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Tidal-Inlet Fills as Hydrocarbon Reservoirs: Example from Halfway Formation, Alberta

When placed within the context of their depositional setting and compared to modern analogs, the proven hydrocarbon reservoirs of the Middle Triassic Halfway Formation provide models for future exploration of similar sequences in the stratigraphic record. The Halfway sandstones accumulated along the northeastern margin of the Triassic seaway. Barrier-strandplain deposits amassed along a depositional embayment in western Alberta downdrift of an area of sediment influx into the basin in eastern British Columbia.

Along the Halfway coastline, porous deposits accumulated either in the wave-reworked upper shoreface-foreshore zone of barrier islands or in tidal-inlet areas. The barrier-island reservoir sandstones are thin (less than 5 m) and elongate with depositional strike, whereas the tidal-inlet deposits are thick (up to 20 m) with abundant shell-hash lag conglomerates and elongate with depositional dip. Similar to modern coastal configurations, the frequency and thickness of tidal-inlet sequences increase toward the center of the depositional embayment because of tidal amplification. There, more conduits through the barriers were necessary to exchange the larger volumes of water during a tidal cycle.

Most of the significant Halfway hydrocarbon reservoirs have been inlet-fill sequences. An excellent example is the Wembley field. Positioned near the center of the Halfway depositional embayment, this field contains 37.5 million bbl of oil. A majority of the reserves are found in inlet deposits. Porosities and permeabilities have been significantly enhanced by secondary solution of the shell lags. Other Halfway inlet reservoirs exist along depositional strike. They are most abundant near the axis of the embayed shorelines where tides were amplified. Future hydrocarbon exploration along other embayed coasts should emphasize the locations and abundance of inlet-fill deposits.

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Fan-Delta Hydrocarbon Reservoirs: Example from Utikuma-Nipisi Fields, Alberta

Because large amounts of hydrocarbons have been found in reservoirs of deltaic origin, deltas have been extensively studied in both the modern and rock record. Internal morphologies and geometries of reservoir-potential deposits within most types of deltas are today reasonably well understood. Fan deltas and the geometries of their sandstone reservoir bodies are exceptions.

To provide a better understanding of fan-delta reservoirs, 700 wells and 365 cores from the Utikuma-Nipisi fields of north-central Alberta were studied in detail. The Utikuma-Nipisi fields, which contain 751.4 million bbl of oil reserves in fan deltas, produce from structural-stratigraphic traps in Middle Devonian Gilwood sandstones of the Watt Mountain Formation. These sediments are part of the clastic apron that surrounded the Peace River arch, a positive granitic terrane that had relief of more than 2,300 ft during Middle Devonian time.

In the Utikuma-Nipisi area, arkosic sediments were transported from the Peace River arch by ephemeral braided streams and deposited as a fan delta at the margin of the Elk Point Sea. In upper reaches of the delta, porosities and permeabilities in the coarse alluvial fan–braided stream portions have been occluded by fine-grained sieve deposits. Seaward of the delta front, prodelta sediments act as fine-grained permeability barriers. Only in the delta front have significant reservoir-potential porous deposits accumulated. These primary intergranular porosities and permeabilities are attributable to sorting and reworking by fluvial processes as well as wave and tidal energies in the depositional basin. Discontinuities in these delta-front reservoirs were the result of delta-lobe switches.

Results of this analysis suggest hydrocarbon exploration in fan deltas should target delta-front depositional settings.

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Effects of Abnormal Flooding Events on Microbial Mat Communities and Aragonitic Stromatolites, Laguna Mormona, Baja California, Mexico

Laguna Mormona (Baja California, Mexico) is a coastal sabkha that contains a variety of microbial (cyanophycean and bacterial) mat communities. Studies conducted during 1971-76 concentrated on the microstructure, macrostructure, and degradation of these microbial mats and aragonitic stromatolites and the information they provide that is relevant to the interpretation of Proterozoic stromatolites, silicified microbial mats, and their contained microfossils. Abnormally high rainfall in 1979-80 flooded the sabkha to depths exceeding 1 m and profoundly affected these microbial communities by lowering the salinity of the water and depositing 5-10 cm of very fine grained, organic-rich mud over most of the microbial mats. The water level has returned to normal, and diatoms, cyanophytes, and bacteria locally form millimeter-thick mats upon this mud in areas that previously contained well-developed mats; however, it is unclear whether these mats will eventually attain the thickness (up to 30 cm) of their predecessors.

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Effectiveness of Offshore Three-Dimensional Seismic Surveys: Case Histories

Gulf began to investigate 3-D seismic in the mid-1960s. During the late 1960s, modeling was used to simulate acquisition and processing. By the early 1970s, Gulf had completed its first offshore 3-D seismic project.

Some of the advantages 3-D seismic has over 2-D are the following. It can help with the refinement of structure and stratigraphic interpretation; it helps define paleogeology; it can reveal details that otherwise are not apparent; it can help define reservoir limits through improved interpretation of structure and hydrocarbon indicators; it is a means of obtaining subsurface control under surface obstructions, such as platforms, rigs, etc; it provides the opportunity to construct profiles in any direction desired; and it lends itself to interactive interpretation.

Most certainly, 3-D seismic should improve resolution. This, in turn, helps define the best location possible for both wildcat and development wells. Developing additional reserves with outpost wells and finding new reserves in untested fault blocks are also benefits of improved and detailed seismic control. Using 3-D provides a basis for making the development drilling program efficient (i.e., only drilling the wells needed to drain the reservoirs efficiently). For these reasons, the use of 3-D seismic can be a cost-effective way of finding and developing hydrocarbons.

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Seabed Features Caused by Shallow Gas in North Sea

Seepage of shallow gas, mainly methane, recently has been documented visually in the central section of the North Sea at water depths of about 70-80 m. The surface expressions caused by these seeps are not dramatic. They mainly consist of small funnel-shaped craters (20 cm across) in the cover sand. However, in deeper parts of the North Sea, where the cover sediments consist of silt and clay, the surface features are more dramatic. Here the craters (pockmarks) caused by shallow gas eruptions or seepages are up to 20 m deep and 100 m wide. In some areas, the pockmarks are paved with a crust of calcium carbonate cement, which is believed to have formed as a result of gas efflux through the seabed. Furthermore, the presence of these calcium carbonate reefs seems to have attracted a wide variety of marine life. The presence of shallow gas has caused an enrichment of marine life that seems to be significant.

Beside the semicircular and composite pockmarks, gas-induced erosion also has caused elongate depressions. These occur where the top sediment bedding has caused the gas to migrate along certain axes. The mode and speed of formation of the gas-induced erosion features are of major concern to oil exploration and development in the northern North Sea.

Research into these aspects recently has been stimulated by the discovery of one of the world's largest offshore gas reservoirs, which coincidentally lies within a pockmarked area.