GS2025-13

Pilot study of lithium concentrations in mudstone intervals from the Manitoba Potash Corporation core at 3-29-20-29W1, southwestern Manitoba (part of NTS 62K11)

by P.E. Fraino

In Brief:

- Nine mudstone intervals within the Duperow Formation were sampled for Lithium concentrations
- Variable but elevated lithium concentrations of 15.6 – 100 ppm (four-acid digestion) and 17 – 112 ppm (sodium peroxide fusion) were reported
- Geochemistry from core indicate mudstone intervals may be contributors to lithium for basin brines

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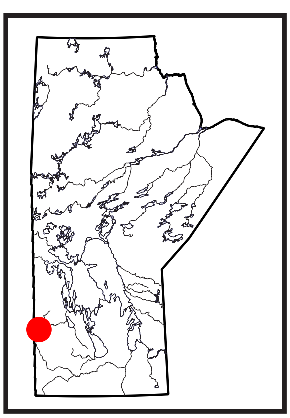

Summary

The first lithium concentration data from mudstone intervals in the Upper Devonian Duperow Formation in southwestern Manitoba were obtained from powdered core samples collected from the Manitoba Potash Corporation (MPC) core drilled at L.S. 3, Sec. 29, Twp. 20, Rge. 29, W 1st Mer. (abbreviated 3-29-20-29W1). Lithium concentrations ranged from 15.6 to 112 ppm depending on the digestion method used (four acid and sodium peroxide fusion). Elevated lithium concentrations were identified in mudstones across multiple members of the Duperow Formation, including the lower, middle and upper Wymark Member and Seward Member. These preliminary results suggest that lithium enrichment in mudstones of the Duperow Formation are not restricted to a single stratigraphic interval and that they may contribute to lithium-bearing brines throughout the formation in southwestern Manitoba.

Introduction

Deep formational brines in sedimentary basins are increasingly drawing attention due to their high concentrations of dissolved metals, particularly lithium (Li; Dugamin et al., 2023). A focus of exploration has been directed toward these brines as potential unconventional sources of Li, a crucial critical element for electric mobility, stationary energy storage, consumer electronics and industrial applications (Bibienne et al., 2020; Dugamin et al., 2021, 2023; Butler et al., 2025). Although elevated Li concentrations in formational waters are now widely recognized across various basins and formations in the world (Dugamin et al., 2023), the origin of the Li-enriched fluids remains poorly understood. One of the main contributors to Li-enrichment is attributed to mudstone deposits composed of clay minerals, whereby Li can be stored through structural substitution or surface adsorption that is then released during long-term diagenetic processes and water–rock interactions with formation waters within the pore space (Kadi et al., 2023; Butler et al., 2025; Lazowski et al., 2025).

In the Williston Basin, the Upper Devonian Duperow Formation presents a compelling opportunity to evaluate this Li source potential. The Duperow Formation is predominantly a mixed carbonate–evaporite succession, consisting of interbedded limestone, dolostone and anhydrite, deposited in restricted marine to sabkha environments (Cen, 2009; Eggie et al., 2012b; Bates et al., 2016; Nicolas and Chow, 2018). Although less abundant, mudstone intervals are present in the Duperow Formation and can be correlated basin wide for hundreds of kilometres in Manitoba, Saskatchewan and North Dakota (Wilson and Pilatzke, 1987; Cen, 2009; Bates, 2016). Previous studies from Saskatchewan have reported elevated Li concentrations ranging from 1 to 120 ppm in core from the Duperow Formation, with the mudstone/dolomudstone intervals having higher Li concentrations (30 to 120 ppm) relative to evaporite and carbonate-rich lithofacies (Jensen et al., 2020; Jensen and Kohlruss, 2023). Therefore, these mudstone intervals are hypothesized to be an important intraformational Li source for the Duperow Formation in the Williston Basin (Jensen and Kohlruss, 2023; Bishop and Robbins, 2025). As a result, the Li concentrations of nine mudstone intervals in the most complete core of the Duperow Formation in southwestern Manitoba, the MPC core located in 3-29-20-29W1 (oil and gas well licence 3884, Manitoba Business, Mining, Trade and Job Creation, Winnipeg; Figure GS2025-13-1), were determined. The objectives of this pilot study were to

1) assess the Li concentration using two different analytical methods; and
2) investigate whether the Li concentrations in the Duperow Formation vary stratigraphically.

These objectives form the basis of a preliminary evaluation of the mudstone intervals to determine if they are one of the primary contributors to Li enrichment in brines in southwestern Manitoba.

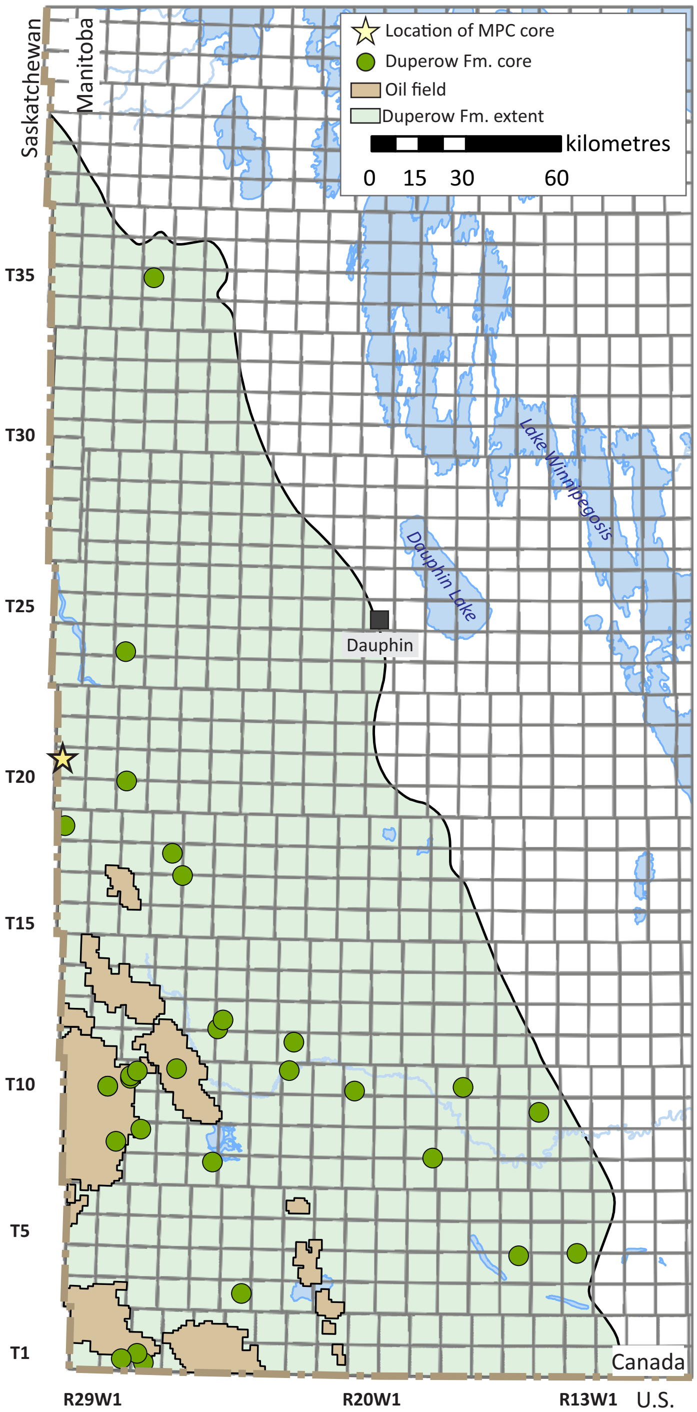

***Figure GS2025-13-1:** Study area in southwestern Manitoba with the Duperow Formation core locations. Yellow star denotes the location of the Manitoba Potash Corporation (MPC) core.*

Duperow Formation stratigraphy in the MPC core

The Upper Devonian Duperow Formation was deposited within the intracratonic Elk Point Basin of the Western Canada Sedimentary Basin (Nicolas and Barchyn, 2008). In southwestern Manitoba, the Duperow Formation records deposition in a shallow-water, restricted, back-reef setting on the eastern platform, sheltered from open marine circulation by the Leduc reef complex in Alberta (Eggie et al., 2012a; Bates et al., 2016). These conditions led to the development of laterally extensive, carbonate–evaporite cycles, recognized across southern Saskatchewan, Manitoba, Montana and North Dakota (Wilson, 1967; Wilson and Pilatzke, 1987).

In the MPC core, the Duperow Formation is fully preserved, spanning 153.36 m in thickness (Figure GS2025-13-2). The Duperow Formation is subdivided into the Saskatoon, Wymark and Seward members. The Saskatoon Member (15.26 m thick) consists of burrow and mottled dolomudstone, fossiliferous wackestone to framestone, and laminated anhydrite beds, representing deposition in a subtidal, slightly restricted marine setting. The overlying Wymark Member is the thickest (97.78 m) and is informally subdivided into the lower, middle and upper units. The Wymark Member consists of interbedded lime mudstone, floatstone, laminated dolostone and massive anhydrite organized into metre-scale, shallowing-upward cycles reflecting transitions from subtidal to supratidal environments. The uppermost Seward Member (40.32 m thick) includes the regionally mappable Seward shale and consists of laminated and mottled dolomudstone with fossiliferous wackestone interbeds (Nicolas and Chow, 2018).

The members and informal unit (lower, middle and upper Wymark Member) subdivisions of the Duperow Formation can be correlated across the basin due to the presence of marker beds that typically consist of a fissile mudstone interval, providing a consistent petrophysical well log pick for regional correlation (Figure GS2025-13-2; Bates, 2016). In addition to these key marker beds, several other mudstone intervals are observed within the lower, middle and upper units in the Wymark Member, as well as within the Seward Member. However, the Saskatoon Member within the MPC core does not contain argillaceous, siliciclastic mudstone intervals, and consequently this member was not sampled.

Geochemical methodology and dataset

Nine mudstone samples from the MPC core were selected for geochemical analysis to assess Li concentrations and associated major-, minor- and trace-element trends. Approximately 8 g of each sample were pulverized to a grain size of <63 µm to ensure analytical homogeneity and minimize grain-size–related biases during digestion. Two digestion methods were employed to compare Li concentrations, four acid and sodium peroxide fusion.

Samples were submitted to Activation Laboratories Ltd. (Ancaster, Ontario) to be analyzed. The four-acid digestion consists of dissolving the powdered material using hydrofluoric acid, nitric acid, perchloric acid and hydrochloric acid, followed by analysis using inductively coupled plasma–mass spectrometry (ICP-MS) and inductively coupled plasma–optical emission spectrometry (ICP-OES). This digestion approach yields near-total elemental recovery for most mineral matrices, although some

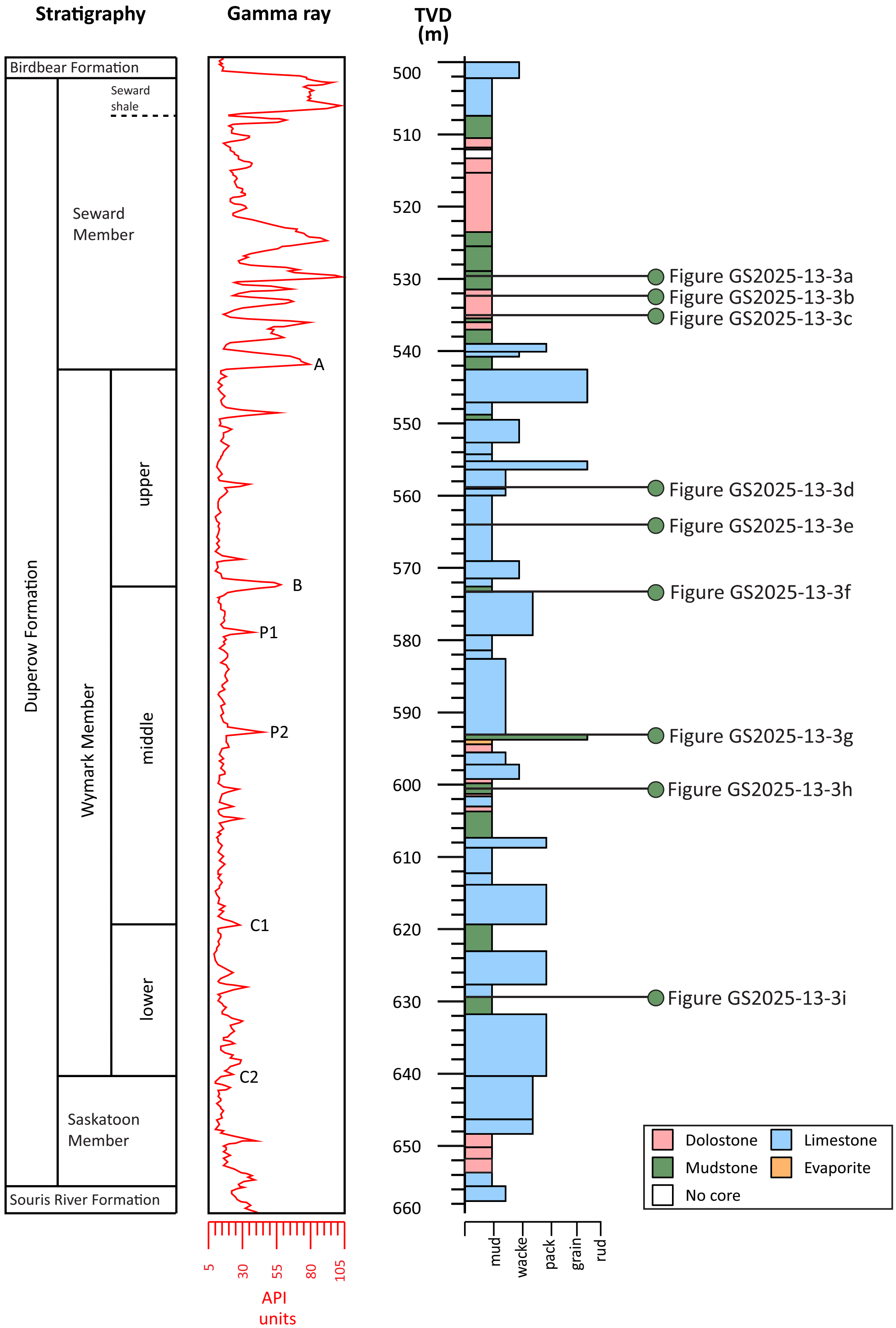

Figure GS2025-13-2: *Core log for the Duperow Formation in the Manitoba Potash Corporation (MPC) core, drilled at L.S. 3, Sec. 29, Twp. 20, Rge. 29, W 1st Mer., showing stratigraphy, gamma-ray downhole wireline geophysics and lithology; prominent basin-wide marker beds (A, B, P1, P2, C1 and C2) are labelled on the gamma-ray track (modified from Nicolas and Chow, 2018). Sample locations for core shown in Figure GS2025-13-3 are labelled in the stratigraphic column. Abbreviations: grain, grainstone; mud, mudstone; pack, packstone; rud, rudstone; TVD, true vertical depth; wacke, wackestone.*

highly refractory phases may remain partially undissolved. The sodium peroxide fusion method fully dissolves all mineral phases, including refractory components. Subsequent analysis by ICP-MS allows for accurate determination of trace-element concentrations, including Li. To verify analytical precision and accuracy, the certified reference material OREAS 750, a Li-bearing pegmatite ore, was included as an internal standard. Recovery values from this reference material were consistent with certified values, confirming the reliability of Li measurements obtained from both analytical methods.

The entirety of the geochemical data is available in MGS Data Repository Item DRI2025023 (Fraino, 2025[1]).

Mudstone interval characteristics

The mudstone intervals observed in the MPC core are typically light grey to olive green in colour and are characterized on geophysical logs by high gamma-ray signatures (Figures GS2025-13-2, -3). Individual mudstone beds range in thickness from approximately 1 to 50 cm. In hand specimen, these mudstones are generally fissile and fragmented (Figure GS2025-13-3c, e, i). Intervals commonly appear as massive with subtle mottling or evidence of low-intensity bioturbation and lack any sedimentary structures (Figure GS2025-13-3f). Rounded, dark grey anhydrite nodules, typically less than 1 mm in diameter, are common throughout several of these intervals (Figure GS2025-13-3a, b, d, i). In some instances, mudstone intervals consist of angular to semirounded clasts within a mudstone or dolomudstone matrix. These clasts are sand to pebble sized and consist primarily of massive dolomudstone to mudstone, some of which preserve primary planar laminations (Figure GS2025-13-3).

Mudstone beds consistently overlie laminated anhydrite–dolostone or massive anhydrite beds and, in turn, are overlain by fossiliferous wackestone or nodular calcareous mudstone (Bates et al., 2016).

Lithium concentrations from mudstone intervals

Lithium concentrations in the nine mudstone samples from the MPC core were determined to range from 15.6 to 100 ppm by four-acid digestion, and from 17 to 112 ppm by sodium peroxide fusion. These results indicate that Li enrichment was observed across all sampled intervals, with values varying by stratigraphic position and lithological composition.

At 569.7 m true vertical depth (TVD), the highest Li concentrations were recorded, with values of 100 ppm (four-acid) and 112 ppm (sodium peroxide fusion). Reported as '(four-acid digestion/sodium peroxide fusion digestion)', other samples with notable elevated Li concentration values include 559.5 m TVD (50.9/60 ppm), 534.4 m TVD (49.7/58 ppm), 594.4 m TVD (44.4/49 ppm), 574.0 m TVD (41.7/51 ppm) and 629.3 m TVD (28.1/32 ppm). Lower concentrations were observed in samples from 532.47 m TVD (15.6/17 ppm), 604.3 m TVD (21.6/25 ppm) and 529.6 m TVD (25.7/26 ppm; Figure GS2025-13-3). Although Li concentrations measured by four-acid and sodium peroxide fusion digestion methods show similar trends across samples, the sodium peroxide fusion method consistently yielded higher values. Notably, the difference in Li concentration between the two methods increases with overall Li content. In samples with higher Li concentrations, the discrepancy between the two digestion methods is more pronounced (Figure GS2025-13-3a–i), suggesting that the sodium peroxide fusion method more effectively captures Li bound in resistant mineral phases. Furthermore, the intervals with the highest Li concentrations also exhibit elevated concentrations of SiO_2, K_2O and Al_2O_3 (Fraino, 2025). This is consistent with the presence of clay minerals, which are known to host Li via structural substitution and surface adsorption (Dugamin et al., 2023), although further analysis needs to be conducted to understand the mineralogy of these intervals.

Lithium concentration comparison to Saskatchewan

Preliminary Li concentration values from the MPC core in southwestern Manitoba are broadly consistent with those reported from equivalent stratigraphic intervals in southeastern Saskatchewan. On the Saskatchewan side, multiple stratigraphic horizons within the Duperow Formation have been shown to host elevated Li in both brines and analyzed core samples. Core analyses have reported Li concentrations of up to 120 ppm in mudstone intervals, whereas produced water analyses have documented values from 25 to 259 mg/L, with a median Li concentration of 115 mg/L (Jensen and Rostron, 2018; Jensen, 2020; Jensen et al., 2020; Jensen and Kohlruss, 2023; Bishop and Robbins, 2025). These elevated concentrations occur in several discrete intervals, supporting the interpretation that Li enrichment is stratigraphically widespread across the formation (Rostron et al., 2023). The Manitoba core results extend these findings eastward into previously unsampled parts of the basin. Elevated Li concentrations were recorded in mudstone intervals from core throughout the Duperow Formation, including the lower, middle and upper Wymark Member and the Seward Member. This suggests that Li-bearing lithofacies may be continuous across provinces. These results provide the first core-based geochemical evidence from Manitoba that the Duperow Formation may host Li-enriched brines comparable in character and distribution to those found in Saskatchewan.

Future work

Based on the results from this pilot study of mudstone intervals from the MPC core, future work will include the following expanded objectives:

[1] MGS Data Repository Item DRI2025023, containing the data or other information sources used to compile this report, is available online to download free of charge at https://manitoba.ca/iem/info/library/downloads/index.html, or on request from minesinfo@gov.mb.ca, or by contacting the Resource Centre, Manitoba Business, Mining, Trade, and Job Creation, 360-1395 Ellice Avenue, Winnipeg, Manitoba R3G 3P2, Canada.

Figure GS2025-13-3: *Photographs of the nine mudstone sampled sections in the Manitoba Potash Corporation (MPC) 3-29-20-29W1 core:* ***a–c)*** *Seward Member;* ***d–e)*** *upper Wymark Member;* ***f–h)*** *middle Wymark Member;* ***i)*** *lower Wymark Member. Note that the Saskatoon Member within the MPC core does not have any argillaceous, siliciclastic mudstone intervals, thus it was not sampled. See Figure GS2025-13-2 for sample locations along the core. Lithium concentration from each sample is shown in blue and green for four-acid and sodium peroxide fusion digestion methods, respectively. Samples are presented in stratigraphic ascending order (true vertical depth is shown in black).*

1) targeted sampling of mudstone (calcareous, dolomitic and clastic) intervals from additional Duperow Formation cores across southwestern Manitoba to assess lateral variability
3) assessment of clay mineralogy using X-ray diffraction (XRD) to evaluate the relationship between specific clay types, bulk mineralogy and Li concentrations derived from trace-element analysis
4) where appropriate, use of Raman spectroscopy to complement XRD by confirming Li-hosting mineral phases

Future work will also explore the relationship between Li and associated major, minor, and trace elements reported in Fraino (2025). Although this report only focused on mudstone intervals, continuous sampling of the MPC core conducted in the summer of 2025 also included other lithofacies. These samples will be analyzed for whole-rock lithogeochemistry to determine the broader distribution of Li across different lithofacies. Having this information will help constrain the temporal variability of Li enrichment within the Duperow Formation and support the assessment of its potential as a Li-bearing brine system in southwestern Manitoba.

Economic considerations

With global demand for Li continuing to rise due to its essential role in battery technologies, sedimentary basin–hosted brines are increasingly being recognized as economically viable sources of Li (Dugamin et al., 2021). Although no analyses of Li concentrations in water presently exist for the Duperow Formation in southwestern Manitoba, Li concentrations from core samples provide an indirect indication of the potential for Li-bearing brines within the formation. The first set of Li concentrations from core is presented in this report and suggests that mudstone intervals within the Duperow Formation contain elevated Li concentrations. These preliminary results highlight the potential role of fine-grained lithologies as a contributor to intraformational Li enrichment in the Duperow Formation in southwestern Manitoba.

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