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.

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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.

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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.

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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-

tween the two profiles being correlated. In the magnetic anomaly application, it reveals asymmetries in the spreading rates at the particular spreading center. Uniqueness of the correlations (at any particular level of resolution) is estimated statistically and analytically.

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Particulate Organic Matter of Jurassic-Cretaceous "Black Shales" in Deep North Atlantic Ocean

More than 650 DSDP samples were studied using Masran & Pocock's 1981 classification of particulate organic matter to define a number of particulate organic matter assemblages; these assemblages are characterized both by their source material and the mode of preservation. Both marine and terrestrial sources can be identified. The distribution of these assemblages shows that: (1) the eastern deep North Atlantic, Gulf of Mexico, Caribbean, and Demerara Rise are characterized by a high proportion of marine derived matter; (2) western North Atlantic sites received a high input of terrestrial organic matter; (3) marine-derived material is dominant in Cenomanian sediments of all areas; (4) highly degraded gray amorphous matter, indicating low oxygen conditions, occurs throughout the deep North Atlantic Ocean; (5) circular bodies, occurring in all areas, are interpreted as remains of seaweed spores; and (6) the distribution of various types of organic matter assemblages agrees with the sedimentology studies given in the various reports of the Deep Sea Drilling Project.

The cyclicity reported by sedimentologists is also recognized in the contained organic matter. Its origin must be explained in terms of preservational mode of the organic matter, its original source (marine or terrestrial), and mode of original and final sedimentary deposition.

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Carbonate Sedimentation of Reef and Associated Shoal-Water Facies, Sligo Formation (Aptian), Black Lake Field, Natchitoches Parish, Louisiana

The Black Lake field is one of the larger Lower Cretaceous carbonate hydrocarbon reservoirs along the U.S. Gulf Coast. The field produces from the Pettet porosity zone of the upper Sligo Formation. This porous zone coincides with a variety of carbonate facies that were deposited on a wave-dominated shelf as caprinid reefs and associated shoal-water deposits.

Distinctive associations of lithologies, textures, fabrics, structures, and faunas provided the basis for recognizing seven major carbonate lithofacies in the field. Lithofacies present in the field include (1) caprinid, (2) oncolite, (3) oolite, (4) bioclastic, (5) bioclastic micritic, (6) foraminiferal, and (7) micrite lithotypes.

A sequence of lithofacies maps and stratigraphic cross sections describe the areal geometry, distribution, growth, and movement of the various major carbonate lithofacies within the field through a short span of geologic time. Sediments deposited under the caprinid reef in the field were predominantly foraminiferal and bioclastic lime mudstones and wackestones characterized by massive bedding, bioturbation, mollusk debris, and abundant remains of *Orbitolina texana.* Caprinids initially began flourishing in the northeastern part of the field as one distinct circular body surrounded by mud-supported sediments. The caprinid lithofacies migrated in a southwesterly direction, suggesting that the predominant movement of longshore currents was from the northeast to the southwest. The caprinids formed a distinct linear carbonate buildup that trended in a northeast-southwest direction. Bioclastic micritic and bioclastic sediments formed on the landward and seaward sides of the reef trend, respectively. This demonstrates the the reef acted as a local wave-resistant barrier or baffle that allowed muddier bioclastic wackestones to accumulate behind (landward) the caprinid reef trend. The cross-sectional geometry of the caprinid lithofacies along with the dominance of reef debris landward of the main reef axis suggests that the caprinid reef developed on a wave-dominated shelf. As the reef development continued, a landward shift in local energy levels occurred. Along with the shift of energy level, the position of the longshore current also moved landward. This allowed stronger currents to move behind the reef trend (landward) and form and deposit coarser-grained sediments. The elongate reef trend was severed presumably by longshore and tidal currents. The resultant buildups were separated by a sub-perpendicular trend that consisted of bioclastic sediments which most likely represented a tidal channel through the caprinid reef. Bioclastic micritic sediments accumulated on the lee side of the reef trend in current sheltered areas. Caprinid reef growth stabilized and shoal-water deposits began to develop on the landward side of the reef trend. These shoal-water deposits consist of oolite and oncolite shoals and bioclastic reef-flank sediments deposited laterally adjacent to the caprinid lithofacies. The shoal-water deposits continued to develop and prograded over the area formerly occupied by the caprinid reef trend.

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Origin of Natural Gases, Po Valley Basin

Natural gases from productive wells in Po Valley basin have been investigated in order to study their origin. $^{13}C/^{12}C$, D/H isotopic ratios and GC analyses have been conducted. Some data on vitrinite reflectance and kerogen composition are also supplied where available.

The gases showed $^{13}C/^{12}C$ ratios in the range of -73 to $-38‰$ and D/H ratios in the range of -210 to $-150‰$.

A first interpretation based on stable isotopes, kerogen composition, maturity, and the geological setting indicates two main processes responsible of gas origin: bacterial (or early diagenetic) and thermogenic. Also, some gases seem to be the result of an interaction between the above mentioned processes.

Data on productive wells are in good agreement with some head-space analyses and with maturity values.

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Evaluation of Potential of Stratigraphic Trends Using Computer Well Data Files

Historical data from approximately 1.5 million wells residing on an IMS data base were computer processed by Amoco's Applications Management and Graphics Systems. Output consists of gridded "blindspot" maps for each stratigraphic section within each of thirty-four United States stratigraphic trend areas. In addition, a table of computed statistics was prepared for each trend in order to characterize rate of drilling, grid success ratio, and the projected number of years needed to find various percentages of remaining reserves of hydrocarbons based on current drilling rates.

From this information, it was possible to identify relatively untested, large scale subbasinal areas which were surrounded by