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STRATIGRAPHIC ANALYSIS OF UPPER DEVONIAN AND MISSISSIPPIAN ROCKS IN MICHIGAN BASIN[1]

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ABSTRACT

Upper Devonian and Mississippian rocks in the Michigan basin are analyzed by subsurface methods. Sections from one hundred sixty-eight oil wells were studied.

Isopach and lithofacies maps serve as a basis for interpreting sedimentation processes, tectonics, and environmental conditions. In order to work out a more complete picture of Upper Devonian and Mississippian sedimentation, it is necessary to subdivide the total section into operational rock units A, B, and C, which are recognized on the basis of lithologic criteria. Respective units are then interpreted in terms of tectonic and environmental conditions responsible for patterns exhibited. Integration of three arbitrary units of Upper Devonian and Mississippian sedimentation presents the regional geologic history.

Sand-shale ratio and per cent carbonate or evaporite in the total stratigraphic unit are used in the statistical analysis.

Interpretation of isopach and lithofacies patterns reveals that tectonics of the depositional area is a very important factor in controlling sedimentary facies. Tectonic conditions from shelf to open basin, to silled basin, are represented.

INTRODUCTION

Most of the area within the Michigan basin is covered with a mantle of glacial drift and only in a few places is bedrock exposed. Early geologists were hampered in their studies concerning the geologic history of the Michigan basin because of scanty information available. Addition of many oil-well data in recent years has helped considerably in deciphering puzzling problems of structure, stratigraphy, and sedimentation.

Until recently, structural and stratigraphic details were to be found, for the most part, only in the works of Newcombe (1933), Pirtle (1932), Cohee and Underwood (1944), Cohee (1947), and Cohee, Macha, and Holk (1951). Little attention was given to sedimentary characteristics of the rocks in the Michigan basin and their implications in regard to source areas. The Wisconsin arch or highlands on the west, the Kankakee arch on the southwest, the Findlay arch of the east, and the pre-Cambrian complex (Laurentian upland) on the north and northeast were positive elements which greatly influenced the nature and type of sediments in the basin. The Logansport sag on the southwest, and Chatham sag on the east are known negative elements in areas bordering the basin which periodically connected other basins with the Michigan basin, and likewise must have considerably affected sediments in the basin.

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grained sandstones interbedded with shale. Red shales and siltstone are common in upper sediments. Lateral change from dolomitic sediments of western Michigan to siltstones and fine-grained sandstones of eastern Michigan is gradational. A red stratum which is either dolomite or limestone in western Michigan and shale or siltstone in eastern Michigan, is present at the base of the Coldwater formation throughout the Michigan basin.

The lower Marshall sandstone consists of sands and shales with some limestone layers. It has a high iron content and contains abundant muscovite. Cementing material is commonly calcite.

The upper Marshall sandstone (Napoleon) is a medium- to coarse-grained sandstone composed mostly of quartz. In exposures it exhibits cross-bedding and locally is porous. Cementing material is generally calcite.

Petrologically, Marshall sands contain a variety of minerals. Quartz forms the bulk of minerals present with pyrite, magnetite, ilmenite, and leucoxene the most abundant accessory minerals. Minerals occurring in minor amounts in western Michigan differ from those of eastern Michigan (Stearns, 1933, p. 103). Western assemblages are more varied and contain garnet, pink zircon, hornblende, epidote, actinolite, and biotite as characteristic minerals. Eastern assemblages contain tourmaline, colorless zircon, and weathering products of the less stable minerals. Garnet and pink zircon are conspicuously absent. Monnett (1948, p. 683) reports a higher feldspar content in sandstones of southwestern Michigan than elsewhere in the state.

The top of the Marshall group is placed at the base of the lowest dolomite or shale in the Michigan formation. Hard (1938, p. 137) reports that, below the dolomite or shale, quartzose sand is encountered.

UNIT C

Analysis of Unit C is made only where the Bayport formation is overlain by Pennsylvanian rocks, so that a minimum of error is introduced because of erosion.

The Michigan formation is composed of quartzose sandstone, greenish gray to dark gray shale, thin limestone and dolomite beds, and gypsum and anhydrite. Gypsum and anhydrite occur throughout the Michigan formation, commonly grade laterally into shale, and in many places are interbedded with shale. Gypsum and anhydrite are more abundant in the lower part of the formation and are most common in the western part of the state (Newcombe, 1933, p. 57).

Landes (1951, p. 7) points out that generally anhydrite in the Lucas formation (Middle Devonian) in the Michigan basin increases in abundance basinward. Not only is the anhydrite-bearing section thicker, but also percentage of anhydrite in any one zone increases basinward. Relationship of increasing anhydrite over gypsum with depth is noted in gypsum deposits in southwestern Kansas (McGregor, 1948) and in the Delaware basin of West Texas (Adams, 1944). In Unit C, the percentage of anhydrite in the section seems to increase basinward.

Mineralogically, sands of the Michigan formation do not differ appreciably

from those of the Marshall group (Stearns and Cook, 1932, p. 433). Absence of feldspar in sands of the Michigan formation is the principal distinction.

The Bayport formation (Point Au Gres limestone, Ehlers and Humphrey, 1944, p. 117) consists of light to dark gray shales, bluish limestone and dolomite, some chert, and a few lenses of sandstone. Sand content increases toward the base. An erosional unconformity separates the Bayport formation from overlying Pennsylvanian rocks.

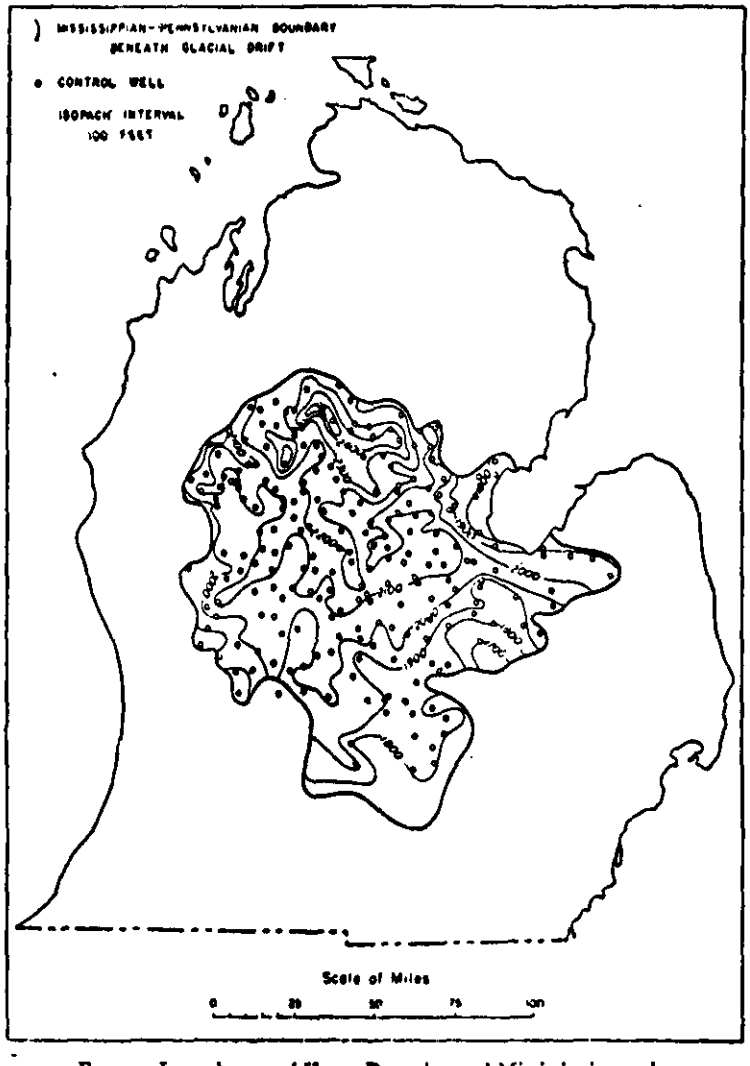

FIG. 2.—Isopach map of Upper Devonian and Mississippian rocks.