Omoa of northwest Honduras, Central America. This model and the similarities between the facies herein described and braided alluvial deposits formed in other humid settings (proglacial) suggest that the deposits of ancient humid alluvial fans may be readily distinguished from those of arid fans.

Humid fans differ from arid fans with respect to slope, gravel roundness, downfan changes in roundness, the patterns of imbrication and long axis orientation, and the abundance of debris flow deposits. Humid fans display a gentle, smoothly sloping concave-upward longitudinal profile, whereas arid fans are steeper and typically consist of segmented straight sections, producing a profile which is concave upward overall. Deposits consist largely of subangular to subrounded gravels and there is typically little change in gravel roundness downfan. Unlike arid fans, angular clasts are rare in humid fans. Imbrication and long-axis orientation transverse to flow are each well developed and, although each may be present on arid fans, their development in a humid setting is more striking. The principal difference, however, is the complete lack, among proximal sediments, of evidence for debris-flow deposition.

Proximal-fan deposits of humid fans are very poorly sorted, clast supported, and have a matrix of granular sand. Deposits generally have a crude horizontal stratification. Distally, there are transitions from clast-supported fine gravel, through sand matrix-supported gravel, to granular sands. In distal-fan areas, horizontal laminations are the dominant sedimentary structure, although high- and low-angle planar cross-stratification and trough cross-bedding may also be present.

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Upper Permian Evaporites of Dolomite Mountains, Northern Italy

The Bellerophon Formation (Upper Permian) of the Dolomite Mountains in Italy is composed of evaporite and carbonate facies. The former are both supratidal (sabkha) and shallow subaqueous in origin. The latter consists of limestone, evaporitic dolomites, and dolomitic arenites. The rocks are underlain by continental clastics of fluvial and overbank facies and are overlain by a predominantly open-marine, shallow-water carbonate sequence. The facies reflect climatic variation, sea-level fluctuation, and changing sedimentologic conditions.

This area has undergone postdepositional tectonic deformation. The deformation is, in part, recorded in a variety of structures in the Bellerophon Formation. Tectonic stylolites, as a response to stress, are widespread in the carbonate facies. In the evaporite facies, deformational fabrics are more varied. Flow structures and mylonitic textures clearly reflect bedding-parallel shear, whereas in the layered dolomite-evaporite parts of the sequence folding is a more common response to tectonic deformation.

Recognition of the extent and nature of these varied structures provides a greater understanding of the geologic history of this and adjacent regions. The deformation seen in the evaporites may provide clues to an understanding of fluid migration in other tectonically stressed areas in which evaporites are found.

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A Stable Isotope Study of Carbonate Cements in Sligo Formation

The Sligo Formation in Texas is an Early Cretaceous subsurface carbonate sequence representing the upper part of a transgressive cycle. The Sligo carbonates attain a maximum thickness of 305 m at the ancestral shelf edge where the sequence consists of rudistid boundstones and grainstones at depths of 4,570 m.

Porosity and permeability within the Sligo are controlled by the abundance of radiaxial fibrous calcite cement and/or coarse equant-calcite-spar cement. Other cements recognizable in thin section are meniscus calcite and clear euhedral dolomite. The equant calcite spar has an average of $\delta^{18}O$ relative to PDB of -1.92 and $\delta^{13}C$ of 2.80. The radiaxial fibrous calcite has average $\delta^{18}O$ of -1.77 and $\delta^{13}C$ of 1.61. The average whole-rock values are $\delta^{18}O$ of -1.52 and $\delta^{13}C$ of 2.61. The similarity between these values suggests isotopic homogenization due to diagenesis; however, the equant-calcite spar has a range in $\delta^{18}O$ of -4.98 to 0.29 indicating deposition by meteoric waters. The radiaxial fibrous-calcite cement has a narrow range in $\delta^{18}O$ of -2.10 to -1.70 consistent with an origin as an early marine replacement cement.

Intriguing correlations exist between modal abundances of cement types and their $\delta^{18}O$ and $\delta^{13}C$ values. These data provide important constraints for models predicting porosity and permeability evolution during carbonate diagenesis and have important implications for hydrocarbon exploration strategies.

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Tidal Deposition of Cypress, Ridenhower, and Bethel Sandstones (Chesterian, Late Mississippian), La Salle Anticlinal Belt, Lawrence and Crawford Counties, Illinois

Sandstones in the Chesterian (Late Mississippian), including those in the Cypress, Ridenhower, and Bethel, are major oil producers in the Illinois basin. Significant oil reservoirs occur as structurally influenced stratigraphic traps along the northwest-trending La Salle anticlinal belt of Lawrence and Crawford Counties, Illinois. Analyses of electric logs, sand thickness maps, and sedimentary structures show that these sandstones were deposited in tide-dominated deltaic, tidal-flat, and subtidal environments.

Coarsening upward, tide-dominated deltaic sequences inferred from spontaneous potential (SP) log signatures are composed of prodelta shales, delta-front shales and silts, and distributary-mouth bar sands.

Tidal-flat sand bodies are indicated by SP log signatures with blunt bases and tops. Cores from these 20 to 70-ft (6 to 21 m) thick, laterally discontinuous units contain: (1) fine to medium-grained, rippled sandstone with infrequent rippled shale laminations, (2) lenticular bedding with little bioturbation, (3) flaser bedding, (4) bioturbated sandstone and shale that were apparently horizontally bedded, (5) plant fragments in shale, and (6) channel lag consisting of deformed shale clasts and rounded carbonate mud pebbles.

Off the flanks of the anticlinal belt, the Cypress, Ridenhower, and Bethel coalesce into single massive sand units up to 200 ft (61 m) thick, distinguished by blocky SP log signatures with abrupt bases and tops. Sand thickness maps showing these units as long linear bodies aligned parallel with major anticlinal axes suggest that they are subtidal sand ridges.

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Role of Algal Assemblages in Middle Ordovician Deposits in St. Lawrence Lowlands

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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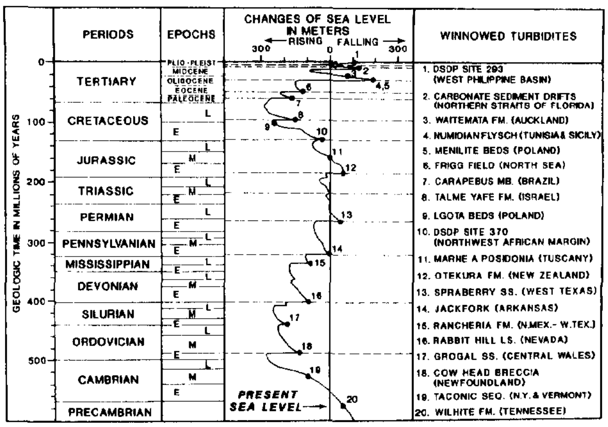
Eustatic Control of Deep-Sea Reservoir Facies

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