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Exploration Concepts for Syntectonic Sediments of Triassic and Jurassic Age along Northern and Eastern Rim of Gulf of Mexico Basin

Current tectonic models for the formation of the Gulf of Mexico generally include continental rifting starting in the Triassic and continuing through the Jurassic. A comparison between the sedimentology and structural geology of known continental rifts (such as the Gulf of Suez, Egypt) and the Triassic and Jurassic of the Gulf of Mexico suggests the following. (1) The interior salt basins of Texas, Louisiana, Mississippi, and Alabama probably were deposited within a failed continental rift. (2) Positive features such as the Angelina-Caldwell flexure, Wiggins arch, and Middle Ground arch probably represent the southern edge of the failed rift. (3) Positive features such as the Sabine uplift and Monroe arch are probably isolated horst blocks within the failed rift.

Pre-evaporite sediments account for much of the production in the Gulf of Suez, and these rock sequences are well exposed there on shore. Depositional and structural histories for these rocks are similar in both the Gulf of Mexico and Gulf of Suez, and a careful comparison suggests new play concepts for the Gulf of Mexico. The post-evaporite sequences of the Gulf of Suez are also similar to the Norphlet and Smackover Formations of the Gulf of Mexico, although Smackover equivalents are currently being deposited in the Gulf of Suez. Comparisons between the two rift systems indicate that a clearer understanding of the structural setting of the Gulf of Mexico at the time of deposition of the Norphlet and Smackover should lead to better exploration plays for these syntectonic formations.

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Barrier-Bar System in Cerro Negro, Orinoco Petroliferous Belt, Venezuela, and Its Implication in Oil Exploration and Exploitation

Barrier bars are important stratigraphic traps for oil and/or gas because of deposition in relatively shallow and often agitated waters, which allow barriers to develop excellent primary porosity and high permeability. Barrier bars can be developed as component facies of other depositional systems such as deltas or as independent interdeltaic systems associated with a major delta. In each case, different facies relationships such as distributary channel, mouth-bar, distal-bar, and prodelta facies would be present in a deltaic setting. Barrier bars, lagoons, washover-fans, and nonmarine facies could occur in an independent interdeltaic system. Different sand geometry patterns and reservoir characteristics are found in each system. In the Cerro Negro area, the sedimentary parameters are composite sand bodies, *Ophiomorpha*-type burrows, bioturbation structures, shell fragments, and an interfingering of brackish and shallow-marine fauna. Seven continuously cored wells and more than 100 geophysical well logs were used to determine lithofacies associations and to construct computer-drawn maps. These data were used to propose and support an independent interdeltaic barrier-bar system as the depositional model for the Cerro Negro area. Barriers were found to be mainly parallel to a paleoshoreline, and to have porosity values greater than 20% and permeability values greater than 500 md. It is interesting to note that different rates of heavy oil production can be related to the facies present.

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Dolomitization of Fossiliferous Siliciclastic Sediments in Salisbury Embayment

Bioclastic, medium-grained sand beds in the Chesapeake Group formations (Miocene) of Maryland and Virginia, contain abundant intergranular dolomite and calcite cement. The sand beds are dominated by fairly well-sorted subrounded quartz grains (mean grain size approximately 250 μm), molluscan-shell debris, and variable amounts of mud and iron oxides that coat many of the grains. The surfaces of the quartz grains surrounded by carbonate cement are etched and pitted, indicating high pH conditions within the diagenetic environment. Initially abundant primary porosity and permeability may be completely filled with diagenetic equant calcite spar and/or rhombic dolomite. However, shell material may be completely dissolved by this process, creating a conspicuous secondary porosity.

Dolomitization appears to be stratigraphically controlled by impermeable silty clay layers, above and below the sandy beds, which confine the diagenetic fluids to these zones. Though calcitization appears to be more variable, it also seems to be stratigraphically controlled.

Preliminary ^{13}C and ^{18}O results indicate that the dolomite and calcite cements are in isotopic equilibrium, and a ^{14}C-age determination suggests that dolomitization began less than 30,000 yr ago. The abundant presence of limpid dolomite suggests a fresh or brackish water origin for these cements, and the presence of ferroan dolomite may indicate an organic influence in the dolomitization process.

The confinement of diagenetic fluids in thin (1-2 m) permeable sand layers may induce the concentration of the necessary available cations to initiate dolomitization.

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Early-Diagenetic Sheet-Crack Cements of Guadalupian Shelf, Yates and Tansill Formations, New Mexico—a Field and Chemical Study

Tepee-associated sheet-crack structures and carbonate cements that largely fill them are developed in the carbonate facies of the back-reef Capitan Reef complex, Guadalupe Mountains, New Mexico. Sheet cracks, their cements, and associated teepee structures were studied to better understand the timing, nature of precipitating waters, and environment of deposition of the sheet-crack cements. Sheet-crack cements were field classified into 8 morphologic fabrics.

Contrary to previous work, this study found that sheet-crack fillings developed symmetrically from roofs and floors. Sheet-crack cements, the sheet cracks, and associated teepee structures developed repeatedly and episodically. Most are erosionally truncated and cross-cut by overlying surfaces. Most cements show isopachous growth indicative of precipitation under phreatic conditions. Some pendant cements suggest precipitation in a vadose environment, indicating occasional exposure of the outer-shelf and shelf-crest facies.

Calcite-cement fabrics (39 samples) were analyzed for Sr, Mg, Fe, $\delta^{13}C$, and $\delta^{18}O$. Chemical compositions range from: Sr = 116 to 5,244 ppm; Mg = 215 to 9,188 ppm; Fe = 7 to 758 ppm; $\delta^{18}O$ = −5.6 to +0.4 ‰; and $\delta^{13}C$ = +4.9 to 7.5 ‰ (PDB). Sr exhibits distinct groupings of more than 2,000 ppm and fewer than 500 ppm. Samples with high Sr are associated with lower $\delta^{13}C$, $\delta^{18}O$, and Mg compositions. The converse is true for the low Sr values.

Isotopically heavier samples are interpreted as precipitated from restricted marine waters. Isotopically lighter samples are interpreted as precipitated from mixed meteoric and marine waters. The meteoric water is inferred to have originated from shelfward, terrestrial source areas. It is hypothesized that these waters traveled through an aquifer system and percolated upward as springs to the sheet-crack area.

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Cyrenaican Platform: Structure, Stratigraphy, and Exploration Play Concepts

The structural and stratigraphic history of the Cyrenaican platform of eastern Libya is closely related to that of both the Sirte basin and the Western Desert of Egypt. At the end of the Paleozoic Hercynian orogeny, this area comprised the eastern end of the Sirte arch, the precursor of the Sirte basin. When the arch collapsed in the mid-Cretaceous, initiating the Sirte basin, the Cyrenaican area remained relatively high. A northwest-southeast trending high, the Gabboub arch, formed on the platform in the early Mesozoic, dividing the region into three areas: the high itself, a deep on the southwestern flank related to the Sirte basin, and a deep on the northeastern flank, which plunges into the offshore and appears to relate to the downwarped offshore area of the Western Desert of Egypt.

Sediments of every age, except Triassic, are found in Cyrenaica. Paleozoic sediments are composed primarily of quartzitic sandstones and shales with lesser amounts of limestone, dolomites, and anhydrites.

Mesozoic sediments are a mixture of clastics and carbonates. Cenozoic sediments are predominantly limestones, dolomites, and anhydrites with some sandstones and shales. Environments of deposition range from continental to deep marine.

The Cyrenaican area has not been heavily explored and, until recently, no commercial hydrocarbons were found. Drilling on surface structures of some of the first wells in Libya resulted in one Devonian gas well. A reported 5,600 BOPD Cretaceous discovery offshore Benghazi in mid-1984 demonstrates that hydrocarbon potential exists where thick sediments have been preserved.

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Shoreline, Grain-Size, and Total-Carbon Distribution Changes Before and After Hurricane Alicia, Galveston Island, Texas, 1983

Shoreline, grain-size, and sediment total-carbon changes were monitored, on a monthly basis, on three Galveston Island beaches, from January through December 1983. The study area included: (1) East Beach, obstructed by groins and a seawall; (2) Galveston Island State Park, obstructed by fences artificially stabilizing the dunes; and (3) West Beach, an unobstructed beach.

Beach profiles revealed the effects of beach obstruction, such as erosion and undercutting at East Beach, and truncation of the dunes at Galveston Island State Park. Approximately 20 m of expansional cutback occurred on the beaches after Hurricane Alicia hit on August 18, 1983.

Contour maps of grain-size and total-carbon distributions reflect the movement of beach sand by either onshore-offshore transport during low-energy periods, or longshore, edge-wave transport during high-energy periods.

Statistical analyses revealed a small variation in grain size throughout the year. There were well-defined times of either no correlation or strong correlation between total carbon vs. mean grain size, skewness vs. mean grain size, kurtosis vs. mean grain size, total carbon vs. percent sand, total carbon vs. skewness, and skewness vs. kurtosis. Strong correlation was found in response to high-energy events, whereas no correlation was found in response to low-energy events.

Galveston Island is undergoing net erosion and appears to be in a metastable state, still capable of responding to oceanographic conditions. The economic effects of Hurricane Alicia include considerable loss of the shoreline and destruction of property. Beach nourishment appears to be the only economically feasible solution to counteract the extensive erosion.

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North America–Greenland–Eurasian Relative Motions: Implications for Circum-Arctic Tectonic Reconstructions

The Mesozoic-Cenozoic tectonic evolution of the Circum-Arctic region is based on constraints imposed by (1) relative motion histories of the three major plates (North America, Greenland, and Eurasia) and a number of smaller pieces; and (2) distribution and age of sutures, accretionary prisms, volcanic arcs, fold-thrust belts, stretched continental crust, strike-slip faults, and ocean floor. We conclude that: (1) North America and Eurasia remained relatively fixed to each other until the latest Cretaceous-Paleocene opening of the Labrador Sea–Baffin Bay and Greenland-Norwegian and Eurasian basins (earlier convergence between North America and Eurasia in the Bering Sea region shown on many reconstructions are artifacts of incorrect plate reconstructions); (2) the North Slope–Seward-Chukotka block has constituted an isthmus connection between North America and northeast Asia since at least the middle Paleozoic and did not rotate away from the Canadian Arctic; (3) the Canada basin opened behind a clockwise-rotating Alpha Cordillera–Mendeleyev ridge arc during the Early to middle Cretaceous and consumed older, Paleozoic(?) Makarov basin ocean floor (the Chukchi cap is a detached continental fragment derived from the Beaufort Sea; the North Slope Arctic margin is a left-lateral transform fault associated with the opening of the Canada basin); and (4) the Nares Strait fault has a net relative displacement of approximately 25 km, but actual motion between Greenland and northern Ellesmere was about 250 km of strongly transpressive motion that resulted in the Eurekan and Svalbardian orogenies.

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South China Sea Tectonic Evolution and Hydrocarbon Potential: New Geological and Geophysical Constraints

The South China Sea has yet to receive a DSDP investigation; consequently, numerous untested models have been proposed for its post-Cretaceous evolution. From a compilation of regional oceanographic heat-flow measurements with offshore and onshore bore-hole temperatures, we thermally model and constrain possible interpretations of its tectonic evolutionary path. The heat-flow data, together with magnetic profiles, depth to basement determinations, and regional sediment isopachs, characterize two principal subbasin extensional elements—one trending east-west (northern area between Hainan and Luzon) and the other trending northeast-southwest (central area between Palawan and Vietnam). The thermal models of simple lithosphere cooling suggest the central area began spreading 55-58 m.y.B.P. and the northern region 34-35 m.y.B.P. These dates of incipient extension correspond to two principal unconformities in Paleocene and Oligocene strata of both offshore China and Palawan, and together they indicate regional uplift of the South China Sea owing to thermal expansion prior to the spreading events. The thermal models also suggest that in the northern region, spreading ceased approximately 19 m.y.B.P., which compares favorably with published magnetic estimates of 17.7 m.y.B.P. A late Cenozoic heating event is evidenced by a thermal anomaly in the southern portion of the central region (southern Vietnam margin) that may be related to incipient spreading along a zone of crustal weakness inherited from the Jurassic-Cretaceous Sunda-Tethys suture. Overall, these data tend to support the hypothesis of spreading occurring first in the central region and then in the northern region.

From the geophysical data and observations of Cretaceous ophiolites cropping out to the south in Sabah and Brunei, we kinematically border our model to the south and propose the Palawan Ulugan fault to be a right-lateral suture between continental and intermediate crust. Structurally, within limits of the data presently available, our model further predicts the southern China shelf to have experienced two principal episodes of extension with a net result of younger (<34 m.y.B.P.) east-west trending graben normal faults superimposed upon older (<55 m.y.B.P.) northeast-striking pregraben normal faults. In terms of thermal maturity, geochemical kinetic modeling of Late Cretaceous source rocks suggests depths to the oil ceiling to range from 1.3 to 1.8 km in the northern region and from 0.98 to 1.6 km in the central region. Similarly, depths to the oil floor are estimated to range from 2.4 to 3.4 km and from 1.8 to 3.2 km in the two respective regions.

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Facies and Geochemical Characterization of Mississippian Rocks in Palo Duro and Hardeman Basins, Texas

Mississippian rocks in the southern Texas Panhandle constitute a complex sequence of carbonate deposits formed in a platform-to-basin setting. Following relatively rapid transgression and inundation of the area from the north and east, the Hardeman basin area was characterized by outer platform conditions in which isolated carbonate buildups developed surrounded by relatively deep water. The Palo Duro basin to the west was the site of shallow-water, inner platform deposition. In intermediate areas, limestone turbidites, perhaps derived from carbonate buildups to the east, accumulated in quiet water. After this initial transgression, an upward-shallowing trend resulted in the formation of ooid to skeletal shoals throughout the area

Although current production in the area is coincident with the distribution of organic-rich Upper Mississippian shales in the eastern part of the Hardeman basin, TOC studies indicate that potential carbonate source rocks are present in the western Hardeman and eastern Palo Duro basins. Mississippian rocks in the Palo Duro basin proper have little source rock potential. Vitrinite reflectance studies indicate that Hardeman basin rocks are well within the oil window. However, correlative deposits at