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Recent Salina and Trenton Discoveries Reflect Trend Toward Deeper Formational Drilling in Michigan Basin

Good producers, large lost circulation zones, blowouts, and high proration have focused the attention of the petroleum industry on southern Michigan. The Trenton-Black River formation play in this area and the basal Salina-Niagaran plays in eastern and western Michigan have rejuvenated a declining oil industry in Michigan.

Structurally, Michigan can be defined as a part of an intracratonic basin, flanked on the east and southeast by the Cincinnati arch, on the south and southwest by the Kankakee arch, on the west by the Wisconsin arch and peninsula and on the north and northeast by the Canadian shield.

Previous to the present activity, all the oil production of any consequence had been associated with sediments of Devonian age. However, the present developments have been mainly in Silurian and Ordovician sediments. This activity has been more or less confined to the flanks of the structural basin where the older formations are at a relatively shallow depth.

In eastern Michigan, St. Clair County, the Silurian production is from reef-type build-ups which occurred during late Niagaran deposition. Production has also been obtained from the overlying basal carbonates of the Salina group.

In Western Michigan, Allegan, and Ottawa counties, the producing units are the basal carbonates of the Salina group, namely, in descending order, the A-2 dolomite and the A-1 dolomite. Unlike eastern Michigan, this production is associated with regional structures which appear to have been affected by the lowermost evaporite unit of the Salina group, the A-1 salt.

The present Trenton-Black River development of Middle Ordovician carbonates is located in south-central Michigan on the southern flank of the Michigan basin. Production has been from a secondary dolomite confined to a fracture zone. Structurally, the fracture zone is directly associated with a shallow narrow depression which plunges in a north-northwesterly direction about 50 feet per mile. Approximately 25 linear miles has been partially proven productive with efforts being made to extend the trend and also to prove the inside acreage.

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Geology and Petroleum Possibilities of Quebec

Six regions in the Province of Quebec are geologically favorable for exploration of oil and gas. Very little is known about one of them, the 1,500-square-mile area of flat Devonian (?) rocks just south of James Bay.

The St. Lawrence Lowlands region, about 10,000 square miles in extent, has gently folded Cambrian and Ordovician formations attaining a total thickness of nearly 10,000 feet.

Anticosti Island, near the mouth of the St. Lawrence has an area of about 3,000 square miles. It is underlain by low-dipping Ordovician and Silurian strata, the total exposed thickness of which ranges from 1,500 to 4,000 feet. No drilling has been done on the Island, and there has been only reconnaissance geological mapping.

No drilling for oil and gas has been done, either, in the Mississippian and Pennsylvanian rocks that form the Magdalen Islands, a small archipelago in the Gulf of St. Lawrence.

In the Gaspé region, between two belts of highly disturbed Ordovician rocks, there is a central zone, with an area of about 5,000 square miles, where from 5,000 to probably as much as 20,000 feet of Silurian and Devonian strata are arranged in a series of large anticlinal and synclinal folds. Recent surface mapping is showing that this central Silurian-Devonian belt continues several miles westward beyond the limits of Gaspé Peninsula proper.

Oil seepages and petroliferous strata have been observed in all these regions excepting possibly, Magdalen Island. Gas, in notable although not as yet commercial quantities, has been found in several of the wells drilled in the St. Lawrence Lowlands region. Further testing is required to determine if the formations in themselves possess persistent zones of porosity or if the gas occurrences are related to fracture zones. Oil has been found in several wells in Gaspé, but commercial production has not been obtained yet; most of the wells drilled in this region, however, were either poorly located structurally or did not go deep enough to reach all possible favorable zones.

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Thickness of Sedimentary Section in Appalachian Basin

Nine parallel aeromagnetic traverses were flown by the U. S. Geological Survey across the southern Appalachian Mountains and the plateau regions to the west. These traverses are at right angles to the prevailing structural trend and form a strip approximately 20 miles wide and 250 miles long, extending from the Blue Ridge, just north of Asheville, North Carolina, to the Ohio River at Louisville, Kentucky.

There is a pronounced northeast linearity in the trends of the individual magnetic anomalies and the larger magnetic units which parallels the regional tectonic trends of the Appalachian Mountains. The anomaly pattern implies several sharp contrasts in magnetic expression of the crystalline basement rocks. The dominant feature on the profiles is a group of exceptionally large anomalies which delineate a block of strongly magnetic rock, approximately 100 miles in width, underlying the Appalachian Plateau. Available gravity data along this same strip, although sparse, show a marked resemblance to the over-all magnetic pattern. A positive Bouguer anomaly of about 30 milligals coincides with the group of large magnetic anomalies. It is concluded that these magnetic and gravity anomalies are produced by a large mass of predominantly mafic igneous rock underlying the Paleozoic sedimentary rocks of the Appalachian Plateau.

Estimates of depth to magnetic rock have been made from many individual magnetic anomalies. These magnetic rocks presumably are part of the Precambrian complex underlying the Paleozoic sedimentary rocks. The depths obtained were generally consistent and indicate that in the Appalachian Plateau there are 8,000–10,000 feet of sedimentary rock and the basement surface is 7,000–9,000 feet below sea level. These thicknesses are less than those predicted from stratigraphic considerations but are supported by data from recently drilled wells which reached basement. One well in Leslie County, Kentucky, entered granite 9,412 feet below the surface or 8,233 feet below sea level. The depth analyses of magnetic anomalies in the Valley and Ridge province indicate that the Paleozoic section

thickens to the southeast, although not as much as expected. The average thickness in the Valley and Ridge province is about 17,000 feet and the greatest thicknesses are in the southern part, indicating that the basement surface plunges in that direction.

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Summary of Geology of Atlantic Coastal Plain Province

The emerged part of the Atlantic Coastal Plain is underlain chiefly by Cretaceous and Tertiary sediments above the basement rocks. Some deep beds may be of Jurassic age, and thin deposits of Quaternary age blanket coastal areas. In aggregate, the sediments thicken as a wedge toward the coast; at extreme tips of southern New Jersey and eastern North Carolina they are about 10,000 feet thick, and in southern Florida they are thicker than 15,000 feet.

Predominantly marine sands and clays characterize the entire sedimentary sequence north of North Carolina, as well as the Cretaceous sequence north of Florida. Near-surface calcareous rocks of Eocene age extend from North Carolina through Florida. Pre-Pleistocene rocks of Florida are largely carbonates.

The basement underlying the eastward- and southeastward-dipping homoclinal beds consists chiefly of crystalline rocks and to a lesser extent Paleozoic and Triassic sedimentary rocks. The basement is a shallow platform beneath the updip portion of the Coastal Plain, but in southern New Jersey and eastern North Carolina the slope steepens where the platform adjoins the western border of a north-trending trough. The Peninsular arch of Florida and the Cape Fear arch of North Carolina are two northwest-trending positive elements. An embayment in southeastern Georgia lies between them.

Common tendencies include: (1) downdip change in many formations from coarse clastic to fine clastic to carbonate facies, (2) downdip thickening of beds, (3) downdip increase in number of beds, (4) lack of consolidation of sand and clay except at great depth, and (5) decreasing porosity and permeability with depth in coastal areas.

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Deep Drilling Project

The AMSOC Committee of the National Academy of Sciences-National Research Council has determined that it is both feasible and desirable to drill a hole through the earth's crust for the main purpose of obtaining as much sample as possible of the mantle. The hole must be drilled in either the Pacific or Atlantic Ocean basin where the crust is thin enough to be penetrated. Detailed surveys have been carried out in the area north of San Juan, Puerto Rico, on the rise north of the Puerto Rican trench. The survey area covers about 5 square degrees. In the Pacific a smaller area 50 miles southwest of Guadalupe Island has been surveyed. One of these sites will be chosen for drilling to the mantle. The project will be carried out in 3 phases: Phase I will consist of modifying a drilling barge for deep-water operation. As many test holes as the project can afford will be drilled. Several complete sedimentary core sections will be obtained which will yield information on coring methods in unconsolidated sediments, as well as paleontological, mineralogical, and structural knowledge of deep-sea sediments, which never before has been obtained. The preliminary holes will go to depths of 18,000 feet and in some places it is expected that the second layer will be penetrated. Phase II will begin with the application of the engineering data found in phase I to the design of a new drilling barge. The new barge will be constructed and moved into place. Phase III encompasses the actual drilling of the deep mantle hole, the scientific direction of the work, field analysis of the results, and later laboratory analysis.

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Lower Silurian and Cambro-Ordovician Sedimentation of Northern Appalachian Basin

Subsurface studies in the Northern Appalachian basin reveal several different histories of sedimentation (Cambro-Ordovician and Lower Silurian). Too few wells have been drilled to the Precambrian to reveal anything but very regional data on the Cambrian sediments. The Cambrian thickness varies from 13,000 feet on the outcrop in south-central Pennsylvania to 900 feet in northeastern Ohio and 0 feet in southwestern Ontario. The section is predominantly dolomite and sandstone. The Upper Cambrian isopach map shows a probable regional high in northeastern Ohio. This high seems to trend north-south. Two regional unconformities have been detected within this section.

Middle-Ordovician sedimentation marked a time of emergence with the Adirondack-Tazwell axis in the center of the basin forming a structural and facies barrier separating for the first time the Appalachian basin into two distinct basins of deposition. On the northwest flank of the Allegheny synclinorium, the Crawford arch came into existence along with the Olean embayment and Erie trough (Chatham Sag extension). Unlike the more pronounced Adirondack-Tazwell feature, the Crawford arch did not act as a facies barrier. The Middle Ordovician sediments encountered so far are argillaceous limestones. The exception to this being the dolomitized productive areas on the Findlay arch.

Upper Ordovician sedimentation shows regional east to west thinning with occasional interruptions across local highs. These sediments are predominantly shales with occasional layers of siltstones or sands. The subsequent Lower Silurian deposits also show regional thinning eastward with local variations. Lower Silurian production appears to be confined to within the 200–400-foot isopach interval. Variations within this isopach interval are critical as to the quality of production to be found. Detailed study reveals the productive sand bodies are deltaic rather than offshore bars or shoestring sands.

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Petroleum Possibilities of Peten Basin, Guatemala

The Peten area of Guatemala was intermittently occupied by a marine basin from the late Paleozoic through the Cenozoic. The oldest sediments in the basin probably represent deep-water deposition in Pennsylvanian time. Emergence of the area, in the Permian resulted in the deposition of limestones, dolomites, sandstones, and siltstones. Total emergence by the end of the Permian continued through the Triassic and most of Jurassic. Upper Jurassic encroachment