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Reports

Sedimentation Processes on the Atlantic Southeastern United States Continental Shelf*

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Abstract

In lieu of presenting a summary of activities of the Duke University Marine Geology Program, a summary of sedimentological conclusions concerning the S. E. U. S. Atlantic shelf is presented. These conclusions are based in large part on term papers and thesis projects carried out by geology students at Duke University.

Introduction

Over 2,000 samples from the continental margin of the Atlantic southeastern United States have been collected and studied since the beginning of the marine geology program at Duke University 3 1/2 years ago. For the first two years, aspects of sedimentation on the shelf between Capes Hatteras and Kennedy have been emphasized. At the present time the North Carolina continental rise is being studied on the basis of a growing piston core collection. Other study areas include the Tongue of the Ocean, Bahamas, and the Jamaica slope and Cayman Trough.

Sample collecting has been accomplished from R. V. EASTWARD which is part of the NSF supported program in oceanography at Duke University. The vessel is 118 feet long, can carry 15 scientists on cruises as long as 22 days, and is capable of sampling the deep sea environment.

This report briefly summarizes some of our conclusions concerning regional aspects of shelf sedimentation. It is not intended to be a comprehensive summary of present knowledge of the sea.

During the past year our studies have been supported by the United States Geological Survey heavy metals program. The National Science Foundation supported studies of carbonate sedimentation and funds were also received from the North Carolina Board of Science and Technology. Recently, joint studies of the combined Woods Hole - Duke University shelf sample collection from the Atlantic Southeastern United States have begun. Dr. John Milliman from the U.S.G.S. Woods Hole program is the principal co-ordinator of this work.

The marine geology program at Duke University has benefited from the enthusiastic support and participation by a number of graduate and undergraduate students and many of the conclusions discussed in this report are based on theses and term papers produced by these students. Listed below are the individuals involved, the nature of their participation and their present affiliation.

1. P. Michael Terlecky - oolites - University of Rochester
2. Larry J. Doyle - black shells, mica distribution - University of Southern California
3. William Cleary - Onslow Bay sediments, mica distribution - Pan American Petroleum, New Orleans
4. Jerry S. Kier - heavy minerals - University of Texas
5. John L. Luternauer - phosphorite - University of British Columbia
6. Barry W. Maynard - grain-size distribution - Harvard University
7. Ernest Estes - carbonate fraction roundness - University of North Carolina
8. Blake W. Blackwelder - carbonate fraction - Yale University
9. James B. Judd - iron-stained quartz - Duke University
10. William Smith - iron-stained quartz - Duke University
11. Robert W. Morton - carbonate fraction roundness - George Washington University
12. Michael E. Field - feldspar - Duke University

Many other people have contributed to this study by offering suggestions, comments and criticisms of the techniques and approaches used. I am grateful in particular to Ian G. Macintyre, John Milliman, S. Duncan Heron, George W. Lyntz, William Furbish, David Pevear, and Jack

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Pierce. Needless to say our work has relied heavily on the previous regional studies in this area, particularly those by Gorsline and Stetson.

The following discussion is presented in the form of questions that were asked when our studies began.

1. What is the Source of Continental Shelf Sediment?

The most important source is fluvial. Studies of the heavy mineral fraction of the fluvial sediment component indicate an ultimate and direct Piedmont province source. This is based on the fact that the shelf heavy mineral assemblage is more unstable than that present in river sands of coastal plain rivers but is quite similar to the heavy mineral assemble of Piedmont rivers.

A second source of sediment is eroding coastal plain outcrops on the shelf. These are principally of local importance and are restricted to areas of low sedimentation rates such as the Onslow Bay, North Carolina shelf or the Florida shelf. The regional continental shelf average feldspar content is between that of Piedmont and Coastal Plain rivers which is probably due to this residual contribution.

Calcium carbonate secreted by organisms or precipitated inorganically in the form of oolites is a third source. $CaCO_3$ ranges in abundance from 1% to 90% but usually is well under 50% by weight of the sediment in this area. Oolites are most abundant in Onslow Bay, North Carolina and on the Florida shelf.

2. What is the Present-Day Importance of River Sediment Contribution?

Rivers are contributing significant amounts of materials of finer than sand size. A comparison of the phosphorite grain content of shelf and river sediment indicates that relatively little sand size river material is being deposited beyond the barrier islands. Phosphorite grains make a useful tool for tracing sand sized sediment movement because river sands contain little or no phosphorite, which is however, frequently an important constituent of shelf sediment.

3. If Rivers are not an Imporant Contemporary Source of Sand, What is the Source of Nearshore Beach and Estuarine Sands?

A significant portion of the nearshore beach and estuarine sand is derived from the central and outer shelf as indicated by comparison of the phosphorite grain content of sands from these various environments. A further indication of this fact is the general similarity of heavy minerals, feldspar abundance and $CaCO_3$ abundance between the shelf and adjacent beaches and estuaries.

4. Where is Deposition of Sediment Occurring at Present?

Deposition of $CaCO_3$ is occurring everywhere on the continental shelf and is the most important modern source of sediment.

The distribution of mica flakes in the sediment (assuming hydraulic equivalence of fine sand-size mica flakes and finer than sand-size sediment) indicates that material of less than sand-size is being deposited in (1) a narrow nearshore band, (2) behind the barrier islands, and (3) beyond the shelf break. Fine fractions are being winnowed from the central and outer shelf areas.

Sand movement is more difficult to trace and less is known of the depositional regimes of this component. The "band" of fine sand adjacent to the present shoreline may be an area of active deposition where material is being derived from the central and outer shelf.

5. When was the Present Surficial Shelf Sediment Contributed to the Shelf?

Based on grain-size distribution, the presence of oolites, black shells, worn shells, shallow-water shells and considerations concerning the probable lack of importance of present-day sediment introduction, it is apparent that relict sediments cover most of the shelf. Much of it may have been contributed during the last rise in sea level. The unstable heavy mineral suite indicates that subaerial exposure of the surficial sediment has not been important. Iron staining of quartz grains, which is quite common, does not necessarily indicate subaerial weathering as the sand load of the source Piedmont rivers is highly iron-stained.

On the other hand radiocarbon dates of oolites from Onslow Bay, North Carolina and from the shelf edge off Georgia indicate a time of deposition during the last regression (between 19, 000 and 30, 000 B. P.). One oyster shell date from the inner Georgia shelf also falls within the time span of the last regression. Oolites from the Florida shelf were apparently deposited during the Pre-Holocene sea level rise.

Apparently because of low regional rates of sedimentation the present day surficial sediment cover is a mixture of material deposited during the last regression and last transgression. The relative importance of transgressive and regressive sediment is difficult to assess at present.

6. <u>What are the Regional Variations in Rates of Sedimentation?</u>

In general the entire area is and has been one of low sedimentation rates as suggested by the lack of large rivers.

Assuming that $CaCO_3$ productivity has been relatively constant on the continental shelf throughout the entire study area; the abundance of $CaCO_3$ is then a measure of the rate of dilution by terrigenous materials, hence a measure of rate of sedimentation. Estimates of sedimentation rate based on the percent $CaCO_3$ in shelf sediment correspond closely to estimates, based on run-off figures, of the relative importance of river contribution along any particular stretch of the coast. Apparently the continental shelf off Georgia and South Carolina has been subjected to the highest rate of sedimentation in the study area. The North Carolina shelf exhibits more variable rates of sedimentation. Onslow Bay, the continental shelf between Capes Lookout and Fear, has had a very slow rate of sedimentation owing to the lack of source Piedmont Rivers. Elsewhere off North Carolina, sedimentation rates havé been significantly higher. Florida continental shelf sediment contains the greatest abundances of $CaCO_3$ (average of 60% off Cape Kennedy compared to 10% on the Central Georgia shelf) and has probably been subjected to by far the lowest rate of sedimentation.

7. <u>How Important has Lateral Transportation been on the Shelf?</u>

The areal distribution of phosphorite grains indicates that lateral transportation between the cuspate embayments of the North and South Carolina coasts is limited. Each embayment is bounded by extensive shoals and acts more or less as a separate entity with regard to sediment transport.

The small amount of transportation that has occurred has been from north to south. Some north to south lateral transportation must have occurred to account for the terrigenous material on the Florida shelf where no important source rivers exist. Florida shelf sediments contain both unstable and stable heavy mineral assemblages so possibly some of the shelf sediment here is derived from erosion of coastal plain formations by the transgressing sea rather than lateral transport. The occurrence of iron-stained quartz abundance anomalies on the shelf adjacent to Piedmont River sources on the Georgia and Southern South Carolina shelf indicate that lateral transportation here has not been extensive.

8. <u>In what Sedimentary Environment was the Relict Shelf Sediment Deposited?</u>

The roundness of the carbonate fraction, the size distribution of the feldspar and the relict fauna indicate that most of this sediment was not deposited in a beach environment. Rather the relict shelf sediment appears to be of nearshore or inner shelf origin.

9. What will be the Distinguishing Characteristics of the Present-Day Relict Sediment if it is <u>Buried and Preserved in the Geologic Column?</u>

Until the new equilibrium between sediment supply, deposition and transportation is achieved, calcareous skeletal material will be the principal sediment source. Thus the present day shelf surface will very likely be distinguishable as a $CaCO_3$ rich layer. The shell material in most cases will be worn in appearance, highly fragmental and will represent a mixture of environments.

If, however, glacial fluctuations in sea level continue to occur in the future (which seems likely) it is most probable that the present day relict sediment will not be preserved as a distinct layer but will be redistributed with and diluted by a fresh influx of Piedmont river sands during times of lowered sea level.