NORTHEASTERN BRITISH COLUMBIA LITHIUM FORMATION-WATER DATABASE PROJECT





Lithium has garnered significant interest in recent years as an essential constituent in lithium-ion batteries—a necessary component in the plan to decarbonize energy infrastructure in the coming decades. Having been deemed a critical mineral necessary for the future clean energy economy (Natural Resources Canada, 2021), it has grown increasingly important to catalogue prospective lithium resources and explore possible synergies with existing oil and gas operations to position Canada for the forthcoming electrified economy Formation waters collected from oil and gas wells have previously only been data remaining quite limited in the public domain (BC; Eccles and Jean, 2010) This compares to the more than 1600 and 200 brine analyses in Alberta and Saskatchewan, respectively (*Figure 1*; Eccles and Jean, 2010; Jensen, 2012, 2016; Jensen and Rostron, 2017). This data scarcity in the lithium brine dataset in BC requires additional sampling and analysis to improve the understanding of these prospective resources in the province and the geological mechanisms driving such enrichments.

This study, which is a joint venture between Canadian Discovery Ltd. (CDL) and Matrix Solutions Inc. (Matrix), aims to deliver a preliminary inventory dataset of lithium and other dissolved-metal brine data in northeastern BC through a large-scale sampling program. The study which commenced in the fall of 2021 aims to collect and analyse formation water samples from approximately 300 active oil and gas wells throughout northeastern BC (NEBC) (Figure 2). To date, various challenges have reduced this number to 200 active wells as of the end of 2022 and provide important learnings for future initiatives.

Defining current lithium concentrations and quantities in subsurface brines enables the evaluation of novel resource potential, which will use existing infrastructure and expertise in current operations, while supporting job creation and development in an emerging industry.

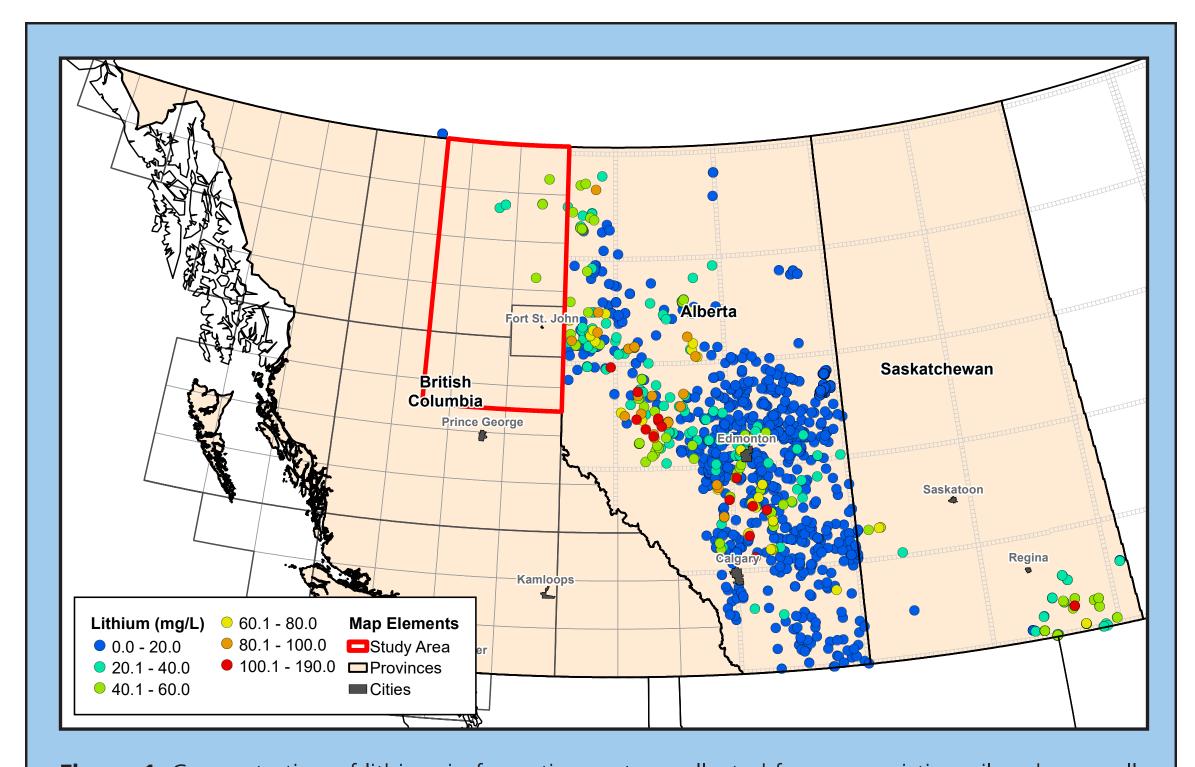


Figure 1. Concentration of lithium in formation waters collected from pre-existing oil and gas wells nroughout the Western Canada Sedimentary Basin. Currently, only a handful of lithium data points exist in the study area in northeastern British Columbia (outlined in red; data from Eccles and Jean 2010), as compared to more than 1600 in Alberta and Saskatchewan (data from Eccles and Jean, 2010; Jensen, 2012, 2016; Jensen and Rostron, 2017).









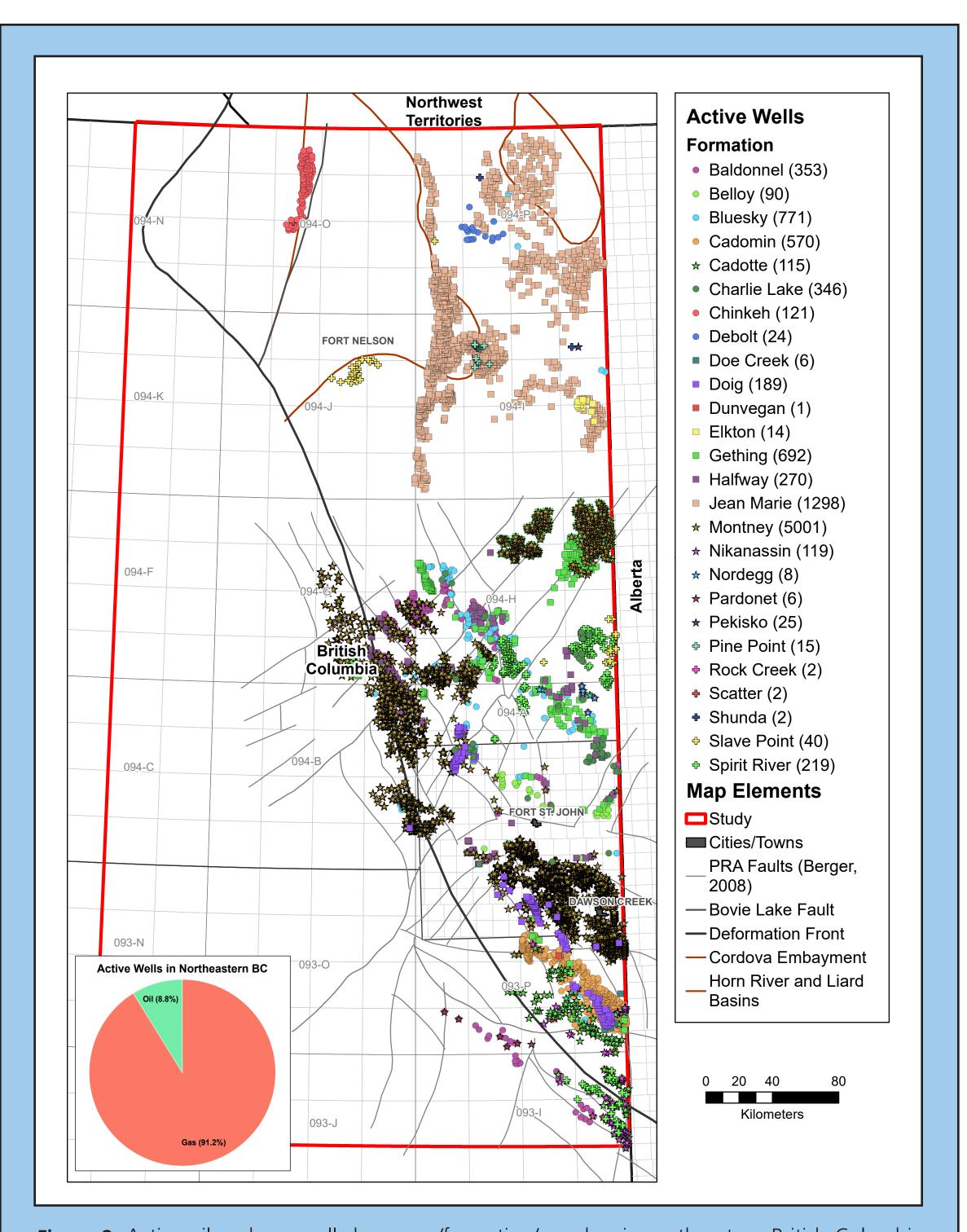


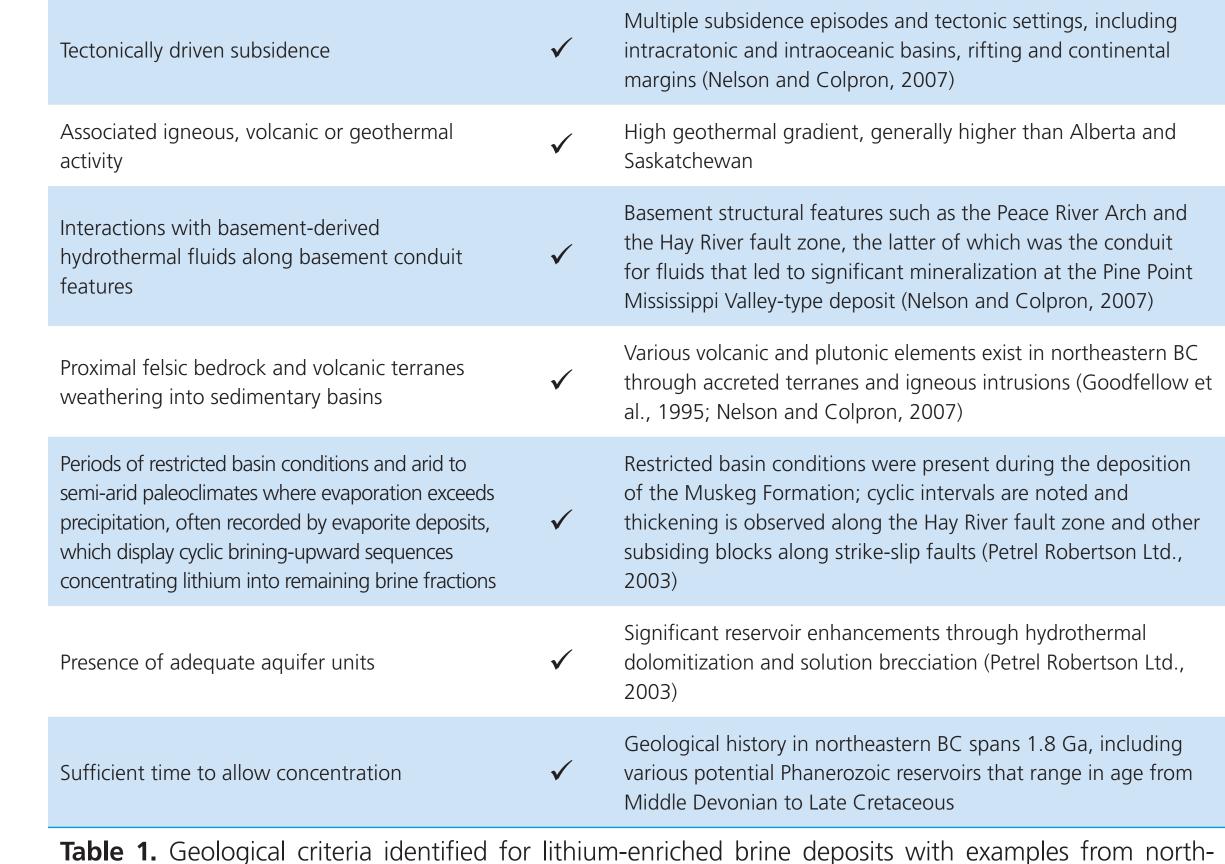
Figure 2. Active oil and gas wells by group/formation/member in northeastern British Columbia (BC; well data supplied by geoLOGIC systems ltd. © 2021). Inset shows breakdown between oil and gas producers, this highlights the dominance of gas wells within the study area.

Examples identified in northeastern BC

potential lithium enrichment

(modified from Bradley et al., 2013)

eastern British Columbia (BC).



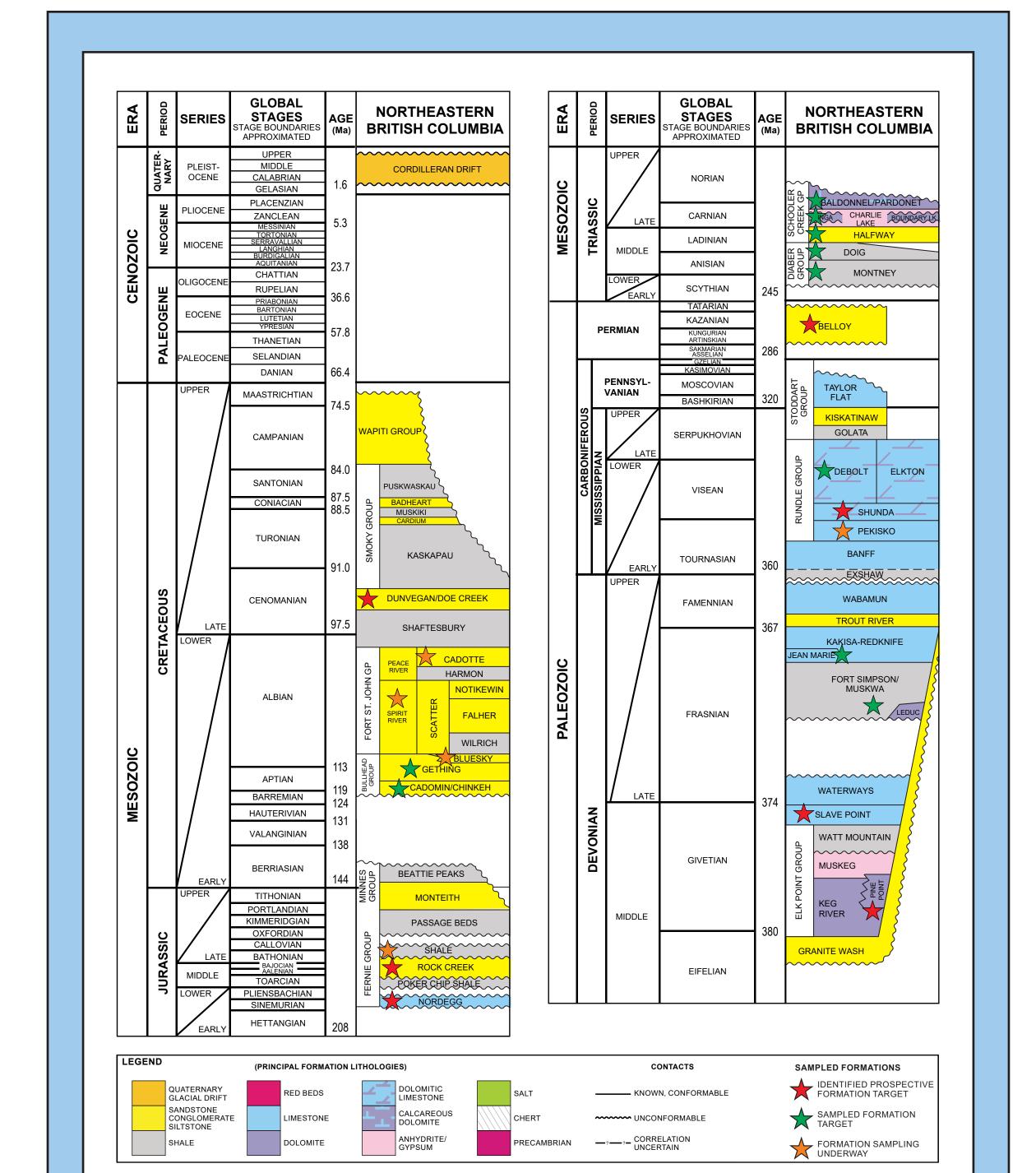


Figure 3. Stratigraphy of northeastern British Columbia (modified and reproduced with permission from Core Laboratories Petroleum Services, 2017). Targeted groups/formations/members are indicated

Background

Lithium occurs naturally in a variety of rock types, brines and groundwater; however, most concentrations are not economic. The content of lithium in the Earth's upper crust has been estimated to be between 20 and 70 ppm by weight (Kamienski et al., 2004). Lithium enrichment occurs in felsic continental crust, with particular appreciations in highly differentiated granites and pegmatites. Lithium brine deposits by contrast are saline groundwater accumulations that are enriched in dissolved lithium, often orders of magnitude higher than background oceanic concentrations of approximately 0.1 ppm. Globally these are present in a variety of settings, such as the Andean salar brines in South America, and various formation waters (wastewater) produced during oil and gas or geothermal

The mechanism of lithium enrichment in brines is not fully understood, but a variety of sources and processes for enrichment have been identified and proposed. These are derived in part from the physical characteristics of lithium, which is exceptionally mobile and has a strong affinity to remain in solution in either magmatic or brine systems during fluid/rock interactions (Teng et al., 2004). Geological criteria have been identified for various lithium-enriched brine deposits and these criteria are evident in NEBC, as outlined in *Table 1*. These criteria were considered to inform stratigraphic targets identified for sampling in NEBC (Figure 3). Figure 4 illustrates some of the potential geological criteria for mobilization of lithium in a Devonian carbonate reservoir in western Alberta which shares similar geological elements as those in NEBC.

Project Design and Progress

This project represents the first regional brine sampling program of its kind in NEBC and is developed in a three-phased approach slated to take place over approximately 24 months.

The three project phases include:

- Design and scoping (Completed: Q2 2022)
- a. project co-ordination, logistics and safety standards
- b. prospective formation review and high-level scoping of wells to be sampled
- b. operator engagement, access negotiations and field logistics
- 2. Field sampling and data analysis (Target end date: end of Q2 2023)
- a. field sampling program b. laboratory analysis
- c. data processing, quality assurance—quality control (QA-QC) and analysis

3. Geological interpretation and lithium potential (final report) (Target end date: TBD)

- a. incorporate data into the broader geological and hydrogeological framework
- b. advance the understanding of geological controls and natural variability of lithium in formation waters
- c. preliminary assessment of aquifer volumes, deliverability and economic viability of lithium extraction

Metadata Collection

Metadata parameters are considered those which are not explicitly analyzed but collected prior to and as part of the program activities. These parameters are organized into three main categories corresponding to their order of collection.

- . Pre-field metadata
- 2. Field collected metadata
- 3. Post-field quality check and assurance data
- The full list of metadata parameters is displayed in *Table 2*.

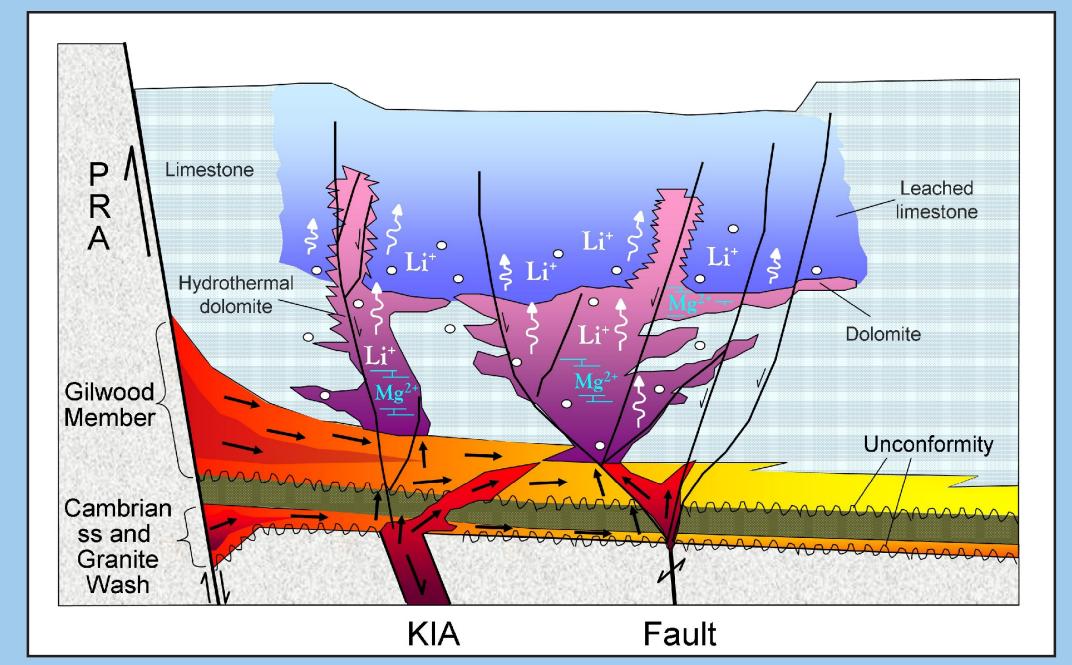


Figure 4. Schematic diagram illustrating various potential mechanisms for lithium enrichment in formation waters (Eccles and Berhane, 2011). Geological criteria favourable for enrichment include: associated igneous, volcanic or geothermal activity; interactions with basement derived hydrothermal fluids; proximity to felsic bedrock and volcanic terranes; periods of restricted basin conditions and presence of evaporite deposits; presence of adequate aquifer units.

Conclusion & Future Work

S coordinates northin

Formation sampled (formation name)

Formation member name (if available

GeoScout downhole temperatue (°C

Well completion depth top (elev masl)

Well completion depth base (elev masl)

Water Cut (percentage if known ex: 75%)

Collecting operator: last name, first name

Sample ID(s) (Pre-populated; coincides with COC)

Infrastructure type sampled (ex: separator, wellhead ect.)

Degree of emulsification (appx. Percentage ex: 10%)

Observations about sample when analyzed, if applicable

22 formations considered prospective, 19 are slated to be sampled

Additional prospective units may be sampled depending on timing

• 74 samples collected and analyzed as of Q4 2022 (14 different

• Figure 5 illustrates the approximate sample areas as of Q4 2022

Higher concentration samples are deemed to be within the range

Many of the elevated lithium concentrations encountered differ in

character and distribution than other lithium enriched brines in the

for Direct Lithium Extraction (DLE technologies (Grant, 2022)

Infrastructure additional comment (single or multi-well, in test condition and

Description of sample - clear/cloudy, colour, emulsion, product, smell, gassy, turbid, etc.

(1) Matrix collected, (2) operator collected + handoff, (3) operator collected and shipped

Pressure of producing well?

Operator Company

Collection date, time

COC number

Lab arrival date & time

Table 2. Metadata collection parameters for sampling program.

encountered during the sampling program

mechanisms in this part of the basin.

Collection and Transit time

by conclusion of project

(5 additional formations)

and operator agreements

formations/members)

being sampled

だせる Transmittal Details

Number of sample bottles

Confirm if sample is sour (Y/N)

Field note / additional comments

Date sample processed and analyzed

Preliminary Sampling Results and Outcomes

100+ samples to be collected and analyzed in Q2 2023

Timeline has been extended to accommodate for challenges

Well type comment: Fracked well, flowback or other condition of produced water

Most recent well intervention type and date - workover, frac, etc.

Certainty of singular prod zone (ranked: 1-low to 10-high)

Geological age (eg. Devonian)

Production zone, if known

Well type: Oil / Gas

Operator company

Producing field name

Characterizing the formation water chemistry in NEBC is an important first

- Inform regulatory policy considerations,
- De-risk early exploration activities to incent investment and development,
- Support academic advancement of knowledge on resource prospects such as geothermal and dissolved mineral production, particularly for critical minerals/metals.

Sub-surface brine resource exploration is accelerating in North America as the demand outlook for critical minerals points to shortfalls before the end of the decade. Currently a window of opportunity exists to evaluate and identify the potential to develop these new resources. The fluid database from this project will assist in these activities and help support the development of a broader critical minerals/metals industry in British Columbia, and Canada. The fluid database will be accompanied by a final report that interprets and maps the final outcomes of the project for the public domain.

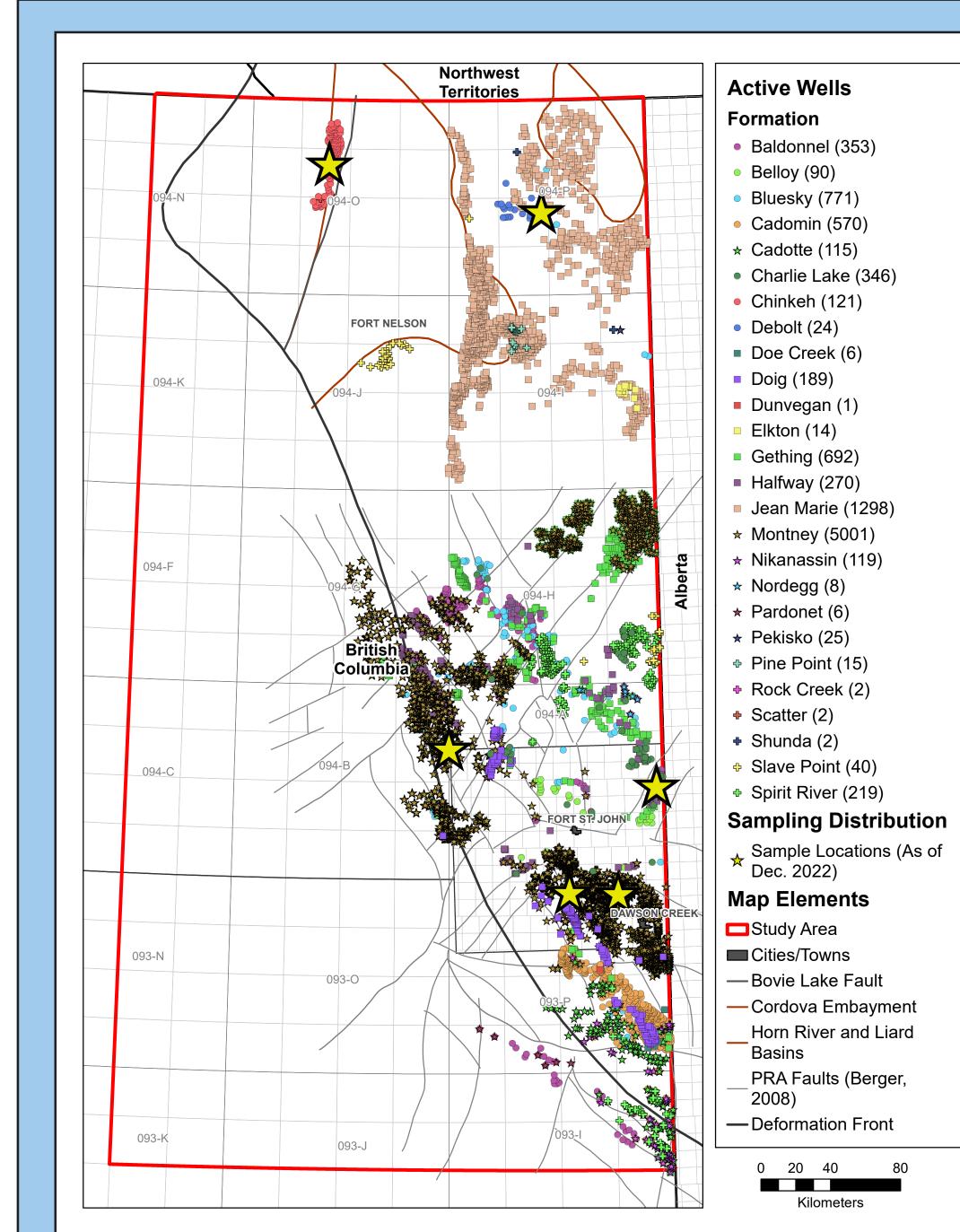
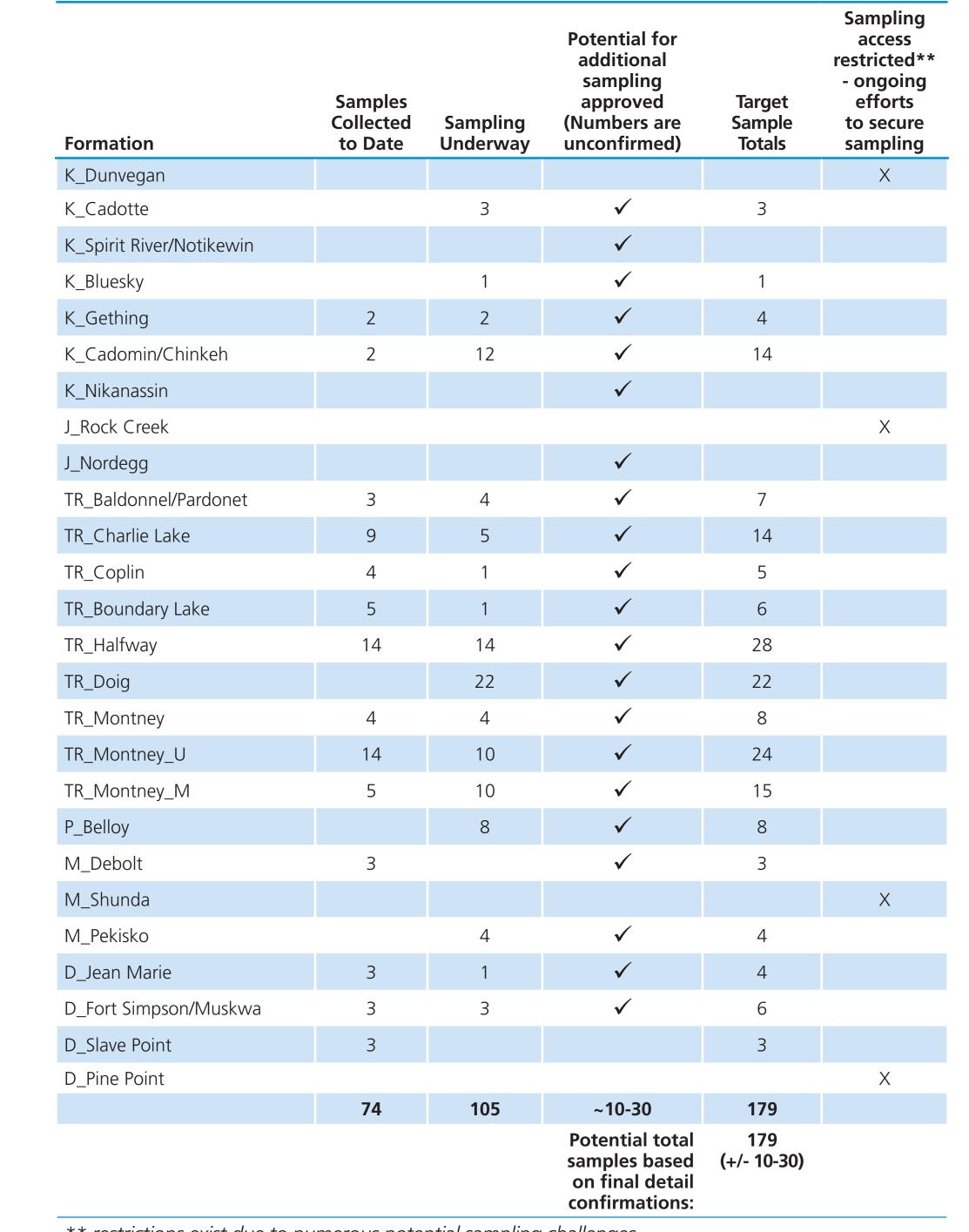


Figure 5. Active oil and gas wells by group/formation/member in northeastern British Columbia western Canada basin and may indicate a deviation in enrichment (BC; well data supplied by geoLOGIC systems Itd. @2021). The yellow stars represent the approximate location of sampling programs completed in 2022.



** restrictions exist due to numerous potential sampling challenges including operator well availability, operator capacity, infrastructure configurations and

Table 3. Sampling progress by formation as of the end of 2022.

Acknowledgements

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