the ebb-tidal delta did not develop solely through progradation, but was also formed through erosion of the surrounding Gulf bottom. Accordingly, the shoal is termed "ebb-tidal delta retreat body."

ISPHORDING, W. C., Univ. South Alabama, Mobile, AL

Interpretive Mineralogy: Examples from Miocene Coastal Plain Sediments

Gulf Coast Miocene sediments are among the most lithologically complex in the entire nation. This varied lithology stems in part from multiple source areas that were active during this interval; but also it reflects major tectonic events that influenced depositional patterns throughout the Gulf Coast during the Miocene. Because fossils are scarce or lacking in many of the units, important questions relating to a number of geologic problems have been addressed by analysis of sediment mineralogy. Examples are discussed illustrating how such analyses can be used to: (1) clarify stratigraphic relationships between units in contact, (2) define environmental conditions in the depositional basin, (3) reconstruct paleoclimate conditions, and (4) identify provenance areas. A major anomaly in the mineralogy of central Gulf Coast Miocene sediments is explained by postulating a major "ancestral Tennessee River" originating in the southern Appalachians and flowing southwestward across Alabama and Mississippi to a terminus in the ancient Gulf of Mexico.

KELLER, WALTER D., Univ. Missouri-Columbia, Columbia, MO, CHARLES G. STONE, Arkansas Geol. Commission, Little Rock, AR, and ALICE L. HOERSCH, LaSalle College, Philadelphia, PA

Textures of Chert and Novaculite: An Exploration Guide

Textures of chert and novaculite observable in scanning electron micrographs (SEMs) are useful as a practical, geologic thermometer for estimating the maximum temperature of those rocks since deposition. Such information may be further applied during exploration for hydrocarbons (maturation or degradation), and for metallic and nonmetallic minerals, in those and associated rocks.

Scanning electron micrographs taken of cherts and novaculites that crop out in the Ouachita Mountain foldbelt of Arkansas and Oklahoma, and in areas adjacent to exposed and buried intrusives, show a sequential range in textures from cryptocrystalline, anhedral quartz in the nonmetmorphosed chert and novaculite to coarse euhedral, polygonal, triple-point quartz 60 μm in diameter. A similar range of textures occurs in chert of a contact metamorphic aureole on the Isle of Skye, Scotland, where classic metamorphic mineral suites from talc through tremolite, diopside, and forsterite grades are represented. Hence, some chert and novaculite of the Ouachita Mountain foldbelt shows textures morphologically correlative with classic representatives of varied metamorphic conditions.

Measurements were made of grain sizes of the quartz along transects across the SEMs of chert and novaculite from the Ouachita foldbelt. From them an isopleth map was made showing mean grain sizes of the polygonal triple-point texture developed. The map defines a linear 25 to 65 km (15 to 40 mi) wide belt that extends from Little Rock, Arkansas, about 250 km (155 mi) west to Broken Bow, Oklahoma. The texture increases from the margins to the core of the Ouachita Mountain foldbelt and contains two coarse-grain anomalies, one near Little Rock (35 μm diameter) and another near Broken Bow (15 μm diameter). This textural belt, with anomalies, conforms to the most intense, predominant late Paleozoic, structural deformation in the Ouachita Mountains. Previous interpretations have considered the rocks in the core of the foldbelt to have attained a maximum metamorphic grade in the zeolite to lower greenschist facies.

Cherts and novaculites adjacent to Magnet Cove, a Cretaceous age pluton in the eastern Ouachita Mountains of Arkansas, illustrate a superposed overprinting of polygonal triple-point texture. It ranges from a background of about 2 μm (talc grade) in chert 1,370 m (4,500 ft) from the pluton to about 45 μm (forsterite grade) from near the contact. Private drilling operations indicate that the pluton contact dips about 45° beneath much of the sedimentary rock that exhibits locally anomalous crystallinity. Homogenization temperatures of vein quartz, determined by H. Jackson in 1973, show a gradient along this profile of slightly more than 200°C (390°F) in quartz 1,370 m (4,500 ft) from the pluton, to about 440°C (825°F) near the contact. Novaculite xenoliths in the adjoining Potash Sulphur Springs intrusive are coarser in texture, 60 μm or larger, and represent the higher temperature periclase metamorphic grade, approximately 760°C, 1,400°F, at Crestmore, California, according to Carpenter.

The triple-point texture and coarseness of chert and novaculite are related to the degree of thermal maturation resulting from various heating events. The crystal morphology is equivalent in the two processes described (regional and contact metamorphism), but the changes due to individual agents, temperature, physical deformation, time, depth of burial, and mineralizers have not yet been resolved separately.

Very small quantities of chert and novaculite, by using SEM techniques, can serve as a guide to areas that have undergone elevated rock temperatures resulting from deep burial, mechanical stresses, intrusions, exhalations, and other thermal events. These investigations are relevant in determining temperature levels that may mature or degrade hydrocarbons, and offer clues in exploration for thermally related metallic and nonmetallic minerals. SEM studies of cherts and novaculite now provide another method of ascertaining the thermal maturation of rocks.

KONTROVITZ, MERVIN, and RENÉ A. DE HON, Northeast Louisiana Univ., Monroe, LA

Diagenetic Changes to Microfossils: Experimental Study

An understanding of taphonomic processes including diagenesis would enhance the usefulness of fossils such as the Foraminifera. In this study, shells of five modern species of calcareous Foraminifera were subjected to temperatures and pressures (T-P) that simulated burial. One kilometer (0.6 mi) increments were used with a maximum simulated depth of 10 km (6 mi) in wet sediment.

An increased alteration of shells occurred at each higher T-P in each sediment type (quartz, illite, or calcite). Shells in quartz were more altered than those treated in either illite or calcite. Compared to untreated shells, pores in quartz at 5 km (3 mi) were enlarged by 15%, and tiny hillocks were visible at high magnification (2,000 X). At 6 km (3.7 mi), high sharp pinnacles were formed and pores were enlarged 30 to 50%. At 7 km (4.3 mi), long narrow solution channels developed while pores were increased by 40 to 60% in diameter. The next T-P increment (8 km, 5 mi) caused even greater pore solution, whereas at 9 km (5.6 mi) sutures were obliterated and the previously formed pinnacles were removed. At the highest T-P (10 km, 6 mi), chambers and shell outlines were highly altered and newly formed crystals appeared. There were platelets oriented perpendicular to the shell surface; often they were arranged as rosettes.

Under experimental conditions, alteration features of Foraminifera shells appear diagnostic of certain T-P levels. If such features develop on shells in natural sediments they may be useful to reconstruct some conditions of diagenesis.

KOSTERS, ELISABETH C., Louisiana Geol. Survey, Baton Rouge, LA, and ALAN BAILEY, Univ. Southwestern Louisiana, Lafayette, LA

Characteristics of Peat Deposits in Mississippi River Delta Plain

Variations in organic-rich sediment (peat) from the Mississippi River delta plain can be explained by differences in three interrelated parameters: (a) depositional setting, (b) balance between subsidence and detrital influx, and (c) marine inundation. Variations are observed in geometry of the overall deposits, organic matter content, and the mineralogy of peats and related ashes.

Using a vibracorer, samples were collected from two brackish areas (Avery Island/Sale-Cypremort and Barataria basin) and one freshwater area (Gueydan). Geometries of the deposits are different for the two brackish settings; interdistributary peats of Barataria basin tend to be discontinuous and somewhat thicker than blanket peats of Avery Island/Sale-Cypremort. The freshwater peat is an elongate body in a Pleistocene channel cut.

Peats in all areas average 90% moisture content. Dried peat averages 81.3% organic matter with a bulk density of 0.12 g/cm^3. Holocene differential compaction has been minimal (< 4%).

Conventional ash values indicate different distributions of organic material for the two brackish areas. For the area containing interdistributary peats, approximately 5% of the subsurface contains more than 70%

organic matter, whereas for blanket peats, 14% of the section has more than 70% organic matter.

Mineralogic data collected on low-temperature ashes indicate that major minerals in brackish peat consist of kaolinite, quartz, and water-soluble salts, whereas minerals from freshwater samples are primarily kaolinite and quartz. X-ray diffraction and electron microscopy show the presence of smectite, illite, abundant siliceous spicules, framboidal pyrite, biotite, pyroxene, and rutile in the insoluble fraction.

Suitability of these deposits as coal precursors has been discussed by several workers. Superficial examination of data generated so far suggests that only thin coal seams with high ash would be produced. However, the presence of decomposing siliceous sponge spicules in the ash and the possibility of ash being leached by fresh ground water, suggest that much ash may be lost during early diagenesis. Hence, this environment may have more potential as a modern coal-forming model than it first appeared.

LEVIN, DAVID M., Levin Consulting, San Antonio, TX

Deep Wilcox Structure and Stratigraphy in Fandango Field Area, Zapata County, Texas

The Fandango field in Zapata County, Texas, is a new deep Wilcox trend extension. The deep Wilcox sands are commonly found at depths of 15,000 to 20,000 ft (4,500 to 6,100 m). Enough well log and seismic control now exists to make an accurate integrated interpretation of regional deep Wilcox structure and stratigraphy.

Deep Wilcox structure and stratigraphy are controlled by regionally extensive shale anticlines. These shale uplifts control deep Wilcox sand distribution, create large anticlines, and cause regional growth faults which commonly influence local structure. Each regional uplift presents a new exploration frontier holding the promise of vast reserves in the deep Wilcox.

The history of Frio-Vicksburg exploration is an analogy to the deep Wilcox trend today. It took 40 years to expand Frio exploration from shallow stratigraphic traps down into the enormous reserves in the Gulf of Mexico, because each new fault-block extension was considered to mark the downdip limit of Frio production. This was, of course, not true and is not true in the deep Wilcox today. The deep Wilcox trend remains virtually unexplored and it is my belief that continued work will prove the existence of much more deep Wilcox potential than is currently thought to exist.

LEVIN, DOUGLAS, Louisiana State Univ. and Louisiana Geol. Survey, Baton Rouge, LA, DAG NUMMEDAL, Louisiana State University, Baton Rouge, LA, and SHEA PENLAND, Louisiana Geol. Survey, Baton Rouge, LA

Tidal Inlet Variability in Mississippi River Delta Plain

Stratigraphic sequences of deltaic and shallow marine origin commonly contain sand bodies transgressively overlying lower delta-plain and delta-front deposits. Although generally ascribed to barriers formed during the destructive phase of the delta cycle, most of this sand is probably of tidal-inlet origin because of the high preservation potential for sediment deposited below the base of the retreating shoreface in deep migratory tidal channels and their associated tidal deltas. To facilitate the identification of such units, this paper reviews the temporal evolution of the inlet sand bodies found along the rapidly transgressive shoreline of the abandoned Holocene Mississippi River deltas. This study also reveals that tide dominance or wave dominance of a coastline is not simply a function of tide range and wave height; it depends largely on the tidal prism, an inlet parameter which, in Louisiana, changes rapidly over time.

Three distinct stages can be identified in the evolutionary sequence for Louisiana tidal inlets: (1) wave-dominated inlets with flood-tidal deltas, (2) tide-dominated inlets with large ebb deltas, and (3) wide, "transitional" inlets with sand bodies confined to the throat section.

Stage 1.—Tidal inlets ranging in age from 50 to a few hundred years are associated with flanking barrier systems attached to erosional deltaic headlands. The barriers enclose restricted interdistributary bays. Small inlets occur at the entrance to abandoned distributary channels within the headland section proper. The tidal prism being exchanged through either of these inlet types is small; the morphology of the inlets and adjacent coastline is wave-dominated, and most of the inlet sand is associated with a flood-tidal delta. The inlets are generally shallow.

Stage 2.—The Holocene Mississippi River deltas are subject to rapid subsidence and consequent local sea level rise. One gage at Grand Isle indicates a sea level rise of 30 cm (12 in.) over the past 20 years; however, the long-term average is somewhat less. Subsidence leads to an expansion of back-barrier open water environments, an increase in tidal prism, and an evolution of the inlet into a tide-dominated morphology with a deep main channel and large ebb-tidal delta. The recent evolution of Pass Abel and Quatre Bayou Pass represents the transition from wave dominance to tide dominance. Sand bodies developed in stage 2 inlets have the greatest preservation potential because they generally lie below the base of the retreating shoreface.

Stage 3.—Further subsidence generally leads to development of an open sound, permitting efficient tidal exchange with the gulf along the sound margin (Chandeleur Sound). As a consequence, the inlets play only a minor role in the tidal exchange pattern. At this stage, the inlet sand bodies evolve along two distinctly different paths, apparently controlled by sediment supply. Barriers with adequate coarse sediment produce many small well-defined inlets with large flood-tidal deltas (washover fans) and only transient, post-storm ebb deltas. The island shore is distinctly wave dominated. Along coastal segments where coarse sediment is scarce, one finds rapid island deterioration, shoaling of the inlet channel, and reworking of the ebb-tidal deltas into a "transitional" configuration with the sand tied up in throat section shoals.

As the inlets migrate during the transgression, they will leave behind on the continental shelf, tidal sand bodies with a landward succession of facies changing from those characteristic of wave dominance, into tide dominance, and back again to "transitional" or wave-dominated inlets.

LIEBER, ROBERT B., Tesoro Petroleum, Houston, TX, and MARSHALL C. CAROTHERS, El-Can Exploration, Metairie, LA

Harmony Field, Clarke County, Mississippi: A True Stratigraphic Trap

Harmony field in Clarke County, Mississippi, has produced approximately 2 million bbl of oil since its discovery in 1968. Production has been from oolitic grainstones in the upper Jurassic Smackover Formation.

The trapping mechanism at Harmony field is a complex stratigraphic trap. Porous oolitic grainstones pinch out updip into tight carbonates and anhydrite. Structure contour maps on top of the Smackover Formation indicate a low relief structural nose associated with the field. Additional structure maps contoured at the top of the Haynesville anhydrite, approximately 500 ft (150 m) above the top of the Smackover, reveal only regional southwesterly dip. An isopach map of the interval between the two structural markers shows a thinning of Haynesville section coincident with the field area. Evidence suggests, therefore, that the porous Smackover in Harmony field was deposited with depositional relief above the surrounding sediments. This relief had been completely masked by the time the Haynesville anhydrite was deposited.

Stratigraphic and structural cross sections using the Haynesville anhydrite as datum indicate the Smackover in Harmony field consists of not one, but multiple, thin oolitic zones which are productive in various portions of the field. These zones grade laterally as well as updip into nonporous anhydritic carbonates.

The Smackover Formation is often considered to be a chronolithologic unit. In the Harmony field area it is a lithostratigraphic unit, i.e., a unit defined not by time but by a particular rock type, in this case a porous limestone.

During the Late Jurassic, the Harmony field area was near the updip limits of the Mississippi salt basin. Porous oolitic grainstones are interpreted as washovers or storm deposits into lagoons containing tight carbonate muds. Such a model can provide excellent exploration targets in similar areas within the Mississippi salt basin. As Harmony field demonstrates, we are looking for features with little structural expression and great variations in rock type—true stratigraphic traps.

LOCK, BRIAN E., Univ. Southwestern Louisiana, Lafayette, LA, BRUCE K. DARLING, Pennzoil Co., Midland, TX, and ILENE D. REX, Univ. Southwestern Louisiana, Lafayette, LA

Marginal Marine Evaporites, Lower Cretaceous of Arkansas

The mixed evaporite/carbonate/terrigenous clastic sediments of the DeQueen formation, in southwestern Arkansas, were deposited at the