, a 500-mg sample was digested with $HClO_4$. CO_2 was evolved and carried into a coulometric cell. The CO_2 was converted into a strong acid by ethanolamine and was titrated coulometrically following the technique of Engleman and others (1985).

INSULAR SHELF

Bathymetry

The bathymetric base map was prepared by the USGS from National Ocean Survey smooth sheets at various scales and from three bordering USGS quadrangles at a scale of 1:20,000. A bathymetric contour interval of 2 m to a depth 50 m was used for the insular shelf. From 50 to 100 m depth, a 10-m contour interval was used where space permitted, and in deeper water the contour interval was 50 m. The base map was used in compiling the results of our November 1990 field survey and the results of earlier offshore sedimentary studies.

The insular shelf is 26 km wide at its widest point due west of Laguna Joyuda. Shelf width narrows to 3 km west of Punta Algarrobo, north of Mayagüez. Seaward from the coast, the shelf deepens gradually and irregularly; the sea floor is marked by shallow carbonate banks that are only 4 to 6 m deep and by a few channels up to 24 m deep that wind to the shelf edge, where at 20 to 30 m depth, the transition to Mona Passage takes place. North of lat 18°5′, the shelf break is stepped or terraced and occurs between 10 and 40 m.

Thickness of bottom-sediment cover

The seismic contrast between the rock platform and the unconsolidated calcareous sediment (Holocene?) overlying it allowed mapping of a discontinuous sediment cover on 3.5-kHz profiles, by allowing us to measure the two-way traveltime difference between the sea floor and the conspicuous acoustic reflector beneath it (fig. 3). The thickest area of sediment is seaward of Mayagüez, where over 10 m of sediment has accumulated on the outer insular shelf and slope. The profiles, whose tracklines are shown in figure 2, do not extend close enough to shore to let us infer the sediment thickness at the landward most part of the shelf. Numerous shallow carbonate banks dot the inside part of the shelf; their sediment cover pinches down to less than what can be resolved geophysically (<1 m), suggesting that the banks have been actively building during the accumulation of the sediment blanket (fig. 3). Figure 2 shows that the sediment cover is present over the landward half of the shelf, where thicknesses of 5 to 10 m occur between Cabo Rojo and Punta Ostiones and between Punta Guanajibo and the northern limit of the study area. Over much of the landward half of the shelf, the cover thins to 1 to 3 m. On the seaward half of the shelf, the sediment cover is either absent or is present only in isolated pods less than 1 m thick.

To the west of Cabo Rojo, Trumbull and Trias (1982) mapped a calcareous sand deposit and reported it to be as thick as 27 ft (8 m) (see fig. 2). Their sand deposit is lens shaped and covers a hard rock floor. By using more closely spaced seismic profiles than ours, they were able to map the isolated buried limestone outcrops that help to define the limits of unconsolidated sandy carbonate sediment-cover west of Cabo Rojo. They also were able to contour the deposit on a 2-ft (0.6-m) interval. The deposit lies mainly within the 10-m bathymetric contour in this area and covers an area of approximately 2.5 x 9 km^2 (Trumbull and Trias, 1982, fig. 1, table 1). The thickest part of the deposit is 2 km southwest of Punta Aguila. Where it was vibracored in eight sites, more than 3 m of calcium carbonate sand was encountered south and southwest of Cabo Rojo.

Composition of bottom-sediment cover

The insular shelf is covered by sand and mud of varying composition and grain size depending on the location. The texture and composition of the bottom sediment northward to lat 18°03′ N. was mapped and discussed by Shideler (1980). Our sediment types were determined by combining the description of bottom grab samples collected during the 1970's and 1980's by Grove, Rodriguez, Trias, and Trumbull (see section on Methods for references), with our own description of samples collected in November 1990.

Adjacent to the coast at Mayagüez, the dominant sediment types are silty sand and mud having high terrigenous content, similar to what Grove (1983) mapped on the insular shelf north of the study area. The sediment is probably derived from runoff of the Río Yagüez and from erosion of the hilly landscape around Mayagüez. North of Mayagüez, the insular shelf (2–10 m water depth) is covered by a dark-gray, fine- to medium-grained sand that has a muddy component and also contains shell fragments. Occupying the main part of the shelf in the area is an olive-gray, fine-grained sand that blankets the shelf out to 150 to 170 m water depth at the northeastern limit of the survey.

Adjacent to the coast is dark-gray, fine- to medium-grained terrigenous sand that contains shell fragments. The sand covers the inner shelf south and north of Mayagüez, and toward the south it becomes more calcareous and also contains foraminifera; in some areas like Bahía de Boquerón, a black organic-rich mud underlies the sand, suggesting that the sand is a recent deposit in the bay.

Several isolated areas of silty clay and clayey silt cover the shelf and deeper areas west of Mayagüez. The sediment is a brownish-gray to olive-gray mud containing some very fine grained sand, shell fragments, and foraminifera. The silty clay and clayey silt also covers the landward half of the shelf off Laguna Joyuda to Bahía de Boquerón. The mud here contains shell fragments. Shideler (1980, figs 4 and 8) shows the area as greater than 80 percent mud. The sand fraction is 90 percent molluskk shell fragments. The mud also is present in sheltered bays like Puerto Real and Bahía de Boquerón.

A widespread covering of calcareous sand veneers the middle and outer shelf covering broad areas from west of Laguna Joyuda to most of the shelf south and east of Cabo Rojo. The sand was studied and cored by Trumbull and Trias (1982) and Grove and Trumbull (1978) in areas to the west, south, and east of Cabo Rojo. It is pale olive to yellowish gray and rich in foraminifera, *Halimeda* fragments, shell fragments, coral fragments, and spicules. The medium- to coarse-grained calcareous sand varies in thickness from several meters to thin, discontinuous patches over bedrock toward the outer third of the shelf.

Fine- to coarse-grained gravelly sand occurs in several inshore areas between Bahía de Boquerón and Punta Pitahaya. The debris, mainly volcanic and sedimentary rock fragments, is present where hills and outcrops are being cut into by coastal erosion. The deposit on the southern side of Bahía de Boquerón is an accumulation of detritus from erosion of Peñones de Melones, and the deposit of volcanic rock fragments of Punta Molino is the result of erosion of the Sierra Bermeja. The bluffs and outcrops at Cabo Rojo are the source of the deposit in Bahía Salinas.

Between El Combate and Punta Guanajibo on the inner half of the shelf, numerous irregularly shaped, elevated (<10 m) areas of the shelf are banks and reefs (fig. 3) where encrusting coral, shells, sponges, and other benthos grow in great profusion over a rocky bottom. At some spots the water over the banks is less than 4 m deep. Margarita Bank, south of Bahía Sucia, continues eastward toward Parguera (east of the map area) where reefs and several islets exist (Morelock and others, 1994).

A few areas of calcareous mud occur adjacent to areas of calcareous sand and shallow encrusted banks midway across the insular shelf. Fernandez (1978, fig. 9) mapped micritic mud facies along the shoreline of Bahía Sucia where mangrove swamps and adjacent *Thalassia* beds produce and trap fine-grained carbonate, an area that is mainly calcareous sand offshore.

Over the outer part of the insular shelf, a wider variety of sediment types discontinuously covers carbonate bedrock, although the most common sediment type is biogenic calcareous sand. The rock platform, which is exposed over much of the outer one-third of the insular shelf, is probably Miocene limestone or dolomite, judging from the composition of Isla de Mona to the west (see fig. 1) (Rodríguez and others, 1977; Fernandez, 1978, p. 51–52). Our bottom grab sampler retrieved only minor amounts of sediment and a few encrusting organisms at many of the stations on the outer one-third of the insular shelf.

Carbonate distribution within the bottom-sediment cover

For most of the offshore area, calcium carbonate is the main constituent in the sediment. Beach sands are composed mostly of carbonate grains derived from fringing reefs and carbonate banks; highest insoluble values (noncarbonate fraction up to 96.5 percent) are along the shore where terrigenous input from rivers and erosion of outcrops elevate the noncarbonate fraction. The distribution of carbonate on the insular shelf (fig. 4) shows a high concentration around Cabo Rojo (as adapted from Trumbull and Trias, 1982) and northward along the inner shelf to Laguna Joyuda. We used Shideler's map (1980, fig. 7) of acid-insoluble residue in sand-size sediment and a plot of insoluble residue of the entire area to infer the areas of lower and higher carbonate sediment in and adjacent to Bahía de Boquerón, inshore coastal areas north and south of Mayagüez, and the area immediately north of Cabo Rojo. We found his map useful because it covers a wider area than that of Trumbull and Trias (1982); their map shows the distribution of carbonate in much more detail than we do, but it covers a much smaller area southwest of Cabo Rojo. The narrow section of the shelf adjacent to Mayagüez is low in carbonate because of the active input of terrigenous sediment (K.M. Scanlon, unpub. data, 1995). A scattered suite of bottom-sediment samples was analyzed for total carbonate along the outer shelf, south of the insular shelf (see fig. 4). In a narrow, northwest-trending band across the outer part of the shelf (a hardground), sediment cover is a thin veneer and calcium carbonate values range from 95 to 97 percent.

ACKNOWLEDGMENTS

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EXPLANATION

- **Silty sand and mud**—Fine-grained sand and mud
- **Nearshore and shelf sand**—Dark-gray to olive-gray, fine- to medium-grained sand with shell fragments
- **Silty clay and clayey silt**—Brownish-gray to olive-gray; contains some very fine grained sand, shell fragments, and foraminifera
- **Calcareous sand**—Pale-olive to yellowish-gray; contains foraminifera, shell and coral fragments, spicules, and algae
- **Gravelly sand**—Fine- to coarse-grained; volcanic and sedimentary rock fragments
- **Shallow carbonate bank or reef**—Commonly veneered by sediment-encrusting organisms
- **Calcareous mud**—Greenish-gray; contains shell fragments
- **Hardground**—Coral-encrusted sediment
- **Contact**
- **Sediment sample locality**

SCALE 1:40 000

1 0 1 2 3 MILES
1 0 1 2 3 4 5 KILOMETERS
1 0 1 2 3 NAUTICAL MILES

BATHYMETRIC CONTOUR INTERVALS: 2 METERS TO DEPTH OF 50 METERS;
50 METERS FROM 50 METERS DEPTH TO MAXIMUM DEPTH;
NORTH OF LAT 18°10′, 10 METERS FROM 50 TO 100 METERS DEPTH. DATUM: MEAN LOW WATER

TOPOGRAPHIC CONTOUR INTERVAL 5 METERS;
DOTTED LINES REPRESENT SUPPLEMENTARY 1-METER CONTOURS. DATUM: MEAN SEA LEVEL

SHORELINE REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER.
THE MEAN RANGE OF TIDE IS APPROXIMATELY 0.2 METER

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1999

MARINE GEOLOGIC MAP OF THE SOUTHWESTERN INSULAR SHELF OF PUERTO RICO—MAYAGUEZ TO CABO ROJO

By
John S. Schlee,[1] Rafael W. Rodriguez,[2] Richard M.T. Webb,[2] and M.A. Carlo[2]
1999

AUTHOR AFFILIATIONS
[1]U.S. Geological Survey, Woods Hole, MA 02543.
[2]U.S. Geological Survey, San Juan, PR 00906.

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