NORTH DAKOTA GEOLOGICAL SURVEY

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Stratigraphic Sections of the Devonian System in Western North Dakota and Adjacent Areas

by

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STRATIGRAPHIC SECTIONS OF THE DEVONIAN SYSTEM IN WESTERN NORTH DAKOTA AND ADJACENT AREAS

By Donald Towse

Abstract

The subsurface Devonian sections presented in this report form a cross section from the northeastern part of the Williston Basin in Manitoba to near the southwestern edge on the Cedar Creek anticline in southeastern Montana.

This cross section crosses the Basin axis near the Nesson anticline, where it illustrates Devonian rocks typical of the southern part of the deep basin area. Not shown is the stratigraphy of eastern North Dakota, where gradual changes in facies and absence of some Middle Devonian rocks give the section a different aspect.

Introduction

This report is the result of detailed study of cores and cuttings from selected wells. Other wells not shown were used to establish correlations and units. Those shown were selected for their good core and sample information and as examples of the stratigraphy of each area.

Further work and more information probably will change present concepts of regional stratigraphy and present nomenclature, but the rocks will remain the same. It is hoped that the lithologic information here presented will provide basic data for further investigation.

Oil was discovered in the lower part of the "Woodbend equivalent" in the Clarence Iverson well at Beaver Lodge, but the Devonian is now shut in, and no oil is being produced from Devonian rocks in the area covered by this report.

The logs show general lithology in the central strip. Color is shown by a narrow strip on the left. The pattern of the strip indicates hue, and its width indicates density of color, as shown in the legend. Color was determined by use of the Rock Color Chart of the National Research Council.

Texture of carbonate rocks may be described in many ways, but rather than to use any classification based in part on subjective genetic features, an objective description is used.

Grain size is described by modification of the Wentworth scale for fragmental rocks. "Fine", "medium", and "coarse" correspond to Wentworth's scale, but "very fine" also includes sizes corresponding to clay and silt.

Fabric terms used are sugary, crystalline, fragmental oolitic, and rubble. Non-interlocking aggregates of crystals or angular crystal fragments are described as sugary if no rounded grains or obvious rock or fossil fragments are present. Aggregates of rounded grains and obvious broken pieces of rock or fossils are fragmental. Crystalline rocks are those with interlocked crystals, and they usually have little intergranular porosity. Rubble is made of large angular fragments. Spherical to subspherical grains are called oolites without regard to internal structure.

Many mixtures of fabric types are possible, and they are shown by appropriate combinations of symbols on the log. Texture is shown by a strip on the right side of the log. The pattern of the strip indicates fabric type, and the width of the strip shows grain size.

Dolomite, calcite, and mixtures of the two were identified by the 7:1 dilute hydrochloric acid test described by Low.[1]

Fossils are noted where present. They are more easily found in cores than in cuttings, obviously, so the fossil content as described is dependent to a great extent on the amount of cored interval and the quality of the cuttings.

Stromatolites are identified as fine crystalline laminated carbonate structures of probable organic origin. No identification of the responsible organism is indicated on the log. As with fossils, identification of stromatolites is difficult in cuttings. Fine crystalline curved plates in cuttings are identified as probably stromatolitic and are indicated as stromatolites on the log.

Corals are identified as such only if recognizable coral structure can be seen. Many vugular dolomites may also be coralline, but alteration has made identification impossible, especially in cuttings. Where porosity is judged sufficient for oil production, a line is drawn on the left edge of the log. Porous zones so noted have intergranular porosity. Vugular porosity is shown by a different symbol.

Nomenclature

Different names are used for the same unit by different workers, and the same rock units in parts of the Williston Basin are called by various names. Consequently, the nomenclature of the units in the Devonian system is confused, as is natural in a region so little studied. Although nomenclature is confused, most workers use essentially the same rock units over much of the area. Rather than to coin new names or to redefine old formations, the writer prefers at present to use the valid formation names that have been published in the past, by this Survey and others, and to apply informal names to Upper Devonian rocks not before differentiated.

At a recent conference, a regional American Association of Petroleum Geologists coordinating committee on names and correlations in the Williston Basin agreed on a standard system of nomenclature, but the report has not been published, nor have type sections been designated. A. D. Baillie[2] published a proposed system of nomenclature as this report was going to press. As type sections were not designated, nor were the new names formally defined, it is considered unwise at this time to use the new or changed names.

The accompanying table shows the nomenclature system used in this report and that suggested by Baillie and the A.A.P.G. committee. Changes can be expected before a standard nomenclature for the Williston Basin Devonian is widely accepted.

The following units are used here: (In ascending order) Ashern formation, Elm Point formation, "Beaverhill Lake equivalent", "Woodbend equivalent", "Nisku equivalent", and Lyleton formation. The Devonian section (cored except for the "Nisku equivalent") was described in detail in the writer's "Summary of the California Company's Blanche Thompson No. 1 well, Bottineau County," *No. Dakota Geol. Survey Circular* 7 (1952). The Upper Winnipegosan evaporite is not present in that well, but is typically developed in the Amerada H. O. Bakken No. 1 well at the Tioga fiield.

The Lyleton, Manitoban, Winnipegosan, Elm Point, and Ashern formation are traced by lithologic character and stratigraphic position from the type exposures on the Manitoba outcrop, as defined and described by Baillie.[3] The usage here followed is common in the literature and in field practice in the North Dakota part of the basin. The Manitoban is considered to be the upper formation of the Middle Devonian series.

The "Nisku", "Woodbend", and "Beaverhill Lake" equivalents are Upper Devonian, but the basal "Beaverhill Lake" may be Middle Devonian.[4]

The type sections of the Nisku member of the Winterburn formation, the Woodbend formation, and the Beaverhill Lake formation are in the Edmonton area, Alberta.[5]

The correlation of the units here called "equivalents" with the formations in the type area is generally accepted and has been published in preliminary studies.[6]

Correlations in southwestern North Dakota are hampered by lack of data, and some changes of detail may be necessary as more wells are drilled.

Description of Units

Ashern formation. The Ashern formation is a thin unit of red or reddish-brown shaly dolomite overlying the very light-colored crystalline dolomite of the Silurian. The Ashern may be sugary to crystalline, but is never coarser than medium grained. Anhydrite is sometimes present in small amounts. In the deeper parts of the basin the color may be gray or greenish gray, and calcite may be present instead of dolomite.

Elm Point formation. The Elm Point formation is a dark-colored, fine-crystalline, shaly mixture of limestone and dolomite lying between the Winnipegosan above and the Ashern below. In the shallower parts of the basin it is lighter colored and more dolomitic. It is thickest in the Nesson anticline area and is missing in south-western North Dakota. Small amounts of halite and anhydrite may be present. It is generally tight. The best section is in the Amerada H. O. Bakken No. 1 well in the Tioga field.

Winnipegosan. The Winnipegosan formation is a thick sequence of pale brown to grayish-orange-pink, fine-to-medium-sugary dolomite, lying between the Elm Point below and the Manitoban formation above. In the deeper parts of the basin a thick salt, shale, and anhydrite section (The Prairie evaporite) is present at or near the top. The evaporite unit is represented by a coarse rubble in the California Thompson well in Bottineau County. The top bed of the Winnipegosan is often a brown or reddish shale, but the shale may be gray in deeper portions of the basin. The dolomite in the upper part is a grayish-orange-pink color, and is a useful marker when the shale at the top is not apparent. The Winnipegosan is thin outside the area of evaporite deposition (as in the California Thompson well). The formation thins by absence of evaporite and thinning of carbonates in the south and southwest. The Winnipegosan is pink crystalline limestone in the Kelly-Plymouth Leutz well.

The dolomites are usually porous, and both vugs and intergranular pores are present.

Manitoban. The Manitoban formation is a light olive to yellowish-gray fine-to medium-sugary dolomite and limestone sequence. It is lighter in color and less shaly than the "Beaverhill Lake equivalent" above, and is separated from the pink to brown dolomites of the Winnipegosan below by the shale at the top of the Winnipegosan. The Manitoban has a distinctive gamma log characteristic well shown on the cross section.

Small amounts of shale, sand, and anhydrite are present. Its thickness is more uniform than the other Devonian formations. Facies change to crystalline limestone is common, and some fragmental beds are present. Intergranular and vugular porous layers occur throughout the formation.

"Beaverhill Lake equivalent". The "Beaverhill Lake equivalent" is typically a shaly and anhydritic limestone and dolomite unit above the Manitoban and below the "Woodbend equivalent". Light to yellowish gray is the most common color, and the carbonates are more sugary than those above. The top is marked by several medium-light-gray to dusky-red dolomitic shale beds. The top picked in this report is a short distance above that picked by the A.A.P.G. committee and by Baillie. Limestone is usually more often present than in the formation above and below, but the lithologic character of the entire unit is quite variable.

"The Beaverhill Lake equivalent" thins southwestward, and it has very little effective porosity. It is tentatively considered to be the basal formation of the Upper Devonian series in western North Dakota. The top of the "Beaverhill Lake equivalent" is difficult to pick in cuttings samples, but the shaly character is apparent on gamma ray logs and may be easily recognized.

"Woodbend equivalent". The "Woodbend equivalent" is a thick, medium to dark brown dolomite above the "Beaverhill Lake equivalent". It is separated from the similar limestone of the "Nisku equivalent" above by a widespread thin greenish gray shale bed that is usually considered to be the partial equivalent of the Ireton shale of Alberta. The "Woodbend equivalent" is generally fine to medium crystalline or sugary, and limestone, anhydrite, fragmental beds and thin shales are included. It is absent in the southwestern corner of North Dakota. The "Woodbend" is lighter, more sugary dolomite on the basin edges, and grades to darker crystalline limestone in the center of the basin. There are scattered vugular and porous zones, and the production in the Amerada Clarence Iverson well was from intergranular and pinpoint porosity in a stromatoporoidal bed near the base.

"Nisku equivalent". The "Nisku equivalent" is a yellowish gray to dark brown medium crystalline limestone above the "Woodbend equivalent" and below the Lyleton formation. It is a persistent bed about 100 feet thick that is usually vugular and quite porous. It is described as reefoid by some workers and may be a biostromal layer. The Nisku member is the Devonian "D-2" in Alberta. Anhydrite beds and inclusions are usually present. The "Nisku equivalent" is similar in appearance and difficult to differentiate from the underlying "Woodbend equivalent" in samples. If the thin greenish gray shale at the base is found it is a good marker, and the shale is readily identified on gamma ray logs.

The "Nisku equivalent" is missing in the southwestern part of the state as is the "Woodbend equivalent".

Lyleton formation. The Lyleton is a reddish-brown, fine to medium crystalline shaly dolomite and dolomitic limestone. It lies below the gray limestone, shale, and silt of the basal Mississippian Englewood formation and above the "Nisku equivalent". Anhydrite is usually present, and the Lyleton may be yellowish gray at the base. It may be porous where it is medium sugary. It thins toward the edges of the basin and is less red in the deeper parts of the basin.

Conclusion

The Devonian system as a whole may be recognized by its position below the Englewood formation and above the Silurian system. The reddish Lyleton and Ashern are good markers. The carbonates may be quite similar in lithology, but the Winnipegosan formation and the Elm Point are easily recognized and traced. The "Nisku", "Woodbend", and "Beaverhill Lake" equivalents are difficult to separate precisely, but the shale beds used as markers are usually identifiable on gamma ray logs and good quality electric logs.

The facies changes from light-colored sugary dolomites on the edges of the basin to darker, shaly, more crystalline, and more calcitic rocks in the deeper parts of the basin must be considered in tracing the formations.

The dolomite basin-edge facies is more porous and makes a good reservoir rock, whereas the darker crystalline carbonates may better serve as source beds.[7] Proper combinations of the two facies, as in the lower part of the "Woodbend equivalent" at Beaver Lodge, provide opportunities for oil production.

The Winnipegosan, with its widespread porosity, and the Manitoban are also possible producers given adequate structure.

The "Nisku equivalent" may be a good possibility on structure, because it has good porosity and probable source bed characteristics.

The "Beaverhill Lake equivalent" has less porosity, but cannot be dismissed as a possible producing formation until it has been thoroughly explored.

Corals have been identified in the Winnipegosan formation, and the "Nisku equivalent" may well be of biostromal origin. Vugular and stromatolitic beds are also common in the "Woodbend equivalent" and the Manitoban formation. No definite Devonian reef structures in North Dakota are known to the writer, but the organic structures cited might develop reefs under proper subsidence conditions. Any substantial thickening of the organic beds should be further explored for evidence of possible reefs.

Much more stratigraphic information and intensive study of anomalies in the Devonian system are needed before the stratigraphy and oil possibilities will be adequately explored.

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[1] Low, Julian W., "Examination of Well Cuttings", Quarterly of the Colorado School of Mines Vol. 46, No. 4, pp. 15, 16, Oct. 1951.

[2] Baillie, A. D., "Devonian Names and Correlation in Williston Basin Area", *Amer. Assoc. Petrol. Geol. Bull* Vol. 37, No. 2 pp. 444-447, Feb. 1953.

[3] Baillie, A. D., "Devonian Geology of Lake Manitoba-Lake Winnipegosis Area." *Manitoba Dept. Mines and Natural Resources Publication* 49-2, 1951.

[4] Ower, J. R., "The Subsurface Stratigraphy of Southwestern Manitoba", Canadian Institute of Mining and Metallurgy Petroleum and Natural Gas Division meeting, Winnipeg (unpublished manuscript), Oct. 1952.
Layer, D. B., *et al*, "Devonian Nomenclature in Edmonton Area", *Amer. Assoc. Petroleum Geologists Bull.*, Vol. 34, No. 9, pp. 1807-1825, Sept. 1950.

[5] Ower, J. R., *op. cit.*; Baillie, A. D., *op. cit.*

[6] Weeks, L. G., "Factors of Sedimentary Basin Development that Control Oil Occurrence, *Amer. Assoc. Petroleum Geologists Bull.*, Vol. 36, No. 11, pp. 2111-2116, (Nov. 1952).

Comparison of Devonian Terminology

THIS REPORT	A.A.P.G. COMMITTEE	BAILLIE	N.D.G.S. CIRC. 7
	Qu'Appelle group	**Qu'Appelle group**	
Lyleton formation	Three Forks formation	Lyleton formation	Lyleton formation
	Saskatchewan group	**Saskatchewan group**	
"Nisku equivalent"	Nisku	Nisku equivalent	Devonian "A"
"Woodbend equivalent"	Duperow formation	not named	Devonian "B"
	Beaverhill Lake group	**Manitoba group**	
"Beaverhill Lake equiv."	Souris River formation	not named	Devonian "C"
Manitoban formation	Dawson Bay formation	Dawson Bay formation	Manitoban formation
	Elk Point group	**Elk Point group**	
Winnipegosan formation	Prairie evaporite	Prairie evaporite	(no evap. present)
(includes Prairie evap.)	Winnipegosis formation	Winnipegosis formation	Winnipegosan formation
Elm Point formation	(includes Elm Point)	Elm Point formation	Devonian "F"
Ashern formation	Ashern formation	Ashern formation	Ashern formation

CARTER N.P.R.R.
19-4N-62E

KELLY LEUTZ
28-142N-89W

AMERADA C. IVERSON I
6-155N-95W

AMERADA H. BAKKEN I
12-157N-95W

CALIF. CO. THOMPSON
31-160N-81W

CAL. STD. DALY 15-18
18-10-27WPM

ENGLEWOOD fm. (Mississippian)

LYLETON fm.

"NISKU equivalent"

"WOODBEND equivalent"

"BEAVERHILL LAKE equivalent"

MANITOBAN fm.

WINNIPEGOSAN fm.

ASHERN fm.

SILURIAN

ELM POINT fm.

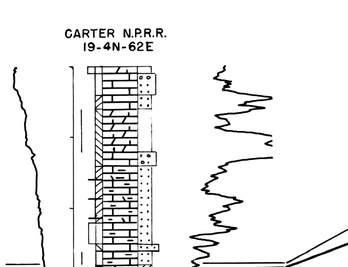
12 MILES
Not to Scale

Only Cored Intervals are plotted

(Amplified Normal)

no samples

7500
7900
9000
9500
10,000
10,400
10,500
11,000
11,500
11,730
11,600
5500
6000
6500
6650
2500
3000
3500
4000
4300



INDEX MAP

COLOR

Density

Light to medium
Dark

Hue

Brown, brownish gray, olive gray
Gray, yellowish gray
Dark gray, black
Very light gray
White or very pale. Red, reddish brown, orange
Green
White and gray mixed
Gray and red mixed
White and red mixed

TEXTURE

Size

Very fine
Fine to medium
Coarse

Fabric

Dense crystalline
Sugory
Fragmental
Sugary and crystalline
Oolitic
Rubble
Sugary and fragmental
Crystalline and fragmental

- Porous
- Oil show
- Oil production
- Stromatolitic
- Fossiliferous
- c Corals
- v Vugular
- Radioactivity log

LITHOLOGY

Limestone
dolomitic
shaly
sandy
anhydritic
Shale
calcareous
dolomitic
Salt
Anhydrite

Dolomite
calcitic
shaly
sandy
anhydritic
Sandstone
shaly
calcareous
dolomitic

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