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Significance of Middle Tertiary Large Foraminifera Common to West Africa and Caribbean

The criteria used for the identification of species and genera of Cenozoic large benthic Foraminifera strongly affect interpretations of their geographic distribution. Some researchers contend that migration of large forams between west Africa and the Americas became impossible after the middle Eocene because of increased distance and of ecologic barriers. Thus, the discovery of the Eocene genus *Linderina* in west Africa led them to conclude that the cosmopolitan Tertiary genus *Lepidocyclina* evolved from *Linderina* in the Old World, whereas it evolved separately from *Eulinderina* in the Americas. We find it difficult to accept these conclusions, especially in view of the number of Tertiary species of *Lepidocyclina* and *Miogypsina* which are common to the Mediterranean area, Africa, and the Americas. The discovery of additional large foraminiferal species common to west Africa and the Americas supports our view that many species of Oligocene and Miocene large Foraminifera had much greater paleobiogeographic distribution than has been generally realized.

Carbonate buildups dominated by floods of *Heterostegina* have been widely reported from the upper Oligocene and lower Miocene of the Caribbean–Gulf of Mexico region. We have recently discovered much of the large foraminiferal fauna of these so-called "Het reefs" in the upper Oligocene and lower Miocene of Cameroon (west Africa). Included are such typical Caribbean species as *Leipdocyclina canellei*. The species of *Miogypsinoides* present in the sequence may represent an evolutionary trend different from those in other parts of the world. They appear to be most closely related to the Caribbean species *Miogypsina panamensis*. In addition, we have found *Operculinoides cojimarensis* in the upper Miocene of Gabon. This species occurs abundantly from middle Miocene to lower Pliocene rocks in the Caribbean area and represents the end of the nummulitid evolutionary lineage in that region. Its presence in west Africa is further indication that communication persisted between west Africa and the Caribbean at least as late as the late Miocene.

Moreover, a surprisingly large number of species of smaller benthic Foraminifera is common between west Africa and the Caribbean. The literature records an apparent scarcity of species of large Foraminifera common to both the New and Old Worlds. This apparent scarcity suggests that the parameters used to identify these species are not appropriate and should be reviewed.

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Quantitative Basin Analysis and Evolution of Deep-Marine Shale Basin, Middle Ordovician, Southern Appalachians

A quantitative portrayal of paleobathymetry, rate of sedimentation, age, and crustal subsidence of a deep-marine shale basin not only reveals the timing and magnitude of geologic events but also has potential practical application in petroleum geology, as marine shales commonly are a primary source for hydrocarbons.

A quantitative basin analysis of the Middle Ordovician Sevier Shale basin in east Tennessee was made using: (1) lithofacies interpretation, (2) conodont-graptolite biostratigraphy, (3) paleobathymetry, (4) rate of sediment accumulation, and (5) sediment "backstripping" through time. This analysis indicates three main phases of crustal subsidence: (1) an early tectonic and sediment loading phase with a subsidence rate of 3 to 4 cm/1,000 years; (2) a second tectonic phase with a subsidence rate of 60 to 65 cm/1,000 years; (3) a final sediment-loading phase with a subsidence rate of 4 to 15 cm/1,000 years. Five stages of basin evolution were involved: (1) stable-shelf stage, (2) downwarping stage, (3) starved-basin stage, (4) turbidite-fill stage, and (5) contour-current stage.

On the basis of morphologic, stratigraphic, sedimentologic, and tectonic similarities between DSDP site 262 (Pliocene-Quaternary) in Timor and the Sevier basin, it is proposed that Sevier basin evolution may be considered analogous to foredeep basin development in Timor. This development occurred by concomitant basin subsidence and uplift of adjacent tectonic land owing to basinward migration of a topographic wave.

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Rhythms in Deep-Marine Turbiditic Shales and Fine-Grained Debris Flow

Rhythms in fine-grained sediments have not been studied previously because of their complex depositional cycles and diagenetic changes. Examination of nearly 9,000 layers in outcrops, polished slab samples, and thin sections has led to recognition of rhythms in the Middle Ordovician Whitesburg, Blockhouse, and Sevier formations in eastern Tennessee.

Rhythms have been described in four orders, based on their magnitude. First-order cycles (basin-fill sequences, hundreds of meters thick) are composed of thinning-upward debris-flow sequences and thickening-upward turbiditic shale sequences. Second-order cycles (multiple-sedimentation units, tens of centimeters thick) constitute six types: (1) thinning-upward cycles, (2) symmetrical cycles, (3) thickening-upward cycles, (4) minor multiple cycles, (5) uniform cycles, and (6) dubious cycles. Third-order cycles (single-sedimentation unit, tens of millimeters thick) have thinning-upward and asymmetric types. Fourth-order cycles show the grain-size variations within a single silt layer of the third order.

First-order rhythms were controlled by tectonism, progradation of a deep-sea-fan system, and debris flow. Second- and third-order rhythms were controlled by depositional processes, bottom topography, and sediment source. In the fourth-order rhythms, depositional processes, sediment source, and bioturbation were the dominant controlling factors.

Rhythm analyses of fine-grained sediments are significant in understanding (1) major events related to tecto-