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RECIPROCAL DEPOSITION WITHIN NIAGARAN AND EARLY CAYUGAN (SILURIAN) CARBONATES AND EVAPORITES, NORTHERN MICHIGAN BASIN

Time-stratigraphic relations within Silurian strata of the northern Michigan basin provide a model for reciprocal deposition of carbonates and evaporites. The Niagaran of the basin interior consists of crinoidal hematitic biomicrites. Toward the basin margin the biomicrites thicken and lose their hematitic character. A belt of pinnacle reefs marks the approach to the basin margin. The Niagaran pinnacle reefs have a lower crinoidal zone and an upper coral-algal zone. At the basin margin the Niagaran thickens abruptly into a dolomitized barrier reef complex. The barrier reefs were constructed mainly by corals and massive stromatoporoids which prograded basinward over thick skeletal forereef calcarenites.

Niagaran barrier and pinnacle reef construction was halted in the early Cayugan by an episode of evaporite deposition. Karst features within Niagaran carbonates suggest subaerial exposure of the barrier and pinnacle reefs at this time during a period of lowered sea level. Return of high sea level caused cessation of evaporite deposition and rejuvenation of the pinnacle reefs; also, fringing reefs developed along the margin of the former barrier reef trend. However, the renewed reef development was of a considerably different biotic character. These early Cayugan reefs possess a lower massive encrusting algal zone and an upper laminar stromatoporoid-stromatolite zone. Corals are notably absent. Reef development again was halted by evaporite deposition followed by another episode of carbonate deposition generally devoid of reef rejuvenation.

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HYDROCARBON ACCUMULATIONS IN FOLDED APPALACHIANS OF SOUTH

In the Folded Appalachians of the south most of the petroleum interest and all of the oil and gas production have been within or close to a unique structural feature, the Cumberland overthrust block. This large mass includes parts of Virginia, Kentucky, and Tennessee. Displacement of the block toward the northwest is about 11 mi along its southwest edge in Tennessee and about 4 mi along its northeast edge in Virginia. Rocks of all systems from Cambrian to Pennsylvanian are involved, totaling approximately 20,000 ft in thickness. Oil has been produced from rocks of Ordovician age and gas from rocks of Devonian and Mississippian ages. Other targets exist.

Two reasons are adduced to account for the fact that hydrocarbon accumulations persist in rocks subjected to such extensive displacement. First, gravity sliding rather than tectonic lateral stress seems best to explain the structural relations from surface to basement. Thus, the "overthrust" rocks were under little if any more compressional stress during faulting than before it, and they have not been compacted, recrystallized, or cemented to an extent precluding effective porosity. Second, the Pine Mountain fault, which underlies the block, is a bedding plane fault throughout most of its extent, but locally it ramps upward from one weak zone to another. Four weak zones that favored localization of the fault plane are known. Only at, and northwest of, the ramps are older rocks piled on younger, resulting in abrupt thickening of the sedimentary section.

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STRATIGRAPHY AND PETROGRAPHY OF UPPER SILURIAN WILLIAMSPORT SANDSTONE, WEST VIRGINIA

The Upper Silurian Williamsport Sandstone at the type section in Grant County, West Virginia, is typically composed of very fine-grained green and brown sandstone with some siltstone and shale. A local carbonate member, the Cedar Cliff Limestone Member, is present in the middle of the formation in nearby outcrops in western Maryland. On the north in Pennsylvania, the Williamsport can be traced into the Moyer Ridge Sandstone Member of the Bloomsburg Formation. Eastward, in the eastern panhandle of West Virginia and Maryland, the Williamsport pinches out in the middle of the nonmarine red Bloomsburg facies. Farther south the Williamsport undergoes a facies change into clean well-sorted mature sandstone. The subsurface continuation of this sandstone extends to the Ohio border, where it has been found to be an important reservoir for natural gas.

Sandstones of the Williamsport in the subsurface are very fine to fine grained, subrounded to rounded, well sorted, and texturally mature and supermature. In general, sandstone is most abundant in the upper half of the unit, whereas carbonates become interbedded with sandstone layers in the lower half. Syntaxial quartz overgrowths serve as the primary cement in the upper part of the formation, but dolomite becomes important lower in the section. Gypsum, anhydrite, and barite are minor cements. Intergranular porosity is greatest near the top of the formation.

The immature sandstones and siltstones of the Williamsport in northeastern West Virginia probably were deposited on low-energy mud flats in front of the Bloomsburg delta. Sediments were supplied by rivers from source lands farther east in Pennsylvania. The limestones and hematitic beds of the Cedar Cliff Member are interpreted as having been deposited in a lagoon associated with this tidal flat. Farther south, the cleaner, coarser, more mature sandstones were deposited in a barrier island-coastal complex. Regression of the shoreline spread a blanket of sand over the underlying subtidal to intertidal McKenzie Formation. As the shoreline and barrier island complex regressed westward the lagoonal sediments of the Wills Creek Formation were superposed on the clean sand of the Williamsport.

Gas accumulation in the Williamsport is due to a combination of stratigraphic and structural trapping. Salt water is present downdip in all fields, and updip porosity and permeability decrease where the sandstone thins westward. Gas flows in this formation are the greatest recorded in the Appalachian basin, making the Williamsport the most important deep target for drillers in West Virginia. Future exploration should examine the possibility that combination stratigraphic and structural traps exist near the eastern edge of the sand body in central West Virginia and near the southwestern sandstone pinchout in south-central West Virginia.

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SUBSURFACE DATA BEARING ON TECTONIC STYLE OF VALLEY AND RIDGE PROVINCE

Selected seismic lines and well data in the Valley and Ridge province between the Anthracite region, Pennsylvania, and the Pine Mountain region, Virginia-Kentucky, support the hypothesis that the region is characterized by a thin-skinned style of deformation.

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POTENTIAL IMPACT OF OIL DEVELOPMENT ON ECOLOGY AND ENVIRONMENT OF MIDDLE ATLANTIC OFFSHORE AREA

Oil drilling and exploitation have made a calculable impact on the environment in the mid-Atlantic offshore area. Oil pollution is related to the overall polution problem, but there are possibly other direct consequences of oil drilling and exploitation. From actual known oil pollution occurrences, both natural