Lower Jurassic Radiolaria, San Hipolito, Formation, Vizcaino Peninsula, Baja California Sur

Lower Jurassic radiolarian faunas recovered from the sandstone member of the San Hipolito Formation, Baja California Sur, indicate a younger age for much of this member than previously assumed. The San Hipolito Formation, exposed at Punta San Hipolito on the Vizcaino Peninsula, consists of 2,400 m (7,875 ft) of marine sedimentary rocks. The oldest member, a *Halobia*-bearing green chert, lies on pillow basalts and is successively overlain by limestone, breccia, and sandstone members. Upper Triassic (upper Karnian? and/or lower Norian to lower upper Norian) radiolarians have been described from the chert member. The hemipelagic pelecypod *Monotis* cf. *M. subcircularis* (Gabb) of Late Triassic (late Norian) age is found in the upper part of the limestone member.

The uppermost member of the San Hipolito Formation, a volcaniclastic sandstone 1,840 m (6,035 ft) thick, previously yielded only poorly preserved radiolarians, and was inferred to be of Late Triassic age. In this study, well-preserved radiolarians were not recovered from the sandstone and tuff beds. Thin limestone beds at the very base of the sandstone member contain a unique radiolarian fauna with some forms similar to Triassic radiolarians described from Austria and Italy. Discoidal limestone concretions and thin limestone beds from the top of the lower part of the sandstone member yielded abundant, well-preserved Lower Jurassic radiolarians.

No ammonites are found in association with the San Hipolito Lower Jurassic radiolarians, but the radiolarians are similar to Lower Jurassic radiolarian faunas from British Columbia and Oregon, for which excellent ammonite biostratigraphy is available. Based on the occurrence of the radiolarian genera *Canoptum, Droltus, Bagotum, Canutus, Hsuum, Lupherium* and *Pseudoheliodiscus*, a Pliensbachian and/or Toarcian age is assigned to the top of the lower part of the sandstone member of the San Hipolito Formation. The continuation of radiolarian studies in British Columbia, Oregon, and Baja California will provide a basis for further elaboration and refinement of a Lower Jurassic radiolarian zonation.

WHITE, THOMAS C., Baylor Univ., Waco, TX

Diagenesis of Permian Sabkha Carbonates and Evaporites, San Andres Formation, West Howard County, Texas

The San Andres Formation, on the basis of cores from west Howard County, Texas, consists of a westward-prograding sequence in the Midland basin. It is composed of five principal facies: (1) intrabasinal to basinal limestones; (2) open-marine bivalve or crinoid wackestones and/or packstones; (3) open-marine fusulinid wackestones and/or packstones; (4) subtidal to intertidal lagoonal mudstones and/or wackestones; and (5) intertidal to supratidal carbonate-evaporite sabkha. Contacts between facies are uniformly gradational.

The formation shows a complex diagenetic history. Carbonate sediments have undergone pervasive dolomitization, marked principally by complete dolomitization of the mud matrix, leaching and destruction of allochems, and partial void fill by subhedral to euhedral dolomite rhombs. Matrix-crystal enlargement occurs at the upper end of the sequence, where the sabkha reaches its greatest development. Anhydrite is ubiquitous in the formation, and is well developed throughout the sequence. Primary crystal habits are chaotic, blocky rectangular, radial, and poikilotopic. Anhydrite has been subjected to substantial diagenesis, including replacement by length-slow chalcedony, lutecine, hematite, pyrite, sphalerite, and free sulfur. Two major zones of leaching are marked by nearly complete solution of anhydrite and precipitation of coarse blocky and fibrous calcite, with levels of porosity exceeding 20%. Rehydration of anhydrite to satin spar and pseudomorphic gypsum is common, particularly concurrent with zones of leaching. Although paragenetic indicators are sparse, poikilotopic and rectangular void-filling anhydrite apparently postdates precipitation of nodular anhydrite, and solution of evaporites postdates replacement of anhydrite by length-slow chalcedony, as indicated by loose spherulites in the bases of leached voids.

WILKINSON, BRUCE H., AMANDA L. SMITH, and SUSANNE U. JANECKE, Univ. Michigan, Ann Arbor, MI

Low-Magnesium Sparry Calcite Marine Cements in Phanerozoic Hardground Grainstones

Many zones within Phanerozoic cratonic carbonates exhibit numerous features demonstrating synsedimentary submarine lithification at or near the sediment-water interface in normal-marine settings. Two such units, one from the Middle Ordovician Verulam Formation in Ontario, the other from the Upper Jurassic Sundance Formation in Wyoming, occur in sequences with multiple hardground zones, consist of coarse grainstones, and contain numerous borings of endolithic invertebrates which crosscut both allochems and early cement. The presence of borings in these grainstone units provides an unequivocal criterion for the discrimination and evaluation of hardground cement habits in that they constrain the timing of early cementation. Marine cement in both units consists of equant crystals of clear, inclusion-free, luminescent, low-magnesium calcite.

These cements are identical in habit to meteoric phreatic cement in calcitized Pleistocene sequences and are strikingly unlike Holocene marine cements which consist almost exclusively of acicular crystals of aragonite and/or high-magnesium calcite. Their presence in these two Phanerozoic normal marine carbonate sequences demonstrates that generalizations which relate cement morphologies to cement compositions, and which relate cement compositions to the chemistry of water in various cementation environments in modern systems, may not be valid when applied to ancient limestones.

WILSON, DOUGLAS, ARCO Exploration Co., Lafayette, LA

Petrography and Paleoenvironment of Upper Cretaceous Anacacho Formation in Southwest Texas

The Anacacho Formation is an Upper Cretaceous carbonate-bank sequence that formed in a narrow zone between the waning Cretaceous seaway and the young Gulf of Mexico. The Anacacho crops out along the Cretaceous Gulf coastal trend from Kinney to Bexar Counties, Texas. The most complete and extensive exposures occur in the Anacacho Mountains in Kinney County and the Whites Mine area of Uvalde County where asphalt is actively mined.

In this study area, the Anacacho Formation was deposited in the northern Rio Grande embayment on the fringe of a structural transition zone between compressional features on the west and extensional faulting on the east. The compressional features resulted from Carboniferous continental collision on the southern margin of North America, and Late Cretaceous subduction on the western margin. These events resulted in deep crustal weaknesses and the penetration of mafic intrusions which produced bathymetric highs where Anacacho organisms began to flourish.

In the Anacacho Mountains of Kinney County, the Anacacho is primarily composed of tan-orange recrystallized, molluscan, sorted biosparite. In addition, there are two interbedded chalky micrites which are distinguished from massive calcrete crusts on the biosparites. At the top of the northeast end of the Anacacho Mountains, some patches of molluscan, bryozoan, biosparrudites occur. In the Whites Mine area of Uvalde County, the biosparite also occurs; however, three mines penetrate an asphaltic, molluscan, unsorted biosparrudite.

The diagenetic sequence of the Anacacho Formation began with early diagenetic events such as micritization, authigenic growth of glauconite in foraminiferal tests, and authigenic growth of framboidal pyrite nodules. Postdepositional diagenesis included the development of microspar, syntaxial overgrowths of spar, recrystallization of allochems, and calcite spar fill. Further burial caused severe compaction, evidenced by fracturing and pressure solution features. The sediments of the Anacacho Formation were then uplifted and subjected to ground-water circulation in the freshwater phreatic zone. This resulted in dissolution of spar and microspar followed by precipitation of "dog tooth" sparry cement. This secondary porosity development primarily occurred in the Whites Mine area biosparrudites; however, paleokarstic development which may have occurred during this stage of diagenesis is found throughout the Anacacho in this area. Following the transgression of Upper Cretaceous and lower Tertiary marine shales, the unconformable surface of the Anacacho was sealed and ultimately trapped migrating hydrocarbons. As the hydrocarbons penetrated secondary freshwater porosity, "dog tooth" spar crystals were dislodged and incorporated into the hydrocarbon matrix by mechanical and/or chemical mechanisms. The hydrocarbons were devolitalized to asphalt following exposure of the Anacacho and, possibly, by thermal activity from local mafic intrusions.

The biosparrudites in the Whites Mine area represent biostromal bank buildups on bathymetric highs that produced abundant skeletal debris. This debris migrated to the southwest, primarily as prograding sand waves, and resulted in deposition of biosparite in the Anacacho Mountains. The skeletal debris built up sufficient bathymetric relief into the photic zone that biostromal growth became active. Therefore, through time, the bank migrated to the southwest over skeletal debris.

WILSON, J. E., Consulting Geologist, Denver, CO, and E. L. KASHAIand P. F. CROKER, Oil Exploration Ltd., Tel Aviv, Isreal

Hydrocarbon Potential of Dead Sea Rift Valley

The Dead Sea Rift is one of the world's unique geologic and topographic features, whose petroleum potential has not yet been evaluated. The sector of the Dead Sea is an asymmetric graben 20 km (12 mi) from rim to rim and over 120 km (75 mi) long. The total throw from the west rim, where the Upper Cretaceous crops out to the deeper portion of the grabens, is more than 8 km (26,200 ft). Throw on the eastern side is considerably greater as the valley wall is largely Precambrian. The level of the Dead Sea is −400 m (−1,300 ft)—the lowest place on earth.

Asphalt blocks floating from the Dead Sea, along with asphalt and heavy oil seeps in the valley, have been known since biblical times. These are suggestive of leaks from deeper accumulations.

Although some exploration drilling has been done, no test has yet reached objectives in the deeper sunken block where the Miocene is figured to be at a depth of at least 7 km (23,000 ft).

WINKER, CHARLES D., Univ. Arizona, Tucson, AZ, and RICHARD T. BUFFLER, Univ. Texas, Austin, TX

Evolution and Seismic Expression of Mesozoic and Cenozoic Shelf Margins, Gulf of Mexico and Vicinity

Mapping and classification of modern and ancient shelf margins provide a basis for a concise post-rifting history of the Gulf of Mexico basin. Many hydrocarbon occurrences in the basin can be related to styles of shelf margins and their associated slope with implications for frontier exploration in deep-water facies. Seven basic types of shelf margins have been recognized.

1. Reef-dominated carbonate margins surrounded the deep basin during the Early and middle Cretaceous. This category can be subdivided into: (a) low-relief, short-lived (ca. 10 m.y.) margins in Louisiana and Texas (Stuart City and Sligo), and (b) high-relief (1 to 3 km; 3,280 to 9,843 ft), long-lived (ca. 40 m.y.) margins elsewhere (Florida, Campeche, and Blake escarpment, Golden Lane, El Abra), which are typically associated with fore-reef talus.

2. Sigmoidal progradational carbonate margins developed landward of drowned mid-Cretaceous margins of the Florida and Yucatan platforms during the Cenozoic. Large-scale gravity slides with rollover structures have occurred along the Yucatan slope contemporaneously with deposition of sigmoidal carbonate margins.

3. Carbonate ramps with little or no seismic expression characterized the Late Jurassic, when a deep marine basin was first established, an the Late Cretaceous, following drowning of mid-Cretaceous carbonate platforms.

4. Stable progradational clastic margins with well-developed, undeformed, large-scale clinoform stratification are relatively rare in the Gulf basin. Modern examples are limited to offshore Alabama and Veracruz.

5. Unstable progradational clastic margins result from gravity sliding of the continental slope, commonly associated with salt and shale diapirism, which obscures large-scale clinoform stratification. Growth faults with major expansion and rollover characterize the shelf margin; folds and/or thrust faults characterize the lower slope. This type of shelf margin has dominated the northwestern Gulf during the Cenozoic, and now extends from offshore Mississippi to offshore Veracruz. Numerous episodes of deltaic progradation to the shelf margin have been identified in Texas and Louisiana; these clastic influxes have prograded the shelf edge as much as 350 km (215 mi).

6. Tectonically active progradational clastic margins are present in Tabasco and eastern Veracruz. There the shelf margin has prograded up to 200 km (125 mi) since the early Miocene in an area of active compression and sinistral wrench faulting. Interaction of basement tectonics with diapirs and probably gravity sliding has created great structural complexity in thick Neogene deltaic sequences.

7. Tectonically active sediment-bypassing margins characterize the early Tertiary. The continental margins of Veracruz and Cuba underwent major compressional deformation and did not develop broad constructional shelves; instead, most sediment was probably bypassed to the deep basin. At the same time, a deep-water foreland basin, probably with a similar type of margin, extended into Chiapas and central Guatemala.

WINKER, GREGORY J., Phillips Petroleum Co., Denver, CO, and ROBERT R. BERG and THOMAS T. TIEH, Texas A&M Univ., College Station, TX

Facies and Diagenetic Controls on Reservoir Rock Properties of Hosston Sandstones, Washington Parish, Louisiana