higher mineral potential where geochemical and geophysical methods may be applied in the field to pinpoint the location of specific deposits and give quantitative estimates of profitable outcome.

BAARS, D. L., Department of Geology, Washington State University, Pullman, Wash., and W. R. SEAGER, Department of Geology, New Mexico State University, Las Cruces, N. Mex.

DEPOSITIONAL ENVIRONMENT OF WHITE RIM SANDSTONE (PERMIAN), CANYONLANDS NATIONAL PARK, UTAH

The White Rim Sandstone of Leonardian age forms prominent topographic benches west of the Colorado River in Canyonlands National Park. Its origin has been interpreted as eolian or marginal marine by various authors without specific evidence other than the large-scale cross-stratification which is generally conspicuous.

A detailed study of the gross geometry, cross-stratification, ripple marks, trace fossils, and facies relations of the sandstone revealed a subaqueous environment of deposition which was probably sub-littoral marine. The formation contains numerous offshore bars that were constructed by surf and longshore currents moving from the northwest as shown by bar trends and cross-stratification analyses. Numerous small bars with 10–20 feet of relief occur in a northwesterly trending swarm northeast of Elaterite basin near the Green River. A larger elongate bar with 200 feet of relief extends in an arcuate northwesterly direction for about 10 miles through Elaterite basin. Excellent exposures of sedimentary structures reveal that the original geometric configuration of the bar is preserved. The sandstone grades abruptly into fine-grained lagoonal redbeds just east of the Elaterite bar, forming a stratigraphic oil trap that has been exposed by Recent erosion. The shallow-water bar apparently was constructed on the nose of the Monument upwarp which was mildly positive, providing shoal conditions at the time of sedimentation.

Pre-Triassic (Hoskinnini?) redbeds were deposited across the White Rim Sandstone, draping over the bars preserved at its upper surface. Subsequent erosion prior to Moenkopi (Triassic) sedimentation produced local angular unconformities along the margins of the bars.

BANDY, ORVILLE L., Department of Geology, University of Southern California, Los Angeles, Calif.

PALEONTOLOGICAL GUIDES TO DEPOSITIONAL ENVIRONMENTS

Foraminiferal-environmental relations provide criteria for (1) the reconstruction of marine basins of the geologic past, (2) the determination of structural trends based on differential subsidence rates, and (3) the identification of important producing trends within the sediment and environmental framework.

One of the primary guides to depositional environments is the patent foraminiferal zonation from marsh to deep-sea environments. This may be summarized for southern California as follows: (1) marsh, *Jadammina-Miliammina* fauna; (2) euryhaline lagoon, *Ammonia beccarii tepida* fauna; (3) intertidal zone, *Rotorbinella* fauna; (4) open ocean 0–20 m., *Buliminella elegantissima* type of fauna; (5) 20–100 m., *Florilus-Nonionella* fauna; (6) 100 m. upper depth limit, *Bolivina acuminata-Uvigerina peregrina* fauna; (7) 400 m. upper depth limit, *Bolivina argentea-Bolivina spissa* fauna; (8) 700 m. upper depth limit, *Bulimina striata mexicana* fauna; (9) 1,000 m. upper depth limit, *Uvigerina hispida* fauna; and (10) 2,400 m. upper depth limit, *Melonis pompilioides-Uvigerina senticosa* fauna. Bathyal species such as *Uvigerina peregrina, hispida, senticosa,* and *Melonis pompilioides* are essentially isobathyal showing little if any evidence of temperature control in their distribution patterns in different oceanic areas.

Other guides to depositional environments include the bathyal bolivine trend within the general oxygen-minimum zone (0.3–0.7 ml./l.); specimens of this group become larger and more abundant with increasing organic content and depth. Oxygen values of about 0.1 ml./l. or less result in an absence of larger invertebrates and a concentration of depositional laminae with very fragile hyaline bolivines and other Foraminifera. The largest benthic bathyal Foraminifera (measuring several millimeters in length) require oxygen values of more than 1.5 ml./l. and nitrogen values of more than 0.15 per cent; these occur in homogeneous or disturbed sediments, characteristics resulting from the activities of larger invertebrates. Displacement processes may produce intercalations of these various facies; variations in water masses may result in somewhat similar fluctuations of facies.

Planktonic foraminiferal abundance and diversity increase seaward into the bathyal zone. Although most planktonic Foraminifera live in the photic zone, some such as *Globigerina pachyderma* (typical form) and "*Sphaeroidinella*" are characteristic of the bathyal zone when they are fully developed. Many planktonic Foraminifera add a crystalline crust to their test as they descend into deeper waters of the bathyal zone. Radiolarians are of primary importance in middle bathyal-to-abyssal depths.

BANDY, ORVILLE L., AND JAMES C. INGLE, JR., Department of Geology and Allan Hancock Foundation, University of Southern California, Los Angeles, Calif.

NEOGENE PLANKTONIC EVENTS AND RADIOMETRIC SCALE, CALIFORNIA*

More than seven significant events are recorded by planktonic microfossils of the Neogene for the eastern Pacific and the Pacific Coast of North America, correlated with provincial microfaunal stages and a radiometric scale based on available K-Ar dates. (1) There was a significant evolution from *Globigerina concinna* to *Globigerina bulloides* about 17 m. y. ago marking the approximate Relizian-Luisian boundary of California. (2) The youngest known dextral specimens of *Globoquadrina altispira* occur about 12 m. y. ago correlating with part of the upper lower Mohnian. (3) The youngest known sinistral specimens of *Globorotalia maveri* occur about 12 m. y. ago, correlating with part of the lower Mohnian. (4) The radiolarian, *Prunopyle titan*, spans the interval of about 15–10 m. y. B.P., becoming extinct before the end of the Miocene (Delmontian). (5) The transition from *Sphaeroidinellopsis* to *Sphaeroidinella*, the SPHAEROIDINELLA DEHISCENS DATUM, and the introduction of *Globorotalia inflata* marks the Miocene-Pliocene boundary (approximate Delmontian-Repetto boundary) and is about 9 m. y. B.P. (6) *Globorotalia* (*Truncorotalia*) *truncatulinoides* ranges from basal Pliocene to Recent; however, it is most characteristic

* Grateful acknowledgment is made to the U.S. National Science Foundation (Grant GF 105) for support.