A tool for the exploration of undercover ore deposits:

Laser ablation ICP-MS method for the in-situ measurement of element contents and Pb isotope ratios on fracture coatings

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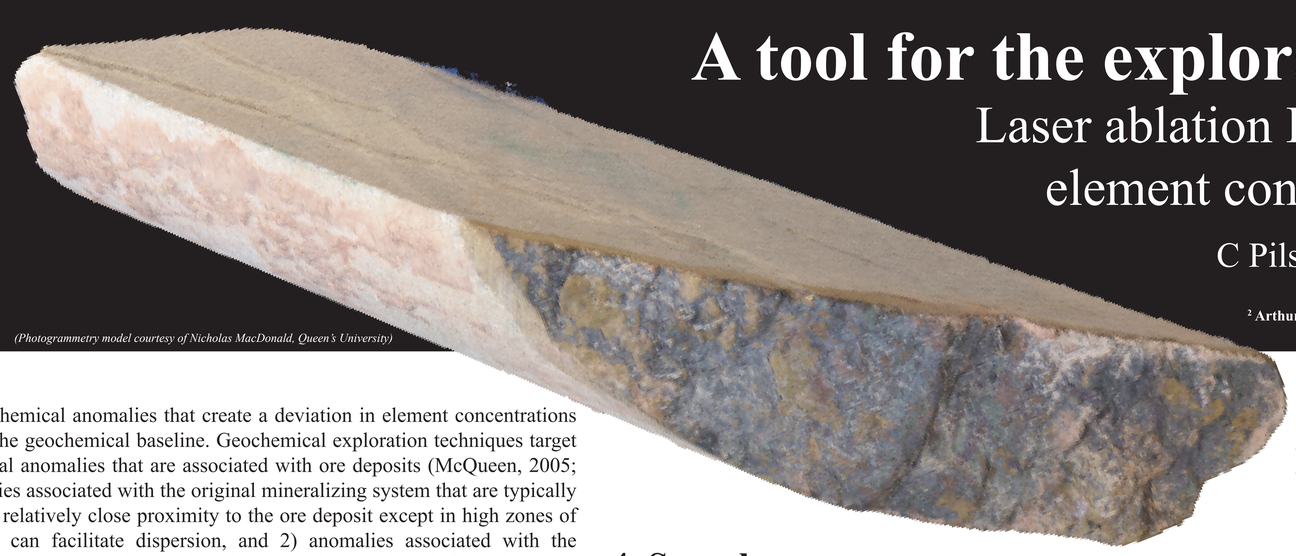
QUEEN'S FACILITY FOR ISOTOPE RESEARCH



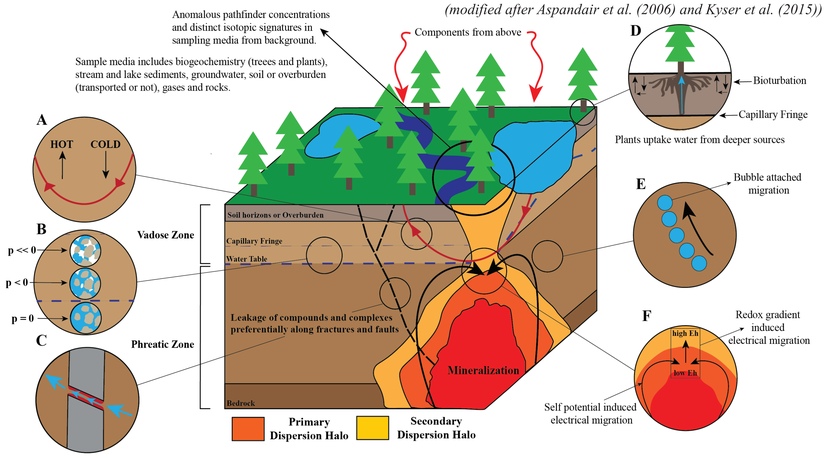
(Photogrammetry model courtesy of Nicholas MacDonald, Queen's University)

Black Fracture Coating

1. Introduction

Ore deposits are distinct geochemical anomalies that create a deviation in element concentrations and isotopic signatures from the geochemical baseline. Geochemical exploration techniques target two main types of geochemical anomalies that are associated with ore deposits (McQueen, 2005; Kyser et al., 2015): 1) anomalies associated with the original mineralizing system that are typically limited in extent and occur in relatively close proximity to the ore deposit except in high zones of permeability where fractures can facilitate dispersion, and 2) anomalies associated with the remobilization of elements from the ore or primary alteration zone after ore deposit formation.

(modified after Aspandair et al. (2006) and Kyser et al. (2015))

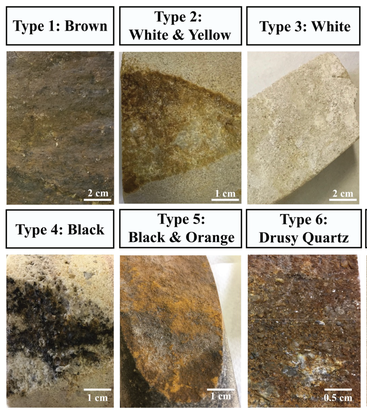


A = Convection, B = Capillary rise, C = Fractures, D = Bioturbation, E = Bubble migration, F = Electrochemical

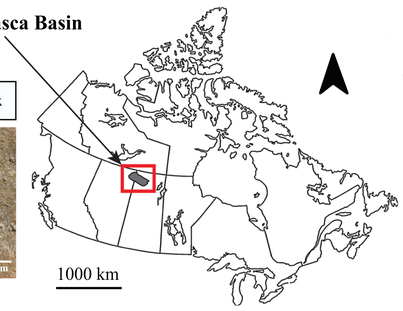
Fractures aid element dispersion by providing open permeable pathways in which fluids and gases can move from mineralization into the surrounding rocks and overburden. Element dispersion can be recorded by a distinct mineralogical and geochemical signature on the fracture surface.

2. Previous Work

Fracture coatings extend the footprint of ore systems.



Valentino et al, 2021a; 2021b studied the mineralogy and chemisty of fracture coatings around the unconformity-hosted uranium McArthur River deposit.



3. Objectives of Research

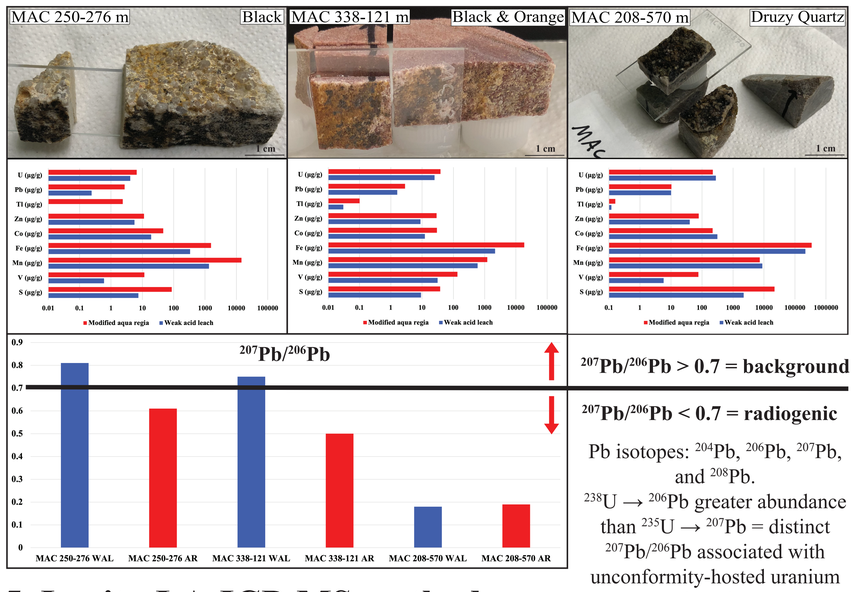
1. Research needs to be applied to other ore deposits in different geological environments.

2. Studying fracture coatings in other geological environments is a challenge, as not all deposit systems have fractures with sufficient coatings for acid digestion methods.

GOAL OF RESEARCH: The development of an in-situ LA-ICP-MS method for analyzing the chemical composition and Pb isotope ratios on the fracture coating.

4. Samples

Samples selected had increased pathfinder concentrations.



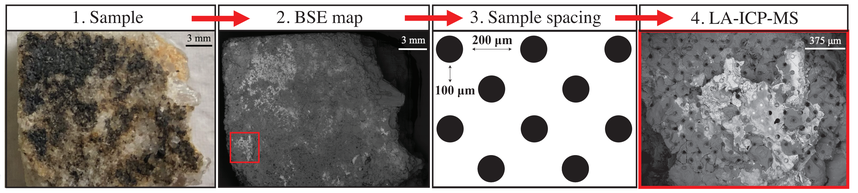
$^{207}Pb/^{206}Pb$ > 0.7 = background

$^{207}Pb/^{206}Pb$ < 0.7 = radiogenic

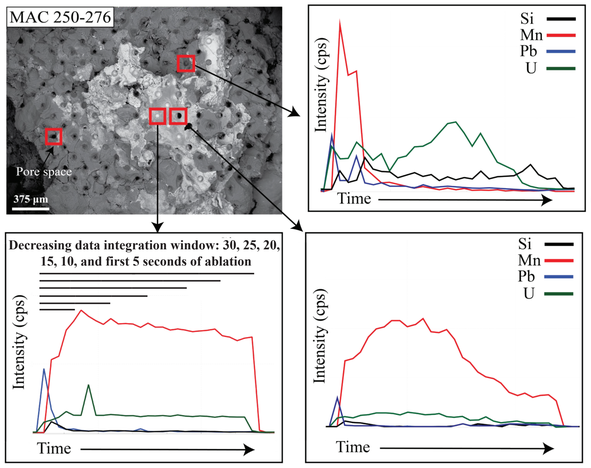
Pb isotopes: ^{204}Pb, ^{206}Pb, ^{207}Pb, and ^{208}Pb.

$^{238}U \rightarrow {}^{206}Pb$ greater abundance than $^{235}U \rightarrow {}^{207}Pb$ = distinct $^{207}Pb/^{206}Pb$ associated with unconformity-hosted uranium deposits.

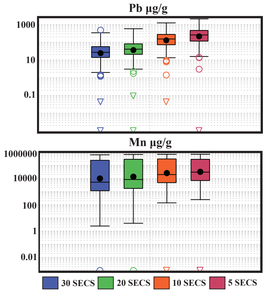
5. In-situ LA-ICP-MS method



Data reduction within Iolite™ v.4.5.7 to generate element content of the fracture coating.

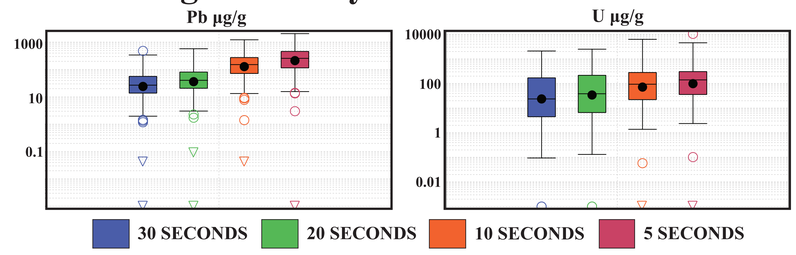


Fracture coatings vary in thickness!



5 seconds = increased sensitivity and analysis targets the surface of the fracture representing the most recent fluid flow.

6. Increasing sensitivity



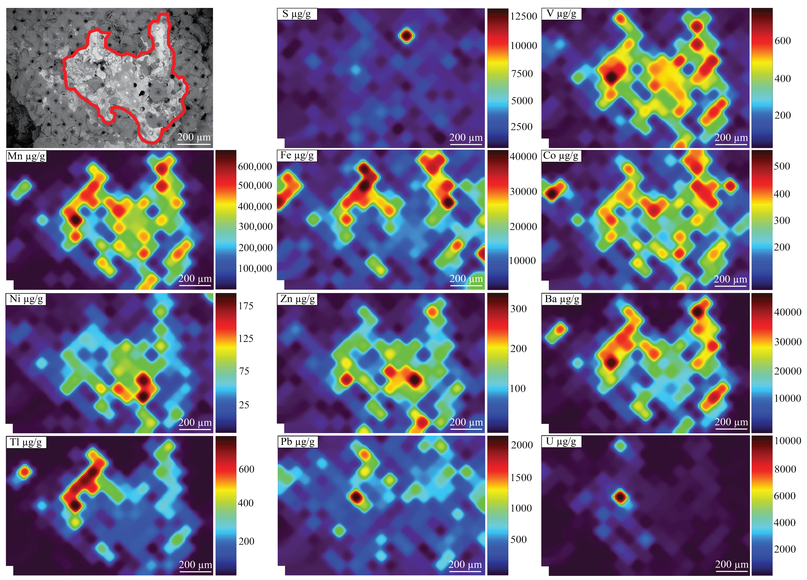
Modified aqua regia Pb = 2.73 µg/g
Weak acid leach Pb = 0.24 µg/g
LA-ICP-MS (5 seconds) Pb = 267.1 µg/g

Modified aqua regia Pb = 6.60 µg/g
Weak acid leach Pb = 4.08 µg/g
LA-ICP-MS (5 seconds) Pb = 247.2 µg/g

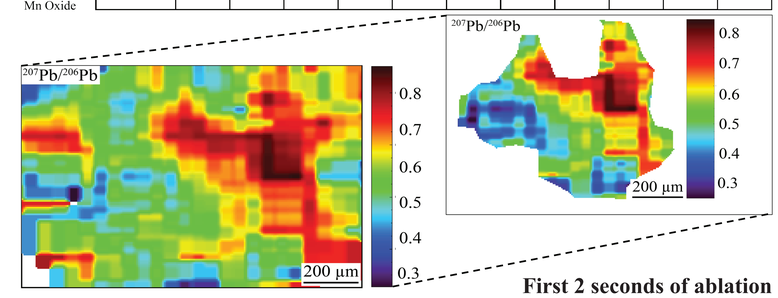
LA-ICP-MS method more sensitive than WAL and modified AR.

7. Results

First 5 seconds of ablation



Element	S	V	Mn	Fe	Co	Ni	Zn	Ba	Tl	Pb	U
µg/g	1196	396.9	320043	15376	274.8	63	132	20467	249	405	426



First 2 seconds of ablation

8. Key takeaways

1. First application of using LA-ICP-MS for measuring element content and $^{207}Pb/^{206}Pb$ in-situ on fracture coatings.

2. This method increases sensitivity of measurements, only samples the fracture coating (no geochemical contribution from host rock), and allows for the measurements of lean fractures.

3. Shows the spatial distribution of elements on fracture coatings = tool for exploration.

References

Aspandiar, M. F., Anand, R.R. and Gray, D.G., 2006, Geochemical dispersion mechanisms through transported cover: implications for mineral exploration in Australia: CRC LEME Restricted Report 230, 84 pp. (Reissued as Open File Report 246, CRC LEME, Perth, 2008). **McQueen, K., G, 2005,** Ore deposit types and their primary expressions: Regolith expression of Asutralian ore systems, V. 12, p. 1 - 14. **Kyser, K., Barr, J., and Ihlenfeld, C., 2015,** Applied Geochemistry in Mineral Exploration and Mining: Elements, v.11, no 4, p.241-246. **Valentino, M., Kyser, T. K., Leybourne, M., Kotzer, T., Quirt, D., Layton-Matthews, D., and Joyce, N., 2021a,** Geochemistry of fracture coatings in Athabasca Group sandstones as records of elemental dispersion from the McArthur River Uranium deposit: Applied Geochemistry, v. 128. **Valentino, M., Kyser, T. K., Leybourne, M. I., Kotzer, T., Quirt, D., Lypaczewski, P., Layton-Matthews, D., and Joyce, N., 2021b,** Mineralogy and petrogenesis of fracture coatings in Athabasca Group sandstones from the McArthur River uranium deposit: The Canadian Mineralogist, v. 59, no. 5, p. 1021-1047.