LITHIUM EXPLORATION IN THE WILLISTON BASIN

AND THE POTENTIAL OF MADISON BRINE WATERS IN WESTERN NORTH DAKOTA

BY TIMOTHY O. NESHEIM

INTRODUCTION

Lithium is utilized for a variety of applications including pharmaceuticals as well as automotive/industrial lubricants. Most commonly, however, lithium is a key component within batteries. Demand for electric vehicles has been steadily rising over the past several years, vehicles that require large batteries and substantial amounts of lithium. Assuming the demand for electric vehicles continues to climb, the demand for the lithium necessary to construct the electric vehicle batteries will also likely increase.

LITHIUM EXPLORATION IN THE WILLISTON BASIN

Exploratory drilling for lithium in subsurface brine waters of the Williston Basin was initiated during 2021. Prairie Lithium recently drilled the first reported lithium brine exploration well in the history of Canada and the greater Williston Basin, which reportedly encountered 53m of net pay (Businesswire, 2021). The company holds mineral permits over 360,000 acres in southeastern Saskatchewan and drilled their exploration well near Torquay, just across the border from Divide County in northwestern North Dakota (fig. 1).

Publicly available data and information on Prairie Lithium's exploration project is still limited. However, the Saskatchewan Geological Survey has been intermittently conducting brine water analyses from oil and gas wells over the past two decades, including two recent sampling projects with water samples extracted from wells proximal to Prairie Lithium's area of exploration (Rostron et al., 2002; Jensen, 2012; Jensen and Rostron, 2017; 2018).

Brine waters sampled and analyzed by the Saskatchewan Geological Survey from reservoirs spanning the Birdbear, Duperow, Madison, Red River, Torquay (Three Forks), and Winnipegosis Formations yielded lithium concentrations ranging from 4 to 78 mg/L (Jensen and Rostron, 2017; 2018). The highest reported lithium concentrations were samples extracted from the Duperow (41-78 mg/L) and Winnipegosis (45-63 mg/L) Formations, both of which extend southwards into western North Dakota.

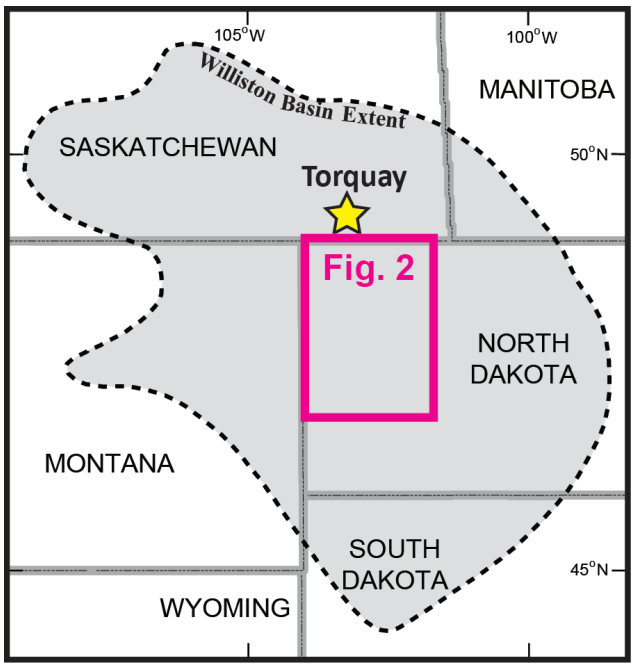

FIGURE 1.
Williston Basin extent map showing the approximate location of Torquay, Saskatchewan and the Prairie Lithium exploration area as well as the Figure 2 map area.

LITHIUM POTENTIAL IN NORTH DAKOTA

More than 3,000 water analyses from Madison Group reservoirs have been compiled within the North Dakota Oil and Gas Division database (NDOGD, 2018). Preliminary review of those 3,000+ analyses revealed 31 analyses that included lithium concentrations from a total of 24 wells (Table 1, fig. 2). The remaining ~99% of the water analyses did not reportedly test for lithium. While the reasoning for why these 31 water analyses included lithium is unknown, all 31 of these Madison analyses were completed within a limited, ~2 ½ year time window of April 1963 to August 1965 (Table 1).

The 31 Madison water samples were from 24 oil and gas wells distributed across six counties spanning western North Dakota, half (12) of the wells were from Burke County.

The reported lithium concentrations from the brine waters produced from Madison reservoirs ranged from 1 to 345 mg/L (Table 1). Three of the 4 samples with the highest reported lithium concentrations (>80 mg/L) cluster together in Burke County (fig. 2). The two highest reported lithium concentrations are from wells #3349 in Burke County (345 mg/L) from the Rival subinterval (upper Frobisher-Alida) and #3700 of Stark County (200 mg/L) from the Midale/Berentson subinterval(s) of the lower Ratcliffe Interval (fig. 3). These concentrations are several times higher than any of the analyses reviewed from southeastern Saskatchewan (Rostron et al., 2002; Jensen, 2012; Jensen and Rostron, 2017; 2018) as well as southwestern Manitoba (Nicolas, 2017), and therefore may represent future opportunities for solution mining of lithium from Madison brine waters in North Dakota.

All of the water analyses reviewed in this article are publicly available in the respective oil and well wells files through the North Dakota Industrial Commission. Additional water geochemistry data containing lithium concentrations of other, non-Madison stratigraphic units may also be available publicly for review. Lithium exploration and solution mining potential likely exists in the other, non-Madison stratigraphic units such as the Duperow and Winnipegosis Formations.

TABLE 1. General well information (well numbers and location) with Lithium (Li) concentrations and related information from Madison brine water analyses.

NDIC Well #	API Well Number	Location			Analysis Date	Test Interval (ft)		Li (mg/L)	NaCL (mg/L)
		Sec	Twp	Rng		Top	Bot		
2186	33013002250000	35	163	92	01-Nov-63	6,140	6,163	**10**	309041
2611	33053004510000	14	145	101	14-Sep-64	9,436	9,440	**24**	323652
3135	33013004770000	15	162	92	24-Apr-63	6,200		**164**	320735
3349	33013005240000	10	162	92	03-May-63	6,200		**85**	312996
3349	33013005240000	10	162	92	09-Jul-65	6,350	6,373	**345**	290920
3353	33061001710000	28	158	91	17-Apr-63	7,776	7,830	**1**	306531
3367	33013005320000	14	162	92	24-Apr-63	6,200		**164**	320735
3367	33013005320000	14	162	92	20-Jun-63	6,336	6,358	**4**	327051
3372	33013005330000	4	162	92	25-Jun-63	6,327	6,351	**5**	93821
3372	33013005330000	4	162	92	25-Jun-63	6,327	6,351	**20**	293549
3372	33013005330000	4	162	92	25-Jun-63	6,327	6,351	**20**	283774
3441	33023000790000	3	162	102	07-Nov-63	6,877	6,899	**10**	320822
3446	33013005560000	4	159	90	16-Nov-63	7,178	7,218	**8**	214257
3455	33013005580000	25	161	92	26-Dec-63	7,100	7,114	**1**	51992
3455	33013005580000	25	161	92	26-Dec-63	7,100	7,114	**4**	46705
3456	33023000800000	35	163	103	30-Nov-63	6,617	6,641	**20**	311286
3456	33023000800000	35	163	103	30-Nov-63	6,638	6,671	**20**	316151
3498	33013005700000	2	161	93	23-Feb-64	6,959	6,970	**4**	125601
3510	33013005740000	12	161	94	16-Mar-64	7,475	7,531	**10**	172302
3540	33061001730000	30	158	88	08-May-64	6,860	6,907	**10**	300360
3575	33061001740000	3	157	89	09-Jun-64	7,048	7,126	**10**	308312
3576	33105006480000	14	159	103	09-Jun-64	7,724	7,767	**10**	327356
3578	33013005870000	13	161	94	19-Jun-64	7,555	7,615	**10**	266534
3581	33061001750000	5	156	88	23-Jun-64	6,979	7,029	**10**	273590
3590	33013005910000	33	162	93	17-Jun-64	7,028	7,053	**10**	270108
3590	33013005910000	33	162	93	17-Jun-64	7,044	7,094	**10**	289805
3596	33023000830000	35	163	103	29-Jun-64	6,630	6,658	**10**	311533
3597	33023000840000	25	162	103	14-Jul-64	6,928	6,995	**10**	267764
3604	33013005950000	17	159	90	20-Jul-64	7,229	7,262	**10**	312682
3604	33013005950000	17	159	90	20-Jul-64	7,262	7,312	**10**	304068
3700	33089000170000	29	140	96	10-Nov-64	8,767	8,814	**200**	338449
3909	33023000900000	22	163	103	10-Aug-65	6,564	6,584	**4**	278785

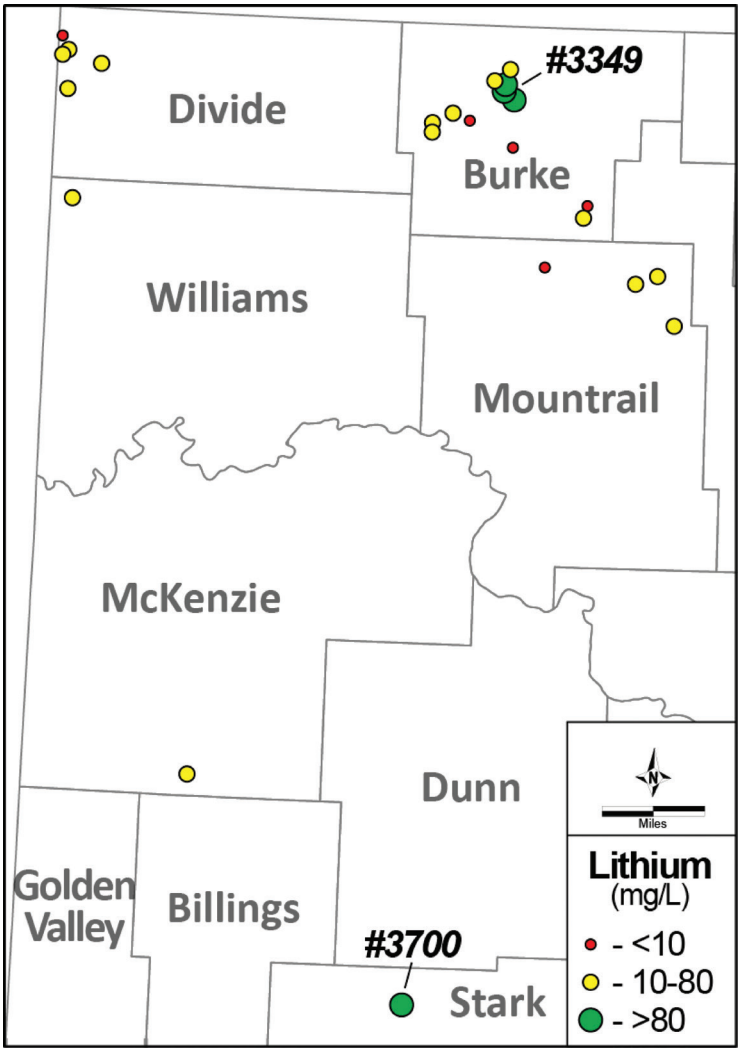

FIGURE 2.
County map of western North Dakota with the distribution of 24 wells with Li concentrations measured from brine waters collected from Mississippian Madison Group reservoirs. For wells that contain multiple (2-3) Madison water analyses with reported lithium concentrations, the maximum Li concentration is reflected by the bubble map.

REFERENCES:

Businesswire, 2021, Prairie Lithium Makes Big Discovery on the First Lithium Brine Well Ever Drilled in Canada: (originally posted November 9th, 2021 and retrieved June 3, 2022). https://www.businesswire.com/news/home/20211109005948/en

Jensen, G.K.S., 2012, Initial results of a brine sampling project: investigating the mineral potential of brines in southeastern Saskatchewan; in Summary of Investigations 2012, v. 1, Saskatchewan Geological Survey, Sask. Ministry of Economy, Misc. Rep. 2012-4. 1, Paper A-8, 8 p.

Jensen, G.K.S. and Rostron, B.J., 2017, Investigating the mineral potential of brines in Saskatchewan: results from the 2017 field season for the brine sampling project; in Summary of Investigations 2017, v. 1, Saskatchewan Geological Survey, Saskatchewan Ministry of the Economy, Miscellaneous Report 2017-4.1, Paper A-1, 6p.

Jensen, G.K.S., and Rostron, B.J., 2018, Investigating the mineral potential of brines in Saskatchewan: new results from the brine sampling project for 2018; in Summary of Investigations 2018, v. 1, Saskatchewan Geological Survey, Saskatchewan Ministry of Energy and Resources, Miscellaneous Report 2018-4.1, Paper A-5, 8p.

Nicolas, M.P.B., 2017, Preliminary investigation of the potential for lithium in groundwater in sedimentary rocks in southwestern Manitoba; in Report of Activities 2017, Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey, p. 183–190.

North Dakota Oil and Gas Division (NDOGD), 2018, North Dakota water analysis database: Madison Group (retrieved December 15th, 2018).

Rostron, B.J., Kelley, L.I., Kreis, L.K., and Holmden, C., 2002, Economic potential of formation brines: Interim results from the Saskatchewan brine sampling program; in Summary of Investigations 2002, v. 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2002-4.2, CD-ROM, Paper C-1, 29p.

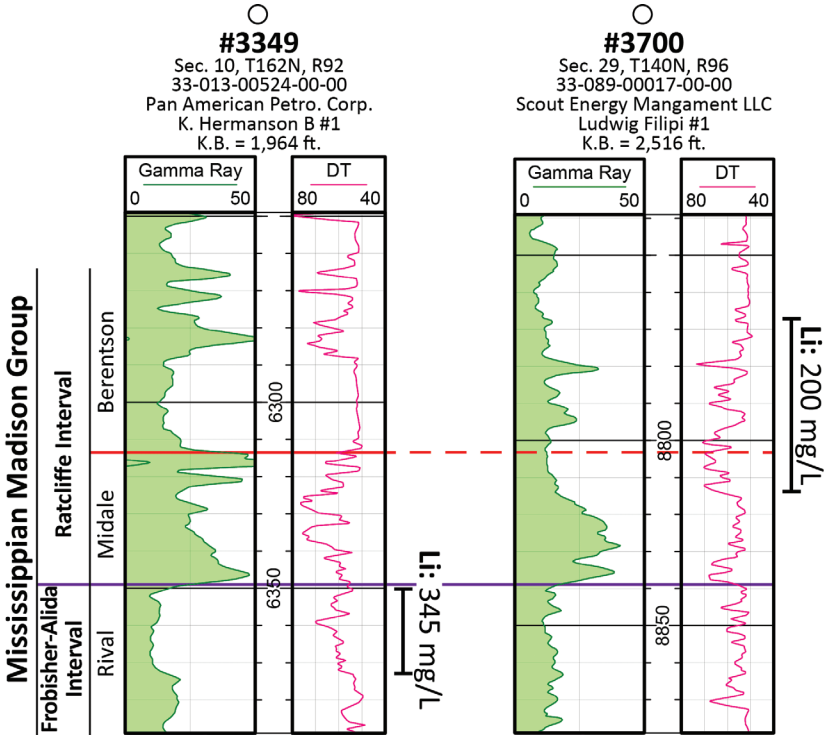

FIGURE 3.
Stratigraphic cross sections of wells #3349 and #3700 showing the reported water sample interval along with the reported lithium concentrations. Well locations are indicated on the Figure 2 map.