Stratigraphy and Hydrocarbon Potential of Upper Jurassic Formations in Northeastern Gulf of Mexico Area

Upper Jurassic Norphlet, Smackover, and Haynesville deposition in Mississippi, Alabama, and Florida was controlled by the Mississippi Interior Salt Basin (MISB) and the Manila and Conecuh Embayments. Salt movement produced local variations in sediment distribution, and pre-Jurassic paleo-highs modified sedimentation. Norphlet lithofacies include eolian quartzose sandstone, alluvial-fluvial red-bed sandstone, alluvial conglomeratic sandstone, and bay black shale. The eolian lithofacies is best developed in the MISB area. The Conecuh Embayment and northern parts of the MISB and Manila Embayment are characterized by red-bed deposits, whereas the conglomerate lithofacies occurs in the updip parts of the study area. The shale lithofacies is present in the MISB and the Conecuh Embayment areas. In the tristate region, the Smackover Formation consists of a lower intertidal to subtidal, laminated mudstone lithofacies that overlies the Norphlet and an upper subtidal to intertidal lithofacies sequence dominated by grain-supported textures. The upper subtidal oolitic grainstone lithofacies is best developed in the MISB area. The Conecuh Embayment is characterized by subtidal peloidal packstone and intertidal laminated mudstone. Peritidal dolostone is the dominant lithology in the Manila Embayment area. The Buckner Anhydrite Member of the Haynesville Formation usually overlies the Smackover. This evaporite lithofacies is well developed in the southeastern part of the MISB, but thins eastward into the Conecuh Embayment. Upper Haynesville lithofacies change from alluvial-fluvial red bed dominated lithologies in the northern parts of the study area to supratidal-intertidal evaporite, limestone, and shale to the south. Over 100 oil and gas fields have been discovered in the tristate area with Smackover carbonate and Norphlet sandstone the primary reservoirs. Petroleum traps are combination traps involving favorable stratigraphy and salt features. Smackover algal mudstone is probably the source rock for the Jurassic oil.

MANNS, F. T., Univ. Toronto, Toronto, Ontario, Canada

Use of Dolostone Rhythmite Stratigraphy to Interpret Origin of Cross-Cutting and Manto Breccias Hosting a Lead-Zinc Deposit at Robb Lake, Northeastern British Columbia

The Robb lake lead-zinc deposit occurs within a brecciated Silurian-Devonian dolostone succession of transgressive-progradational sabkha rhythmites. The rhythmites are characterized by light gray color, white sparry dolomite cemented bird's-eyes, dolomite pseudomorphs of gypsum, and zebroid textures, which are diagnostic evaporitic cementation structures. The rhythmites were identified by logging color and lithologic variations observed in diamond drill core. The light gray tops of rhythmites are attributed to penecontemporaneous oxidation during sabkha progradation; the darker gray bases of rhythmites are attributed to penecontemporaneous reduction during marine transgression. Recording the color variation encountered in drill cores, even of highly brecciated intervals, permits stratigraphic correlation based on key beds and rhythmites. Relative sag of groups of rhythmites from the brecciated areas demonstrates the origin of breccias by collapse. Correlation also suggests that manto-like breccias formed after gentle tilting of the host succession. Tilting probably resulted from differential consolidation of an underlying shale-carbonate facies front. The orientation of the manto-like breccias is interpreted to have been controlled by infiltration of migrating formational fluids along horizontal planes within the tilted evaporitic succession.

Well-defined rhythmites in the upper half of the succession average 2.8 m in thickness with a standard deviation of 1.8 m (N = 1,295). Poorly defined rhythmites in the highly brecciated lower half of the succession have an average thickness of 4.4 m with a standard deviation of 3.7 m (N = 791) proving that even monotonously repetitive and brecciated strata can be differentiated by careful attention to thickness data.

MARION, DON, Calgary, Alberta, Canada

Jurassic Subcrop and Its Effect on Sedimentation, West-Central Alberta

In eastern and central Alberta, topography on the Pre-Cretaceous surface reflects the presence of a northwest-trending drainage system which intermittently carved into older Paleozoic rocks from Late Mississippian until earliest Cretaceous time. Lower Cretaceous sedimentary rocks mapped across the area fill and cover the valley and ridge system. To the west, successively younger units subcrop at the Pre-Cretaceous surface. As a result, unconformity bounded Jurassic quartz sandstones are present beneath Cretaceous sandstones and, in the absence of paleontologic control (usual situation), can only be distinguished with difficulty. The tendency has been to include these sands in the Lower Cretaceous "Basal Quartz," masking the unconformity surface. Subsequent interpretation of Lower Cretaceous sedimentation patterns is seriously affected.

Mineralogically pure, fine-grained quartz sandstones of the Rock Creek Member (Middle Jurassic) in west-central Alberta are distinct from quartz sandstones of Early Cretaceous age, which have greater grain-size variation and significantly higher percentages of unweathered chert grains. The resulting Jurassic subcrop pattern reveals cuestas of resistant Rock Creek sandstone, similar to those composed of Mississippian carbonates farther east.

Erosional lows on the surface of the Rock Creek Member are commonly filled by estuarine and nearshore sediments of the Ellerslie Member, reflecting invasion of the Early Cretaceous sea into the area.

MARKERT, JOHN C., and ZUHAIR AL-SHAIEB, Oklahoma State Univ., Stillwater, OK

Diagenesis and Evolution of Secondary Porosity, Minnelusa Formation, Powder River Basin, Wyoming

The upper member of the Minnelusa Formation in the Raven Creek and Reel oil fields of the Powder River basin consists of a sequence of interbedded sandstones, dolomites, and anhydrites of Early Permian age. This sequence represents depositional environments ranging from sabkha type to a coastal eolian dune complex. The sandstones of the Minnelusa Formation are predominantly moderate to well-sorted, fine to very fine-grained quartzarenites.

Silica overgrowth and anhydrite cement represent an early stage of diagenesis. Dissolution of anhydrite cement was the major process in the development of secondary porosity in the Minnelusa reservoir. Pore-filling dolomite and dolomite replacing anhydrite are late stage diagenetic products. The euhedral dolomite rhombs are ferroan in composition. Authigenic illite-smectite mixed-layered clays are formed contemporaneously with the diagenetic dolomite. Dissolution of anhydrites, formation of secondary porosity, and hydrocarbon accumulation may have occurred during Late Jurassic and terminated during Laramide orogeny.

An analysis of the subsurface formation waters from the Powder River basin was made using WATEQF computer programs. Results indicate that waters are supersaturated with respect to anhydrite and dolomite. The saturation indices of anhydrite and dolomite in the subsurface waters are plotted on maps. A

trend is noted where saturation indices appear to increase away from the producing zones of the Minnelusa in the northeastern part of the Powder River basin. Therefore, saturation indices may be used as an indicator of secondary porosity development and consequently as an exploration tool for hydrocarbon accumulation in the Minnelusa Formation.

MARLEY, WALTER E., North Carolina State Univ., Coal Geology Associates, Raleigh, NC

Subfacies Controls of Coal Bed Discontinuities, Southern Wasatch Plateau, Utah

The lower Blackhawk Formation and the Star Point Sandstone of the southern Wasatch Plateau are the lower deltaic and nearshore facies, respectively, of an Upper Cretaceous regressive deltaic sequence. Economic coal beds are associated with peat-forming environments in both the lower delta plain and the accretionary ridge–distributary mouth bar subfacies of the delta.

Discontinuities (rolls, splits, and pinch-outs) within the coal beds of the accretionary ridge subfacies are controlled primarily by: (1) proximity of the peat marsh to the high-energy shoreline environment, (2) relative compaction ratios of channel sands and finer detritus over which the peat marsh developed, and (3) topographic expression of the paleodrainage network incised within the top of the underlying Star Point sediments. Discontinuities (rolls, splits, pinch-outs, and washouts) within the coal beds of the lower delta plain subfacies are controlled primarily by: (1) proximity of the peat swamp to laterally contemporaneous distributary channels, (2) relative compaction ratios of underlying sands and finer detritus, and (3) erosion of the heat beds by basal scouring of overriding distributary channels.

Detailed outcrop measurements and drill hole data are used to develop accurate, site-specific, paleoenvironmental models to define the areas of potential coal-bed discontinuities and to aid in local exploration and mine planning.

MARROQUIM, M., M. B. ARAUJO, and M. MELLO, PETROBRAS, Rio de Janeiro, Brazil

Models of Oil Entrapment in Ceara Basin, Brazil

Five oil fields have been discovered in Ceara basin, northeastern Brazil, as a result of 33 wildcats drilled. All of the discoveries are localized in Mundau area in the eastern part of the basin. In this area four major stratigraphic units are recognized in seismic and well data: rift (Aptian), transgressive (Albian/Cenomanian), slope (Upper Cretaceous/Miocene), and shallow platform (Paleocene/Miocene) sequences. The main potential reservoirs are deltaic-lacustrine sandstones of the rift sequence and turbiditic sandstones of the slope sequence. Good source characteristics are exhibited by the shales of rift and transgressive sequences; the slope sequence offers fair to good content of adequate organic matter, but is partly immature.

Three distinct types of oil traps have been found in Ceara basin. (1) Structural traps, with the reservoir, source, and seal belonging to the rift sequence; the pool is confined to horst blocks, formed by the intensive faulting which affects this sequence. (2) Combined traps, where rift sequence reservoirs, dipping landward, are truncated by an unconformity and sealed by overlying transgressive shales; the source may be from both rift and transgressive sequences. (3) Stratigraphic traps, formed by turbiditic sandstones immersed in the shales of the slope sequence, which provide both source and seal.

The fields discovered so far are small, with areas ranging from 2 to 5 sq km. Delineation is made difficult by faulting (traps of types 1 and 2) and by lack of continuity of reservoirs (traps of type 3). Advance seismic techniques, such as 3-D migration and higher resolution surveys, have been used as a help in solving these problems.

MARTINEZ, RUBEN D., G.S.I. de Mexico, S.A., Mexico City, Mexico, and JORGE STANFORD B.,, Petroleos Mexicanos, Tampico, Mexico

A Seismic Stratigraphy Case History in Northeast Mexico

A study was made using seismic work to define stratigraphic features in the Tampico basin in Mexico. The Tampico basin is in northeast Mexico, south of Tampico. The objective of the study was to define stratigraphy features within the Mesozoic and Tertiary parts of the basin. The lithologic sequence includes (a) consolidated Tertiary sands and shales, and (b) Cretaceous clastics and limestones, shales, and sandstones. Oil in the area is produced from turbidites and conglomerates which fill paleocanyons of Eocene age. The paleocanyons appear in a fan form. The lithology in the Late Cretaceous and Upper Jurassic section displays no major structural features, except a regional dip toward the Gulf Coast which is conformable with the basement. Conventional multichannel common-depth-point (CDP) reflection seismic data were collected and processed in the area during 1977 to 1980. After a preliminary structural interpretation was made on data, a seismic line which ran transverse to a fan in a paleocanyon was selected to use as a base for a seismic stratigraphy study. This seismic line was reprocessed through wavelet processing sequence to produce a true amplitude section. The wavelet processing sequence was used to reduce distortions in the basic wavelet and to recover high frequencies lost due to transmission and absorption effects. From the true amplitude section, seismic anomalies such as bright spots and flat spots were identified. Following this, the data were processed through a rigorous wave equation inversion to produce an interval velocity section which then became the main tool for stratigraphic interpretation. Low velocity anomalies were encountered within the Eocene, the top and base of the Late Cretaceous, and the Upper Jurassic. These anomalies corresponded to those identified in the true amplitude section and are postulated to be oil-saturated zones. The anomalous zones were then mapped laterally using the other seismic sections in the area.

MARTINSON, DOUGLAS G., Lamont-Doherty Geol. Observatory, and Columbia Univ., Palisades, NY

Correlation of Time Series: An Inverse Approach with Applications in Geology and Geophysics

A simple mathematical inverse method has been developed to correlate two time series $Y_1(x_1)$ and $Y_2(x_2)$, where these two signals are related to each other by a mapping function $x_1(x_2)$. The mapping function describes differences between the two signals and is parameterized in terms of a sum of simple functions of unknown coefficients, a_i. These coefficients are estimated from the time series with the assumption that the best coefficients are those which minimize the difference between $Y_1[x_1(x_2)]$ and $Y_2(x_2)$. The standard analytic errors in the estimates of a_i and thus the uncertainty in $x_1(x_2)$, have been calculated and are negligible.

The method has been applied to the correlation of stratigraphic records, well logs, seismic records, and magnetic anomalies. In all cases, high resolution correlations have been attained and continuous mapping functions recovered. The mapping functions in the first three of these applications reveal the continuous change in relative sedimentation rate histories or thickness of strata be-