The calcareous Algae of the Middle Ordovician sequence of the St. Lawrence lowlands show a lateral and regional constancy which reflects the stability of the shelf at that time. In addition, the algal groups, when considered separately, suggest aptitudes to adapt themselves to various habitats and conditions.

Chazy rocks in the Lake Champlain area, New York, Trenton deposits outcropping in the Trenton region, New York, Black River section in its type section at Black River, New York, and the Simcoe Group in Lake Simcoe, Ontario, are studied and sampled for the examination of their algal contents.

Thirty-four taxa are identified in these various deposits. Petrographic evidences and the interpretation of the algal microfacies in the four regions studied reveal the presence of as many as 22 types of lithological units distinguishable on their algal content and their relation to specific paleoecological environments.

The abundance of Algae and algal components in the Middle Ordovician sequence, underlines the importance of their role in relation to sedimentation on the shelf in the regions studied. The diversity and the specificity of the Algae in the units and in the environments reflect a pattern of distribution which follows certain environmental controls similar to those prevailing in the modern seas.

The algal assemblages show responses to physical, biological, and chemical variations of the environments. These assemblages play in the sedimentation the same role assumed by recent Algae, production of carbonates, trapping and stabilization of the sediments, algal mats, formation of oncolites and algal encrustations, and edification of bindstones-framestones.

Although the Algae are not always useful as chronostratigraphic indices, they remain in the Ordovician successful paleoenvironmental indicators.

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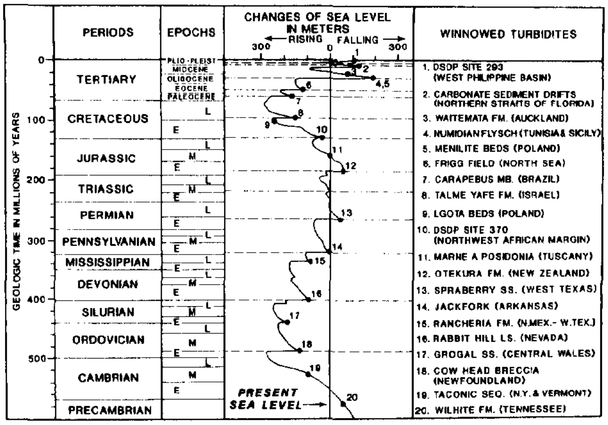
Eustatic Control of Deep-Sea Reservoir Facies

Global changes in sea level, primarily the results of tectonism and glaciation, control deep-sea sedimentation. During periods of low sea level the frequency of turbidity currents is greatly increased. Episodes of low sea level also cause vigorous bottom currents (i.e., contour currents) which winnow away the fine-grained material of turbidites. In the rock record, the occurrence of most



turbidites and winnowed turbidites closely corresponds to lowstands of paleo-sea level. For example, plotting of all known winnowed turbidites on the global sea level curve indicates that 19 of 20 examples fall on or near lowstands.

An important exploration attribute of these observations is the possibility of predicting the occurrence of potential deep-sea reservoir facies in the geologic record by using seismic data in conjunction with information on global sea-level changes, basin geometry, and paleo-oceanography.

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Geology of Gulf Canada's Pelican Oil Sands Pilot Project, Alberta, Canada

Gulf Canada Resources Inc. is operating an experimental oil sands pilot project (Pelican Lake Project) in the Wabasca deposit in northeastern Alberta intended to recover bitumen by steam stimulation followed by combustion. The geology of the pilot site is actively being studied through an extensive logging and coring program aimed at defining the detailed vertical and lateral variability of the Wabiskaw A sand reservoir, particularly with a view to defining such parameters as porosity, permeability, oil saturation, and isopach, net pay, and structure.

The Wabiskaw A sand at the pilot site is a thin (averaging about 5 m), glauconitic, coarsening-upward sheet sand interpreted as part of an offshore (shelf) bar system. The major part of the sand body at the pilot site consists of a northeast-southwest-trending bar. This grades into an interbar facies at the southeast corner where the sand thickness and net pay decrease and the clay content of the reservoir increases.

Structures due to burrowing (predominantly *Asterosoma*) are common throughout the Wabiskaw A, giving the sand a dirty appearance. However, bioturbation did not completely homogenize the sand and mud, and much of the clay fraction remains as pods. Thus, the effective porosity and permeability of most of the reservoir remain high (average 28% and 800 md, respectively). These characteristics, combined with a relatively low-viscosity oil in place, make the Wabiskaw A sand an attractive target for an enhanced-recovery tar sands pilot project.

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Non-Oolitic, High-Energy Carbonate Sand Accumulation: the Quicksands, Southwest Florida Keys

Approximately 162 km of high-resolution subbottom seismic reflection profiles, collected in the Quicksands area west of the Marquesas Keys off south Florida, indicate extensive westward transport of *Halimeda* sand. The east-west-oriented, carbonate-sand accumulation is up to 12 m thick and encompasses an area 13 by 29 km. The Quicksands area is ornamented by east-west-trending submarine sand dunes 2 to 3 m high, which are shaped by strong, reversing north-south tidal currents. Many dunes break the surface at low tide. Submarine dunes lie directly on Pleistocene bedrock at the eastern end of the study area, but at the western end, dunes lie on 7 to 10 m of Holocene carbonate sand. Near the western terminus, the sands have accreted over carbonate muds.

Westward drift, probably caused by prevailing east and southeast winds superimposed on the tidal currents, is indicated by (1) thickening of the Holocene accumulation to the west and (2) large-scale, westward-dipping, accretionary bedding. Seismic reflection profiles show spitlike accretionary bedding in a package up to 1 km long at the western end, where carbonate sands spill onto deeper water muddy carbonates.

The submarine sand body is surrounded on the south, west, and north by equivalent-age, topographically lower lime muds and silts up to 7 m thick. The configuration and pattern of deposition suggest that this area could be used as a petroleum exploration model. The model consists basically of a reservoir-size porous carbonate-sand ridge surrounded downdip by organic-rich carbonate muds, which could serve as source beds. Reversing tidal currents and bed forms are identical to those of oolitic areas in the Bahamas, however, the Quicksands area does not contain ooids.

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Fractured Devonian Shale Reservoir, Appalachian Basin

Detailed structural analysis along the west flank of the Appalachian basin in Kentucky and West Virginia demonstrates the importance of detached and basement deformation in developing fracture permeability within Devonian shales. A porous fracture facies of regional extent within the organic-rich lower Huron Member of the Devonian shale partially relates to unique physical properties of the organic sediments, but an important factor for widespread gas production is fractures caused by differential shortening of sediments above a detachment surface in the lower Huron Member. Mineralized, uniquely oriented, and slickensided fractures, and increased fracture intensity within the organic lower Huron shales perpendicular to Alleghanian stress support this interpretation. The porous fracture facies is most permeable (commercial) beyond the region of major tectonic transport where permeability is only local in extent. Linear trends of abnormally high final open flows in the producing area relate to trends of intensely fractured organic shale. These fracture zones seemingly reflect unique, complex, and perhaps more intense shear stress within organic shale found in flexures above basement faults. Gas migrated updip along open fractures placing the best wells slightly updip along the fracture trend or on the flank of adjacent low-relief flexures. This unique reservoir forms its own source and seal, and the lithologically restricted fracture facies imparts the permeability. Tailoring completion techniques which limit the vertical extent of induced fractures and which enhance recovery in the more common orthogonally fractured shale of the mid-continent region will be important for future development of this huge resource.

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Mechanism for Framework Grain Dissolution (Secondary Porosity in Sandstones)

We propose that organic and clay maturation in concert are responsible for much framework grain dissolution (secondary porosity). Petrographic observations indicate a pulse of porosity formation near the top of the oil-generation window and that there is often not enough authigenic clay to account for the aluminum removed from the dissolved grains. Geochemical considerations indicate that H+ ions are required for aluminosilicate dissolution and that the aluminum must be complexed to concentrations greater than 100 ppm in order to transport aluminum out of the sandstone using water volumes available in most basins. The smectite to illite conversion, which is coincident with early organic maturation, produces additional pore water and can desorb organic molecules from the smectite interlayers. The early stages of organic-matter maturation generates H+ (as carbon dioxide), volume-change pressures to move fluids, and water-soluble organic matter. The soluble organic matter can contain ligand compounds (e.g., short-chain fatty acids) which complex aluminum. The organic ligands in the shale complex aluminum at relatively low concentrations because aqueous aluminum activity is depressed by the formation of illite from smectite. The H+ and organic ligand-bearing solution is expelled into sandstones where the aluminum activity is buffered at higher levels by feldspar, thus allowing higher levels of complexed aluminum. The solution dissolves the feldspars and other aluminosilicate components and complexes much of the resulting aluminum for transport out of the sandstone.

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Evolution of Floating Drilling Systems

Offshore exploration over the past 30 years has progressed from mud flats to almost 5,000 ft (1,500 m) of water. Exploratory systems for obtaining geologic information have progressed from scuba divers and small ships outfitted for grabbing rock and soil samples from the ocean floor to drill ships over 600 ft (180 m) long capable of maintaining station without anchors. Specialized subsea equipment has been developed from elementary drilling bases with wire rope guidelines to blowout preventer systems weighing over 400,000 lb (181,000 kg) and standing 40 ft (12 m) high which utilize acoustic and television reentry methods. Motion compensation systems are now available which make drilling from a floating vessel as similar to land drilling as is possible from a continuously moving platform. Engineers and the supplier industry continue to develop drilling systems to meet ever-changing environmental conditions.

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Gravity Interpretation of Northern Overthrust Belt, Idaho and Wyoming

A gravity interpretation of the northern Overthrust belt of eastern Idaho and western Wyoming was made to determine the structural configuration of the Precambrian basement and overlying sedimentary veneer. Two east-west gravity models of geologic cross sections were constructed along lat. 42°30′N and 43°N and one north-south section was constructed along long. 110°30′W. Two-dimensional analysis of the models reveals the presence of two basement highs—one beneath the leading edge of the Prospect fault and one beneath the Absaroka plate. Limited data also suggest another basement uplift may be present beneath the Meade thrust.

The location of the easternmost basement high suggests that it may have formed prior to the completion of thrusting and acted as a buttress to movement along the Prospect, causing the thrust to climb toward the surface. The uplift beneath the Absaroka was probably formed after thrusting, and lifted the overlying Absaroka plate toward the surface, as is evidenced by the exposure of Cambrian, Ordovician, and Devonian sole rocks within the Salt River Range. The uplifts appear to have influenced the subsurface structural geometries of the overlying sedimentary rocks, but not the depositional thicknesses of the Triassic, Jurassic, and Lower Cretaceous units. It may therefore be concluded that the uplifts of the Precambrian basement were formed after the deposition of the overlying sedimentary rocks.

Gravity modeling has also indicated the presence of high-density masses within the Precambrian basement, both beneath the Green River basin at lat. 43°N, and along lat. 42°45′N.

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