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Structural Patterns in Western Canada Basin

A detailed structure contour map of the sub-Cretaceous unconformity within the Western Canada basin was analyzed by spatial filtering to display the sizes and trends of contained features for interpretation. Spatial filters are applied by computer to digital maps for the extraction and display of individual features free from the distracting presence of conflicting larger and smaller scale trends. The original maps were automatically posted using well information, well identification (X-Y location), and geologic correlations obtained from a computer file of drilling history on over 70,000 wells. This file contains information on wells in the sedimentary basin east of the structurally disturbed belt from Alberta to Manitoba.

The data were contoured manually then the contours were digitized for the computer analysis. Four nondirectional, band-pass filters were used to display structures ranging in width from 20 to 40 km (12 to 25 mi) and two directional filters to enhance structures with northeast-southwest and northwest-southeast trends.

The filtered maps indicate that the structures are controlled largely by the basement trends and are dominantly tectonic in origin with the frequency of structures increasing toward the disturbed belt. In addition to the tectonic structures, there are areas of Manitoba and Saskatchewan where solution of the Devonian salt formations produced prominent collapse features. The filtered structures suggest that Precambrian basement trends have controlled both the tectonic and erosional patterns of the sedimentary section and have subsequently influenced the migration and entrapment of petroleum and natural gas.

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Organic Geochemical Studies of Cretaceous Sediments, Jamaica—Their Petroleum Potential

Cretaceous sequences in Jamaica are best exposed in inliers which interrupt the monotonous Tertiary limestone cover that forms the surface geology over most of the island. Surface samples were collected over the major inliers of western, central, and eastern Jamaica. Conventional cores from shallow boreholes enabled sampling of subsurface formations. Cretaceous lithologies include gray to black mudstones and shales (only these were sampled for geochemical analyses) commonly associated with fine-grained sandstones and conglomerates dominated by andesitic clasts.

Total organic carbon values are variable but are generally in excess of 0.5%. Vitrinite reflectance (R_O) measurements for the western and central inliers average 0.80% and are well within the oil-generating zone. The Blue Mountain inlier of eastern Jamaica has R_O values above 1.0%, reflecting the heat flow associated with Cretaceous volcanism.

The organic matter preserved in these sediments consists predominantly of coaly to woody material; exinites are rare and fluorescence studies indicate traces of hydrocarbons and minor amounts of spores. Pyrolysis of selected samples suggests Type III kerogens with fair to poor production indices. Capillary gas chromatography of the saturate fractions of dichloromethane extracts reveals marginally mature to mature sediments with organic matter showing a dominant contribution from higher land plants. All samples analyzed have a low extract yield relative to their total organic carbon contents (<60 mg/g) indicating a low convertibility of the organic matter to liquid hydrocarbons.

Geochemical analyses of a number of Cretaceous samples to determine maturity and source-rock potential reveal a variable maturity with potential for gas generation (and possibly high-wax crudes) at depth.

ROGHANI, FOAD, and KHOSROW BADIOZAMANI, Morrison-Knudson Co., Boise, ID

Application of Geostatistics to Coal Exploration, Reserve Estimation, and Quality Studies

Application of traditional methods of ore-reserve estimations to coal-reserve evaluation, quality studies, and mine planning in many circumstances do not allow the accurate prediction of the quantity and quality of coal at different parts of a deposit. Conventional methods do not produce any information with regard to continuity of the variable of interest and range of influence of the samples to be used in drill spacing during development drilling.

Geostatistical methods of ore-reserve estimation, however, produce information about continuity of the variable of interest, range of influence of the drill holes, and the trend of deposition. A combination of information obtained from variogram(s), and geologic data can assist in determination of the appropriate drill-hole spacing. The estimation variance and geologic data can provide assistance in decision-making with regard to additional drilling required to improve reserve estimation and quality evaluation.

This method is especially helpful if specified sets of standards such as maximum level of sulfur and ash or minimum level of BTU contents need to be met.

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Late Paleozoic Regional Unconformities: Their Stratigraphic Significance and Correlation

Regional and interregional unconformities in late Paleozoic strata can be traced across the stable portions of cratonic shelves, the areas covered by former epicontinental seas, and onto some stable cratonic margins. These unconformities are overlain by a wide variety of transgressive sedimentary deposits. These include: (1) a sandstone-shale-limestone succession in predominantly clastic facies of Upper Mississippian and Pennsylvanian strata; (2) evaporite-brecciated limestone succession in some shallow carbonate shelves of middle Mississippian strata; (3) stacked shelf-edge carbonate buildups at basin and stable cratonic margins in Pennsylvanian and Lower Permian strata; and (4) Devonian and Lower Carboniferous "bone beds" and nodular and clastic beds at paraconformities. The stratigraphic interval between the base of the Middle Devonian to the top of the Permian in central to southwestern United States has a large number of these types of unconformities; perhaps as many as 19 in Middle and Upper Devonian beds, 12 or more in Mississippian beds, 15 or 16 in Pennsylvanian beds, and 9 to 10 in Permian beds.

Similar regional and interregional unconformities are widely recognized in continental shelf and slope sediments in Mesozoic and Cenozoic strata where they are interpreted as interruptions in sedimentation caused by fluctuations in relative sea level. Because regional unconformities of this type are physically traceable features and because sediments between them are essentially time-bracketed, these unconformities are valuable tools for correlation and regional depositional analysis.

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Petroleum Origin: Heavy Rains, River Plume, Ocean Stratification

A new model of anoxic facies and petroleum source-bed formation is based on the sapropel control deciphered in the eastern Mediterranean. During the Late Jurassic, the Cretaceous, and other warm periods, formation of black marine sediments occurred near emerged lands, in semi-enclosed deep basins (South Atlantic); shallow basins on carbonate platforms (Saudi Arabia); and the open Equatorial Pacific. The globally warm climates, even at high latitudes, were very rainy. The tropics had a monsoon and a dry season. The small hemispheric temperature gradient weakened the atmospheric circulation, particularly the Hadley cell. Very weak tradewinds annihilated most of the coastal upwelling. Ocean surface currents were sluggish and bottom waters were warm, saline, and hardly circulating. The land drainage resulted in the accumulation of large deltas (Niger, Barreirinhas), but the sediment yield of rivers varied widely, as they do today. The key event for marine stagnation was the spreading on the sea surface of the huge river plumes which accumulated a low-salinity surface layer undisturbed by the weak winds, a process very common today off the tropical river mouths. The strong vertical salinity gradient (2 to 4‰) stratified the upper ocean and interrupted the (thermo) haline convection, so that the bottom waters, isolated in the basins or hardly circulating in the open ocean, became stagnant and oxygen-depleted. Sediments can therefore become organic-rich source beds whatever their lithology. Ocean productivity in the plume was greatly enhanced when rivers drained volcanic areas or swamps.

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Evaporitic Environments and Their Relationship to Porosity of Associated Carbonates in Williston Basin (Mississippian)

Evaporite morphologies, indicative of specific environments of deposition, have been identified in late Cenozoic sediments, and are now recognized in the Williston basin (Mississippian, Little Knife field). The evaporitic environments which are represented include the supratidal (sabkha), the intertidal, and the shallow subaqueous. The development of the sabkha facies exerts a major control on porosity production in associated marine carbonates. Those evaporites forming subaqueously in related lagoons and other water bodies may occlude porosity within similar carbonate sediments. However, subaerial and subaqueous evaporites are now seen in the form of massive to nodular anhydrite and are usually classified together (in cores and well logs), but in fact they contain relic morphologies that permit more precise definition and separation of original facies. Subsequent porosity occlusion and/or creation may also be affected by later deformation of the regional structure and its effect on fluid migration. The recognition of the various evaporitic morphologies leads to a new understanding of porosity development in sediments of varied origins and may aid in distinguishing early from late phases of diagenesis.

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Diagenetic Sequence, Oil Migration, and Reservoir Quality in Peace River Oil Sands, Northwestern Alberta

Extensive deposits of heavy oil occur in updip pinch-out of the Bluesky and Gething Formations (Lower Cretaceous) of northwestern Alberta. In-situ extraction technologies require a detailed knowledge of porosity, permeability, and mineralogy within the reservoir and the effect of diagenesis on these properties.

Marine sands in the upper part of the Gething Formation are composed predominantly of quartz and chert with lesser amounts of clastic carbonate, rock fragments, and feldspar. Emplacement of heavy oil forming the Peace River oil sands effectively stopped or slowed diagenesis. Thin-section petrography and scanning electron microscopy provide the means of establishing a diagenetic sequence and of timing of oil migration. Three wells with abundant core have been chosen to illustrate the relations among diagenesis, hydrocarbon migration, and reservoir quality.

Authigenic minerals, in their probable order of emplacement, include pyrite, quartz overgrowths, feldspar overgrowths, kaolinite, and illite. Kaolinite and illite are most abundant in the water sands. An unusual secondary carbonate mineral, dawsonite, $NaAlCO_3(OH)_2$, occurs in only the richest oil sands but the timing of its deposition is in question. Secondary porosity was formed after feldspar overgrowths but before deposition of kaolinite. Oil migration took place after part of the kaolinite formed.

Diagenesis is an ongoing process and the various stages probably continued until migration of oil into the reservoir. Porosity is better in the good oil sands than in the water sands. Permeability is reduced by the heavy oil.

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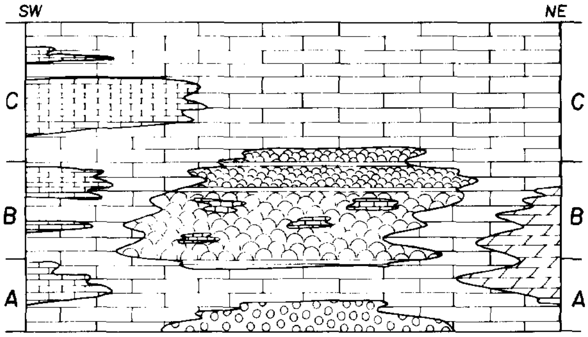
Sedimentation and Depositional Environments Between Mistaya and Survey Peak Formations, Western Alberta, Canada

A regressive-transgressive cycle is recognized within the Mistaya Formation (uppermost Cambrian) and the basal silty member of the Survey Peak Formation (Ordovician) in western Alberta. The regressive cycle consists of shallow-water peritidal carbonates which reflect a gradual shallowing of the carbonate-shoal complex, culminating in a subtidal to supratidal sequence. Lithofacies recognized within this basal sequence A are: (1) interbedded biosparite and millimeter-laminated biomicrite (open platform-subtidal shelf); and (2) interfingering oosparite, intraclastic biosparite, and biosparite (oolitic shoal complex). These lithofacies grade vertically into sequence B of: (1) laminated biosparite and biomicrite (open platform-subtidal shelf); (2) algal



biolithite composed of algal thrombolites, and columnar and polygonal stromatolites (bioherm complex); (3) cross-stratified biosparite and intrasparite (tidal channels); and (4) dolomitic intramicrite, laminated mat algae, and laminated and fenestral dolomite (supratidal flat). The distribution of lithofacies reflects a shallowing of the carbonate complex, culminating in the intertidal stromatolites and supratidal mat algae developing on top of the thrombolitic bioherm.