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Probable Holocene Transgressive Effects on the Geomorphic Features of the Continental Shelf off New Jersey, United States*

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Introduction

Continental shelves have been greatly influenced by Quaternary events, particularly those of the Pleistocene Epoch. Detailed United States Coast and Geodetic Survey shelf and slope soundings off eastern United States from Georges Bank to North Carolina made it possible for Veatch and Smith (1939) to direct attention to various geomorphic forms in this region. Veatch and Smith (1939, p. 13) found that generally the shelf surface showed northeast-southwest trending bars and lagoons with occasional prominent terraces all of which are of marine origin or altered by marine erosion. South of New York numerous shelf linear ridges and depressions have been described as comparable to the barrier islands and their inner lagoons that extend along much of the coast (Shepard, 1963, p. 213), to relict Pleistocene shoreline forms (Sanders, 1962, p. 278), and to sand swells forming at present during intense storms (Uchupi, 1968, p. C17).

Recently a series of large scale bathymetric charts at a one-fathom contour interval was published for the New Jersey shelf (ESSA, 1967: 0807N-52, 53, 54, 55, and 56) from which additional detail can be observed regarding this shelf's relief. The purpose of this paper is to (1) redefine the geomorphic forms and their associations and (2) ascertain the effect of the Holocene transgression on the shelf's surface. Details concerning the origin and evolution of these features are the subject of a study now in progress by the senior author.

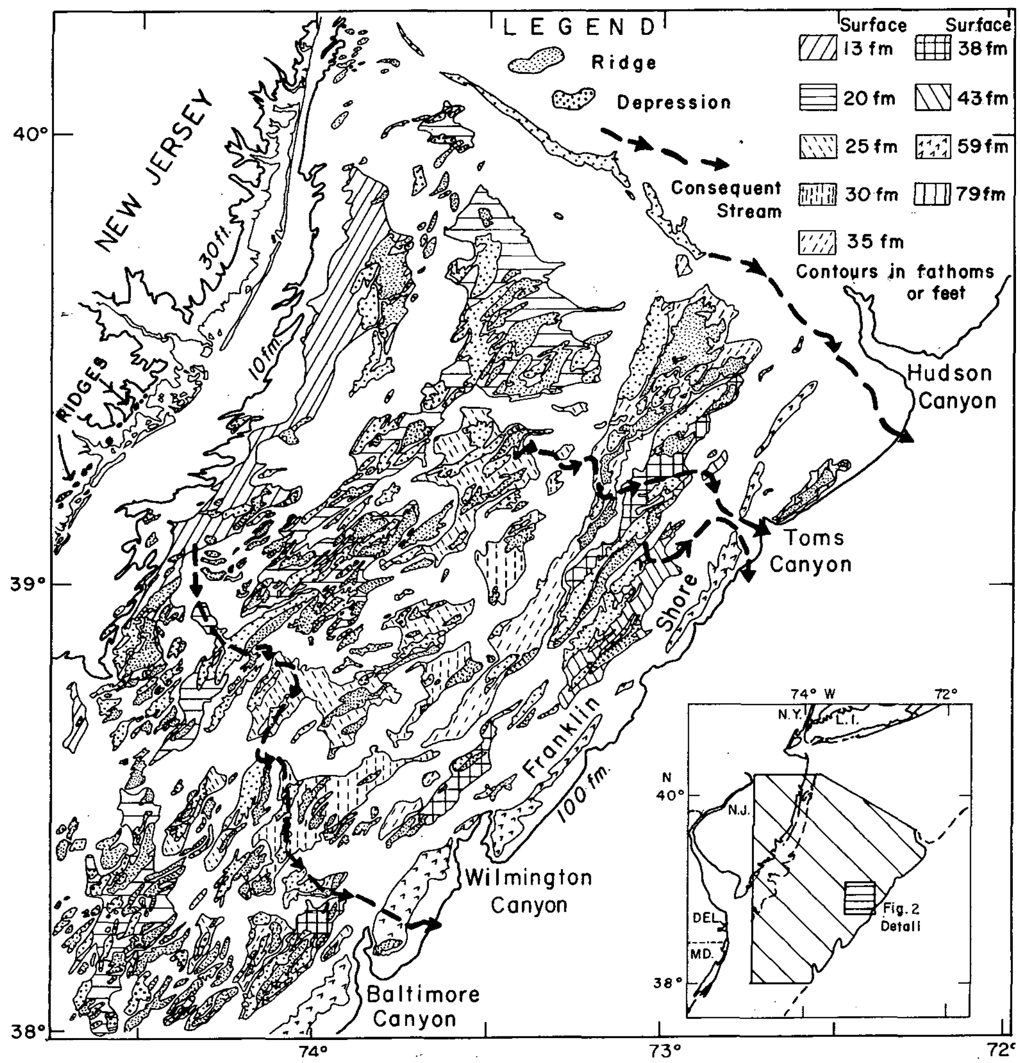

Figure 1 - Topographic chart of New Jersey continental shelf and coastal area, with index map. Areal extent of median isobath surfaces, major closed contour ridges and depressions (relief greater than one fathom) and consequent stream courses are shown.

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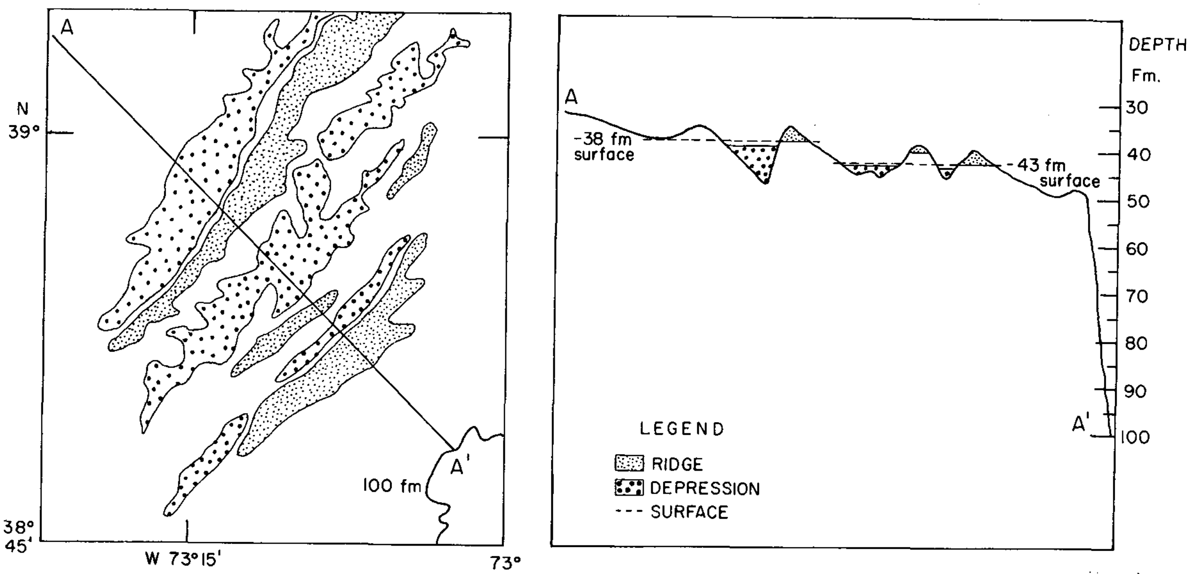

Figure 2 - Detail of a closed contour ridge and depression area with a profile illustrating the median isobath surface location. See Fig. 1 for location.

Specifically the area under investigation is located between Hudson Channel and latitude 38°N over a depth range of 10 to 100 fms (18 to 180 m) (Fig. 1) and lies outside the region directly affected by the ice sheet. No consideration was given to the nearshore zone less than 10 fm (18 m) because of the dynamic aspects of this environment under present conditions.

Results

The shelf surface is dominated by more than 1000 minor linear ridges and depressions, the majority of which parallel the northeast-southwest trend of the shoreline and shelf edge and occur generally in pairs with the ridge seaward of the depression (Fig. 1). However, the linearity becomes less distinct and the pattern of paired topographic highs and lows is less typical in water shallower than 20 fms. These features range from 1 to more than 20 miles in length, 0.5 to 10 miles in width, and 1 to 10 fms above or below the general bottom surface. Mean values show lengths of 4 to 5 miles, widths of about 1 mile, and relief of 1 to 2 fms. The largest ridges and depressions occur in the northeastern part of the area. For approximately 85 percent of the features, the ridges are attached toward the southwest and the depressions have their lowest sills toward the northeast.

A trellis drainage pattern is apparent with subsequent streams passing through the depression predominantly toward the northeast although many of the basins have more than one outlet. Southeast trending consequent valleys carried the discharge across the shelf (Fig. 1). This apparent drainage type is in marked contrast to the present dendritic pattern landward of Barnegat Bay.

The inner edge of a persistent terrace that contains no paired ridges and depressions (Fig. 1) is defined by the 59 fm isobath. From this terrace the bottom shows a gentle rise which marks the Franklin Shore (Veatch and Smith, 1939, Charts 1B and 2B).

Eight profiles were drawn across the shelf's surface and these revealed no related system of terraces and scarps. Although median contour standards showed distinct levels these terraces, too, could not be correlated generally so that one profile could be quite unrepresentative of the area. However, this approach showed that ridge-depression pairs were not randomly distributed but clusters of these features occurred at certain depths.

Ridge heights vary from 2 to 10 fms above the bottoms of adjacent depressions throughout the area which probably reflects in part the erosion of prominences and the filling of depressions. When a median isobath value between the base of the closed contour highs and tops of the closed contour lows was used, plots of the values showed sufficient uniformity to define a series of distinct surfaces at 79, 42, 38, 35, 30, 25, 20, and 13 fms (Fig. 2). By applying this closed-contour approach to the eight profiles, all large and most of the small paired ridge-depression features had median depth values that lie on one of these surfaces (Fig. 1). Specifically 72 percent of the features with greater than one fathom of relief, that were defined on the bathymetric maps, are associated with one of these surfaces. Moreover, changing these surfaces by as much as one fathom would place several of the large closed contour features above or below these specific surfaces and reduce the above percentage accordingly. Finally, those features identified with specific surfaces show greater average length and relief than those not on the defined surfaces.

Discussion

Sediment sampling has revealed that sand is the predominant sediment on the surface of the New Jersey shelf (Emery, 1966, Fig. 1, Donahue, et al., 1966, p. 155, Frank, 1971, p. viii and others). Specific sampling by the senior author has shown that the ridge-depression forms have a sand cover.

Sub-bottom profiling indicates that the structure of the near bottom surface-sediment section is complex (Knott and Hoskins, 1968, Figs. 6-7, and Ewing et al., 1963, Fig. 3). Numerous erosional surfaces have been described (Knott and Hoskins, 1968, p. 12 and Ewing et al., 1963, p. 6312), but the relationships of most of the surface geomorphic forms to these erosional surfaces is difficult to establish because of the quality of resolution and limited coverage. Also sub-bottom profiling obtained at 3.5 KHz has failed to clarify this relationship. Some of these erosional surfaces have been completely covered with younger sediments; others are partly filled over and partly exposed. The Nicholls and Franklin Shores of Veatch and Smith may express the extent of sediment fill, or may designate erosional effects in the younger sediment (Knott and Hoskins, 1968, Figs. 6-7, Garrison and McMaster, 1966, p. 278, and Ewing et al., 1963, p. 6315). Garrison and McMaster (1966, p. 270) suggest that the general terrace exposures east of Block Channel may be covered with more recent sediment rather than representing erosional scarps at the inner edge of a terrace. These findings and supposition indicate clearly the complex history of the present surface relief, and imply that the ridge-depression forms and the surfaces on which these rest present a complicated relationship which probably encompasses the entire Quaternary period.

Based on the closed-contour approach specific levels on the bottom surface across the New Jersey shelf have been defined with a persistent terrace noted at 59 fms (Table 1). Ages of the geomorphic forms associated with these levels have not been determined but by comparison with dated submerged Holocene shoreline forms from the Texas Gulf Coast (Curray, 1960, Fig. 18) (Table 1) it may be possible to distinguish the Holocene marine erosional effects from erosional and depositional events that took place during earlier changes of sea level.

Table 1 - Prominent Submerged Shorelines and Erosional Levels (Depth in fathoms)[1]

New Jersey Shelf: (Inferred)	13	20	25	30	35	38		43		59		79	
(Textural and Echogram Data)[1]		20					40				68		80
Texas Shelf: (Holocene Dated)[1]	12 to 15	21	22 to 25		35				45	65			

The comparison of stillstands and levels shows reasonable agreement over most of the shelf in each area with the obvious exception of the outer shelves. On the New Jersey shelf the 59 fm terrace may reflect infilling at the base of the Franklin Shore that followed the shoreward migration of the shoreline. From reports of other workers cited above, the possibility would appear to have merit so that a more realistic depth for this wave-cut terrace would be much closer to Curray's 65 fm stillstand. The 79 fm surface is probably associated with Pleistocene events. Donn, et al., (1962, p. 213) report a radiocarbon age of greater than 30,000 years B.P. for shell material from a buried erosional bench at 80 fms off New Jersey (Ewing et al., 1960, p. 1860), which would signify that some younger sediment is draped over the erosional surface. Moreover, there is considerable evidence that the last Wisconsin sea level lowering was in the order of only 60 to 70 fms (Morner, 1971, Fig. 12, Milliman and Emery, 1968, p. 1123, Curray, 1960, Fig. 18, Donn, et al., 1962, p. 214, and Fairbridge, 1961, p. 131).

Further complications regarding the association of coastal forms of different ages within the same locale can be demonstrated by the presence of the shoreline features on land near an elevation of 30 feet along the present New Jersey coast (Fig. 1). These features forming the surface configuration of the Pleistocene Cape May Formation are dominantly northeast-southwest trending ridge, depression and cliff forms that are considered to be products of marine activities with ages older than late Pleistocene but younger than Yarmouth (MacClintock, 1943, p. 461, and 472). In general the depressions have surface outlets but no drainage down the axis of the troughs.

[1] Frank, 1971, p. 74, Curray, 1960, Fig. 18.

Conclusion

Re-examination of the submarine topography on New Jersey's continental shelf indicated that most paired linear ridges and depressions between 10 and 100 fms lie on distinct erosional-depositional surfaces. Those surfaces at 13, 20, 25, 30, 35, 38, 43, and 59 fms are suggested as products of the Holocene transgression on the basis of reasonable correlation with prominent, dated, shoreline forms on the Texas shelf.

Acknowledgements

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