O'CONNELL, SUZANNE, Lamont Doherty Geol. Observatory of Columbia Univ., Palisades, NY, JOHN B. ANDERSON, Rice Univ., Houston, TX, and LEG 96 SCIENTIFIC PARTY

Channel Sand Bodies in Lower Mississippi Fan

More than 20 terrigenous sand beds, 1-9 m thick, were cored at 2 DSDP sites in the lower Mississippi Fan, in 3,300 m of water, 600 km from the shelf edge. The shallowest sand beds occur 15 and 23 m below the sea floor, and constitute 50% of the recovered cores.

These beds were sampled at 20-30 cm intervals for size analysis. Sand content averages 80% with 10-15% variation within a bed. Mean and modal sand is fine grained and averages 2.75-3.0 phi. Maximum sand size ranges up to coarse sand, and within some beds, it varies between 0.5 and 2.0 phi. Grading is poorly developed on the scale of 1 m and larger. There is no consistent grading trend, and in some intervals, mean and maximum sand size show opposite trends. These data confirm that, like many ancient fans, the lower Mississippi Fan was a major site of sand deposition, but unlike them, consistent coarsening-upward sequences are not defined.

The poorly developed grading, variations in grading trends, and changes in sand percentages result from sand deposition within a broad, shallow, meandering or braided channel in which sands are reworked. The many separate beds are probably the result of changes in channel position that occurred on the average of once every 7,000 yr. Sand transport to the lower fan ended at least 2,000 yr before Holocene time. These newly discovered sand bodies, interlayered with finer clastic, potentially organic-rich material, suggest that stratigraphic reservoirs may be present in deep water, lower fan environments.

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North African Petroleum Geology: Regional Structure and Stratigraphic Overview of a Hydrocarbon-Rich Cratonic Area

North Africa, including Sinai, contains some of the most important hydrocarbon-producing basins in the world. The North African Symposium is devoted to examining the exploration potential of the North African margin in light of the most recent and promising exploration discoveries. The geologic variety of the region is extraordinary and can challenge any exploration philosophy.

Of primary interest are the Sirte basin of Libya, which has produced several billion barrels of oil, and the Gulf of Suez, a narrow, evaporite-capped trough with five fields that will produce more than 5 billion bbl. Both are extensional basins with minimal lateral movement and with good source rocks in direct proximity to reservoirs. Structural models of these basins give firm leads for future exploration.

More difficult to evaluate are the "Tethyan realm" basins of the northern Sinai, the Western Desert of Egypt, the Cyrenaican Platform of Libya, and the Tunisia-Sicily shelf area, where there are only limited subsurface data. These basins are extensional in origin also, but have been influenced by lateral tectonics. Favorable reservoirs exist, but source rocks have been a problem locally. Structural models with strong stratigraphic response offer several favorable play concepts.

The Paleozoic Ghadames basin in Libya, Tunisia, and Algeria has the least complex structural history, and production appears to be limited to small structures. A series of stratigraphic models indicates additional areas with exploration potential. The Paleozoic megabasin of Morocco, with its downfaulted Triassic grabens, remains an untested but attractive area.

O'HEARN, TERRENCE C., Texaco U.S.A., New Orleans, LA, and CLYDE H. MOORE, Louisiana State Univ., Baton Rouge, LA

Fluid Inclusion Study of Diagenetic Mineral Phases, Upper Jurassic Smackover Formation, Southwest Arkansas and Northeast Texas

Homogenization and final melting temperature data from primary and secondary two-phase fluid inclusions within carbonate and sulfate mineral phases reflect the physical re-equilibration of pre-burial calcites and the precipitation of late diagenetic mineral phases during the burial of the upper Smackover (Upper Jurassic, Oxfordian) lime-grainstones in southwestern Arkansas and northeastern Texas. Homogenization temperatures range from 83.0°C to 153.8°C (uncorrected for excess ambient formation pressures at time of trapping). Final melting points range from −33.4°C to −13.5°C.

Statistically distinct temperature populations reveal the re-equilibration of pre-burial bladed calcite cements and parallel the subsequent paragenesis during burial of nonfabric-selective dolomite, zoned equant mosaic calcite, anhydrite, celestite, unzoned poikilitic calcite cement, and baroque dolomite cement under conditions of increasing temperature and salinity.

Re-equilibration/precipitation began after a minimum depth of burial in the range of 0.95 to 1.75 km. Re-equilibration/precipitation resulted, in part, in response to the original connate meteoric to marine pore water system being mixed with, and subsequently replaced by, basinal brines that migrated into the upper Smackover grainstones from the Louann Salt.

Melting temperature data indicate that fluids trapped within the two-phase fluid inclusions are highly saline, varying from 17 to 27 wt. % NaCl. Melting temperature data also indicate that the fluids are $CaCl_2$-rich brines with NaCl and probably $MgCl_2$ and $FeCl_2$ as additional chloride components.

OLANDER, A. M., Exxon Co., USA, Houston, TX

Wilcox Depth Prediction at Katy Field, Waller County, Texas: Problem and Solution

Velocity anomalies large enough to cause severe errors in depth maps may not be recognized from prior drilling experience, from regional velocity control, or from seismic reflection configurations. A chastening example of one such anomaly is an outpost well near the Katy field in Waller County, Texas. This outpost well, the Exxon 1 Sparks, tested Wilcox sands, which were both dry and 500 ft low to seismic prediction from Vibroseis data. The well came in structurally low as a result of incorrect predictions of both near-surface and post-Wilcox velocities. Additional studies indicated that the Sparks well was drilled on the flank of a structure that was later drilled and proved to be the discovery of a new Wilcox field.

Accurate velocities are becoming increasingly important in all phases of oil and gas exploration, particularly in mature exploration areas where prospects are subtle and difficult to find.

OSSIAN, C. R., ARCO Oil and Gas Co., Plano, TX

Exhumed Shoreface and Tidal-Delta Complexes in Lower Cretaceous Ferron Delta (Central Utah)

Numerous studies of modern shoreface and tidal-delta complexes have appeared in the literature, but few well-documented ancient examples are known. In the Lower Cretaceous (Turonian) Ferron delta complex of the Mancos Shale in central Utah, such a system has been recognized in outcrop. This complex is part of the transgressive destructional phase of the Ferron delta and represents a shoreface setting overstepped by rapid transgression, buried and preserved within fine-grained, shallow shelf sediments. The facies tract is now exposed by erosion and the exhumed surface has been examined in detail.

The exposed parts of the shoreface complex consist of 9 km of upper-shoreface and foreshore settings, tidal inlets with recurved accretionary spits, ebb-tidal delta bodies, and extensive washover fans. Within the outcrop belt, two inlet complexes have been positively recognized and parts of a third complex may be present. Behind the shoreface complex are shallow and restricted lagoons with locally extensive tidal channels.

Geometry of the ebb-tidal delta bodies and their suites of preserved sedimentary features support a model of strong longshore current systems from south to north along the edge of a large embayment. Studies of basin geometry, shelf width, probable nature of the adjacent land surface, and paleocirculation patterns have all combined to provide data for this model of a mesotidal setting with associated shoreface, lagoonal, and tidal-facies tracts.

OWEN, DOUGLASS E., and JOHN C. WEST, U.S. Dept. of Interior, Corpus Christi, TX

Late Quaternary Seismic Stratigraphy of a Shallow Marine Estuary, Corpus Christi Bay, Texas

A series of maps constructed from seismic data trace the late Pleistocene and Holocene development of Corpus Christi Bay. The seismic data consists of 320 km of older sparker data, 80 km of older Uniboom data, 160 km of recent ORE Geopulse data, plus some 3.5 kHz Datasonics data.

Seismic facies and the principal sedimentary features are mapped. Main unconformities such as the Holocene/Pleistocene erosional unconformity and the thickness of Holocene fill are contoured.

Vertically stacked channels indicate that the ancestral Nueces River meandered across the same geographic area during the late Quaternary. Seismic signatures suggest extensive distribution of sand as channel fill, bars and spits, and reworked older deposits. Numerous moundlike structures are interpreted to be ancient oyster banks, which occupy areas in the bay where no living oyster reefs exist today. Holocene evolution indicates progressive widening of the estuary and filling from both the Nueces River and the landward migrating barrier islands.

PALMER, A. R., GSA, Boulder, CO, R. M. EGBERT, Sohio Petroleum Co., San Francisco, CA, R. SULLIVAN, San Francisco State Univ., San Francisco, CA, and J. S. KNOTH, Sohio, San Francisco, CA

Cambrian Trilobites with Siberian Affinities, Southwestern Alaska

Cambrian trilobites occur in two levels (about 7 m apart) in the core of a large, complex anticlinal structure in the area between the Taylor Mountains and the Hoholitna River in southwestern Alaska. The lower collection contains *Erbia, Macannaia* (a species close to Soviet forms described as *Pagetia ferox* Lermontova), two species of *Kootenia* (including one perhaps conspecific with forms from the central Brooks Range), and several species of ptychoparioid trilobites. It is clear that biogeographic affinities are with the transitional facies of the eastern Siberian platform and the south Siberian foldbelt. In Soviet terms, the age of the collection falls in a disputed interval called latest Early Cambrian (Tojonian) by some authors, and earliest Middle Cambrian (Amgan) by others. In North American terms, *Macannaia* is known only from early Middle Cambrian beds. The younger collection contains abundant agnostids, a variety of conocoryphids, *Paradoxides*, and several species of ptychoparioid trilobites. This is an assemblage of undoubted late Middle Cambrian age, comparable to faunas described from the Maya Stage of the Siberian platform and the *Paradoxides paradoxissimus* Stage of the Baltic region. Both faunas are from ocean-facing or outer shelf environments. None of the key non-agnostid or non-pagetiid elements have been seen previously in deposits of Cambrian North America.

PARKS, JAMES M., Lehigh Univ., Bethlehem, PA

Fluvial Sand Shapes: Effects of Tributary Mixing

Similarities and differences in gross shapes of fluvial quartz sand grains contain information useful for interpretation of sediment transport history. The shapes of sand grains in a given river depend on the source, or sources, of sand within the drainage basin and on the abrasion and shape sorting that has occurred during transport. It is highly unlikely that 2 major streams will carry precisely similar-shaped grain suites. Therefore, when 2 streams join, the resulting sand can be recognized, on the basis of shape, as being mixtures of the 2 input streams.

The multiple rotations method of quantitative shape analysis characterizes sets of grain shapes with 5 or 6 numerical factor loadings, and individual grains are described by 5 or 6 factor scores. Trends of shape changes, such as those that occur along the length of a river, show up well on bivariate-factor score plots. These trends are interrupted and offset by mixing of sands contributed by tributary streams. Shapes of sands obtained from the Missouri River above the junction with the Platte River in Nebraska are different from those from below the Platte; but when Platte River sand shapes are subtracted, the remaining differences are insignificant. Farther downstream, sands from the Kansas River show the same relationships. The relative contributions of sand from a river and its tributaries, and the rates of mixing of the sands, can be estimated from quantitative shape analysis of several samples.

PAYNE, J. H., Exxon Co., U.S.A., Houston, TX

Paleopedogenesis in Lower Cretaceous Hensel Formation, Central Texas

The extensive matrix facies of the Hensel Formation consist of calcretized (calichified) red mudstone, and thin, sheet sandstone, interpreted as paleosols and overbank deposits. Framework facies include cross-stratified lenses of conglomerate and sandstone that represent low-sinuousity to meandering streams of small fluvial systems. These systems were active during the transgression that resulted in deposition of Glen Rose and Fredericksburg Group carbonates. The pervasive development of calcrete, desiccation cracks, and pseudo-anticlines within the Hensel paleosols, as well as the overall depositional style of the unit, suggest an arid to semiarid, seasonal climate.

Paleopedogenesis resulted in the formation of authigenic kaolin and illite, intense red-orange coloration, and various types of calcrete. Paleocalcrete within the mudstone facies commonly assumed a nodular habit. It is frequently observed to be coalesced into honeycomb structures. Locally calcretized, thin-bedded sandstone and mudstone were buckled into pseudo-anticlines. These structures were partly produced by fluctuating ground water and other inferred soil-forming processes. Paleocalcrete accumulated in the sandstone facies as undulating hardpans and vertically oriented rhizoliths. Microscopic textures characteristic of all these calcretes include low-magnesian calcite, crystallaria, and circumgranular cracks.

Carbon and oxygen isotopic values from each type of calcrete confirm a pedogenic origin for the authigenic calcite. A "heavier" oxygen isotopic value in the dolomite, peculiar to the pseudo-anticline calcrete, denotes enrichment of meteoric ground water by extreme evaporation. These conditions would have existed near a continental playa, an environment compatible with the seasonal, arid to semiarid climate.

PERKINS, RONALD D., Duke Univ., Durham, NC

Timing of Syntaxial Cement

Echinodermal fragments are commonly overgrown in ancient limestones, with large single crystals growing in optical continuity over their skeletal hosts (i.e., syntaxial overgrowths). Such syntaxial cements are usually considered to have precipitated from meteoric pore waters associated with a later stage of subaerial exposure. Although several examples have been reported from ancient carbonates where petrographic relationships may indicate an early submarine formation of syntaxial cement, no occurrences have been noted in Holocene submarine-cemented rocks.

Syntaxial cements of submarine origin have been found in Bermuda beachrock where isopachous high-magnesian calcite cements merge with large optically continuous crystals growing on echinodermal debris. Examination of other Holocene sediments cemented by magnesian calcite indicates that echinodermal fragments are not always overgrown syntaxially, but may be rimmed by microcrystalline calcite. The reason for this difference is not clear, although it may be a function of the spacing of nucleation sites and rates of crystal growth.

A review of syntaxial cements from several localities in ancient carbonate sequences reveals that many are best interpreted as having formed in the submarine setting, whereas it is more clear that others formed from meteoric precipitation. These occurrences suggest that care should be exercised in inferring meteoric diagenesis from syntaxial overgrowths and that the possibility of submarine formation should be considered.

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Recognition of Two Distinctive Diagenetic Facies Trends as Aid to Hydrocarbon Exploration in Deeply Buried Jurassic Smackover Carbonates of Southern Alabama and Southern Mississippi

Petrologic investigations from wells drilled in the southern Mississippi Interior Salt basin and in the northern Gulf Coast Salt basin have revealed regionally predictable diagenetic-facies trends within the deeply buried (19,000-22,500 ft) Smackover Formation. Within deeply buried Smackover trends, calcitic facies and dolomitic facies are recognized.

The calcitic facies is areally widespread and exhibits diagenetic intensities ranging from well-preserved grainstones to pervasive neomorphism. Petrographic evidence of multistage cementation, solution compaction, replacement fabrics, and cement-occluded secondary porosity is common. The calcitic facies is characterized by low porosity and low permeability.

The dolomitic facies is less abundant, and its distribution can be related to the Jurassic paleotopography. The Wiggins uplift, a prominent basement element extending across southern Alabama and southern Missis-