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Origin of Sulfate Minerals in San Andres and Grayburg Formations, Crane and Upton Counties, Texas

Analysis of four cores from Crane and Upton Counties, Texas, provides a basis for interpreting the origin of calcium sulfate minerals in Guadalupian-age carbonates. The San Andres and Grayburg Formations along the eastern margin of the Central Basin platform consist of basinward prograding supratidal to shallow marine carbonate facies. These units have undergone dolomitization and frequently contain large amounts of gypsum and anhydrite. Carbonate deposits are periodically interrupted by terrigenous clastic influx.

Investigation began with hand sample observation of core from Gulf Oil Corp. wells in the Dune and McElroy fields of Crane and Upton Counties. To define diagenetic fabrics better, core analysis was augmented by the preparing and observing 200 thin sections. Electron microscopy was performed on selected samples to provide a three-dimensional view of the nature of calcium sulfate pore fill and intergranular cement. In order to understand the relationship between dolomite and anhydrite/gypsum, detailed chemical analysis was conducted with the x-ray diffractometer and the electron microprobe.

Calcium sulfate minerals occur in a variety of forms in the San Andres and Grayburg Formations. The complex interrelationships between gypsum and anhydrite indicate multiple stages of dissolution, reprecipitation, hydration, and dehydration. The result of these processes is the occurrence of anhydrite and gypsum in the following forms: (1) nodules, (2) fracture fill, (3) pore fill/replacement, (4) poikilitic cement, and (5) a variety of gypsum and anhydrite intergrowths. The following occurrences of calcium sulfate minerals are evidence for their secondary origin: (1) replacement of carbonate grains and matrix, (2) pore filling along with pore filling of voids lined with secondary dolomite, (3) anhydrite filling of fractures connecting anhydrite nodules, and (4) occurrence of anhydrite nodules along stylolites.

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Relationship Between Morphological Variation and Environment in Holocene North Atlantic Benthic Foraminifera

Previous workers have found that morphological variability recognized in foraminifera is due in part to the effects of environment. The various environmental factors (water depth, temperature, salinity, etc) generally act interdependently, although one factor may be more influential than another in causing observed changes. C. E. Pflum and W. E. Frerichs suggested in 1976, that water depth may be most important in creating shape variation within a genus. Taxonomic problems are inherent, as species may be inaccurately named on the basis of form when, in reality, they actually represent a morphological continuum rather than several biological species.

The multiple rotation method of quantitative shape analysis is a new approach to measuring shapes of foraminifera. The outlines of many foraminifera are digitized, rotated to a standard orientation, and radial measurements are reduced to a few numerical descriptors by factor analysis. The relationship between quantitative morphological variation and environmental factors, such as water depth, are then determined by correlation analysis.

North Atlantic specimens of *Cibicides* and *Uvigerina* from 36 stations in 4 transects off Cape Cod were used in this study. Water depths ranged from 100 to nearly 4,200 m. The observed quantitative morphologic changes with depth tend to confirm previous hypotheses of the strong influence of environment. Results of this study may form the basis for a tool useful to paleontologists in making environmental interpretations from microfossil assemblages. Testing of the actual species boundaries is feasible, perhaps aiding in the solution of many taxononic problems.

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Crustal Structure and Tectonic Development of Gulf of Guinea Cul-de-Sac from Integrated Interpretation of New Aeromagnetic and Existing Geophysical Data

Data-acquisition difficulties and propriety restrictions on industry data have necessitated liberal extrapolations and generalizations in previous tectono-structural studies of the Gulf of Guinea cul-de-sac. This region is the locus of a postulated Late Cretaceous triple junction whose arms were the transform-dominated Equatorial Atlantic, the northward-propagating South Atlantic, and the Benue Trough aulacogen. Oceanic crust has been inferred to underlie most of the thick sedimentary wedge of the oil-prolific Niger Delta basin.

Integrated interpretation of new aeromagnetic data of the Geological Survey of Nigeria and existing geophysical data corroborates previous work on the general structure of the marginal basins. New aeromagnetic data, however, reveal a detail structure more complex than previously known. Low-frequency magnetic anomalies over the Niger delta indicate that oceanic crust extends northward to about Onitsha. From Onitsha, the edge of oceanic crust trends southwestward along the Benin hinge line (an apparent continental continuation of either the Chain fracture zone or a new Okitipupa fracture zone) and also wiggles southeastward (adjoined by a wide margin of transitional crust) toward the shelf break off Cameroon. Linear magnetic anomalies trending northeast indicate about 7 fracture zones beneath the Niger Delta basin. The region of high-frequency magnetic anomalies west of the Niger delta represent the Okitipupa basement ridge complex, which separates the Niger Delta basin from the Dahomey embayment. In this embayment, 2 wide bands of intervening high- and low-frequency aeromagnetic anomalies are interpreted to represent a basement high or ridge and a fault-bounded trough, respectively.

The change in the directions of fracture-zone trends (from east-northeast in the southeast, to northeast in most of the Niger delta area, and then to a more easterly direction over most oceanic areas) indicates 3 phases of tectonic evolution recorded as changes in sea-floor spreading directions in the Gulf of Guinea cul-de-sac.

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New Dense-Grid Aeromagnetic Map of Gulf of Guinea Cul-de-Sac, Northeastern Equatorial Atlantic Ocean

As part of a major project to procure miscellaneous geophysical coverage of the entire country, the Geological Survey of Nigeria has acquired aeromagnetic data, presented as contour maps at various scales, over the nation's 7 sedimentary basins. The coverage over the Nigerian continental margin, acquired at 2,500 ft above sea level, was flown at 4-km flight-line spacing in a north-northeasterly direction and at 20-km tie-line spacing in a west-northwesterly direction. Another tie line was flown along the coastline.

Twenty 1:250,000, one-degree square, total-intensity aeromagnetic contour maps covering the marginal basins down to the shelf break were assembled into a single aeromagnetic map of the Gulf of Guinea cul-de-sac. The map area lies within lat. 3°-8°N, and long. 2°-9°E. It covers the Nigerian portion of the Dahomey embayment, the Anambra and Niger Delta basins, and the southern portion of the Benue rift. The map covers the location of the postulated Late Cretaceous triple junction involving the Benue Trough aulacogen, the northward-propagating South Atlantic, and the transform-dominated Equatorial Atlantic. In addition to the region seaward of the continental shelf, the map covers the Niger Delta basin, the basement of which is also inferred to consist mainly of oceanic crust prograded by the thick sediments of the Tertiary Niger delta. This area is also the location of the Late Cretaceous coalescence of the North Atlantic and South Atlantic spreading systems hitherto separate from one another.

This new aeromagnetic map fills an important data gap (due to proprietary restrictions and acquisition difficulties) in previous studies of this oil-prolific and geologically unique province. The map would be useful in future structural and tectonic studies of the Gulf of Guinea cul-de-sac.

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Smackover Exploration in the 1980s Along Conecuh Ridge, Southwestern Alabama

Between 1982 and 1983, Smackover oil production was established at three new fields along the Conecuh ridge, southwestern Alabama, dou-