FORAMINIFERAL MODELING OF SEA-LEVEL CHANGE IN THE LATE CRETACEOUS OF NEW JERSEY

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ABSTRACT: Paleoslope models of foraminifera in the Upper Cretaceous of the New Jersey coastal plain are utilized to estimate paleobathymetric change during cycles of rising and falling sea level. The paleoslope method estimates change in sea level from the distribution of foraminiferal assemblages and species on a baseline parallel to the regional dip. The paleoslope is the restoration of the original depositional slope of the basin. The paleobathymetry of the foraminifera along the paleoslope is estimated from the gradient of the original depositional slope. Application of the paleoslope model to the Campanian of New Jersey indicates a maximum rise of sea level of 90 m and 80 m, respectively, during two cycles of sea-level change. By extension, a paleodepth curve is derived for the other cycles in the Late Cretaceous. Eight cycles are recognized in the Late Cretaceous section of New Jersey.

INTRODUCTION

The development of sequence stratigraphy (Vail and others, 1977) has focused attention on the cycles of sea-level change within which sequences are deposited. Vail and Hardenbol (1979) used onlap-offlap sequences to derive a sea-level curve showing relative changes in sea level for the Tertiary. These relative changes in sea level are interpreted by Vail and others (1984) and Haq and others (1987) as due to eustatic changes superimposed on a long-term eustatic sea-level curve. If stratigraphic sequences develop during cycles of eustatic rise and fall of sea level, knowledge of the magnitude of eustatic change is important to understanding the mechanism(s) that cause the change. Estimation of the magnitude of eustatic change relative to present day has been the most elusive data of all to obtain in analyzing sequence stratigraphy. In this paper, a technique utilizing foraminifera is derived for estimating paleo-sea level relative to the present sea level and to derive a eustatic curve for the Late Cretaceous of the western Atlantic margin of New Jersey.

Foraminifera are the most widely used fossil organisms for estimating paleodepth. Paleobathymetric studies utilizing foraminifera have developed around the concepts of direct comparison with modern distribution when dealing with extant species, homeomorphic comparison of fossil and living species (pioneered by Bandy, 1960), and determination of non-specific characteristics such as benthic/planktonic ratios and diversity trends. All of these approaches have proven useful in making estimates of paleodepth. Even so, the accuracy of such estimates is compromised by the uncertainty of a best match with modern depth distribution and, in the case of increasingly older Cenozoic and Cretaceous assemblages, uncertainty about the ecologic role played by extinct species. The problem is compounded when studies are conducted on isolated sections or a single borehole (as most are).

In such studies it is difficult to establish a frame of reference with which to compare foraminiferal assemblages in a stratigraphic section or well to the lateral basinal distribution of foraminiferal species within a chronostratigraphic interval. Thus, most estimates of the paleobathymetry of a foraminiferal assemblage are abstractions derived from a general comparison with modern distributions. A more meaningful comparison would be one with other assemblages within the same chronostratigraphic interval. The method, described here, develops data on the lateral basinward distribution of foraminiferal species within and between chronostratigraphic units. The paleobathymetric significance of distributional patterns of species is derived from the original slope of the basin floor, called the paleoslope. This method does not rely on comparison with modern foraminiferal assemblages. It measures the bathymetry directly from the paleoslope model.

THE PALEOSLOPE MODEL

A paleoslope model is a graphic reconstruction of the distribution of benthic foraminiferal species and assemblages along a profile parallel to the dip slope of the basin (called the paleoslope). In the paleoslope model, distance down dip is used as a measure of increasing paleodepth. Thus, the paleoslope model relates the abundance and distribution of benthic foraminifera along the profile to paleodepth. This allows a more critical evaluation of the role played by benthic foraminifera in ancient shelf, slope, and deep-sea environments.

The Atlantic passive margin of the United States is particularly well suited for paleoslope studies because it is structurally uncomplicated, and because chronostratigraphic intervals can be traced across an entire basin (Fig. 1). The coastal plain of New Jersey has long been recognized for its well-developed Cretaceous and Tertiary stratigraphy and its record of numerous sea-level changes. Furthermore, the coastal plain, which lies at the edge of the Baltimore Canyon Trough and contains non-marine, near-shore, and shelf lithofacies, offers an opportunity to trace foraminiferal assemblages from shoreline environments to shelf and upper-slope environments. A paleoslope model was first completed in the New Jersey coastal plain for the Campanian and Lower Maestrichtian by utilizing samples from outcrops and wells (Fig. 2) in formations deposited during four events of sea-level change. This paleoslope model (Olsson and Nyong, 1984) shows the abundance distribution of key benthic foraminiferal species for inner-shelf to upper-slope environments (Fig. 3). The paleoslope model was subsequently extended into wells in the Baltimore Canyon Trough and into Deep Sea Drilling Sites (Fig. 4) in the Western Atlantic Basin (Nyong and Olsson, 1984).

The paleoslope model makes the assumption that the bathymetric profile has remained constant throughout the history of subsidence of the basin, at least for shelf envi-