phreatic cementation occurred soon after the marine cementation and occluded virtually all remaining primary porosity.

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Implications of Offshore Northern Alaska Geology for Origin of Canada Basin, Arctic Ocean

Geologic mapping and petroleum exploration in northern Alaska and seismic surveys offshore suggest that 2 pulses of rifting created the Canada basin. Mississippian to Triassic miogeoclinal rocks in northern Alaska, derived from a now-displaced northerly source land, correlate with similar strata in the Canadian Arctic Islands. Underlying Ordovician and Silurian argillite and graywacke may correlate with the clastic succession in Heezen trough of the Arctic Islands. Closing Canada basin about a Mackenzie delta pole would rejoin these correlative rocks and recreate a unified pre-Jurassic Arctic paleogeography. Rifting began in earliest Jurassic time, creating a west-northwest-trending trough beneath the Beaufort Shelf and probably the southern Canada basin. The main rifting pulse, however, began in late Neocomian time, and the main post-rift progradational sedimentary prism off Alaska is Aptian or Albian and younger.

Apparently both late Neocomian and Laramide rifting thinned the crust beneath North Chukchi basin. Marked basinward thickening of Cretaceous strata records the earlier event, and extensional faulting and basinward thickening of Tertiary strata record the later one.

The high-standing, north-trending ridges and troughs of the Chukchi borderland, which trend into the North Chukchi basin from the north, may represent localized Laramide(?) crustal extension subparallel to that which created the Laramide(?) and Cenozoic Makarov and Eurasia basins of the Arctic Ocean. This model requires crustal shortening between the Chukchi borderland and Canada basin and transform faults north and south of the borderland. North of our seismic lines, the southern transform may be buried by Tertiary sediment of the North Chukchi basin.

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Paleoenvironmental and Diagenetic Analysis of Wichita Group, Palo Duro Basin, Texas Panhandle

The Wichita Group in the Palo Duro basin represents the Wolfcampian-Leonardian transition from carbonate to predominantly evaporite deposition. An interbedded series of dolomitic, anhydritic, and terrigenous clastic lithofacies reflect deposition in inner shelf and evaporitic tidal flat environments. An arid setting and restricted marine circulation over the broad expanse of the basin were conducive to the onset of early diagenesis, which masked much of the Wichita depositional framework.

Petrographic analyses revealed diverse lithofacies in the Wichita Group. Dolomitic lithofacies include (1) pyritic to argillaceous mudstones, (2) organic wackestones, (3) algal-intraclastic wackestones and packstones, (4) skeletal-peloid packstones, (5) coated grain-ooid grainstones, and (6) pisoid grainstones. Nodular-mosaic and massive to laminated anhydrite and terrigenous shales and siltstones complete the sequence. Noncyclic relationships are characterized by rapid vertical change, laminated to thin bedding, and gradational to sharp, commonly erosional contacts.

Wichita subfacies reflect deposition in a complex patchwork mosaic of evaporative supratidal, intertidal, shoal, and subtidal environments rather than a normal shelf to tidal flat transition. Close lateral association of these subenvironments in a low topographic setting yielded rapid facies migration in response to periods of increased terrigenous influx, storm erosion and redeposition, and normal tide and sea-level fluctuations.

Subaerial exposure and hypersaline brines initiated penecontemporaneous sulfate deposition and dolomitization. Two to three stages of dolomite cements were deposited. Primary sulfates provided a source for late poikilitic, blocky, and bladed anhydrite cement. Pseudocubic and bladed anhydrite replacement of dolomudstone is common.

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Fusselman-Cisco Play, Roosevelt Positive, Roosevelt and Curry Counties, New Mexico

The Roosevelt positive is bounded on the south by the petroliferous Northwest Shelf province; the Tucumcari basin lies to the north.

The current Fusselman-Cisco play was ignited in June 1978, by discovery of South Peterson-Fusselman field by Enserch in T5S, R33E. The discovery well had produced over 560,000 bbl of oil to January 1, 1984. In 1981, Energy Reserves Group extended Cisco production into T6S, discovering the East Tanneyhill-Cisco field, now part of South Peterson-Penn (Associated) field.

Present structural trends in the southern Roosevelt positive are northerly and contain all presently discovered oil and gas fields. Structures in the northern province trend westerly where shows have been encountered in the San Andres and Cisco. A paleostructural high projecting from the ancestral Central Basin platform trends across Roosevelt County to the northwestern part of Curry County. All known major fields producing from units below the San Andres are on the crest or flank of this paleohigh.

Pre-Pennsylvanian Paleozoic rocks are truncated around the edge of Precambrian knobs by an Early Pennsylvanian unconformity. Primary objectives are Fusselman Dolomite and Cisco limestone. Fusselman reservoirs in intercrystalline and vuggy porosity produce from truncation or anticlinal traps. Secondary porosity in the Cisco is created by leaching of forams and algal plates. Traps have been found on flanks and crests of anticlinal trends.

The province is considered a good seismic recording area. Although objective formations are relatively thin, high resolution seismic, synthetics, and modeling make reasonable stratigraphic interpretations possible.

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Influence of Basement Islands and Ridges on Smackover Deposition, Southwest Alabama

Pre-Jurassic basement highs, composed of igneous and/or metamorphic rocks, have influenced the deposition of Jurassic Smackover sediments in Clarke, Monroe, Conecuh, and Escambia Counties, Alabama. These basement islands and ridges provided a structural fabric on which Smackover sediments were deposited.

The following 3 basic structural settings illustrate the thickness variations and lithofacies distribution of Smackover sediments on the flanks and crests of these basement highs. Emergent features were never covered by Smackover seas, resulting in nondeposition of Smackover sediments over their crests. Flanking these features are finely crystalline and anhydritic dolomites capped by bedded nodular-mosaic anhydrite. The anhydrite grades upward into Haynesville continental sediments that also overlie the crests of these features. Semi-emergent features were above sea level for most of Smackover deposition. It was not until near the end of Smackover transgression that these islands and ridges were inundated. As the seas regressed, shoaling occurred on the flanks of these features depositing predominantly grain-supported limestones that were later dolomitized. The crests of these basement highs are covered by thin, low-porosity, grain- and mud-supported dolomites capped by bedded nodular-mosaic to distorted mosaic anhydrite. Nonemergent features were submerged through most of Smackover deposition. This enabled carbonates to accumulate as thick organic buildups and shoals over crestal portions of the basement highs. These thoroughly dolomitized and highly porous and permeable crestal sediments grade upward into nonporous, mud-supported dolomites capped by bedded nodular-mosaic anhydrite.

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Facies Relationships and Diagenesis in Smackover Formation—Huxford Field, Southwest Alabama

Huxford field, Escambia County, Alabama, was discovered in late 1982 by the Texaco 2 ATIC 35-6 well. Production was established from the upper Smackover Formation with an initial gauge of 1,070 BOPD and 1.1 MMCFGD. This well tested a seismically identified, sub-Jurassic topographic feature. Four unsuccessful confirmation attempts have revealed not only the difficulty in accurately predicting structural position, but also the complex facies relationships present in the upper Smackover.

Conventional cores from 5 wells reveal that in many places original depositional facies are masked by several diagenetic phases of recrystallization and dissolution. Mineralogically, the upper Smackover section is almost entirely dolomite of probably primary origin in the crestal areas, and early secondary origin on the flanks of the structure. Reservoir porosity and permeability are highly variable across the field and are controlled by several interrelated factors. Primary depositional fabric, completeness of dolomitization, and leaching of nondolomitized components were all important in creating reservoir-quality rock. Dolomitization of moderate to high-energy facies in many places resulted in porous and permeable crystalline dolomite with a sucrosic texture. In some places, incomplete dolomitization left remnants of the primary fabric that were later leached, leaving a vuggy texture. The occurrence of nonreservoir-quality rock can be attributed to (1) nonporous dolomite of supratidal origin, (2) occlusion of pore spaces by several later generations of dolomitization, or (3) occlusion of pore spaces by anhydrite.

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Cyclicity and Paleo-Environmental Dynamics of a 1.9 Ga Passive-Margin Carbonate Terrace, Wopmay Orogen, N.W.T.

The 1.90-1.89 billion year old Rocknest Formation in the Northwest Territories is a west-facing, passive-margin carbonate terrace in the foreland of Wopmay orogen. Initial outbuilding of an accretionary stromatolite rim over downslope facies was followed by upbuilding of the rim, local backstepping of the rim, and terminal subduction-related drowning of the entire shelf. The rim was flanked to the west by deep-water slope rhythmite and breccia, and on the east by a carbonate-shoal complex, separating the ocean from a broad (100-200 km wide) lagoon with a siliciclastic eastern shoreline. Concurrently, the shoal complex underwent repeated eastward expansion over the lagoon to form about 150 shoaling-upward cycles (1-25 m thick), consisting of carbonate tidal-flat tufa that overlies storm-dominated, mixed carbonate-siliciclastic lagoonal facies. Correlation of cycles for over 200 km parallel with and 100 km across depositional strike shows that cycle boundaries abut facies boundaries, indicating that complete shoaling of the lagoon to sea level was not required to induce the next submergence increment, suggesting an allocyclic rather than autocyclic mechanism. Radiometric constraints bracket cycle periodicity between 25,000-40,000 yr/cycle. These values are within the range of known earth orbital cycles (periods at 19,000, 23,000, 41,000, and 100,000 yr), the likely cause of Pleistocene glacio-eustatic sea level oscillations, and possibly Rocknest cyclicity. Rocknest cycles can be modeled using period and amplitude of sea level oscillation, and subsidence and sedimentation rates as variables. Resulting computer-generated cyclic stratigraphies are compared to actual Rocknest cyclic stratigraphy in order to constrain variables responsible for cycle development.

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Continuous Fracture Probability Determination as Applied to Monterey Formation

Most open-hole logs can be used for fracture detection. Each petrophysical measurement responds to fractures in a different way, and much literature exists describing the effects of fractures on tool responses. Most fracture detection programs use either one or two logs or many fracture indicators, but make no attempt to tie them together. Since fracture systems appear to provide nearly all the permeability for production in the Monterey Formation, fracture analysis is essential throughout the well. A program has been written to give a continuous output of fracture probability using all fracture information available from well logs, as well as from mud logs and drilling data. It is easily adaptable to local conditions (in particular, the Monterey Formation) through log analyst input. The program computes a composite fracture probability using all available fracture indicators. Each indicator will give an individual probability of fracturing. These probabilities are then weighted and combined to give a composite fracture probability.

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Crustal Rifting and Subsidence of Sirte Basin, Libya: a Mature Hydrocarbon Province

The complex rifting and subsidence history of the Sirte basin serves as an instructive case study of the tectonic evolution of an intercratonic extensional basin. The Sirte basin formed by collapse of the Sirte arch in the mid-Cretaceous. Marine sediments accumulated following initial crustal arching and rifting as the basin was flooded from the north. Upper Cretaceous strata lie unconformably on igneous and metamorphic rocks of the Precambrian basement complex, Cambrian-Ordovician Gargaf Group, or the pre-Cretaceous continental Nubian Sandstone. The most rapid subsidence and accumulation of basinal strata occurred in the early Cenozoic; however, the basin has been relatively stable since the Oligocene. The basin is floored by a northwest-southeast-trending mosaic of narrow horsts and grabens, an important structural characteristic that distinguishes it from the adjacent intracratonic Kufra, Murzuk, and Ghadames basins.

The details of basin subsidence, sediment accumulation rates, and facies variations have been reconstructed for the northern Sirte basin from a suite of approximately 100 well logs and numerous seismic lines. Subsidence-rate maps for short time intervals from the mid-Cretaceous through the Eocene show a continual shifting of the loci of maximum and minimum subsidence. The nonsteady character of basin subsidence may reflect a periodicity of movement on the major basement-rooted growth faults bounding the underlying horsts and grabens.

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Correlation of Illite Crystallinity and Thermal Maturity in Carboniferous Strata of Ouachita Mountains

Carboniferous shales from the Ouachita Mountains have been studied to determine mineralogy and thermal maturities, the latter ascertained by means of vitrinite reflectance and bitumen/organic carbon ratios.

The less than 2 μm fractions of these shales indicate 2 major clay-mineral components, illite and chlorite, and 2 minor varieties, expandable clays and pyrophyllite. Expandable clays are found at low thermal maturities and pyrophyllite at high maturity. Scanning electron micrographs show differences in clay morphology and texture, which are influenced by the degree of thermal maturity.

Weaver's sharpness ratio for illite and Kubler's crystallinity index are both significantly related to mean vitrinite reflectance. The log of the sharpness ratio increases while the log of the crystallinity index decreases with increasing mean vitrinite reflectance. These relationships suggest that illite crystallinity is controlled by the same geologic agents that control vitrinite reflectance, namely temperature and time.

A plot of vitrinite reflectance and/or crystallinity index versus bitumen/organic carbon ratio shows a maximum analogous to a hydrocarbon window.

These statistically significant correlations provide a useful means of estimating the thermal maturity of these strata where they contain insufficient amounts of vitrinite for thermal maturity evaluation.

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Subcrop-Supracrop Play Concept: Example from Manitoba, Canada

In the Canadian portion of the Williston basin, oil exploration has been based on the concept of the subcrop stratigraphic trap. The truncation of porous Mississippian strata at the Paleozoic angular unconformity, combined with either erosional or Mississippian structure, defines the play. In