# Recovering Magnesium Via Recycling Albertan Fracking Water

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## Summary

In Alberta, toxic but mineral-rich flowback brines are rarely-recycled waste byproducts of hydraulic fracturing operations. Critical minerals present in the brines are essential to fulfill critical mineral value chain development and climate change goals. We estimate critical mineral resources contained within Albertan flowback brines and propose a novel carbon-neutral process to recover magnesium chloride, the most abundant critical mineral within these brines.

We assess the potential impact of this recovery process on development goals with respect to environmental, Indigenous and economic perspectives in Fox Creek, AB, showing that the area can fulfill up to 6% of Canadian magnesium chloride demand. We observe that current policy discourages water recycling, forming economic barriers to implementing the recovery process.

Our results demonstrate how Albertan fracking water, in meaningful partnership with Indigenous communities, can be feasibly recycled to recover critical magnesium in an environmentally and socioeconomically conscious manner while helping fulfill development goals.

## Introduction

The objectives of this study are to determine the quantity of critical magnesium resources within flowback brines, propose a method for their recovery, and assess the potential impacts of their recovery with respect to existing policy goals (Figure 2). We examine the potential impacts of recovering magnesium from flowback brines in the Fox Creek-Alexander First Nation area, AB (Figure 1) to determine if doing so aligns with Alberta's and Canada's water management, low-carbon development, critical mineral value chain and reconciliation goals.

Flowback brines are a waste byproduct generated from the use of hydraulic fracturing to enhance gas well productivity. Most water used in hydraulic fracturing in Alberta is sourced from non-recycled sources and flowback brines are generally permanently disposed of via re-injection into wells. Magnesium has no Canadian production, highly carbon-intensive foreign production, and is the major critical element present in flowback brines. Magnesium content in flowback brines can exceed that of naturally-occurring brines, making magnesium an attractive target for recovery.

The usage of water in hydraulic fracturing increases stress on local water supplies and has the potential to disrupt traditional and contemporary Indigenous land use. We examine the Fox Creek-Alexander First Nation area in Alberta (Figure 1). There has been increasing oil and gas activity since 2011 in this region which accompanied a precipitous decline in farming activities (Alberta n.d.), increased $CO_2$ emissions (Alberta n.d.), and frequent earthquakes (Schultz et al 2018). As the area's average annual water flow volume has decreased (Environment Canada n.d.), hydraulic fracturing water consumption has increased with a majority of sustainable groundwater yield allocated to energy companies in some watersheds (LeMay 2017). There is limited capacity for Indigenous communities to participate in water management issues surrounding hydraulic fracturing given current provincial policies and guidelines.

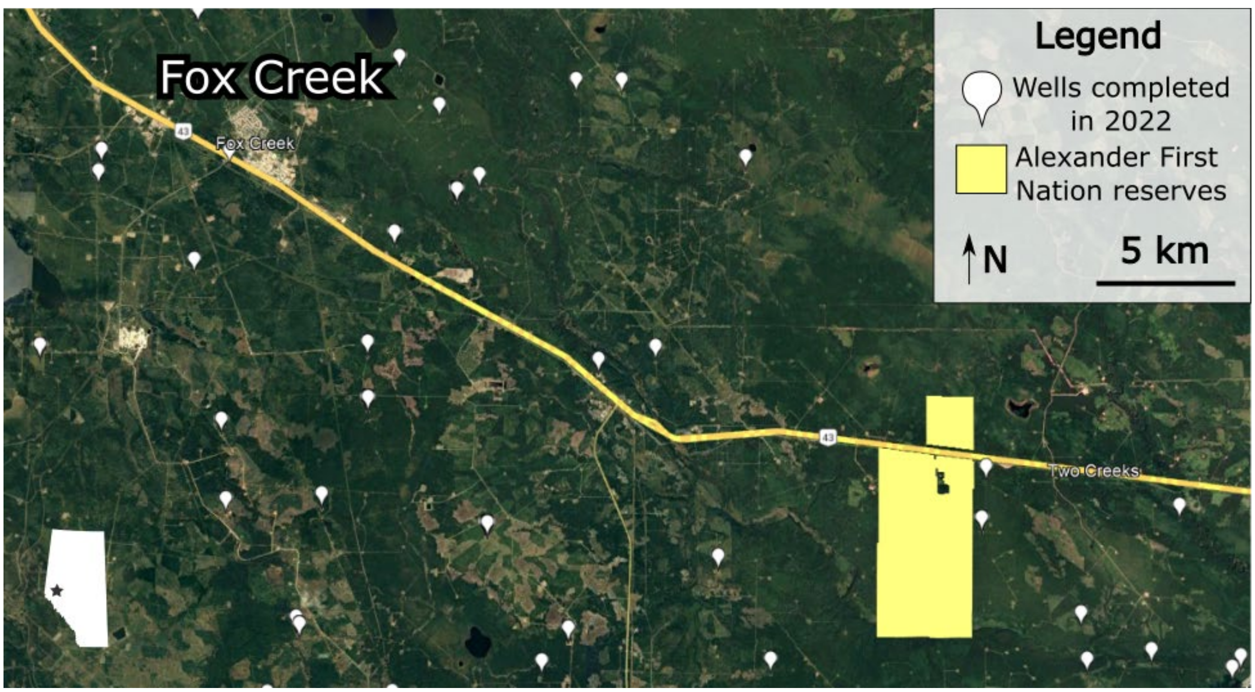

Figure 1: Map of the Fox Creek-Alexander First Nation area showing 2022 well activity in relation to both communities. Inset map depicts location within Alberta. (basemap source: Google Earth)

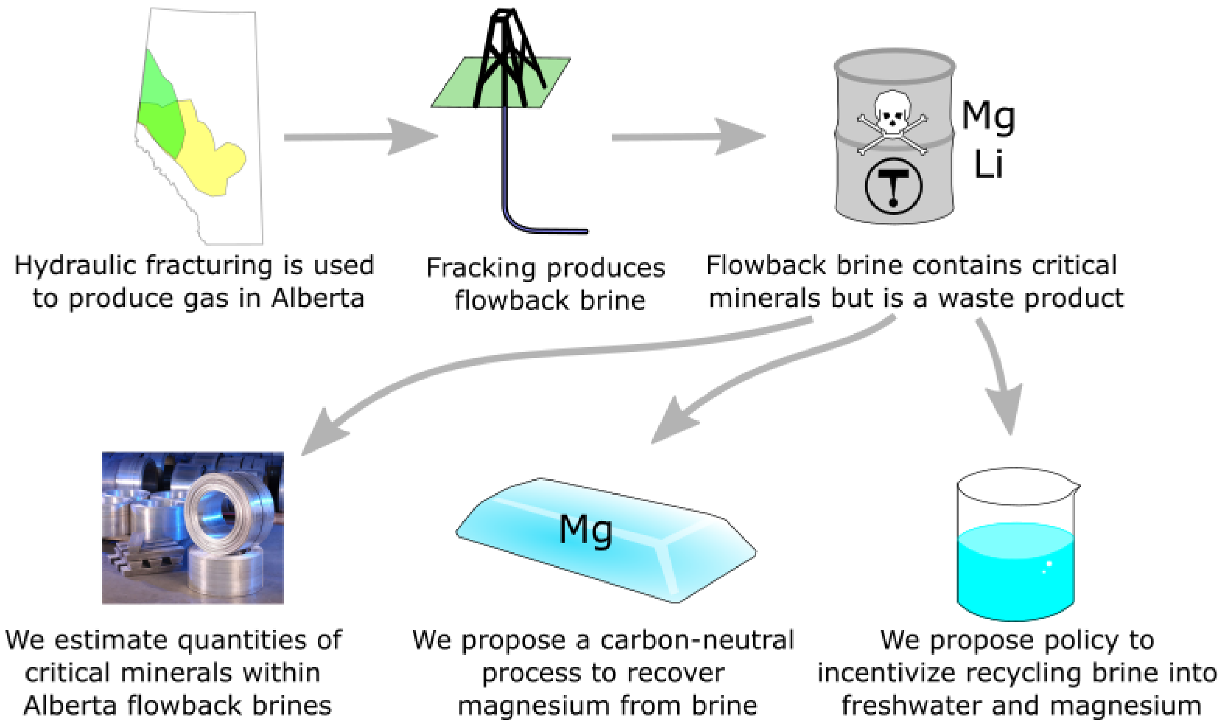

Figure 2: Key context and conclusions of our research (CC-BY 3.0)

## Workflow

We estimate critical mineral resources by determining flowback brine composition and volumes from publicly-available regulatory reporting data from the western Montney formation in British Columbia. We examine the distribution and geostatistical independence of wells to support applying well data from the western Montney across to the eastern Montney in western Alberta. Multiplying flowback volumes and brine mineral composition gives an estimate of magnesium tonnages available annually. As flowback brines are quickly and permanently disposed of, the contained critical mineral resources are ephemeral. We examine variation in water usage to determine the potential range of magnesium tonnage available annually.

We propose a carbon-neutral process for recovering magnesium chloride from these brines, integrating existing technologies in a novel manner. First, flowback brine is purified by reverse osmosis to produce freshwater and concentrated brine. The concentrated brine is electrolyzed, producing hydrochloric acid and magnesium hydroxide. Magnetite particles are added during electrolysis to selectively adsorb precipitating magnesium hydroxide (Lehmann et al 2014). The particles are magnetically separated and mixed with acid to produce soluble magnesium chloride and allow re-use. The only major input throughout this process is electricity, which can be generated by portable renewable sources for carbon-neutral recovery. We estimate power efficiency, mass balances and costs for this process.

We examine our case study area to estimate a usage scenario for the proposed process, generating expected critical mineral recovery, contained value and operating costs. We determine if the proposed magnesium chloride recovery process fits policy goals relating to climate change, critical mineral value chains, Indigenous economic reconciliation and water management. We identify a policy gap hindering the economic feasibility of this process and propose a policy change to encourage critical mineral recovery. We examine the direct and indirect effects of this proposal from economic, Indigenous and environmental perspectives to determine the effects on stakeholders and policy goals.

## Results, Observations, Conclusions

We find that well properties are likely geospatially independent, supporting application of well data from the western Montney to the eastern Montney formation. Magnesium content and injected water recovery as flowback follows a skew normal distribution with means of 1,117 mg/L and 40% respectively, comparing well to previously-reported Albertan results (Osselin 2018 and Owen 2020).

Hydraulic fracturing water usage in the Albertan Montney formation shows significant annual variance. We determined that approximately 135 to 4,000 tonnes of magnesium were contained within these annual flowback brine volumes, with a wide range of uncertainty as gas industry activity is highly variable from year to year.

We propose a magnesium recovery system that consumes 300 kW of electrical power to annually process 0.36 million $m^3$ of flowback into 1,900 t of magnesium chloride, 0.15 million $m^3$ of freshwater and 0.2 million $m^3$ of concentrated brine for disposal.

We observe that the current legal framework on fracking operations does not incentivize the recycling and reuse of wastewater (Genuis 2021), forming economic barriers to implementing the recovery process. We propose a mandate for 2% of water used in Albertan hydraulic fracturing to be from recycled sources, compared to only 1% currently voluntarily recycled (Alberta Energy Regulator n.d.). We qualitatively assess that a reduction in flowback brine volume from recycling would reduce seismic hazard, water stress and impact on traditional and contemporary Indigenous land use in the study area. Our assessment of the economic impact of this policy proposal indicates that approximately 6% of Canadian magnesium chloride demand could be fulfilled from the study area alone, establishing a new critical mineral value chain and economic activity in excess of the new costs imposed on stakeholders. We assess that our project has the potential to advance economic reconciliation through Indigenous-led businesses and Indigenous employment participating in this additional economic activity.

A significant portion of well activity would see no additional costs as recycled water from the proposed recovery process could be available at nearby wells, competitively priced to transported freshwater. Additional costs for recycled water would apply to remaining wells, amounting to a negligible increase in operating costs for energy companies.

We conclude that recovering magnesium from flowback brines is technically feasible, economically feasible and aligned with Alberta's and Canada's environmental, critical mineral value chain, climate change and economic reconciliation policy goals. We propose that water management policy should change to support this goal.

## Novel/Additive Information

We produce the first-ever estimate of critical mineral resources contained within flowback brines in Alberta. We further show technical and socioeconomic feasibility of a novel process to recover magnesium from flowback brines.

## Acknowledgements

In the spirit of reconciliation, we acknowledge that we live, work and play on the traditional territories of the Blackfoot Confederacy (Siksika, Kainai, Piikani), the Tsuut'ina, the Îyâxe Nakoda Nations, the Métis Nation (Region 3), the Mississaugas of the Credit, the Anishnabeg, the Chippewa, the Haudenosaunee, the Wendat, and all people who make their homes in the Treaty 7 region of Southern Alberta and under Treaty 13 in Ontario. The REDEVELOP program is funded by the Natural Sciences and Engineering Research Council of Canada (NSERC) through its Collaborative Research and Training Environment (CREATE) program under the grant CREATE #386133824.

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