

rived from the lake itself. The total amount of organic carbon in the surface sediments increases with distance from the river mouth and is accompanied by a decrease in mineral grain size as expected. However, within a single sediment sample, organic carbon content is not a strong function of grain size over the range from 5 to 11 ϕ . Visual examination of the separated insoluble organic matter showed that structured, wood-derived organic matter predominates in the coarser fractions ($>62\mu$) but the finer fractions ($<62\mu$) contain mainly microorganisms and amorphous material. Pyrolysis experiments gave a ratio of (total response/organic carbon content) that increased from low values in the coarse fractions to higher values in the fine ones—a trend consistent with the visual kerogen observations because high ratios are usually produced by amorphous organic matter. However, infrared spectra of the organic matter from coarse and fine sediments closely resemble that generally observed for the humic substances associated with soils, suggesting that even the finer grained, amorphous organic matter is derived largely from the terrestrial organic matter. X-ray diffraction indicated the presence of quartz, feldspars, calcite, dolomite, mica, kaolinite, illite, and montmorillonite in the sediments. The composition was rather uniform with no major variations due to clay size or areal distribution.

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Controls on Pennsylvanian Hydrocarbon Accumulations in Mid-Continent

Approximately 8.8 billion bbl of oil and about 31.5 Tcf of gas have been found in Pennsylvanian reservoirs in the Mid-Continent as of January 1, 1978. Although these volumes of hydrocarbons were trapped in thousands of fields throughout the region, most of these resources were emplaced in a relatively few fields: about 6.4 billion bbl of oil has been found in 90 significant and giant oil fields, and 18.5 Tcf of gas has been discovered in 50 significant and giant gas fields. Our calculations of the total oil and gas accumulations in Pennsylvanian reservoirs were extrapolated from these data.

Most oil and gas accumulations of Pennsylvanian age in the Mid-Continent were stratigraphically trapped in lenticular sandstone bodies; the environments in which most of the clastics were deposited range from fluvial to deltaic to shallow marine. Even though this region is now in a late mature stage of exploration and development, important stratigraphic accumulations of oil and gas remain to be found. These fields will be discovered through detailed subsurface analysis, the reconstruction of depositional environments, and the application of high-resolution seismic data to stratigraphic problems.

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Upper Morrow Fan-Delta Deposits of Anadarko Basin

The Pennsylvanian upper Morrow fan delta chert conglomerates are located in the Texas Panhandle and Oklahoma parts of the Anadarko basin. The source area for these chert conglomerates was the Amarillo-Wichita

Mountain complex where erosion of cherty limestones and dolomites of Mississippian age occurred. The presence of these chert conglomerates in the upper Morrow sequence precisely defines a time of uplift and erosion of the highlands not previously recorded and therefore provides a new time-stratigraphic marker for the Morrow. Unusually high porosity and permeability in the chert conglomerates at depths greater than 15,000 ft (4,572 m) in a reservoir which may contain a billion cubic feet of gas per net foot of porosity are adequate incentives and justification for deeper drilling in the basins. Successful efforts in the search for these stratigraphic traps have resulted at Shreikay, Buffalo Wallow, Viking, Cheyenne, Elk City, and other fields.

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Stimulation Design for Upper Morrow Reservoirs in Reydon-Cheyenne Area, Western Oklahoma

Recent deep, high-pressure upper Morrow reservoir completions in the western Oklahoma part of the Anadarko basin indicate the area to be a major natural gas producing area. These Morrow sandstone reservoirs consist of poorly sorted medium to coarse-grained feldspar-rich sandstones to chert-pebble conglomerates. Diagenetic minerals present include calcite, siderite, and quartz overgrowths. Clay minerals present include small to moderate amounts of iron-rich chlorite, mixed-layer clays, and illite. Generally, the diagenetic minerals and the clays tend to fill the intergrain pore space. Reservoir porosity ranges from 6 to 12%, and effective reservoir permeabilities range from 0.1 to 10 md.

Wells are generally drilled to total depth, logged, and a 5-in. (12.7 cm) OD liner is cemented back to the intermediate casing. Once perforated and cleaned up, the well is allowed to flow and a pressure buildup test is performed. Buildup-test analysis commonly indicates that a fracture-stimulation treatment may be needed to obtain satisfactory production rates. With bottom-hole temperatures in excess of 260°F (127°C), potassium chloride treated water in a cross-linked gel system is being used as the treatment fluid. Use of high-strength proppant instead of sand appears to help provide sustained production increases after fracturing.

Treatment designs must consider the following parameters: depth, bottom-hole temperature, reservoir pressure, and bottom-hole treating pressure, as well as surface-pressure limitations, tubing size, job volume, and type of proppant system used with respect to closure stresses expected.

Following the stimulation treatment and fluid cleanup, another pressure-buildup test is performed to evaluate the treatment. Field results indicate that stimulation treatments have been successful.

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Deltaic Deposits in Upper Morrow Formation of Anadarko Basin

Environmental facies analysis of Pennsylvanian upper Morrow deposits of the Anadarko basin show a variety of deltaic facies. The important reservoir deposits