STRUCTURAL GEOLOGY OF THE MUERTOS INSULAR SHELF, PUERTO RICO

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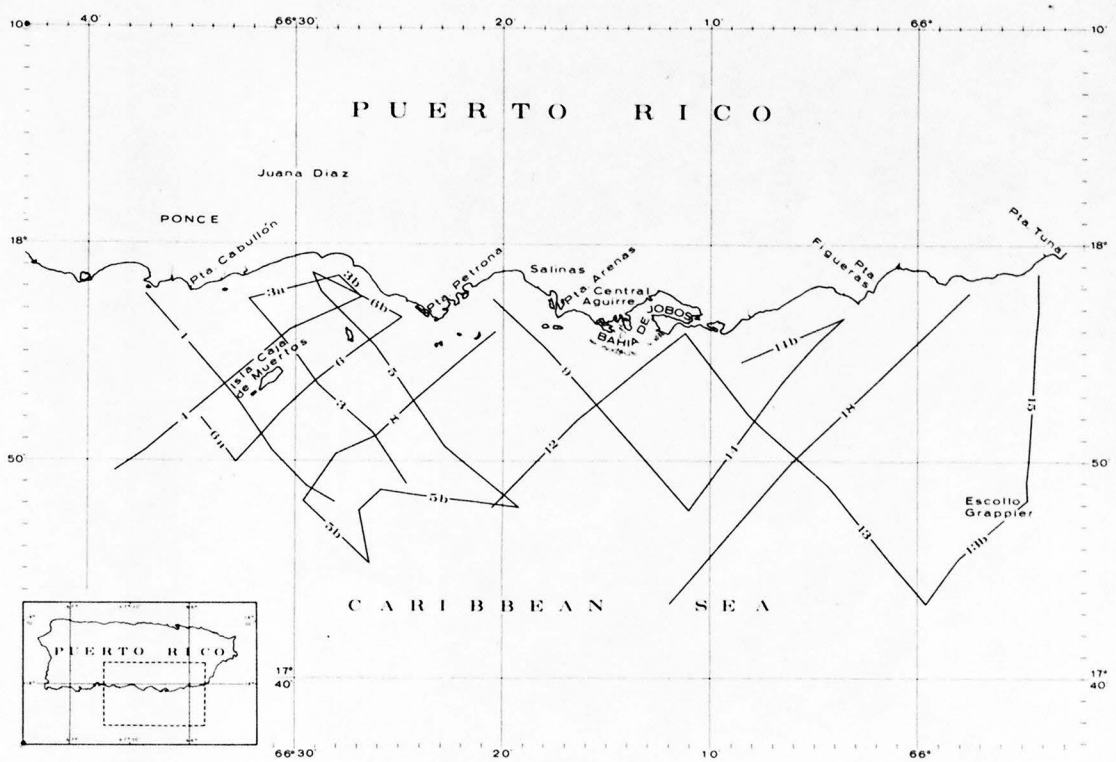
INTRODUCTION

One of the most distinctive physiographic features on the submerged south flank of the island of Puerto Rico is the Muertos insular shelf which borders the coast between Ponce and Punta Figueras (fig. 1). The surface of this shallow platform is approximately 55 km long and 15-18 km wide with water depths generally less than 30 m. The inner portion of the shelf is dotted with shoals and small islands of calcareous sand and living reef organisms. Isla Caja de Muertos, an outcrop of Tertiary volcanic rocks near the western edge of the shelf, is the largest island present and the one from which the shelf derives its name (Glover, 1967). The outer edge of the shelf is rimmed by reefs which flourished during Pleistocene low-sea levels but now lie in water 20 m or more in depth.

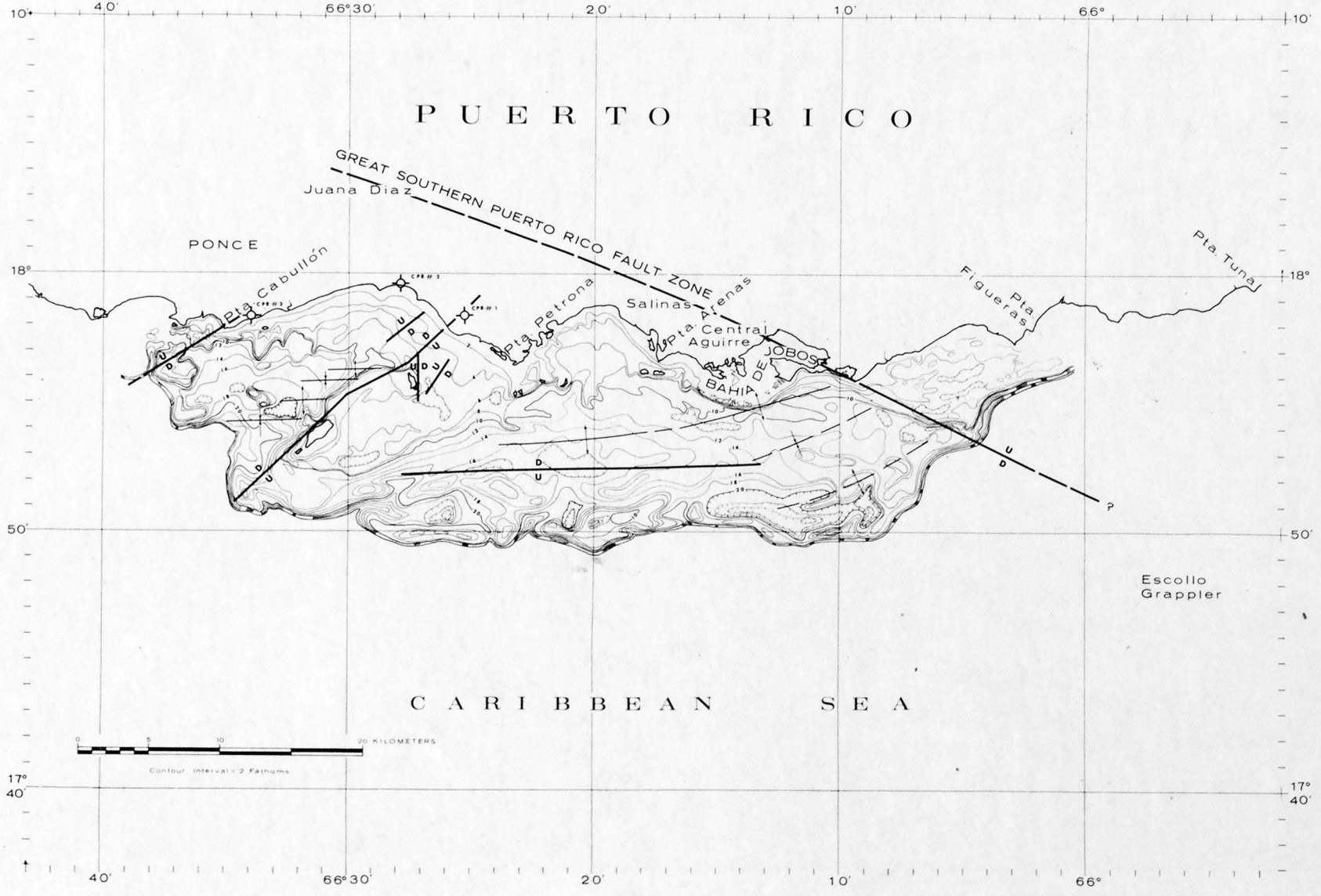
This jutting insular shelf, bounded on three sides by deep water but capped by a thick section of Tertiary and possibly older sediments, is anomalous to the steeply sloping flank of the Antillean ridge. Its geomorphology and structure suggest a tectonic origin.

In January, 1969 as part of a cooperative program between the U. S. Geological Survey and the Puerto Rico Economic Development Administration, a number of continuous seismic profiles


PUERTO RICO
Juana Diaz
PONCE
Pta Cabullón
Pta Petrona
Salinas
Pta Arenas
Pta Central Aguirre
JOBOS
BAHIA
Pta Figueras
Pta Tunal
Isla Caja de Muertos
Escollo Grappler
CARIBBEAN SEA
PUERTO RICO
10'
40'
66°30'
20'
10'
66°
18°
50'
17°
40'

1

were made on the Muertos shelf using a 13,000 joule stored-energy sparker as a sound source. From these profiles the principal structural elements of the shelf have been mapped (fig. 2).


PUERTO RICO
GREAT SOUTHERN PUERTO RICO FAULT ZONE
Juana Diaz
PONCE
Pta. Cabullón
Pta. Petrona
Salinas
Arenas
Pta. Central Aguirre
BAHIA DE JOBOS
Pta. Figueras
Pta. Tuna
Escollo Grappler
CARIBBEAN SEA
10'
40'
66°30'
20'
10'
66°
18°
50'
17°
40'
0 5 10 20 KILOMETERS
Contour Interval = 2 Fathoms

STRUCTURAL GEOLOGY

Faulting

The structure of the Muertos shelf is dominated by three principal faults. Associated with these faults are varying degrees of drag folding or block rotation which create locally steepened dips.

The easternmost of the principal faults strikes N65°W and crosses the coastline near Bahia de Jobos (fig. 2). Profile 14 suggests that the zone of faulting is several hundred meters wide and involves multiple fractures. Net vertical movement appears to have been down to the southwest, but because individual reflectors have not been correlated in this area the amount of displacement is difficult to estimate. The geographic location of the zone of faulting, as well as its west-northwesterly strike imply that it is a southeast continuation of the great southern Puerto Rico fault zone (Glover, 1967). This system of faulting traverses the entire island of Puerto Rico and separates completely different lithofacies in the older rocks. Major vertical and left-lateral strike-slip movements have been ascribed to this zone, and its continuation southeastward at least to Grappler Bank is also indicated by discontinuities in the total magnetic intensity contours in that area (Griscom and Geddes, 1966).

In the western portion of the insular shelf another major fault strikes N47°E along the west side of Isla Caja de Muertos. This fault has been described by Kaye (1957) and Glover (1967). According to the latter author the principal evidence for faulting comes from a seismic reflection survey in 1948 by United Geophysical Company described by Denning (1955). That survey suggested downward movement on the block west of the fault amounting to as much as 1.1 km near Isla Caja de Muertos, but that this movement dwindled to nothing near the shoreline north of Punta Petrona.

The continuous seismic profiles of the present study clearly show this zone of faulting and confirm the down-dropped relationship of the western block. The amount of vertical displacement is not indicated, however, due to uncertainty in identification of reflectors, although the scissors-movement suggested by previous investigators is supported by the apparent decrease in drag-folding between profile 3, near Isla Caja de Muertos and profile 6B northwest of Punta Petrona. The principal fault in this zone may be offset slightly to the south near its shoreward end where several subsidiary faults complete the record (profile 5).

North of the Muertos fault another zone of faulting was crossed by profile 1 (Bajo Tasmanian faults). Because the sea-floor

outcrop of one of these faults is the Bajo Tasmanian reef, it is assumed that the strike of the fault zone lies along that submerged ridge, sub-parallel to the Muertos fault, and probably picks up the strike of the coast at Punta Cabullon. With the down-thrown side to the south, this fault zone may well control the position of the shoreline as far east as Punta Pastillo, and the Ponce Basin may lie within a large graben.

In the central part of the Muertos shelf profiling has revealed a heretofore unreported fault striking almost east-west and down-thrown to the north (fig. 2). Although only 30-35 km in length, this fault is clearly shown on at least five profiles (profiles 3, 5, and 9 for example). The extent of vertical movement across the fault can only be estimated from these profiles, but judging from the difference in acoustical character of reflections from opposite sides of the fault, displacement may be more than 1 km in the middle portion between profiles 5 and 9. In profile 3 in the west only a small, sharply folded syncline marks the presence of the disturbed zone, while east of profile 12 no sign of this fault exists. The fault must therefore be a local sagging of the central shelf relative to the outer shelf; the depth to which faulting has been effective is not known.

The age of faulting has not been definitely established for any of the faults described above, although Glover (1967) suggests that the Muertos(western)fault began in the Miocene and that the great southern Puerto Rico fault system became active in early Cretaceous. From topographic evidence, however, it seems fairly certain that all of the faults on the Muertos shelf are active at present because of their coincidence with linear features on the shelf surface. In figure 2, bathymetric contours at 2 fathom (3.7 m) intervals taken from data on C & GS chart 902 have been drawn to illustrate this relationship with the structure.

The eastern fault is coincident across the shelf with a scarp whose relief is about 15 m with the deeper side on the down-thrown southern block (see also profile 14). On the other hand, the Muertos fault is outlined by a submarine ridge extending northeast and southwest of outcropping volcanics on Isla Caja de Muertos. This ridge is the southern boundary of the Ponce Basin which is a topographic as well as a structural feature (fig. 2; profiles 1 and 3). Across the central part of the shelf an east-west aligned ridge with peak elevations at depths of 20-22m marks the surface trace of the central fault (fig. 2; profile 5). North of this ridge the surface of the down-dropped structural block is a bowl-shaped depression centered on the middle of the fault.

Older Structures

Many of the continuous seismic profiles suggest the presence of a set of open folds apparently older than the later faulting. Preliminary study of these structures indicates a generally east-west strike, although correlation of structural axes from profile to profile is tenuous in some cases. In all cases the structures are present only in the older beds and do not affect reflectors shallower than 0.2-0.3 seconds. Near the Muertos fault in the western part of the shelf they are best shown by profile 4 which parallels the north side of the fault and have been mapped as a closely spaced series of east-west striking folds of no great lateral extent (fig. 2).

In the central and eastern part of the shelf another set of fold axes appear to have a similar strike, but they curve northeastward near their eastern extremes. These folds are broader and more open than those near the Muertos fault, but seem to affect beds of about the same age. The northernmost anticlinal fold was mapped as being continuous for nearly 25 km because of its wide extent and because of the prevalence of north dip in the older beds of the inner shelf. Farther north under Bahia Rincon near Salinas these older beds form the axis of a syncline.

Profile 13 shows the southern anticline and a mid-shelf syncline, neither of which can be traced farther west due to lack of control. Their strikes are assumed to be parallel to the strike of the larger anticline to the north.

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