Abstracts

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Stratigraphic and Lithofacies Computer Modeling in Three Dimensions

A new computer method has been developed to create a three-dimensional lithostratigraphic model from well and seismic data. The model is constructed by interpolating and extrapolating lithofacies data in three dimensions, within a time-stratigraphic framework. Volumes as large as a sedimentary basin or as small as an oil or gas field can be accommodated. The modeling method involves rescaling of original data from a depth to a geologic time scale prior to interpolation, and inverse rescaling thereafter. Displays of the three-dimensional interpretation are in the form of structure contour maps and lithofacies maps representing any geologic time. Also serial cross sections are obtained, which show lithofacies arrangements such as layers, lenses, channels, pinch-outs, reefs, and facies variations. Volumes of all types of sediments are computed. This stratigraphic modeling technique is of interest to exploration and production geologists and geophysicists, because it provides a more complete interpretation than conventional mapping techniques.

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Bottom Boundary Layer Flow Profiling System

An autonomous profiling system is being developed to measure physical and optical properties in ocean-bottom boundary layers. System sensors will include electromagnetic current meters, temperature sensors, transmissometers, and water sample bottles affixed in a vertical array to a bottom-supported instrument frame at heights ranging from 0.25-5.00 m (1-16 ft) above its base. The instrumentation will measure high-frequency property fluctuations (5 Hz) as well as mean values. High-capacity tape recorders will permit unattended deployments for up to 3 months. Field tests will be conducted in the Gulf of Mexico.

The stress exerted by currents on the sea bottom is an important parameter in sedimentologic studies. The level of bottom stress governs the occurrence and the mode (suspension or bed load) of sediment transport. Of particular importance to the determination of bottom stress is the accurate quantification of stress components containing a vertical turbulent velocity term. Direct measurements of this and other high-frequency quantities that control the rates of erosion, deposition, and scour will provide a better understanding of sediment transport dynamics in modern environments and permit the development of rigorous criteria for interpreting ancient marine deposits.

Ocean-bottom boundary layers are characterized by high turbulence levels. An understanding of the flow dynamics thus requires a knowledge of the turbulence field. A large body of evidence indicates that suspended sediment modifies flow dynamics by changing the characteristics of both the mean and turbulence fields. An important change is the reduction in the magnitude and change in direction of the bottom stress. The profiling system will measure turbulence and suspended-sediment quantities contemporaneously. This sampling scheme will allow the determination of flow-sediment interactions and, for the first time, will provide data necessary for the validation of theoretical models of particle-laden flow.

The profiling system is a third-generation device that has an improved capability over any other existing profilers. It is the only one with the capability of evaluating the effects on currents and bottom stress of suspended sediments or temperature gradients very near the sea bed.

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Geochemical Characterization of Rocky Mountain, Northern Great Plains, and Interior Province Coals

Statistical summaries of proximate and ultimate analyses, heat of combustion, and content of 36 major, minor, and trace elements were calculated for 37 Eocene, 470 Paleocene, and 419 Cretaceous coal samples from 31 coal fields or areas in the Rocky Mountain and Northern Great Plains coal provinces and for 503 Pennsylvanian coal samples from 14 areas in the Interior coal province. These analyses show that coals within an age group have similar ranges in composition, and that each group has its own distinctive compositional characteristics. Most variability in element content can be related to changes in rank and differences in ash and total sulfur contents. Mean contents of Ca, Mg, Na, Ba, and Sr are related to rank and decrease as apparent coal rank increases from lignite A to high-volatile B bituminous coal. Mean contents of Si, Al, K, Ti, Ga, Li, Sc, Th, V, Y, and Yb increase as the mean ash content increases (correlation coefficients 0.6), suggesting that these elements are present as aluminosilicates, stable oxides, or phosphate mineral phases. Mean contents of Fe, As, Cd, Co, Cu, Mo, Ni, Pb, Sb, and Zn show high correlation with total sulfur. Contents of these elements are low in Paleocene (0.6% sulfur) and Cretaceous (0.7% sulfur) coals, higher in Eocene (1.8% sulfur) coals, and generally highest in Pennsylvanian (3.9% sulfur) coals. The mean contents of B, Be, Cr, F, Hg, Mn, Nb, Se, U and Zr show no direct relationships to changes in rank or ash and total sulfur contents. Decrease in element content with increased rank probably is related to loss of functional groups that act as cation-exchange sites on organic matter. Ash and sulfur contents are dependent on pH-controlled levels of bacterial activity in ancestral peat swamps.

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Porosity Evolution of Pennsylvanian Morrow Formation in Anadarko Basin, Oklahoma

The Anadarko basin is one of the most outstanding hydrocarbon producers in the North American continent. Examination of more than 50 cores from the Pennsylvanian Morrow sandstones reveals a complex diagenetic history. Although quartzarenite is the major lithology, shell fragments, glauconites, and clayey matrix occur in significant amounts throughout the section. This diagenetic complexity is a function of depositional environment, burial, and thermal history of the basin.

Porosity in the Morrowan sandstones throughout the Anadarko basin is chiefly secondary. Such porosity results from the dissolution of clayey matrix, carbonate fragments and cement, glauconite, and quartz grains and their overgrowth.

Evolution of secondary porosity is related directly to the generation of hydrocarbons. CO_2 gas, with concentrations ranging from 0.3 to 4.7% by volume, was detected in more than 150 natural gas wells examined in the basin. Based on geothermal and geopressure gradients, and on experimental investigations of the solubility potential of CO_2 in formation fluids under elevated temperatures and pressures, a good estimate of solubility of CO_2 in the Morrow Formation water may be attained. Because the concentration of CO_2 appears to increase with depth in the basin, secondary porosity should not be restricted to a particular zone or to particular depths, but definitely would persist with depth. Organic acids at shallow depths and H_2S in deeper zones may be important in enhancement of secondary porosity.

Amounts of porosity and the geometry of pore space are directly related to original lithology. A better understanding of lithofacies is critical in evaluating reservoir quality.

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Importance of People in Resource Assessment

Assessing the world's future undiscovered hydrocarbon resources is important and requires the thoughtful use of extensive data being assembled by large numbers of earth scientists. The soundness of the assessment depends to a significant degree on recognition of the makeup and strengths of the people involved, and how they can most properly reinforce each other in the handling of data available at any given time.

Five factors warrant particular consideration to assure maximum success. One, is the relative dependence placed on effective judgments of experienced workers, as compared to that placed on any predetermined geologic models or apparent implications of data sets. Second, is having effective contributors who can properly apply newly-accepted or evolving geologic principles affecting hydrocarbon occurrence. Third, is the degree to which contributors identify and use geologic analogs properly or improperly. Fourth, is how correctly assessors view the exploration maturity for basins being studied. Fifth, is the manner in which members of an assessment team communicate with each other regarding such elements as geologic concepts and models, adequacy and significance of data bases, statistical approaches, and constructive criticism—"communicating" involves both transmitting and receiving.

Continuing to advance our science is paramount for preparing future and better resource assessments. Concurrently, correctly identifying, educating, organizing, and supporting the right earth scientists for the assessment task is of equal importance.

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Lower Cretaceous Viking Barrier Island, Southwestern Alberta, Canada

A subsurface study of cores and electric well logs from the lower Cretaceous (Albian) Viking reservoir sandstone near Calgary, Alberta, reveals its deposition as a regressive barrier island along the shores of the *Haplophragmoides gigas* sea.

The barrier island trends northwest-southeast parallel to the paleostrandline for more than 120 km (75 mi) and attained a maximum thickness of more than 30 m (100 ft). Swales characterized by isopach thinning suggest that the island was probably breached by two tidal channels. Bentonite chronostratigraphy indicates that the barrier island prograded in a northeasterly and/or easterly direction for up to 24 km (15 mi). This seaward growth was briefly interrupted by an isostatic transgression. Thus, sandstone depositional pattern is of the imbricate type with younger units successively displaced seaward in the direction of progradation.

The barrier-island facies sequence comprises eleven intergradational facies, i.e., ebb-tidal delta, marginal (spillover) channel, middle shoreface, marine shales, upper shoreface beach, dune, back-barrier mud flat, marshy lagoon and overwash, mixed tidal flat, tidal creek channel, and overbank. This sequence differs slightly from that of the Recent classic regressive Galveston Island, Texas, and the ancient Muddy barrier island, Montana, in the presence of an ebb-tidal delta and marine shelf shales beneath and above the middle shoreface facies, respectively. On this basis the South Carolina Recent barrier islands are considered closer modern analogs.

The writer suggests that this sand body be explored further for oil and/or gas accumulations because of its excellent reservoir properties and the generally low well density.

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Lignite Occurrence in Relation to Depositional Facies, Eocene Wilcox Group, Sabine Uplift Area, East Texas—Regional and Local Comparative Studies

Lignite occurrence was related to sandbody geometry in two subsurface studies: a 12-county regional study and a local study of the Trawick gas field area, north-central Nacogdoches County. For both studies, the Wilcox Group was informally divided into lower progradational (deltaic) and upper aggradational (fluvial) units. The local study utilized closely spaced data to investigate a more detailed Wilcox stratigraphy.

The most continuous lignite-bearing zone lies at the transition between lower and upper Wilcox strata. Mapping of lignite occurrence in both studies shows this zone to be coincident with distributary channels indicative of delta-plain settings. Lignites and laterally equivalent muds rest on platforms of sandy sediments. Initiation of peat accumulation in interdistributary basins, with upward and subsequent lateral development as blanket peat, is inferred from the local study. Thickest and most laterally extensive seams occur in Shelby and Panola Counties on the flanks of major delta lobes.

Thick upper Wilcox lignites (> 5 ft, 1.5 m) occur regionally between major fluvial channel sand belts and cap 30 to 40-ft (9 to 12-m) upward-coarsening sequences (crevasse splays?). These lignites are surface-mined in Panola and Harrison Counties at Martin Lake and Darco. Westward, in northern Cherokee County, our drilling shows thick lignites (up to 11 ft, 3.4 m) have limited lateral extent in channel sand belt areas. Similarly, the local study lies within a major sand belt; small interchannel basins limit lateral continuity of lignites.

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Regional Distribution of Wave- and Fluvial-Dominated Deltaic Deposits of Olmos Formation (Upper Cretaceous) in Maverick Basin, Southwest Texas

Regional subsurface analysis in southwest Texas indicates that the Olmos Formation (Gulfian) was deposited by a complex of wave- and fluvial-dominated delta systems in two depocenters. Sediment influx was from the north and northwest. Five deltaic subunits, A through E, were deposited in the western depocenter. Three other deltaic wedges (F, G, H) formed the second depocenter farther east in present-day Frio and LaSalle Counties. Subsidence was greater in the western half of the Maverick basin where thickest (1,300 ft; 395 m) deltaic sediments were deposited. Lower Olmos strata represent a succession from wave-reworked, strike-elongate deltas of subunit A, similar to those of the underlying San Miguel Formation, to fluvial-dominated, dip-elongate deltas of subunits B and C. Extensive (1,200 mi^2 or 3,100 km^2 in Texas) aggradational floodplain deposits of B and C are characterized by diverse electric-log patterns; variation in log character is a response to complex depositional facies on the delta platform. Downdip, toward the Cretaceous shelf edge, delta-plain facies merge with upward-coarsening delta-front sandstones.

Uppermost subunits D and E were deposited by a prograding barrier-island system in an interdeltaic embayment marginal to high constructive deltas of the eastern depocenter. Lagoonal and fluvial-channel deposits are recognized from cores. Eastward migration of deposition was accompanied by an abrupt change of depositional style in the western depocenter from deltaic to coastal-interdeltaic.

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Relationships of Bexar Shale, Hensel Sandstone, and Hensel Dolomite (Basal Upper Trinity, Comanchean Cretaceous) in South-Central Texas

The Bexar Shale has been considered the offshore equivalent of the Cow Creek Limestone, the overlying Hensel sandstone, or of the disconformity between them in outcropping sections.

Cores and outcrops in Comal, Kendall, and northern Bexar Counties preserve calcitic and dolomitic caliche in the top of the Cow Creek Limestone. Above the caliche is 8-16 m (25-50 ft) of laminated or bioturbated, dolomitic siltstone and silty dolomite (Hensel dolomite). Dolomite is euhedral and silt-sized. The lower part contains collophane grains and oyster shells replaced partly by chalcedony. Carbonate grains within the upper part include angular and well-rounded mollusk and echinoid fragments; many are pyritic and coated by glauconite. Terrigenous grains in Hensel dolomite grade upward from silt to coarse subarkose sand from central Texas.

In southern Bexar County, about 35 m (115 ft) of silt-, clay-, and calcite-mudstone referable to the Bexar Shale sharply overlie shallow marine Cow Creek Limestone, and grade abruptly upward into about 7 m (23 ft) of Hensel dolomite. Dolomite is overlain by calcarenite of the Glen Rose Formation containing subarkose sand grains. Similar distinctive sand grains occur in well cuttings of basal Glen Rose beds northeastward through Travis County.

The Bexar represents a flood of clay-sized sediment from a distant source, spread across the San Marcos arch during a rapid transgression. Slightly younger sand, silt, and local clay of the Hensel sandstone were eroded from central Texas by a few flash floods during a major period of caliche formation in that area.

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Grain Size Vertical Progressions as an Exploration Tool

Previous studies of grain size as an indicator of sandstone depositional environments have had mixed results; for that reason, the method is sel-