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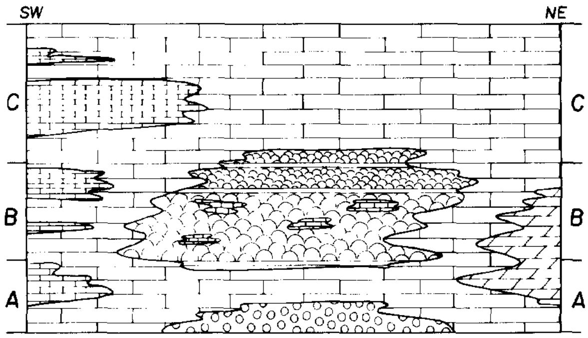
Sedimentation and Depositional Environments Between Mistaya and Survey Peak Formations, Western Alberta, Canada

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.