ANDREW R. FISH and JOHN C. KINARD, Phillips Petroleum Company, Billings, Montana

Madison Group Stratigraphy and Nomenclature in Northern Williston Basin

In the area of the international boundary, in northern North Dakota, carbonates and evaporites of the Madison group attain maximum thickness in the central Williston basin near the town of Williston, North Dakota. Recent drilling has resulted in scores of Madison discoveries in the United States and Canada in which the oil-trapping mechanism can be classified into one or more of the following: (1) predominantly, structurally controlled pools, (2) tilted and truncated porous units sealed under a Triassic shale cap rock, and (3) updip porosity wedgeouts resulting from facies change.

The area has gained prominence in recent years as a new province for stratigraphic oil exploration, and as such, offers the stratigrapher abundant opportunity to apply his ideas.

Considerable effort has been put forth in recent years to introduce a system of nomenclature which is tenable throughout the basin. It is held that the use of local terminology, based on rock types, is a workable answer to the problem. Long-range correlation across the basin is feasible with present well control and stratigraphic correlation is extended from the "east side" truncation belt of Saskatchewan and North Dakota to the Poplar anticline of Montana.

GEORGE FONG, Home Oil Company Limited, Calgary, Alberta

Geology of Devonian Beaverhill Lake Formation, Swan Hills Area, Alberta

Early in 1957, several widely separated oil and gas discoveries were made in the Beaverhill Lake formation in the Swan Hills area of west-central Alberta. Production in this formation comes from the Swan Hills member, a southwest-dipping sequence of clastic organic limestones forming a platform on which small reef mounds are developed. To date, all the known hydrocarbons are trapped in the small bioherms downdip from the regional pinchout edge of the member, but the pinch-out edge itself is only in the early stages of being explored for possible stratigraphic traps. The Swan Hills member contains *Lingula spatulata* (early Waterways) zone fossils and represents early Beaverhill Lake reefing.

At the southwest corner of the type area, the Swan Hills member occupies the entire Beaverhill Lake interval and interfingers with the basal beds of the overlying Windfall reef of Woodbend age.

DONALD I. FOSTER, Continental Oil Company, Casper, Wyoming

Oil Potential of Minnelusa Formation, Powder River Basin, Wyoming

The Pennsylvanian and Lower Permian Minnelusa formation is a proved oil reservoir with 81,000,000 barrels produced to January 1, 1958. This formation is present and prospective throughout the Powder River Basin.

Density of Minnelusa tests is low and many large areas remain undrilled. To date, the structural approach has been used almost entirely in prospecting for Minnelusa oil, and present production is from closed anticlines. Many low-relief structures, similar to that at Donkey Creek field, should be present and oil-productive on the eastern flank of the Powder River Basin.

The Minnelusa is entirely marine in origin, having been deposited in a basin whose area coincides closely with the present Powder River Basin except on the south and southeast. Following deposition of the upper Minnelusa, an anticlinal arch formed in the north-central part of the Powder River Basin which was then truncated and buried by younger Permian shales. The oil found in this area appears to be related to the ancient anticline, with future prospects also being very good.

The Minnelusa formation can be divided by two intraformational unconformities into three separate rock units herein designated as the Upper, Middle, and Lower members. Paleontological evidence indicates that each unit is probably the same in age throughout the basin.

The Upper member of the Minnelusa is a sandstone-carbonate-anhydrite sequence of Lower Permian (Wolfcamp) age. Of the three Minnelusa members, the Upper exhibits the greatest thickness and facies variations and is also the most important for past oil production and future potential. The facies changes of porous sandstones to dense dolomites and anhydrites should provide favorable conditions for the generation and trapping of oil in stratigraphic traps.

The middle Minnelusa is a sandstone-carbonate sequence of Middle and Upper Pennsylvanian (Des Moines, Missouri, and Virgil) age. The "Leo" sandstones of the Lance Creek region (southeast Powder River Basin) are the principal oil reservoirs of the Middle member. Future production may be found in stratigraphic traps formed by the pinch-out of reservoir sands on the flanks of individual structures in the southeastern Powder River Basin and in the regional pinchout of the "First Leo" sandstone on the east flank of the basin.

The lower Minnelusa consists of cherty carbonates and red shales, usually with a basal sandstone unit, and is Lower Pennsylvanian (Atokan and Morrowan?) in age. Some oil production has been

found in a porous limestone unit in the middle of the Lower member. Due to limited control, no precise areas for stratigraphic traps are delineated; but all closed anticlines, especially in the southeastern Powder River Basin, should be tested through the limestone and the basal sandstone units.

JOHN D. HAUN, JAMES A. BARLOW, JR., and C. R. HAMMOND, consultants, Denver, Colorado; Casper, Wyoming; Billings, Montana

Stratigraphy and Conditions Governing Petroleum Occurrence in Lower Cretaceous Rocks, Rocky Mountain Region

Lower Cretaceous stratigraphy of the Rocky Mountain region is complicated by problems of nomenclature, lateral extent, correlation, and age variation of the Dakota group. Lower members of the Dakota group have three different relationships to the underlying Morrison formation: (1) in some areas the basal units were deposited in channels and are unconformable on the Morrison; (2) in many areas the basal units have an intertonguing facies relationship with the upper Morrison, and, (3) a regional unconformity at the base of the Dakota group is developed only in the Great Plains region.

Regional time lines are necessary for an understanding of facies relations. Marine Jurassic formations define an approximate time line at the base of the Morrison in the northern part of the Rocky Mountain region. The Todilto limestone forms an approximate time line in the San Juan basin, but it can not be related precisely to the marine formations farther north. In the northern part of the region the boundary between the Upper Cretaceous and the Lower Cretaceous is placed at the top of the Mowry shale which is marked by the Clay Spur bentonite bed, an excellent time horizon. The marker bentonite of the Denver basin ("X" bentonite), 100–300 feet above the Mowry shale, can be traced throughout the Powder River basin of Wyoming where it marks the base of the Greenhorn faunal zone (Upper Cretaceous). The "X" bentonite bed, and in its absence, the base of the Greenhorn limestone form an excellent time line.

Sediments of the Dakota group were deposited in a sea that advanced from the north and thus these basal sediments become younger in easterly, southerly, and westerly directions. Marine shales of the Thermopolis and overlying Mowry and Graneros formations of Wyoming and Montana were deposited contemporaneously with sandstones of the Dakota group farther south. The lower part of the Dakota group of Wyoming and Montana was deposited contemporaneously with upper Morrison sediments on the south. Over most of the Rocky Mountain region the Dakota group is Lower Cretaceous, but in deposits just south of the San Juan basin the upper part is as young as the Greenhorn limestone, a relation similar to that found in eastern Nebraska, at the type locality, where the Dakota sandstone is largely, if not entirely, Upper Cretaceous.

In Wyoming and Montana, sandstones of the lower Dakota group (Lakota, Fall River, Dakota, Cloverly, Cat Creek, and upper Morrison) produce oil in areas where distinctive, linear, thick sandstones are developed and are notably unproductive in areas of patchy, heterogeneous sand development. In eastern Colorado, the lower part of the Dakota group (Dakota, Lytle, "M", "O", "R", and "T" sandstones) is essentially non-productive. Significant oil production in the Dakota sandstone of western Colorado and the San Juan basin is found in areas characterized by linear sandstone development.

"D" and "J" sandstones of the Denver basin produce petroleum from stratigraphic traps and the southeast limit of significant production coincides with the zero isopach of the Mowry shale. Oil production in the Muddy and Newcastle sandstones of Wyoming (equivalents of lower "J") is stratigraphically trapped in or near linear sandstone trends. Structural entrapments are present where linear trends cross structural highs.

E. L. HERBALY, Consultant, Calgary, Alberta

Geometry of Oil and Gas Accumulations Associated with Edmonton Reef Chain, Central Alberta

The absence of large-scale tectonic disturbances along the eastern flank of the Alberta syncline has made the search for structurally entrapped oil and gas deposits rather minor in comparison with the stratigraphically entrapped deposits. Closed structures occur, but the controlling factors for the closed anomalies lie in draping. Draping is over reef buildups, residual topography on surfaces of unconformity, and structural noses along ancient tectonic trends.

Oil and gas fields along the Edmonton reef chain provide examples of many complex stratigraphic relations which in turn control the entrapment of hydrocarbons. The principal trap along the trend is the carbonate buildup of the Devonian reef entirely enclosed by shale. The geometry of the oil and gas accumulations in the reefs simulates the normal fluid segregations found in simple anticlinal traps. Differential compaction of overlying sediments above the reef massifs causes draping in the overlying sediments and supratenuous anticlines are formed somewhat symmetrically with the reef body. Such features enable seismic exploration to delineate the reef trends, even though seismic records give poor reflections from the reef massifs themselves. Subreef structural relations are unknown at present because of lack of deeper drilling.