BRUHN, CARLOS H. L., JOSE M. CAIXETA, and JULIO C. SCARTON, PETROBRAS, Salvador (BA), Brazil

Sublacustrine Fan Reservoirs of Riacho da Barra Field, Reconcavo Rift Basin, Brazil

The producing sandstone of Riacho da Barra field represents the middle and distal portions of uplap sublacustrine gravitational fans, deposited in a northeast-southwest elongate graben developed during the Early Cretaceous on the northeastern part of the Reconcavo rift basin, Brazil.

Since the earliest stages of exploitation of the field, geologists and engineers have worked together to describe the reservoirs. A geologic and hydrologic model for the Riacho da Barra field was proposed, with emphasis on the lateral continuity of the reservoirs, which was mainly controlled by pressure-gradient correlations. This model was created to guide not only the development of the field, but also to define the possible use of waterflooding as a secondary recovery method.

Two main reservoir sets were identified. The first group corresponds to medium-grained, well-sorted, massive sandstones, with centimetric conglomerate levels, deposited in channels in the middle of gravitational fans. This group represents the best reservoirs, with an average porosity of 16% and average permeability of 100 md, but restricted lateral continuity. Major trends of channel deposits are the most favorable directions for waterflooding.

The second group includes a cyclic sequence of coarse-grained massive sandstones and medium-grained parallel-stratified sandstones, deposited as lobes of middle and distal fans. These sandstones have a wider distribution and contain 85% of the original oil in place of the field (50 million stock tank bbl). However, they have poorer reservoir quality, with average porosity of 12% and average permeability of 20 md. These characteristics are due to the significantly large thickness of poorly sorted parallel-stratified sandstones and also to the thin sandstone beds interlayered with shales, which show high contents of calcite cement.

BUDD, DAVID A., ARCO Oil & Gas Co., Dallas, TX

Freshwater-Phreatic Calcite Cementation, Schooner Cays, Bahamas

Freshwater-phreatic calcite cementation is an active process on 700 and 2,700 yr-old ooid-sand islands in the Schooner Cays, Bahamas. Cement fabrics and textures indicate a general, four-stage model of pore infilling. (1) The precipitation of isolated, decimicron-sized, rhombohedrons of calcite on grain surfaces forms an incipient circumgranular cement. (2) Continued precipitation enlarges crystal sizes and forms new rhombohedral crystals, resulting in a continuous circumgranular rim of cement. (3) Additional cementation quickly masks the circumgranular fabric, producing a partial pore-filling mosaic. (4) The remaining pore space is occluded with a mosaic of calcite cement. Petrographic evidence for the earlier circumgranular rim of cement is not necessarily apparent after the last stage of cementation.

Empty pores and all four stages of phreatic-zone cementation were observed in the diagenetically immature 700 yr-old rocks, but only stages 2 through 4 were observed in the diagenetically more mature 2,700 yr-old phreatic-zone samples. Cements are distributed homogeneously within each pore at every stage, yet because each pore may proceed through the four stages at different rates, each pore can be at a different stage of infilling. This results in an inhomogeneous distribution of cement between pores during the initial stages of cementation.

Recognition of a cement stratigraphy similar to that described here should aid in the identification of freshwater-phreatic diagenesis in ancient carbonate rock sequences. Variability in the amount of freshwater-phreatic cement between pores should be expected and not interpreted as the product of different paragenetic sequences.

BUFFLER, RICHARD T., and DALE S. SAWYER, Univ. Texas at Austin, Austin, TX

Distribution of Oceanic Versus Transitional Crust in Deep Gulf of Mexico Basin—Implications for Early History

Regional studies of seismic reflection and refraction data in the deep Gulf of Mexico basin outline in considerable detail the distribution of oceanic vs. transitional crust. Oceanic crust forms a narrow east-west belt up to 300 km wide across the deep Gulf. Most current models for early Gulf evolution suggest the belt was emplaced in the Late Jurassic following widespread deposition of salt on rifted and attenuated continental crust (transitional crust). The southern boundary is defined by a zone of prominent salt structures along the northern margin of the Sigsbee salt basin. The northern boundary is obscured below the Texas-Louisiana slope, but is inferred from the distribution of large vertical salt structures. The eastern boundary is clearly marked by onlap and pinch-out of thick Jurassic sedimentary sequences. This distribution is corroborated by regional magnetic and gravity data and total tectonic subsidence analysis, and provides constraints for early Gulf basin reconstructions.

An appropriate reconstruction must account for plate motion accommodated by ocean crust formation and extension of continental crust. The data seem most consistent with a model in which the Yucatan block moved generally south and rotated somewhat counterclockwise. This reconstruction implies very little lateral displacement along transform faults between Yucatan and Florida during early basin history. This is supported by seismic stratigraphic studies and DSDP drilling in the southeastern Gulf.

BURKE, KEVIN, Lunar and Planetary Inst. and Univ. Houston, Houston, TX

Plate Tectonic History of the Arctic

The Arctic Ocean represents the last great challenge in establishing the broad outlines of the histories of the present oceans of the earth. The rotation of the Lomonosov Ridge away from the Barents Shelf during the Cenozoic is well established, and a unique present relationship has been demonstrated between the Gakkel Ridge and the Poloussnoye graben system. Earlier history of the Arctic is poorly known, but a possible and testable scenario involves rifting of the North Slope Alaska–Chukotsk block (NSAC) from the Canadian Arctic Islands during the Early Cretaceous and rifting of the New Siberian block (NSB) along strike on the same margin a little later. Both NSAC and NSB were involved, after rapid rotation, in the assembly of northeastern Asia with such other blocks as "Greater Japan" (much of Kyushu, Honshu, Hokkaido, Sakhalin, Sikhote Alin, Kamchatka, and Koryak) and Omolon. During earlier Mesozoic, Permian, and Carboniferous times, NSB and NSAC occupied one Atlantic-type margin of the triangular Boreal embayment of the Pacific, while the Verkhoyansk Atlantic-type margin of Siberia (with the prominent Vilyuy rift embayment) occupied the other. These 2 rifted margins, which are now caught up respectively in the Brooks Range–South Anyui–Sviatory Nos suture zone and the Sette Daban–Chirskiy suture zone, had formed during the Late Devonian close to the site of and shortly after the Innuitian suturing event between Siberia and North America.

BURRUSS, ROBERT C., U.S. Geol. Survey, Denver, CO

Paleo-temperatures from Fluid Inclusions—Advances in Theory and Technique

Recent studies of fluid inclusions in diagenetic cements have attempted to determine paleosubsurface temperatures. Three sets of observations are necessary to make accurate interpretations: (1) detailed petrography to establish the relative time of formation of the inclusions, (2) careful analysis of the burial and tectonic history of the host rocks to relate the diagenetic paragenesis to the geologic history of the basin, and finally, (3) analysis of individual inclusions for homogenization and final melting temperatures, and for chemical composition to define the PVT properties of the trapped fluids.

Once these observations are complete, 2 major limitations on the temperature interpretation remain. First is the assumption that the inclusions have not altered in composition or volume since entrapment. Recently published work shows that inclusions can re-equilibrate, but the extent that this affects most observations in sediments is unknown. Second, we must independently determine a "paleopressure" during inclusion formation, and we must know whether this pressure was hydrostatic or approached lithostatic. Data from both hydrocarbon and aqueous fluid inclusions in core samples from the Mission Canyon formation, Williston basin, North Dakota, illustrate a method for independently determining both paleotemperature and paleopressure from a single set of fluid inclusion measurements. The technique requires petrographic evidence for

simultaneous trapping of 2 immiscible fluids. Theoretical analysis of the PVT properties of coexisting immiscible fluids demonstrates that the isochores for the 2 different fluids must intersect at the temperature *and* pressure of entrapment of the inclusions. Calculation of the PVT properties of each fluid requires detailed chemical analyses of both fluids. Recent results from new analytical techniques, especially capillary column gas chromatography to analyze hydrocarbon inclusions and laser Raman spectroscopy to analyze gases in aqueous inclusions, demonstrate that this approach to paleotemperature studies can be widely applicable in sedimentary environments.

CACCHIONE, DAVID A., DAVID E. DRAKE, SAMUEL H. CLARKE, U.S. Geol. Survey, Menlo Park, CA, and DOUGLAS G. MASSON, Inst. Oceanographic Sciences, Wormley, United Kingdom

Sonograph Mosaic of Northern California and Southern Oregon Exclusive Economic Zone

During June 15 to July 9, 1984, the third leg of the cooperative U.S. Geological Survey–Institute of Oceanographic Sciences GLORIA survey of the conterminous United States Exclusive Economic Zone (EEZ) collected digital acoustic data off northern California and southern Oregon. The region covered during leg 3 extends from the 200-m isobath westward to the 375-km (200-nmi) EEZ boundary and from about 39° to 43°N. The survey used the IOS GLORIA long-range side-scan sonar, a 2-channel airgun seismic reflection system, and 3.5 kHz and 10 kHz high-resolution seismic systems. The GLORIA data were collected in a pattern that permitted overlapping coverage so that a mosaic of the sonographs could be constructed. These sonographs were slant-range and anamorphically corrected aboard ship, and a mosaic was constructed at a scale of 1:375,000.

Among the most striking geomorphic features revealed in this segment of the EEZ is the Mendocino transform fault, which extends for more than 120 nmi along the northern base of the Mendocino fracture zone and delineates the southern boundary of the Gorda plate. Other features clearly revealed are the complex geometry of the Gorda rift valley, and the subparallel flanking ridges and dramatically deformed base of the continental slope at the eastern boundary of the Gorda plate. The data are presently being processed by image analytical techniques to enhance the fine-scale features such as sediment waves, slumps, and areas of differing sedimentary facies.

CARNEY, JOHN L., LOUISE P. DRAPER, JAMES H. GAMBER, ALFRED F. GEEN, and T. KARMEN, Amoco Production Co., New Orleans, LA

Paleoenvironmental Data as Exploration Tool in Lower Miocene of Offshore Texas

Most paleontological reports based on foraminiferal assemblages in well cuttings include an interpretation of the environment of deposition of the sediments penetrated. For an individual well, these data may be summarized as a paleoenvironmental curve. Data on a group of wells can be synthesized into paleoenvironmental maps and cross sections—useful tools for predicting sand distribution. These maps, used independently or in conjunction with net sand maps, can indicate the locations of ancient delta systems, hence sand sources. Paleoenvironmental cross sections graphically display transgressions and regressions.

The lower Miocene sediments in the Mustang Island and Matagorda Island areas of offshore Texas were deposited in a wide range of shelf and upper slope paleoenvironments. Paleoenvironmental maps, based on about 50 wells, suggest that a number of major delta systems developed in the Mustang Island and Matagorda Island areas during the early Miocene. Electric-log data show that thick pods of sand are associated with each of these ancient delta systems. Paleoenvironmental cross sections indicate that, although the section just above *Siphonina davisi* in southern Mustang Island is strongly regressive, the equivalent section in eastern Matagorda Island is transgressive. Determination of such transgressive/regressive trends is vital to predicting the dip position of potential reservoir sands. A cross section through Matagorda block 622 illustrates that a considerable thickness of deep-water sediments can overlie an older, shallower water, sandy interval. Therefore, the penetration of a thick sequence of deep-water shales does not necessarily indicate that underlying prospective sections will not be encountered.

CARPENTER, ALDEN B., Chevron Oil Field Research Co., La Habra, CA

Origin of Na-Ca-Cl Brines in Jurassic and Cretaceous Reservoirs of Gulf Coast

Na-Ca-Cl brines in Jurassic and Cretaceous reservoirs in the Gulf Coast have been attributed to the diagenesis of concentrated Jurassic seawater related to Louann Salt deposition and alternatively to the diagenesis of brines produced by halite dissolution. These brines contain up to 35,000 mg/L Ca, up to 4,000 mg/L Mg, from 400 to 2,400 mg/L Br, and up to 13,000 mg/L K. Mutual relationships of Na, Cl, total divalent cations minus sulfate and bicarbonate, K, and Br are similar to those in seawater that has been evaporated past the initial stage of halite deposition, particularly when the K content of the brine exceeds 5,000 mg/L. The concentrations of divalent cations and K increase, and the mutual relationships of all the dissolved salts become increasingly similar to those in seawater with increasing proximity to bedded salt. The abundance of authigenic K-feldspar in rocks above the salt beds explains the relatively rapid decrease in the K content of the brines upsection. The Ca and K contents of Jurassic Gulf Coast brines are similar to those in Na-Ca-Cl brines in feldspar-poor carbonate sequences in other basins.

C. S. Land and D. R. Prezbindowski suggested in 1980 that the Na-Ca-Cl brines in the Edwards formation of Texas originated from halite dissolution and gained Br from halite recrystallization, Ca from the albitization of plagioclase, and K from the alteration of K-feldspar. Since the Br content of the brines is high and the Br content of halite is low (generally < 100 ppm), Br would have to be stripped from an enormous volume of (impermeable) salt and transferred to a relatively small volume of fluid. Mass-balance calculations indicate that Br would have to be stripped from more than 7.5 km of salt to account for the bromide in the brines of the Mississippi salt basin. If Ca and K in Na-Ca-Cl brines are derived from feldspars, these elements should increase in concentration relative to chloride with increasing distance from the source of NaCl. This is the reverse of the field relations in Mississippi, where unaltered authigenic K-feldspar is present in rocks above the salt, and the K content of the brines decreases relative to Cl with increasing distance from the halite. Finally, it is not clear how 3 completely independent processes can operate to produce such an excellent match to the dissolved constituents of evaporated seawater over such a wide geographic area and in strata with varying amounts of feldspar. The simplest genetic model is that Gulf Coast Na-Ca-Cl brines formed from evaporated seawater and evolved to their present composition accompanying the processes of dolomitization and loss of sulfate.

CARSON, M. A., and P. A. MACLEAN*, McGill Univ., Montreal, Quebec, Canada

Hybrid Eolian Dunes of William River Dune Field, Northern Saskatchewan, Canada

A series of northwest-southeast aligned, large-scale (up to 30 m high) eolian dunes, occurring in a confined (600 km^2) desert area in northern Saskatchewan, Canada, was examined in the field. Observations were made of dune morphology and internal structure, and patterns of sand movement on the dunes were analyzed in relation to wind events during the summer of 1981.

Present cross-sectional profiles exhibit steeper northeast slopes, the lower segment of which are intermittently covered by psammophilous grasses. Dune structure is dominated by northeast-dipping accretion laminae. Three ^{14}C dates from organic material cropping out on the lower southwest slopes reveal that the dunes have migrated as transverse bed forms at rates of roughly 0.5 m/yr during the last few hundred years. However, a progressive increase in height, bulk, and symmetry along the dune axis from northwest to southeast, suggests an along-dune component of sand transport. This view is supported by (1) field measurements of airflow and along-dune sand transport patterns on 2 dunes, and (2) the present-day wind regime (1963-78). Dominated by north-northeast to northeast winds from January to June and by west-southwest winds from July to December, the resultant potential sand transport vector is toward the southeast, virtually identical to the dune axis.

The dunes are viewed as a hybrid type, forming in response to a combination of transverse and longitudinal processes and are probably not uncommon in many deserts. The discordance between the dune structure