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SUBMARINE TOPOGRAPHY OF THE CONTINENTAL SLOPE OF THE NORTHWEST GULF OF MEXICO

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Abstract

A chart of the continental slope of the northwest Gulf of Mexico, contoured at an interval of 50 fathoms, reveals an irregular topography of high relief. The striking basins, ridges and trough-like valleys of the slope, and escarpment are described. Slumping, folding, and faulting are suggested as the cause of the slope topography, and the escarpment is interpreted as a fault zone separating the stable deep sea basin from the unstable slope area. Evidence from foraminiferal fauna distribution in cores is cited in support of slumping.

Introduction

The striking submarine topography found on the continental slope in the northwest Gulf of Mexico was contoured in order to investigate a possible origin of the topography. The basic data were soundings from surveys conducted by the U. S. Coast and Geodetic Survey in the nearshore areas, and by the U. S. Navy Hydrographic Office in offshore areas (see chart inset). Position control for the basic U. S. Coast and Geodetic Survey work was by Radio Acoustic Ranging, astronomical fixes, and dead reckoning; for the U. S. Navy Hydrographic Office surveys, Loran, astronomical fixes, and dead reckoning. Soundings for the U. S. Coast and Geodetic Survey were from non-recording fathometers, checked whenever feasible by vertical wire casts; for the U. S. Navy Hydrographic Office, by recording fathometers. The original data sheets were of scales from 1:80,000 to 1:240,000 for the U. S. Coast and Geodetic Survey work and of 1:500,000 for the U. S. Navy Hydrographic Office work. These soundings were contoured with an interval of 25 fathoms,

to promote more accurate interpretation. These were then reduced to a uniform scale of 1:600,000, joined into a composite sheet, and alternate contours were deleted, leaving the final contour interval of 50 fathoms. No conscious effort was made to interpret the soundings and to fit the contours to any preconceived pattern.

Acknowledgment is gratefully made to the U. S. Coast and Geodetic Survey and to the U. S. Navy Hydrographic Office for the original soundings; to Dr. F. B. Phleger, Jr., for data on the formainifera; and in particular to Dr. F. P. Shepard, under whose guidance this work was done.

Description of the Topography

Continental Shelf

The average width of the continental shelf in the Texas-Louisiana area is 80 miles, with a maximum width of 115 miles southeast of Galveston. The minimum width is off the Mississippi delta, where there is no shelf. The average gradient is approximately 3 feet per mile, a slope of less than 0°02'. In comparison with the adjacent area of the continental slope, the shelf is flat and regular.

The edge of the continental shelf is well defined; the gradient increases abruptly between 50 and 75 fathoms depth to approximately 180 feet per mile, a slope of 1°43'. The edge of the shelf is generally at a depth of slightly greater than 50 fathoms. Prominent features of the shelf edge in this area are the numerous isolated shoal patches, oval in plan, with a flat to slightly concave top; several of these were sounded in detail by the U. S. Coast and Geodetic Survey. They were first studied by Shepard (1937) who suggested that they are salt dome structures, covered with algal limestone. This hypothesis has been further substantiated by recent airborne magnetometer surveys.

Continental Slope

The topography of the continental slope is characterized by its irregularity and high relief over most of the area. In some localities, as southwest of Terrebonne Bay, the irregular topography begins at the shelf edge. Elsewhere the slope has a comparatively even gradient to depths of 300-600 fathoms, as in the vicinity of the Rio Grande and east of the Mississippi delta. Over most of the area, however, scarps and canyons, closed basins, and knobs and ridges are characteristic features. This irregular topography extends from the seaward edge of the continental shelf to the approximate southern limit of the surveys, being terminated by an extensive escarpment running from the Mississippi to the southwestern extremity of the area studied. The overall gradient from the shelf edge to the deep ocean basin is 71 feet per mile (0°41').

Basins

Perhaps the most striking feature of the area is the large number of closed basins which are found on the continental slope. Most of them are elongate, with no apparent orientation of the axes. There are 26 basins in the area studied with a closed depth below sill of more than 100 fathoms, and numerous others of less relief. Their maximum length is approximately 30 miles, with an average of 20 miles; the maximum width is 10 miles, with an average of 6 miles. The sill depth lies usually between 600 and 1,000 fathoms, with the majority grouped around 700 fathoms. The average depth below sill is 200 fathoms, with a maximum of slightly more than 400 fathoms. The steepest slope found within a basin is 47°; this value, based on a single pair of soundings, seems questionable when compared with adjacent parts of the profile. Slopes of 16° and 21° are better substantiated by more uniform data. An interesting feature of most of the basins is their asymmetry in cross-section

with one wall noticeably steeper than the opposite, and having no particular orientation.

Escarpment

A prominent feature of this area is a long, well-defined scarp which trends southwest from about 27°30' N. Lat., 89°30' W. Long., to the edge of the chart. In adjacent seaward Hydrographic Office surveys, which were not included because of space limitations, this scarp can be traced to the southwest to approximately 26°00' N. Lat., 91°00' W. Long., where it turns to the west and continues to the edge of the survey at 26°00' N. Lat., 93°00' W. Long. With this trend, it is probable that it connects with the similar scarp mapped at 26°00' N. Lat., 94°00' W. Long., which continues westward for a short distance and then turns abruptly southward to the end of the survey. This escarpment can be traced for more than 400 miles, with the southwestern end not defined. The escarpment increases in depth to the west; at the northeastern end, the depth of its base is approximately 1,000 fathoms, and at the southwestern extremity it is 1650 fathoms. This escarpment resembles other submarine features which have been interpreted as submarine fault scarps, such as the Gorda and San Clemente escarpments off the California coast (Shepard and Emery, 1941). In several places, the soundings show a narrow trench of a few fathoms depth parallel to the scarp at the base of its slope, and adjacent to the trench a narrow parallel ridge having about the same relief. This furrowing parallel to the base of an escarpment suggests a fault zone. The maximum slope found on the escarpment was approximately 15°, considerably less than the maximum of many of the basins and canyons. The average slope is approximately 5°. The escarpment is fairly uniform in cross-section throughout its entire length except in the northeast, where it flattens out and disappears.

Canyons

Submarine canyons of two distinct types are found. The Mississippi submarine canyon is off an old mouth of the Mississippi River; it is well developed down the continental slope to the limits of the survey at about 1,000 fathoms. Another canyon, farther west, heads at the shelf edge at 91°35' W. Long., and can be traced to a depth of 1,000 fathoms, where it terminates in a closed basin.

The heads and mouths of other canyons are found at widely varying depths, although none extend onto the continental shelf. Their maximum length is 45 miles. None of these canyons have the dendritic pattern which characterizes many submarine canyons, although there are a few branches. Many have their seaward end blocked by an elevation, or terminate in a closed basin, while others fan out and disappear. The maximum wall slope in the canyons of this type is 41°; the majority, however, are much gentler, although slopes as great as 10° are common. Gradients along the axis range from 72 to 180 feet per mile (0°41' to 1°43').

Elevations

Knobs and ridges are found in this area both contiguous to the basins and canyons, and rising from comparatively smooth areas. They are in general notable for being of much smaller relief and areal extent than the various depressions.

Discussion

The bottom topography, particularly the escarpment, basins, and most of the canyons, and their present depth below sea level, suggest a tectonic origin for this topography. There is little doubt that the prominent escarpment represents a fault zone, and diastrophism is probably the only agent that

could produce closed basins of the type and magnitude common in this area. The region resembles more the "continental borderland" off the southern California coast (Shepard and Emery, 1941, chart I) than the continental slope of the east coast of the United States (Veatch and Smith, 1939). It differs from the California area, however, in having a more or less continuous slope downward from the shelf edge to the ocean basin. In the California area, the basins and ridges of the "continental borderland" are of such extent and magnitude that no general slope toward the Pacific basin can be discerned.

The extensive "fault" escarpment defines the seaward boundary of the zone of irregular topography. According to Hydrographic Office surveys to the southward, the sea floor is relatively smooth with wide, gentle basins across the Gulf almost to the edge of Campeche Bank. It seems probable that the continental slope area represents extensive and repeated slumping, folding, and faulting in the unconsolidated and semiconsolidated Gulf Coast marine sediments which were deposited with one side unconfined. The relatively smooth Sigsbee Deep area to the south beyond the escarpment represents a relatively stable deep sea area, perhaps not generally involved in the sedimentation and crustal movements of the Gulf Coast Embayment, with the escarpment representing one of the principal junctures and the plane of movement between the stable and unstable areas.

Evidence suggesting slumping and possible turbidity currents is found by Phleger (unpublished manuscript) in his studies of formainifera in cores from this area. In one instance, a core taken at 1,030 fathoms contains a foraminiferal fauna characteristic of this depth in its upper part, while the lower contains a mixed fauna of which 15 species are characteristic of deep water, and 9 species found at present in water shallower than 550 fathoms, including 3 species which do not range below 165 fathoms. In another instance, two

adjacent cores taken at 1,890 and 1,940 fathoms are found to have a fauna characteristic of those depths in the upper portion of the cores; lower in the cores, the fauna changes sharply to indicate shallow water conditions. An average of 10 species are found which are typical of depths less than 110 fathoms, including 7 not found at present below 66 fathoms, and only 5 species which are considered indicative of deep water depths. The nearest area where this shallow-water benthonic fauna is found at present is 70 miles distant for the first instance, and 75 and 100 miles for the second. Glacial sea level lowering would reduce this distance only slightly.

While slumping of sufficient magnitude to move the sediments and their contained foraminifera en masse for such distances may occur, it seems more reasonable that most of the material moved by slumping travelled shorter distances, and that the attendant agitation placed the light foraminiferal tests and some fine material in suspension, causing turbidity currents which provided the long-distance transport of the faunas.

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96°00'
95°00'
94°00'
93°00'
92°00'
91°00'
90°00'
89°00'
88°00'
29°00'
28°00'
27°00'
26°00'
95°W
90°W
MOBILE
MISSISSIPPI RIVER
GALVESTON
100 FMS
U.S.C. & G.S.
1000 FMS
H.O.
RIO GRANDE
FATHOMS
SCARP N.E. END
SCARP, MIDDLE
SCARP, S.W. END
ISOLATED KNOB
CLOSED TROUGH
CLOSED BASIN
CLOSED BASIN
BASIN & RANGE
CANYON
VERTICAL X 4
HORIZONTAL SCALE
NAUTICAL MILES
POSITIONS
A 27° 26' N 89° 35' W
B 27° 11' 90° 00'
C 27° 02' 90° 21'
D 27° 05' 93° 53'
E 27° 25' 94° 04'
F 26° 46' 94° 17'
G 27° 15' 93° 00'
H 27° 07' 93° 51'
I 26° 57' 91° 36'
J 26° 22' 94° 38'
A' 27° 32' N 89° 35' W
B' 27° 16' 90° 00'
C' 27° 10' 90° 22'
D' 27° 09' 93° 53'
E' 27° 34' 94° 04'
F' 26° 55' 94° 17'
G' 27° 20' 93° 00'
H' 27° 10' 95° 51'
I' 27° 07' 91° 36'
J' 26° 29' 94° 29'
TERREBONNE BAY
BARATARIA BAY
NORTH PASS
S.W. PASS
SOUTH PASS
CONTINENTAL SLOPE
NORTHWESTERN GULF OF MEXICO
MOBILE TO THE RIO GRANDE
SCALE IN NAUTICAL MILES
0 10 20 30 40 50 60
CONTOUR INTERVAL
50 FATHOMS
CONTOURS BY T. K. TREADWELL
USS Tanner sheet
1200
1200
1665
1500