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.

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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.

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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.

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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

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of the 5–3-m. y.-interval or upper Pliocene of southern California. (7) Coiling preferences of *Globigerina pachyderma* are predominantly dextral during the past 11,000 years, mostly sinistral from this point back to 3 m. y. B.P. (Pleistocene), dextral although somewhat variable in the 3–5 m. y. interval (upper Pliocene), sinistral in the 5–7 m. y. interval (middle Pliocene), dextral in the 7–10 m. y. interval (lower Pliocene and uppermost Miocene), sinistral in the 10–11 m. y. interval (upper Mohnian-Delmontian transition), and dextral in its earliest occurrences of about 11–12 m. y. B.P. (within the Mohnian).

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FUTURE OF PETROLEUM GEOLOGISTS

The future of the petroleum industry continues to be bright because of the ever-increasing demand for energy both in the United States and the rest of the free world. There will continue to be a demand for well-trained petroleum geologists both in this country and abroad.

The large oil companies will continue to offer high salaries and increasing technical challenge to those petroleum geologists who can put "Rocks and Dollars" together.

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SEDIMENTARY PROCESSES OPERATIVE ALONG WESTERN LOUISIANA SHORELINE

The western Louisiana shoreline represents the complex interaction of low-energy wave turbulence along a broad, shallow shelf, a small tidal range, and a varying sediment supply of very fine sand and mud. These are in turn modified by shoreline orientation and complex offshore bathymetry, proximity to brackish estuary tidal efflux, and varying nearshore salinity.

Three dominant types of strand-line sedimentation have been chosen as typical of the modern shoreline in the study area. Mud flats, both tidal and subaqueous, form one type. Another dominant type of strand-line deposit is described as a sand-rich, "normal" beach. Facies relations of the "normal" beach are similar to the shoreface sequence described for the tidal mud-flat setting. Intermediate between mud flats and "normal" beaches is a transitional type of strand line consisting of thin swash-zone and breaker-bar deposits resting on eroded, earlier-formed mud-flat and marsh sediments.

Mud-flat progradation is initiated by establishment of a shallow-water breaker-bar system, providing a protected site for subaqueous deposition of mud. As sedimentation raises the level of the mud flat to an intertidal level, sand-rich breaker-bars of low amplitude slowly migrate shoreward across the flat. The flat ultimately becomes intertidal. Thin washover-fan sands associated with this setting constitute one form of strand-line ridge found in the Recent chenier plain.

Shoreface sedimentation in the "normal" beach differs from that of the mud flat in having fewer but considerably larger breaker-bars and a rapid shoreward transition into swash-zone, berm, and thick washover-fan sands. The pronounced increase in thickness of washover-fan sands in the "normal" setting provides a second distinct type of strand-line ridge or "chenier."

The intermediate nature of the transitional beach setting is emphasized as a temporal, highly dynamic phase in strand-line development. Although apparently retrogradational, it nevertheless represents a dominantly progradational strand line which builds seaward at an intermediate rate compared with quickly prograding mud flats and relatively slowly prograding "normal," sand-rich beaches.

A classification of progradational shoreline types based on "energy of coastal processes" *versus* "sediment supply" (*e.g.* Bernard, 1965) can be used to typify rates of progradation in the study area. Energy of coastal processes include (1) deep-water wave period, (2) orientation of shoreline with respect to prevailing wave front, (3) width of inner shelf, and (4) tidal range. Sediment supply includes (1) fresh-water efflux and salinity variation, (2) suspended mud supply, and (3) sand supply

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SEDIMENTS OF NHA TRANG BAY, SOUTH VIET NAM

Textural and chemical analyses of 115 sediment samples from Nha Trang Bay on the central coast of South Viet Nam have permitted detailed mapping of the sediment characteristics within this relatively small area. The results show marked juxtapositions of sediment types and ages. Two areas of relict sand left from a time of glacially lowered sea-level are surrounded by Recent detrital and carbonate material. The exposure of these relict sands is a result of the sweeping away of sediment entering the bay by strong currents that develop during the summer and winter monsoons.

Sediments within the bay fall into four basic groups: (1) clayey silt in low-energy areas between islands and in deeper water on the fringes of the bay, (2) sandy silt to silty sand extending out from the river mouths, (3) sand with low carbonate percentages including the relict sand in areas of vigorous currents; and (4) sand with high carbonate percentages; some of this sand occurs on shallow banks and exposed peninsulas and is in equilibrium with the energy environment, whereas that in shallow protected areas does not reflect the energy system. The distribution of organic materials in the bay is closely related to these sediment types. The highest concentrations of carbon and nitrogen occur consistently in the clayey silt areas with intermediate and low concentrations in the sandy silt-silty sand and sand areas, respectively. Exceptions to this are revealed in the plot of carbon/nitrogen ratios where high organic carbon contents occur in coarse-grained sediments of the nearshore and shallow-bank areas.

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ROLE OF MEMBRANE HYPERFILTRATION ON ORIGIN OF THERMAL BRINES, IMPERIAL VALLEY, CALIFORNIA

Unique saturated Na-Ca-K Cl thermal brines (380°C.) are recovered from geothermal wells near the Salton Sea, Imperial Valley, California. The reservoir chamber is fractured metamorphic rock (mainly greenschist facies) at 3,900–8,000 feet. The shallow waters are relatively dilute $NaHCO_3$-Cl, high in B; NH_4, I, and F are present; the Na/K ratio is less than in the brines; CO_2 gas is abundant. The waters of these brines are dominantly meteoric, as evidenced by