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Oil and Gas Accumulation in the "Main Pay" Zone of the Beaver Lodge Field Williams County, North Dakota

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OIL AND GAS ACCUMULATION IN THE "MAIN PAY" ZONE OF THE
BEAVER LODGE FIELD, WILLIAMS COUNTY, NORTH DAKOTA

Submitted
to
Mr. F. D. Holland

by
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February 18, 1957
University of North Dakota
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ABSTRACT

Enough data has now been obtained on the "main pay" zone of the Beaver Lodge Field to make possible a comprehensive study of the source of the oil, its mode of origin, and the time of its migration and accumulation.

The method of study includes an investigation of the structure, lithology and depositional environment of the "main pay" zone.
OIL AND GAS ACCUMULATION IN THE "MAIN PAY" ZONE OF THE BEAVER LODGE FIELD, WILLIAMS COUNTY, NORTH DAKOTA

Introduction

An exhaustive search of the literature indicates that no effort has been made to find the source of the petroleum, which exists in the "main pay" zone of the Beaver Lodge Field. Enough data has now been obtained on the field to draw some conclusions as to the source of the oil and the time of its migration and accumulation.

Location

The Beaver Lodge Field was discovered by Amerada Petroleum Corporation with the completion of the Clarence Iverson No. 1 well.

The field is bordered on the north by the Tioga Field, and on the south by the Capa Field. The three fields are positioned on the Nesson Anticline in Williams County, North Dakota.

Acknowledgments

The author appreciates the discussions held with members of the North Dakota Geological Survey on the subject matter of the thesis, and the use of their files.

Source of Oil and Gas

Baille (1955, p. 626) pointed out the possibility that the dark colored limestones of northwestern North Dakota may be source rocks for petroleum.
Various approaches may be used to determine the source of the oil and gas and the method of accumulation. Lithology, environment, and structure must be taken into account and interrelated.

Lithology

The top of the "main pay" zone is approximately 250 feet below the last Charles salt. It consists of a granular, dark colored, fossiliferous limestone, and averages 50 feet in thickness. The granules are fragmental and oolitic. There is evidence of some recrystallization. Scattered shale inclusions are found throughout the zone.

The zone is capped by a dense crystalline limestone, which is not fractured for a distance of 8 feet above the "main pay". The cap rock contains a greater amount of shale than the "main pay", making it more flexible and less susceptible to fracturing.

The bottom of the "main pay" zone grades into dense crystalline limestone, which doesn't contain as much shale as the cap rock.

The "main pay" zone and the rocks below it are highly fractured and it is believed that there is communication between the "main pay" and the water level below.

Figure I. Lithologic character of the "main pay" zone of the Beaver Lodge Field.
Environment

The "main pay" zone of the Mission Canyon formation was deposited in a silled basin. During the deposition of the overlying Charles formation, the basin was entirely closed. The "main pay" zone represents a transition from an open basin to a closed one.

The fragmental and oolitic nature of the "main pay" lithology indicates that the Nesson Anticline was a high feature, and was somewhat aerated.

The anticline had enough closure during Mississippian time to cause different environmental conditions on the structure than existed in the surrounding areas. The environment of deposition on the high of the structure caused the destruction of organic matter in the newly deposited sediments, and resulted in pin-point porosity. The conditions of deposition off the structure helped to preserve the organic matter from decomposition.

An examination of Figures III and IV indicate the logic of this theory. The porosity definitely is a maximum at the points of highest structure and decreases rapidly on the flanks of the structure. It is doubtful that the pattern of porosity would be caused by compaction of overlying sediments, unless the structure had been formed after the deposition of the Mission Canyon formation.

The author feels, on the basis of the above considerations, that no production will be found in the central part of the Williston Basin unless it is associated with structure and not with stratigraphic traps.
Figure II. Isopores of the 50 foot interval below the top of the "main pay" zone of the Beaver Lodge Field in Williams County, North Dakota.
Figure III. Contours on the top of the "main pay" zone of the Beaver Lodge Field in Williams County, North Dakota. (Adapted from Sydney B. Andersen.)
Structure

Isopach Maps. Isopach maps indicate that the center of the Williston Basin during the deposition of the Mississippian carbonates was very near to the Nesson Anticline, and that previous to that time, the center of deposition was to the east and north.

![Diagram of geological time and structure](image)

Figure IV. Centers of the Williston Basin in geologic time according to isopach data. Adapted from Laird (1953).

Not until Cretaceous time (Mueller, 1954, p. 109) did the axis of the depositional basin move out of the Williston Basin. Therefore, it is hard to conceive of the source of the oil and gas for the Beaver Lodge Field existing outside of the Williston Basin. It is possible, however, that any oil and gas found in Cretaceous sediments could have their source outside of the basin.

Origin of the Nesson Anticline. There has been considerable speculation as to the time and method of origin of the Nesson Anticline. It is almost certain, however, that some structure
existed during the deposition of the Mission Canyon limestones. This would be consistent with the theory that the forces which caused the anticline have been active, at least intermittently, throughout most of the history of the basin.

The Nessson Anticline definitely controlled the accumulation of oil in the Beaver Lodge Field. There are no unconformities or other stratigraphic traps in the interval being considered.

**Time of Migration and Accumulation of Oil and Gas**

The saturation pressure of an accumulation of oil may be used to determine the approximate time of migration and accumulation.

The Beaver Lodge Pool is an undersaturated deposit, having a saturation pressure of 3110 psig. By using a normal salt-water pressure gradient of 0.45 psi/ft, to convert saturation pressure to hydrostatic head, it is found that the depth of burial required for the formation of the undersaturated condition is 5289 feet. Therefore, the accumulation of oil in the "main pay" zone had been completed at approximately the same time that the Niobrara formation was being deposited.

The migration of the oil, which was only very local, probably occurred at the time when 2000 to 3000 feet of sediments had been deposited on the "main pay" zone. This would place the time of the beginning of migration of the oil as late Permian or early Triassic. The migration continued until the deposition of the Niobrara formation.

The time of migration of oil and gas is important since the
characteristics of the basin which prevailed at this time determined the direction of migration of the oil and the ultimate location of the accumulations.

**Conclusion**

By investigating the lithology, structure and depositional environment of the "main pay" zone of the Beaver Lodge Field, it can be concluded that: (1) the source of the accumulation of oil and gas was local; (2) the migration of the oil began in late Permian or early Triassic time; and (3) the accumulation of oil and gas was completed by upper Cretaceous time.

A knowledge of the time of migration and accumulation, and source of oil and gas will help direct future exploration activities more efficiently.
LIST OF REFERENCES CITED


