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Sedimentology and Petroleum Evaluation of the Upper Devonian Duperow Formation, Southwestern Manitoba

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Introduction

The Upper Devonian Duperow Formation in the Williston Basin is dominated by cyclical successions of limestones, dolostones and evaporites, which were deposited in the Eastern Platform Interior of the Elk Point Basin (Moore, 1988). The Duperow Formation is a proven oil producer in Saskatchewan, North Dakota and Montana and correlates stratigraphically to the Leduc Formation in the Alberta Basin (Pilatzke et al., 1987; Wilson & Pilatzke, 1987; Cen, 2009). Exploration of the Duperow Formation in Manitoba has been limited, in spite of the Exploration and Deep Well Incentive offered by the Province of Manitoba, and no commercial oil discoveries have been made to date.

This project investigates the lithostratigraphy, sedimentology and resource potential of the Duperow Formation in southwestern Manitoba. The study area encompasses Townships 1 to 42 and Ranges 11 to 29W1 (Fig. 1). Full details of the findings of this project can be found in Eggie (2012), Eggie et al. (2012), Bates (2016) and Bates et al. (2016).

Methods

Over 400 wells in southwestern Manitoba intersect the Duperow Formation (Fig. 1). Of the 30 wells with Duperow cores, seven with the longest cored intervals of the Duperow Formation were examined in detail at the Manitoba Geological Survey Midland Core and Sample Library. Stratigraphic correlations and mapping were done using wire-line logs and cores, with formation and member contacts picked using marker beds that are consistent with previous studies (e.g. Dunn, 1975; TGI Working Group, 2008; Cen & Salad Hersi, 2009). Characterization and interpretation of lithofacies were done based on core and thin section observations and well log analysis. Diagenetic features were described using standard petrographic methods, leading to interpretation of paragenesis and relative timing of porosity development. Selected diagenetic features were analyzed for stable carbon and oxygen isotope composition and for trace-minor

element composition. Organic-rich laminite samples were analyzed using Rock Eval 6 to determine kerogen type and hydrocarbon source potential.

Examples

The example of Duperow Formation core on display is from well 100/07-18-010-27W1/00, which was drilled in 1976 and is located in the Daly Sinclair Field. The Duperow core (915.0-949.8 m depth; 3001.9-3116.1 ft) covers the upper 2/3 of the middle Wymark Member. The core is stored at the Midland Core and Sample Library of the Manitoba Geological Survey in Winnipeg.

Results

The Duperow Formation in Manitoba is up to 220 m thick and is divided, in ascending order, into the Saskatoon, Wymark and Seward members based on argillaceous marker beds (Fig. 2). Three lithofacies associations are recognized in this study and are interpreted to represent an arid peritidal setting in the platform interior. The subtidal lithofacies association is composed of lithofacies (A) skeletal wackestone-packstone, (B) intraclast wackestone-packstone, (C) stromatoporoid-coral floatstone, (D) stromatoporoid framestone and (F) massive dolostone. The intertidal lithofacies association consists of lithofacies (E) microbial bindstone and (F) massive dolostone. The supratidal/sabkha lithofacies consists of lithofacies (G) interlaminated dolostone and anhydrite, (H) massive to chickenwire anhydrite and (I) patterned dolostone. These lithofacies associations are stacked into metre to decametre-scale, shallowing-upward cycles, which are interpreted to be due to a combination of regional aggradation and/or progradation and localized tidal-flat island migration.

Diagenetic features observed in this study are interpreted to represent alteration in the marine, burial and meteoric diagenetic environments. Synsedimentary marine diagenesis produced radial fibrous calcite and radiaxial fibrous calcite cements. Burial diagenesis, which appears to have been dominant, produced pyrite, facies-selective dolomicrite and non-facies-selective dolomite, dissolution and compaction features, prismatic and blocky calcite cements, chert nodules and anhydrite cement. Late-stage meteoric diagenesis, attributed to percolation of meteoric fluids from the pre-Mesozoic unconformity surface, resulted in blocky calcite cement, dedolomite and gypsum replacing anhydrite.

Potential reservoir rocks in the Duperow Formation in Manitoba are partially to pervasively dolomitized subtidal and intertidal lithofacies. Cores from all three members of the Duperow Formation show live oil staining. The Wymark Member appears to have the best reservoir quality, with potential reservoir units ranging from 0.6 to 15 m thick, porosity up to 25% and permeability up to 173 mD. Rock Eval analysis of organic-rich laminites in the Wymark Member indicates good generative potential for oil and/or gas; thermally mature laminites may be present in the extreme southwest corner of Manitoba. Anhydrite beds (up to 4 m thick) in supratidal/sabkha lithofacies are potential capping units. The best potential for conventional petroleum plays exists in structural traps related to block faulting along the Birdtail-Waskada Zone and salt dissolution in the Prairie Evaporite; and in stratigraphic traps related to vertically and laterally variable dolomitization and subcrop truncations along the pre-Mesozoic unconformity surface.

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References

Bates, K. 2016: Stratigraphy, sedimentology and petroleum potential of the Upper Devonian Duperow Formation, southwest Manitoba; M.Sc. thesis, University of Manitoba, Winnipeg, Manitoba, 228 p.

Bates, K.B., Chow, N. and Nicolas, M.P.B. 2016: Preliminary results from sedimentological investigations and petroleum evaluation of the Upper Devonian Duperow Formation, southwestern Manitoba; in Report of Activities 2016, Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey, p. 157–167.

Cen, X.C. 2009: Stratigraphy, sedimentology and reservoir characterization of an inner platform carbonate-evaporite sequence: the Late Devonian Duperow Formation of southwestern Saskatchewan, Canada; M.Sc. thesis, University of Regina, Regina, Saskatchewan, 116 p.

Cen, X.C. and Salad Hersi, O. 2006: A revised lithostratigraphic framework and characteristics of the Upper Devonian Duperow Formation, southeastern Saskatchewan; in Summary of Investigations 2006, Volume 1, Saskatchewan Geological Survey, Saskatchewan Industry and Resources, Miscellaneous Report 2006-4.1, Paper A-9, p. 1–17.

Dunn, C.E. 1975: The upper Devonian Duperow Formation in southeastern Saskatchewan; Department of Mineral Resources, Saskatchewan Geological Survey, Sedimentary Geology Division, Report No. 179, 151 p.

Eggie, L. 2012: Sedimentology and petroleum reservoir potential of the middle unit of the Wymark Member in the Upper Devonian Duperow Formation, southwestern Manitoba; B.Sc. thesis, University of Manitoba, Winnipeg, Manitoba, 145 p.

Eggie, L., Chow, N. and Nicolas, M.P.B. 2012: Sedimentology of the Wymark Member (middle unit) of the Upper Devonian Duperow Formation, southwestern Manitoba (NTS 62F14, 15, 16); in Report of Activities 2012, Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, p. 160–171.

Moore, P.F. 1988: Devonian geohistory of the western interior of Canada; in Devonian of the World, N.J. McMillan, A.F. Embry and D.J. Glass (ed.), Canadian Society of Petroleum Geologists, Memoir 14, v. 1, p. 67–83.

Pilatzke, E.H., Fischer, D.W. and Pilatzke, C.L. 1987: Overview of Duperow (Devonian) production in the Williston Basin; in Williston Basin: Anatomy of a Cratonic Oil Province, M.W. Longman (ed.), Rocky Mountain Association of Geologists, p. 423–432.

TGI Williston Working Group 2008: TGI II Williston Basin database; Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, <http://www.manitoba.ca/iem/geo/willistontgi/database.html> [September 15, 2016]

Wilson, J.L. and Pilatzke, R.H. 1987: Carbonate-evaporite cycles in the Lower Duperow Formation of the Williston Basin; in Willison Basin: Anatomy of a Cratonic Oil Province, M.W. Longman (ed.), Rocky Mountain Association of Geologists, p. 119–146.

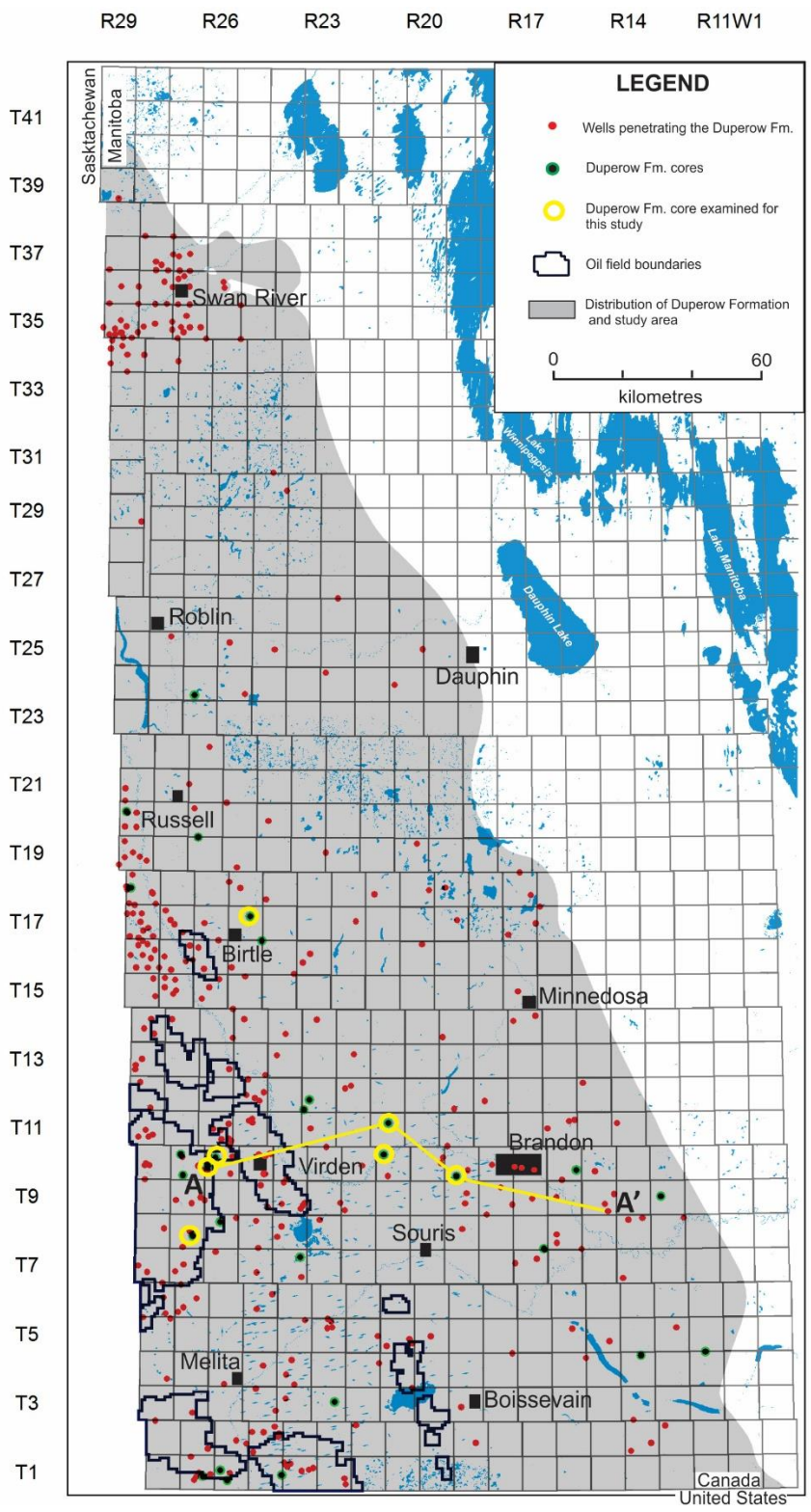

Figure 1. Map of the study area showing the distribution of the Duperow Formation in southwestern Manitoba, wells that intersect the formation, wells with Duperow cores and wells with core examined for this study. Cross section A-A' is shown in Fig. 2. Modified from Bates et al. (2016).

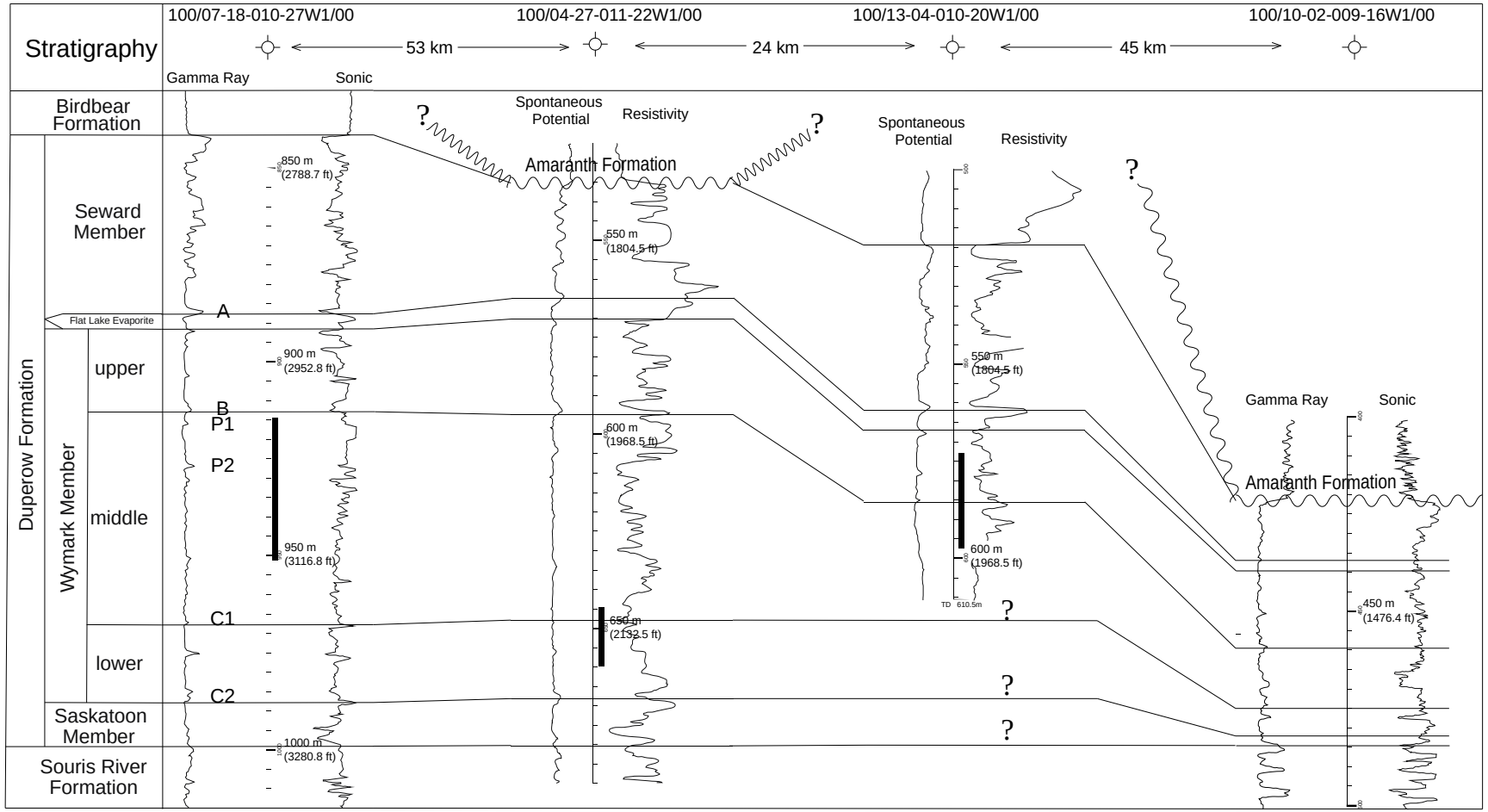

Figure 2. Stratigraphy of the Duperow Formation and stratigraphic cross-section (A-A' in Fig. 1) showing the marker beds (C2, C1, B and A) that define the members of the Duperow Formation. The vertical bold black lines indicate cored intervals. From Bates (2016).