

MACRO TO MICRO FAULT ZONE CHARACTERISTICS, FRACTURE SYSTEMS AND POROSITY IN BASEMENT HOSTED UNCONFORMITY-TYPE URANIUM DEPOSITS OF THE ATHABASCA REGION (SASKATCHEWAN, CANADA)

Maher Abdelrazek¹, Antonio Benedicto¹, Olivier Gerbeaud², Patrick Ledru³

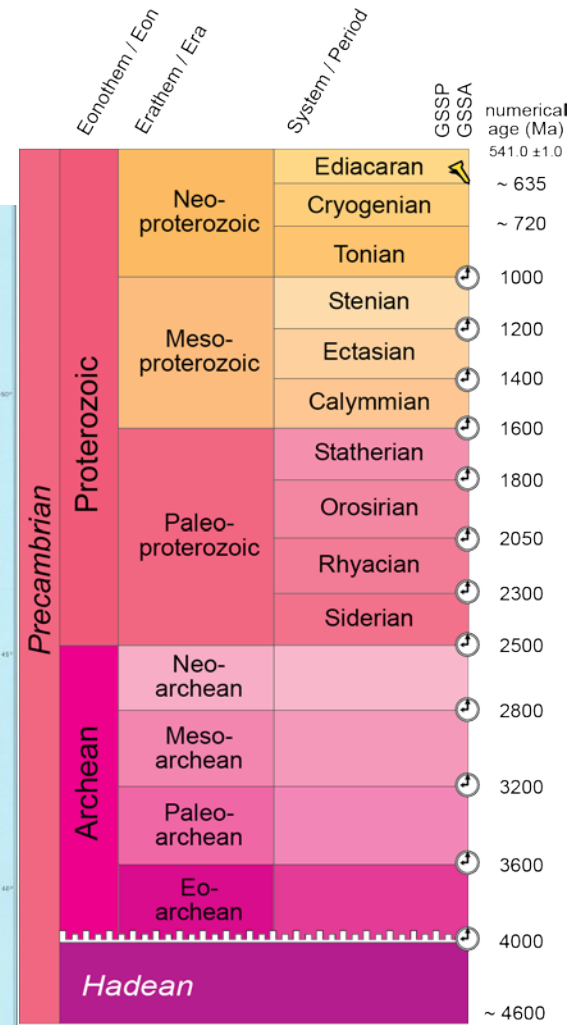
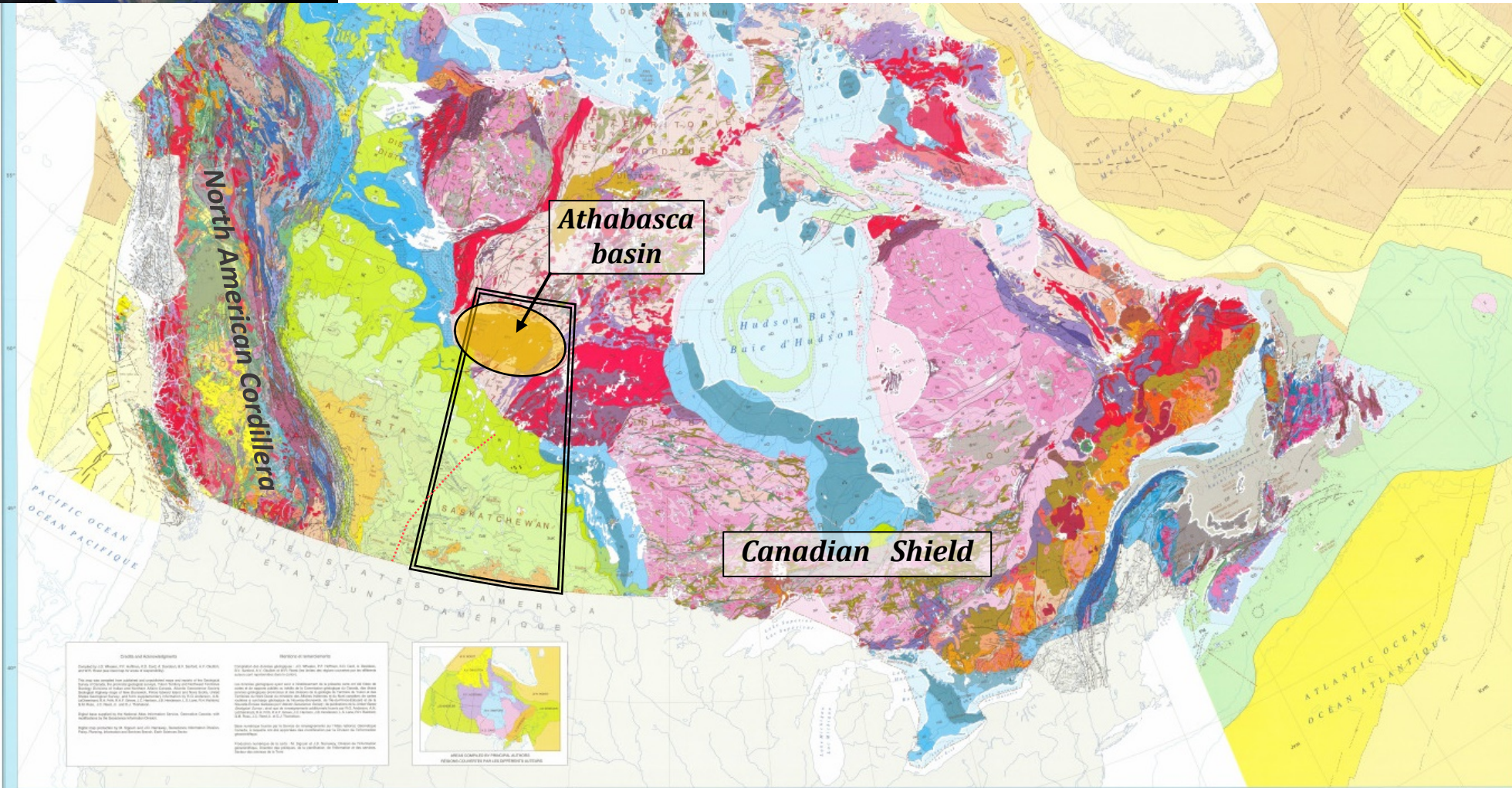
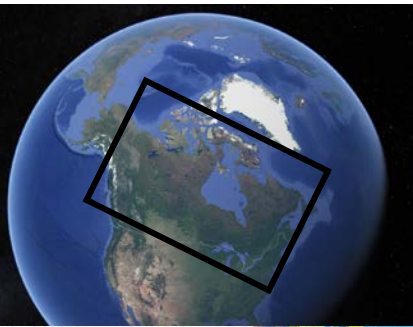
¹ Université Paris-Saclay

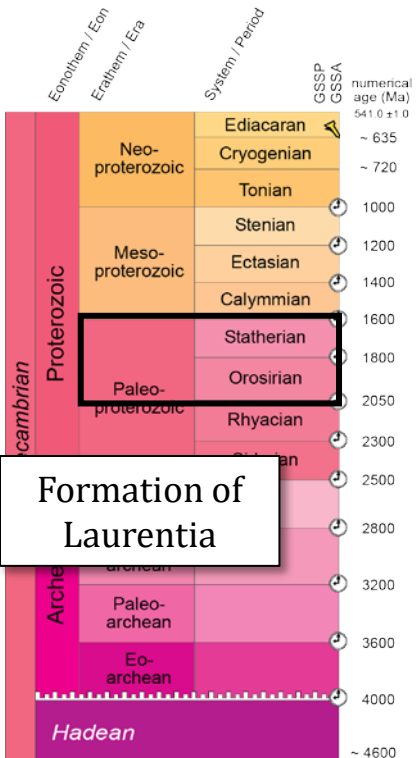
² Orano Mining

³ Université de Lorraine

Journées Uranium 2022

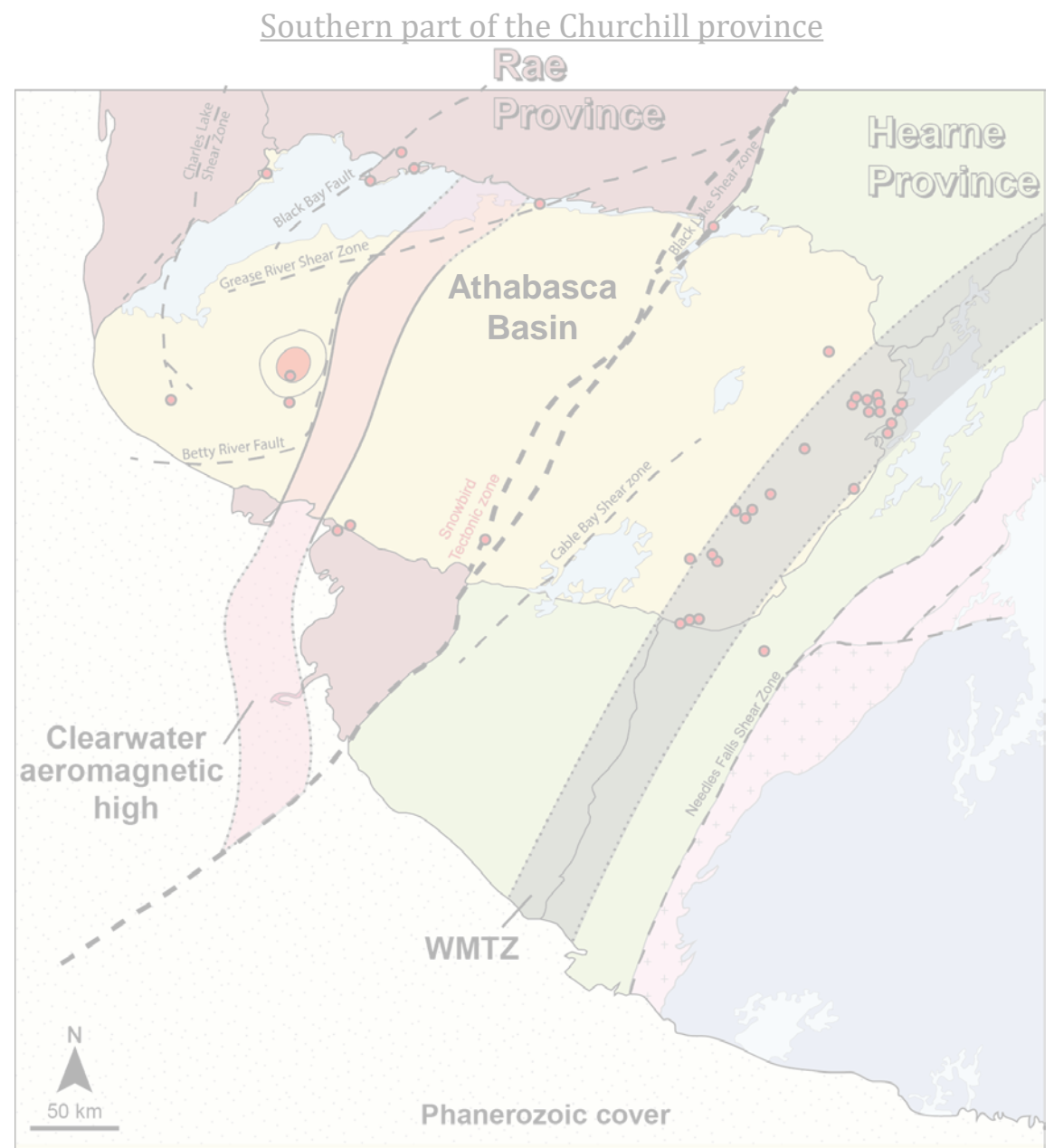






Formation of Laurentia

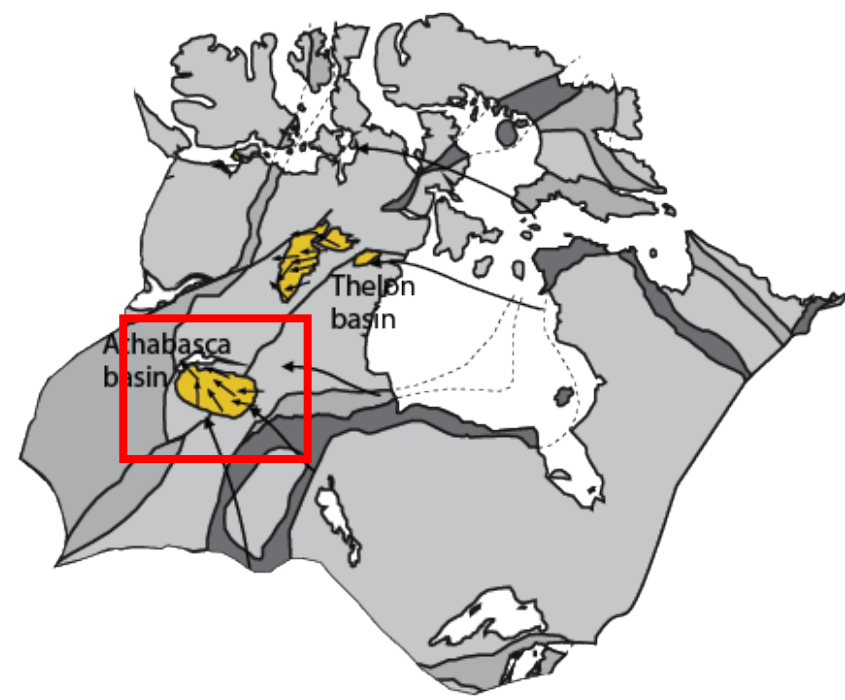
- Rae
- Hearne
- U deposits



Modified from Jeanneret et al. 2016 and Card 2020

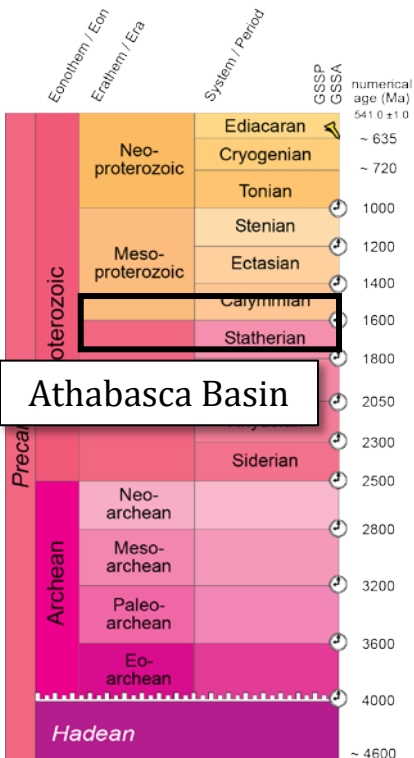
- Archean to Paleoproterozoic gneiss
- Orthogneiss and paragneiss
- Local graphitic paragneiss
- Amphibolitic to granulitic facies

Laurentia at 1.70 Ga

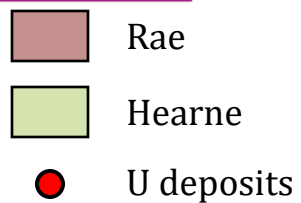


Modified from Furlanetto et al. 2016

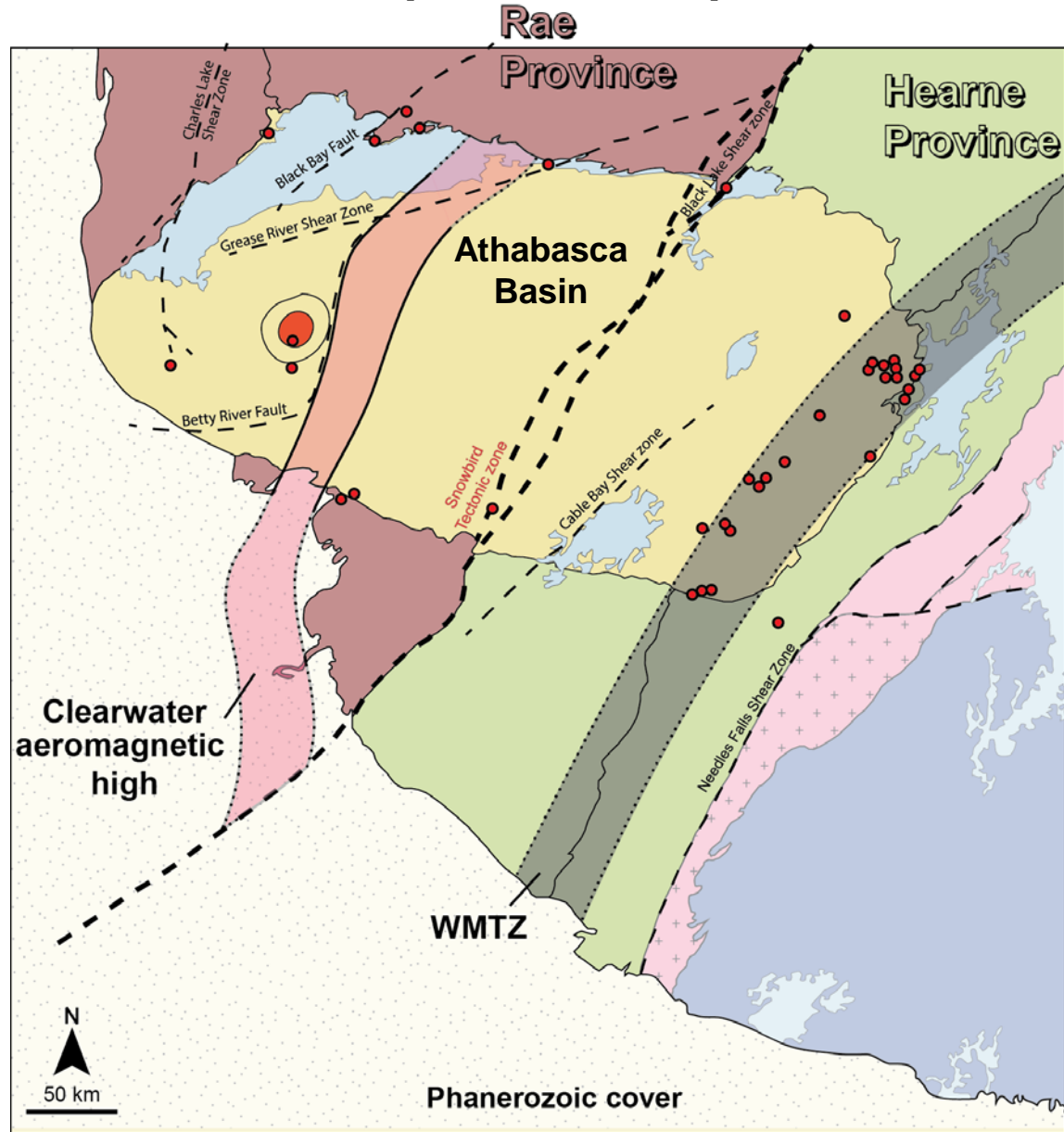
1000 km



Athabasca Basin



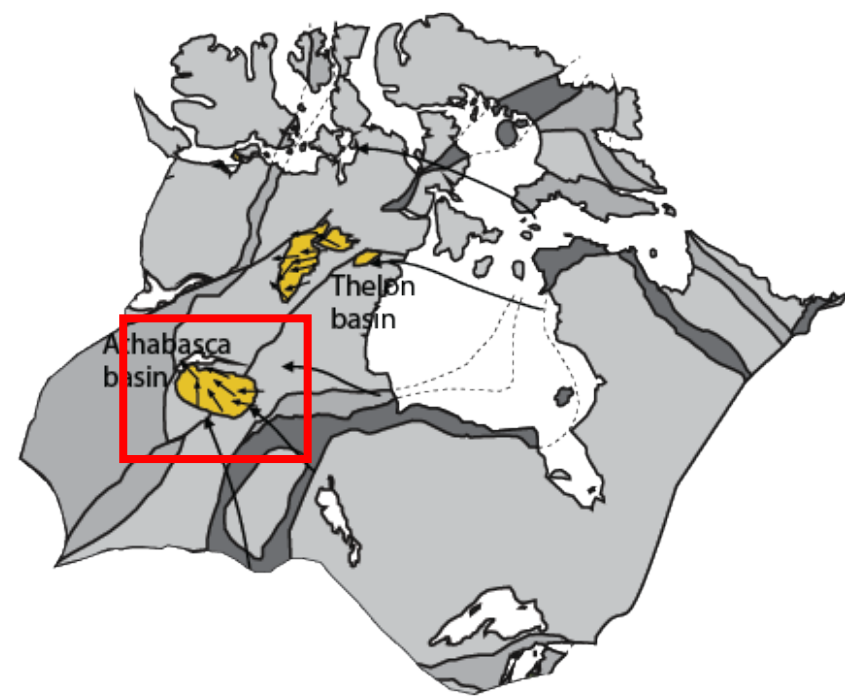
Southern part of the Churchill province



Modified from Jeanneret et al. 2016 and Card 2020

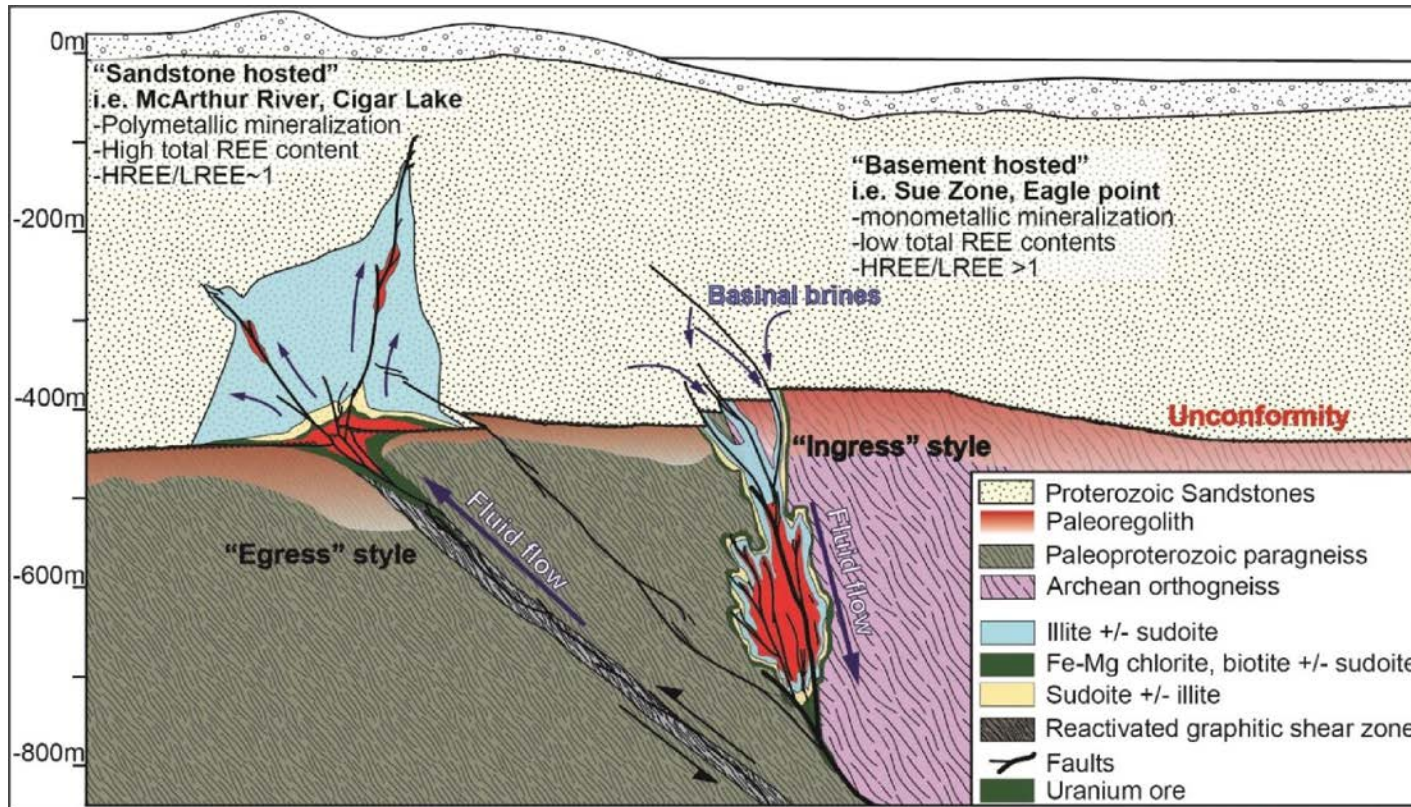
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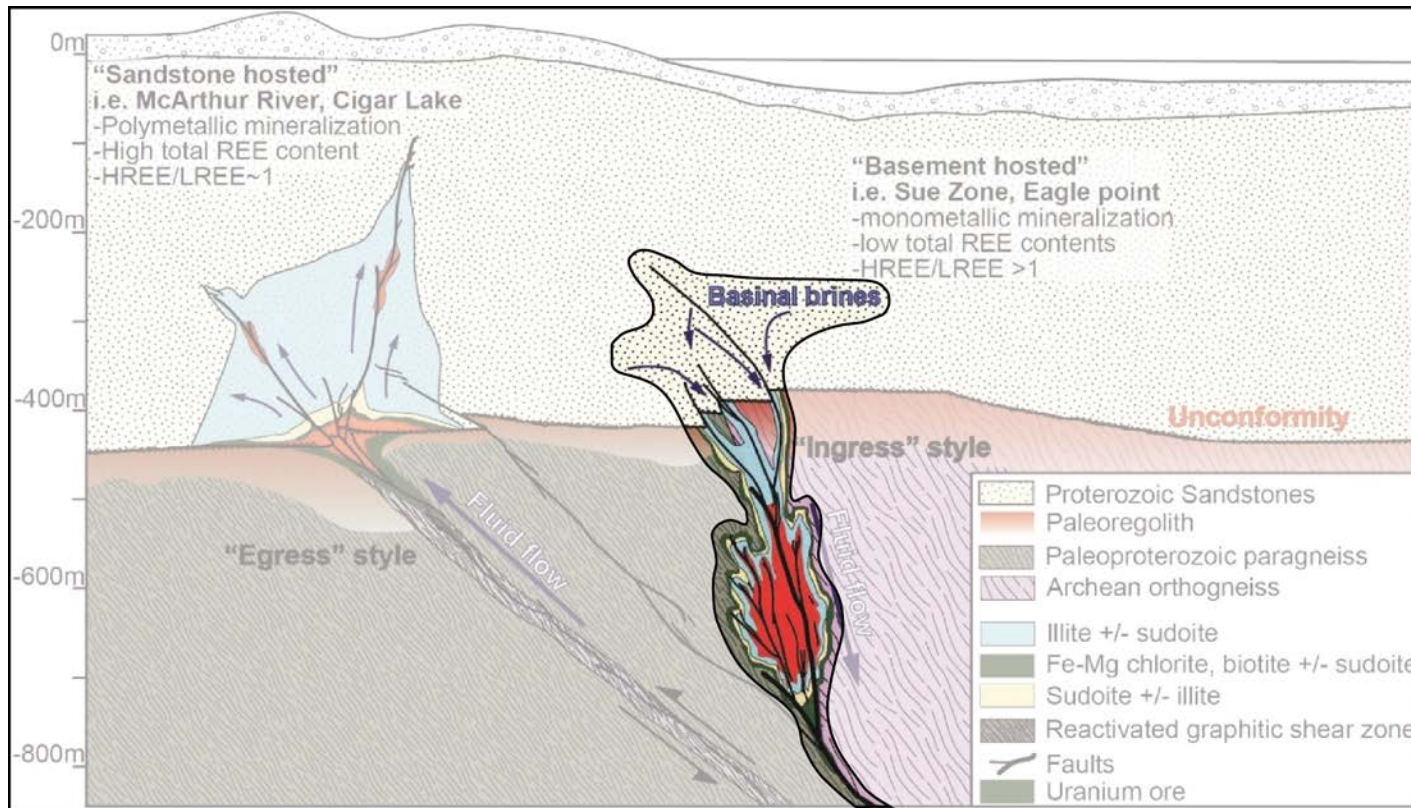
Modified from Furlanetto et al. 2016

1000 km



Grare 2018

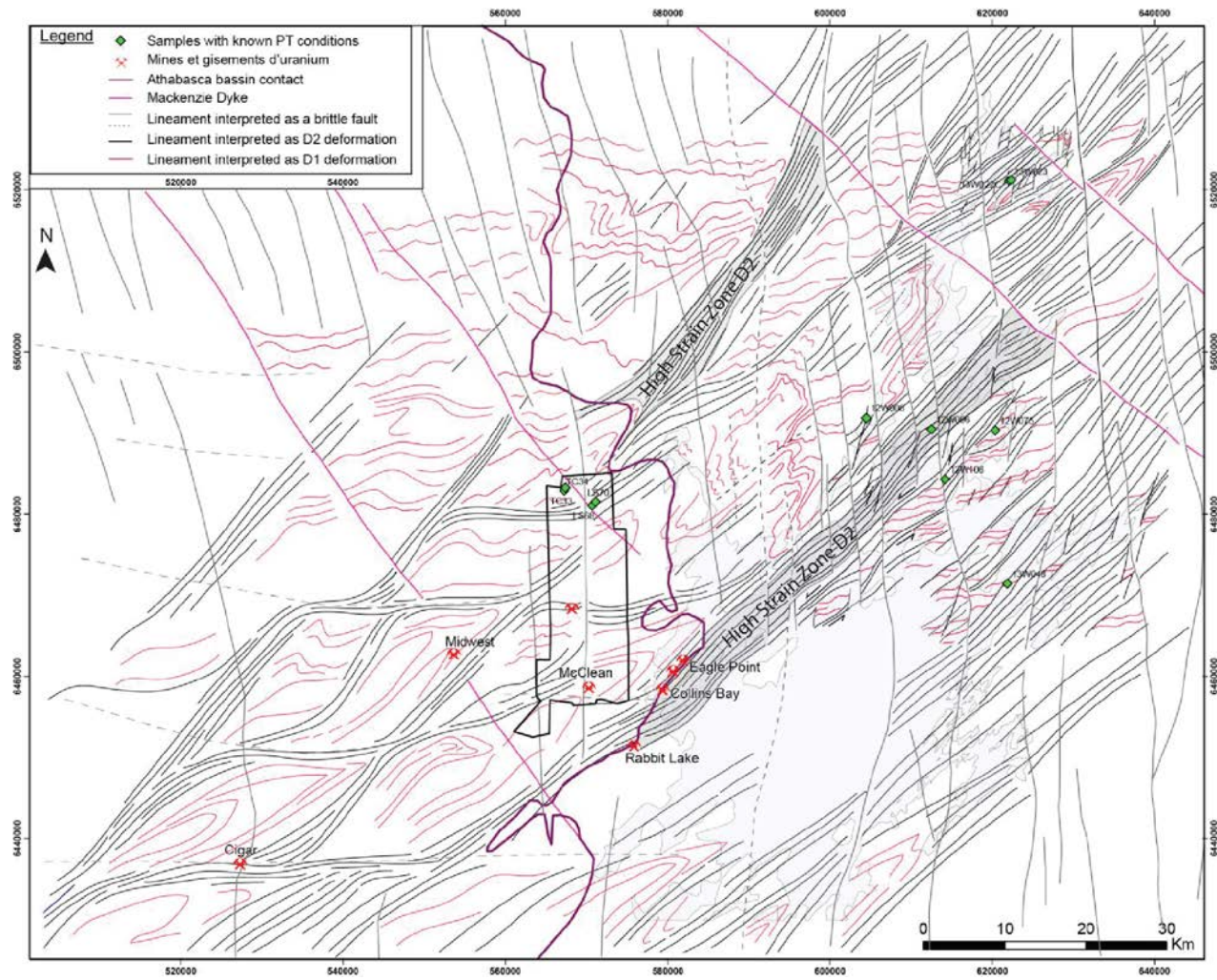
- URU model from eastern deposits
- Associated to Proterozoic unconformities
- At the intersection between the unconformity and graphitic-rich basement reactivated shear zones
- Strong chloritic and illitic alteration halo
- 3 types of ore :
 - Unconformity type
 - Perched ore type
 - Basement-Hosted type



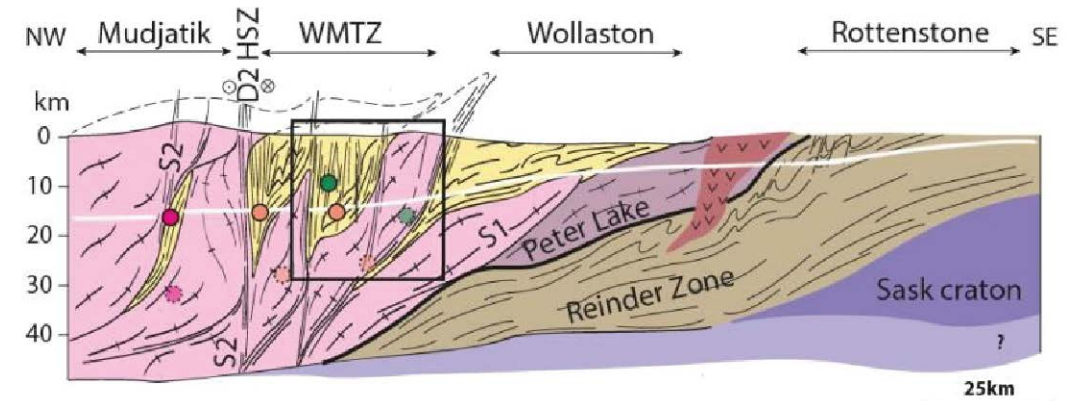
Grare 2018

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- 3 types of ore :
 - Unconformity type
 - Perched ore type
 - **Basement-Hosted type:**

Hosted along brittle basement structures



Jeanneret 2016

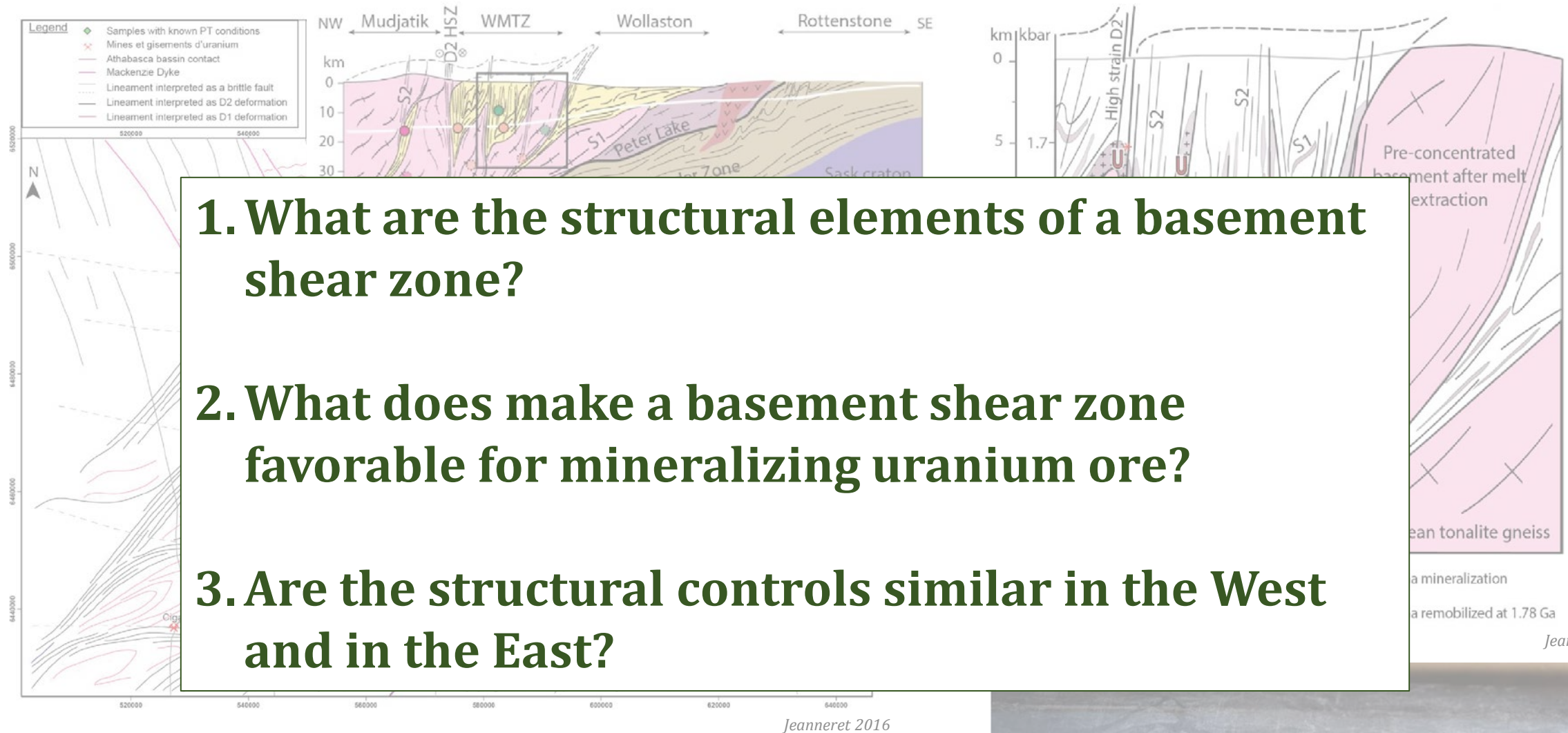


Jeanneret 2016



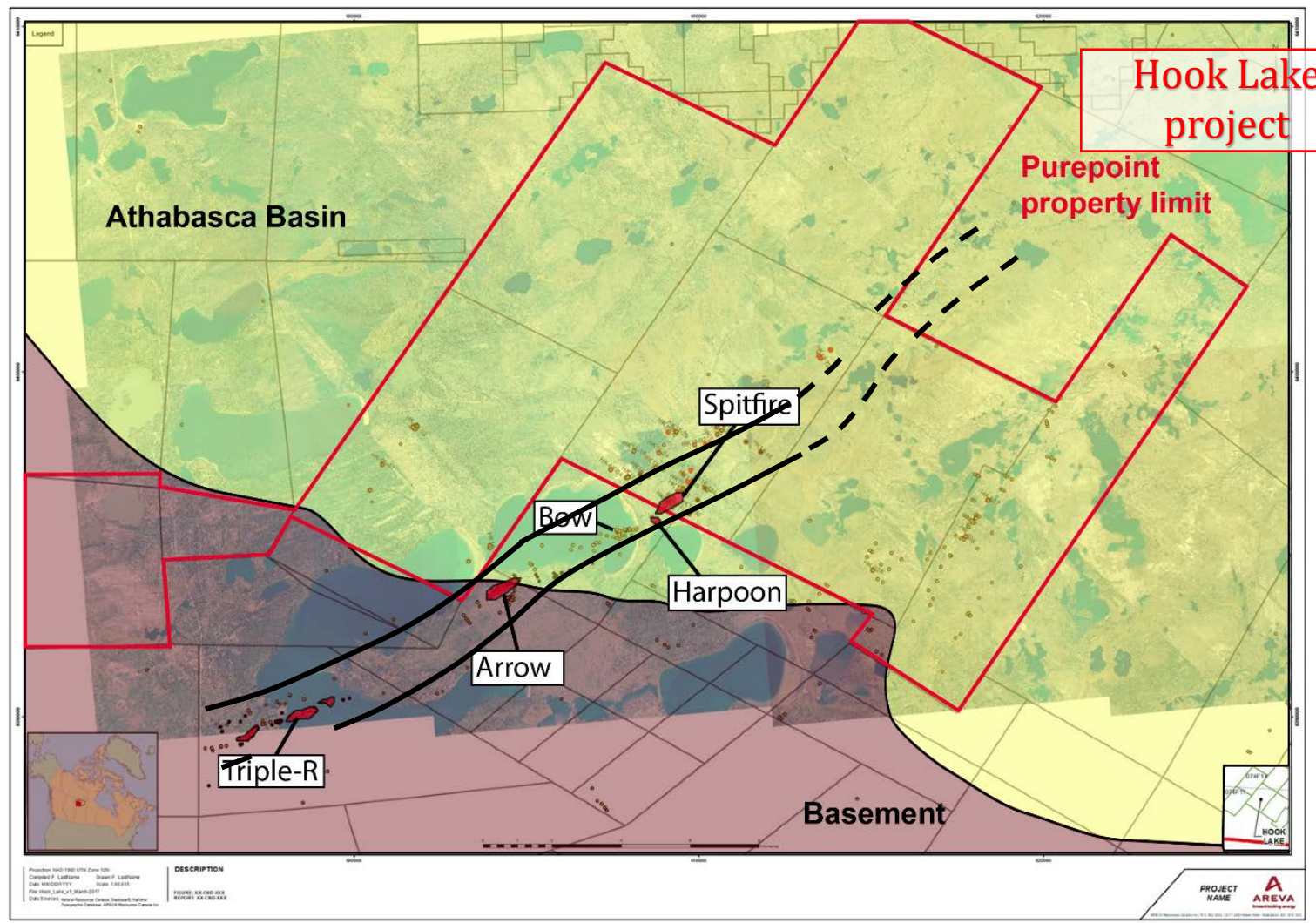
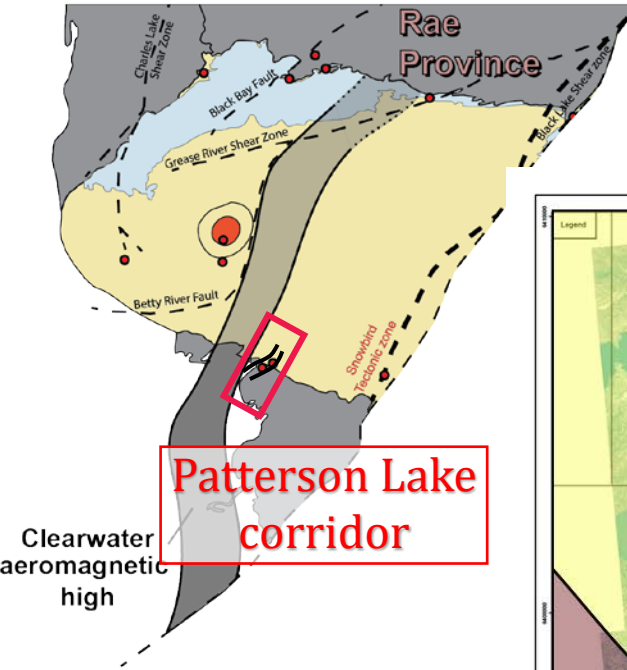
Hillacre 2018

- Mineralization is localized along **highly strained regional shear zones**, locally **enriched in graphite**, and **reactivated in the brittle regime**.
- Brittle structures overprinting inherited shear zones are **geometrical traps** for uranium mineralization.

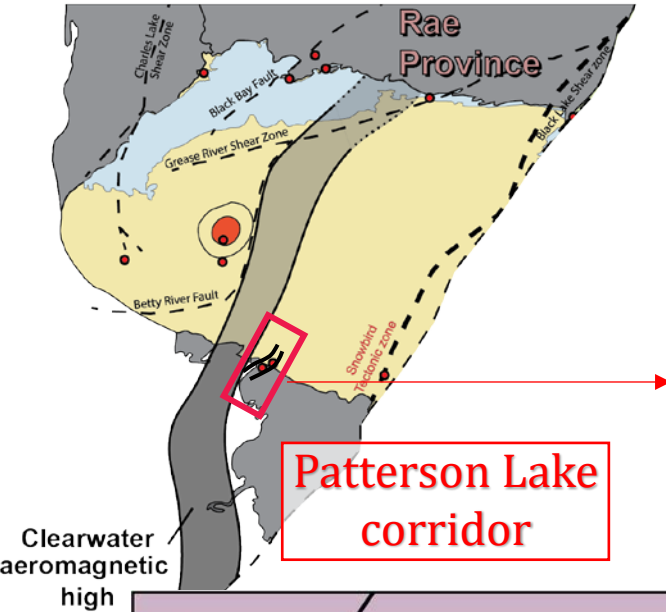


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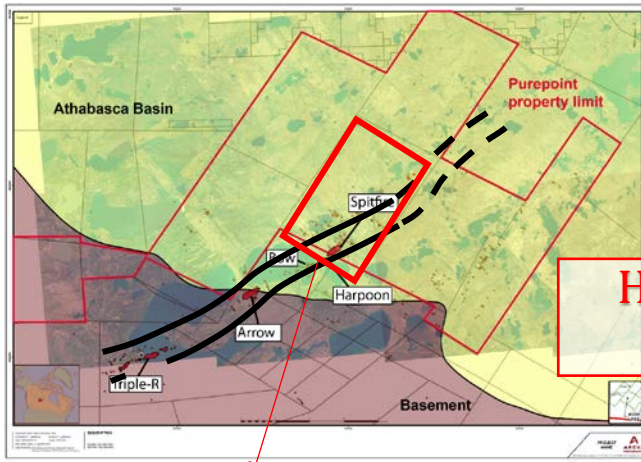




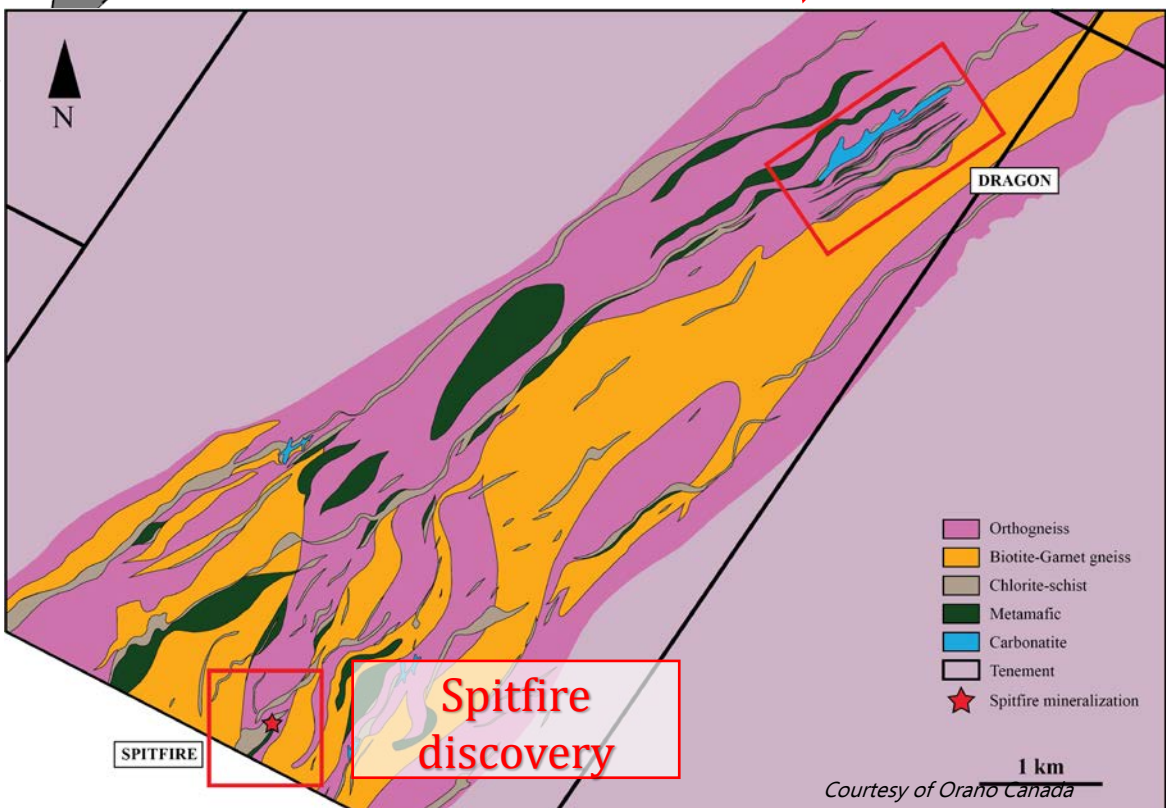
Courtesy of Orano Canada

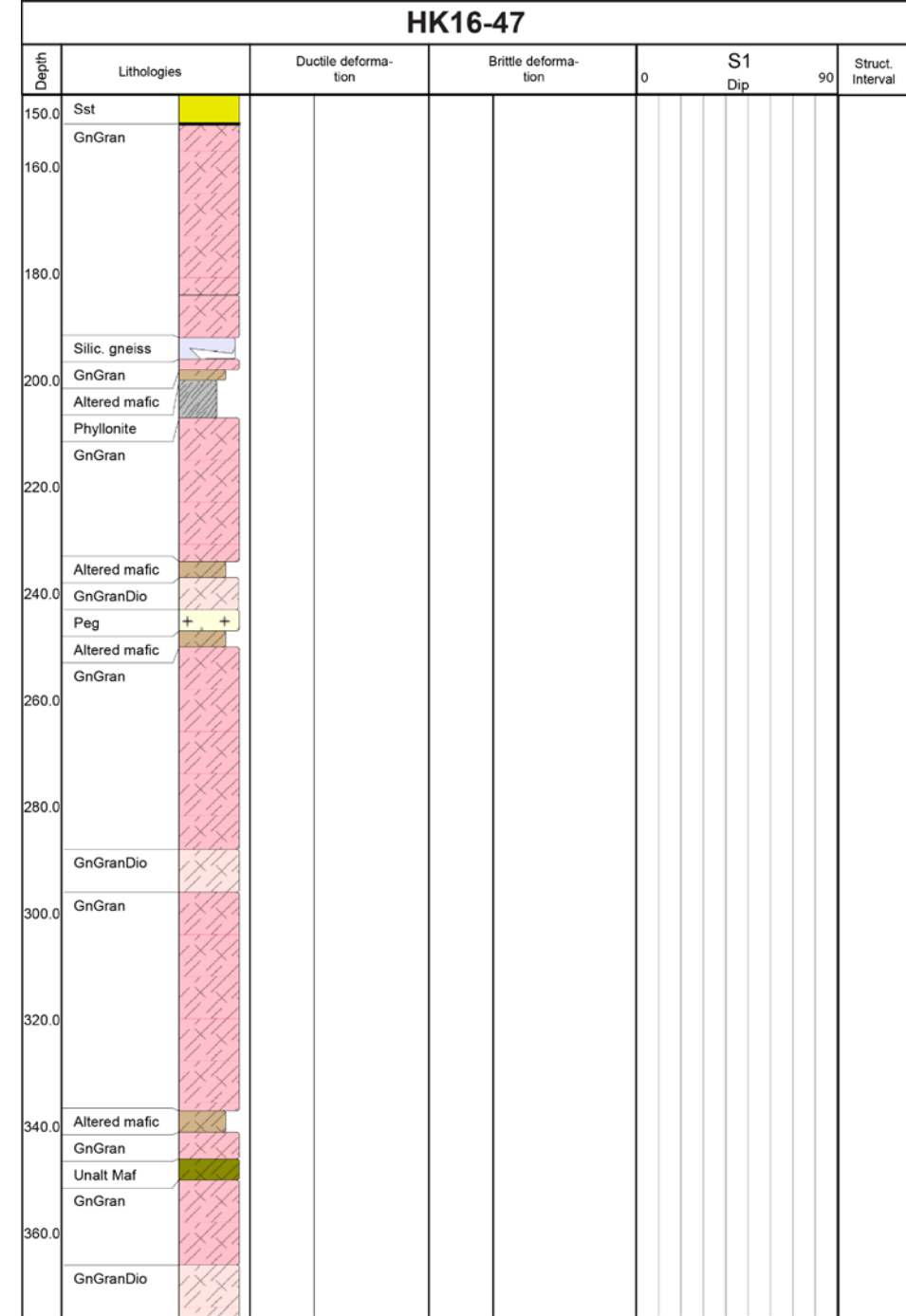


Patterson Lake corridor



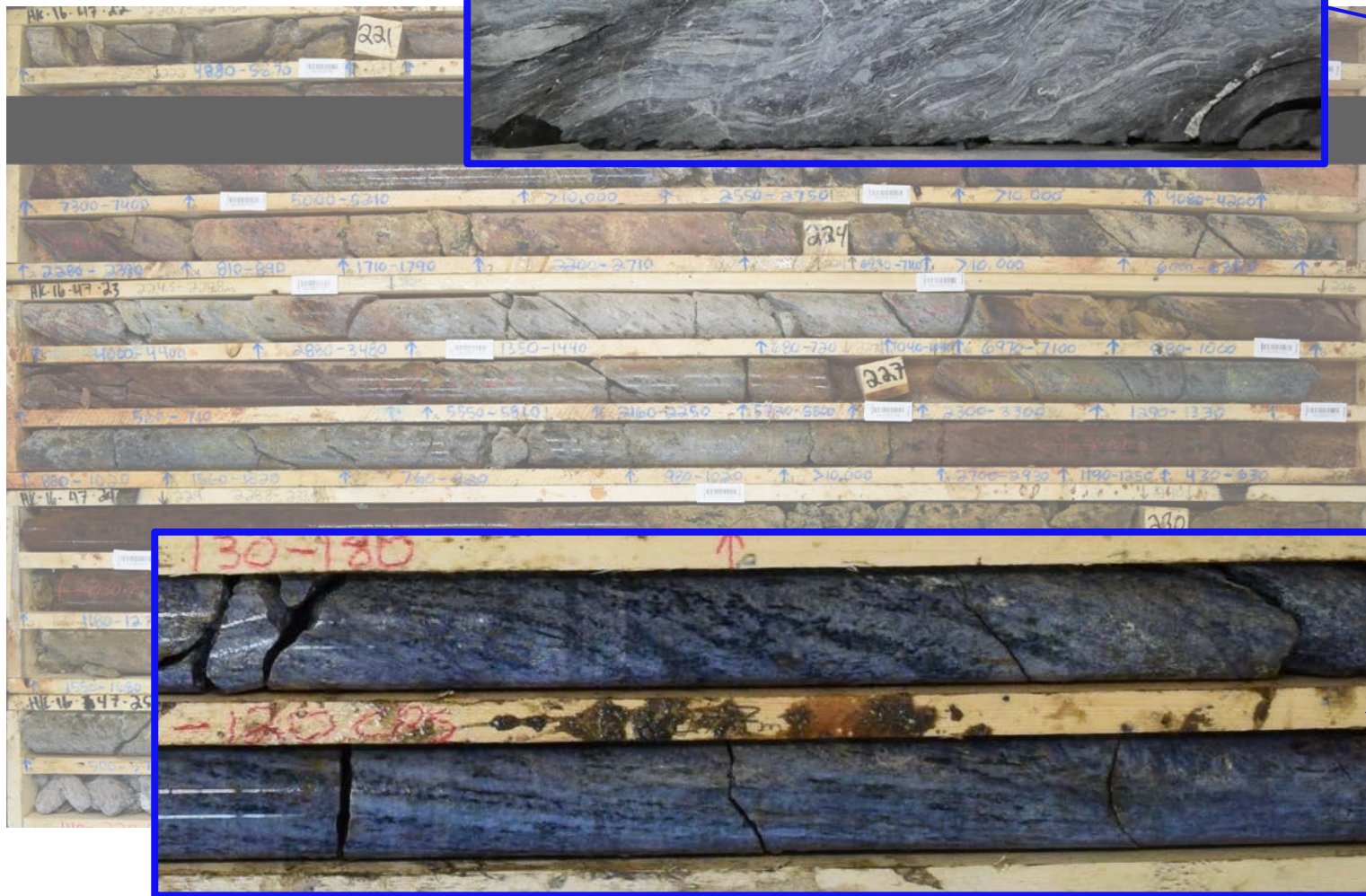
Hook Lake project



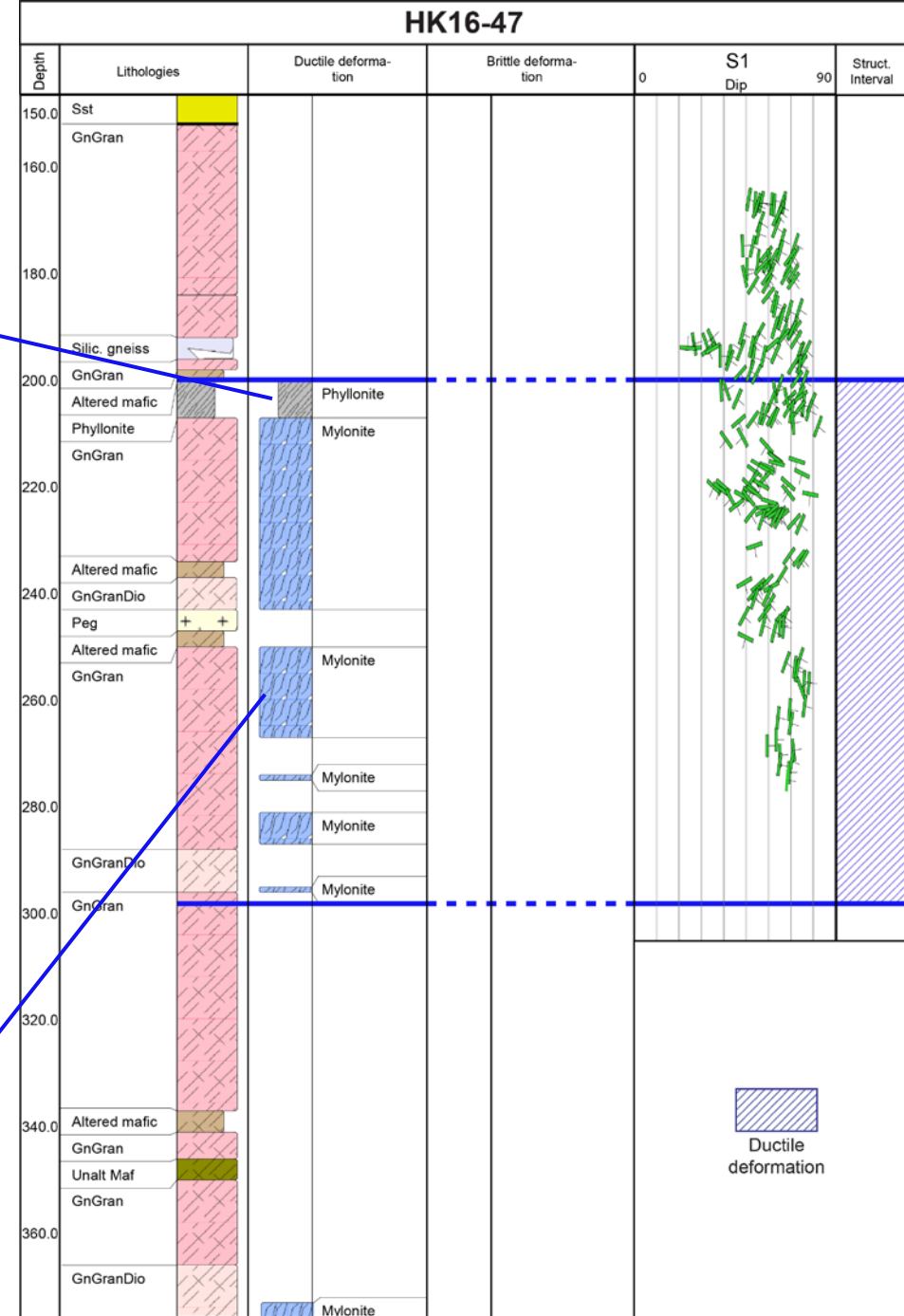




Phyllonite



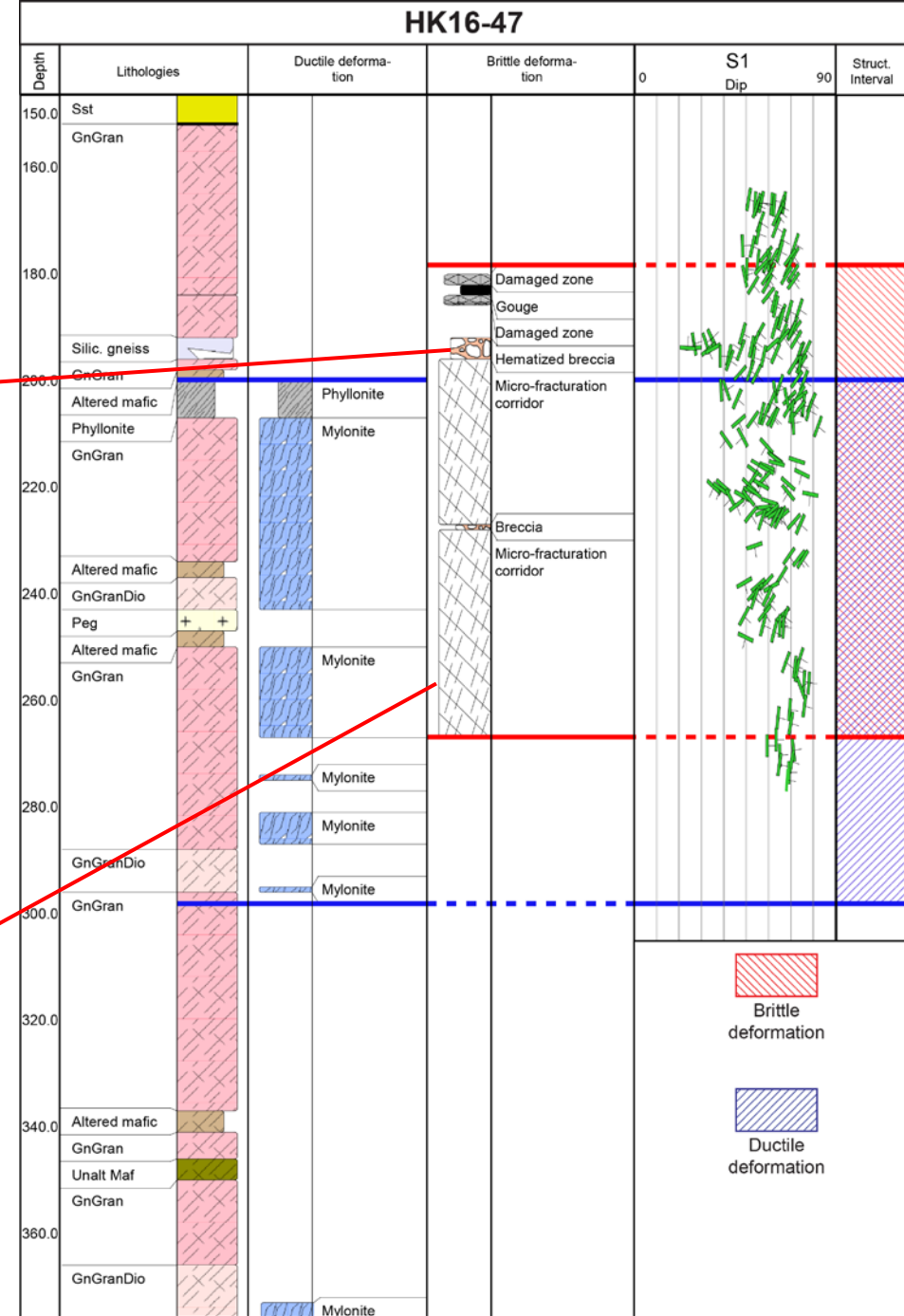
Mylonitic orthogneiss



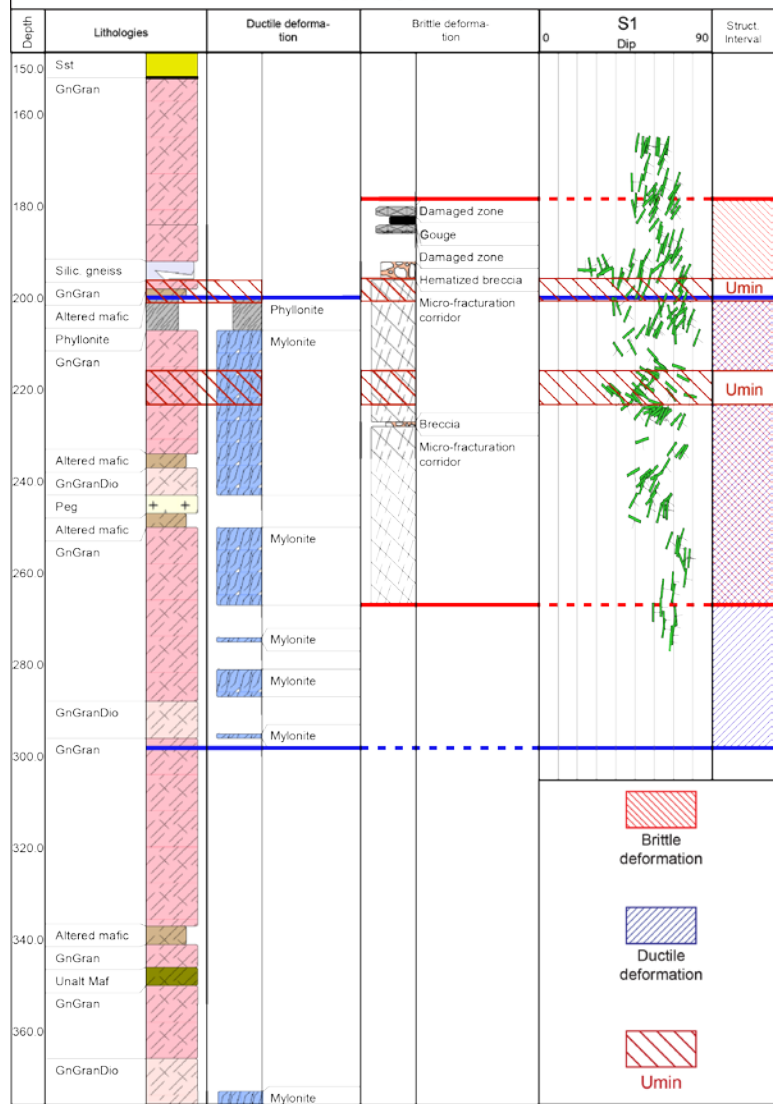
Hematized breccia



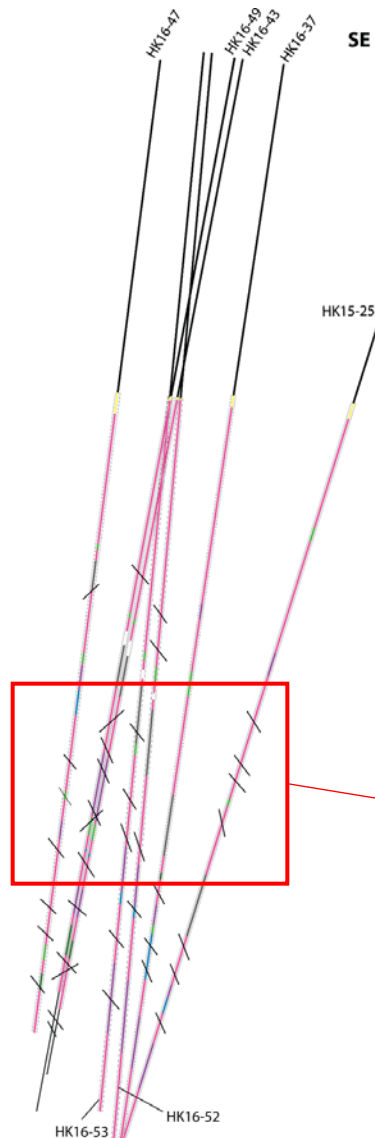
Micro-fractures



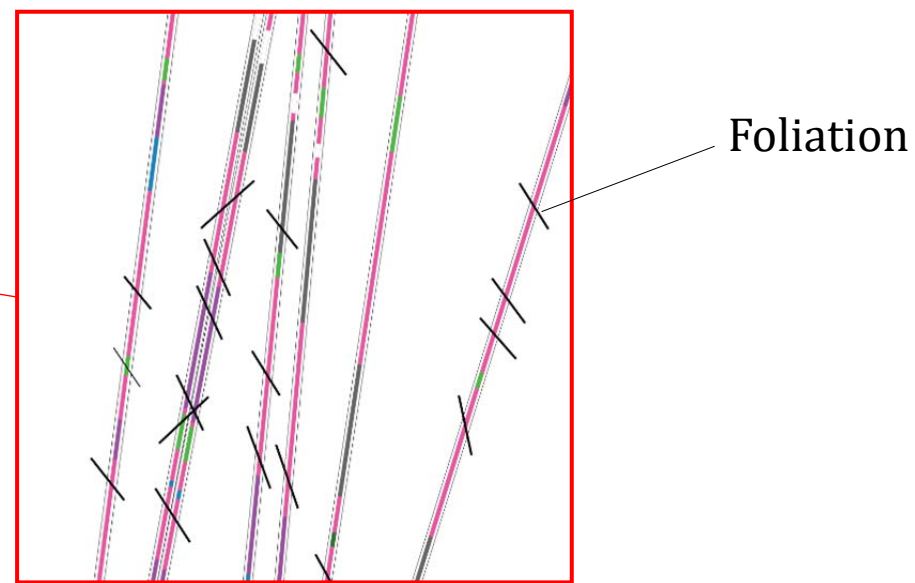
HK16-47



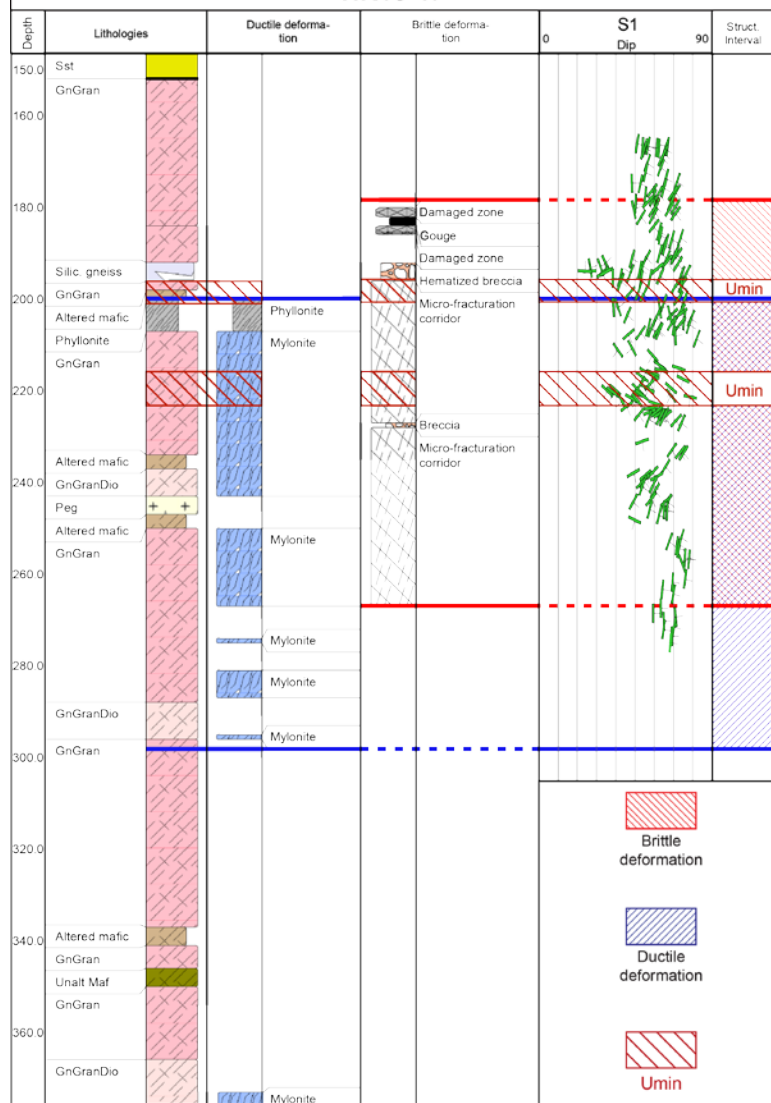
NW



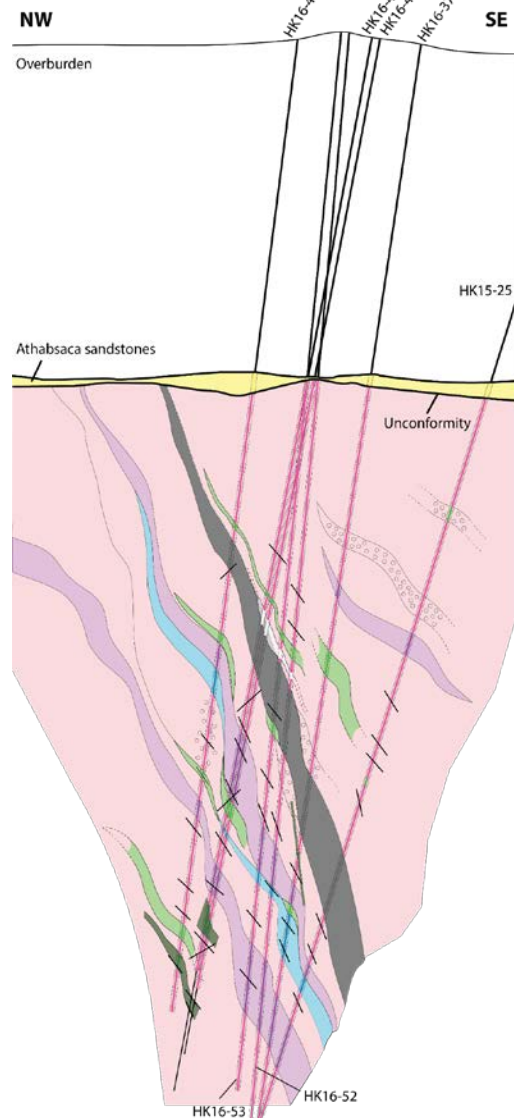
- Correlation of lithologies **must respect** structural data (foliation)
- Logging structural intervals through several drillholes allows defining **the extent** and **the organization** of the shear zone



HK16-47



(a)



Lithology:

- Granodioritic gneiss
- Granitic gneiss
- Pegmatite
- Argilized metamafic
- Metamafic
- White quartz vein

Ductile structures:

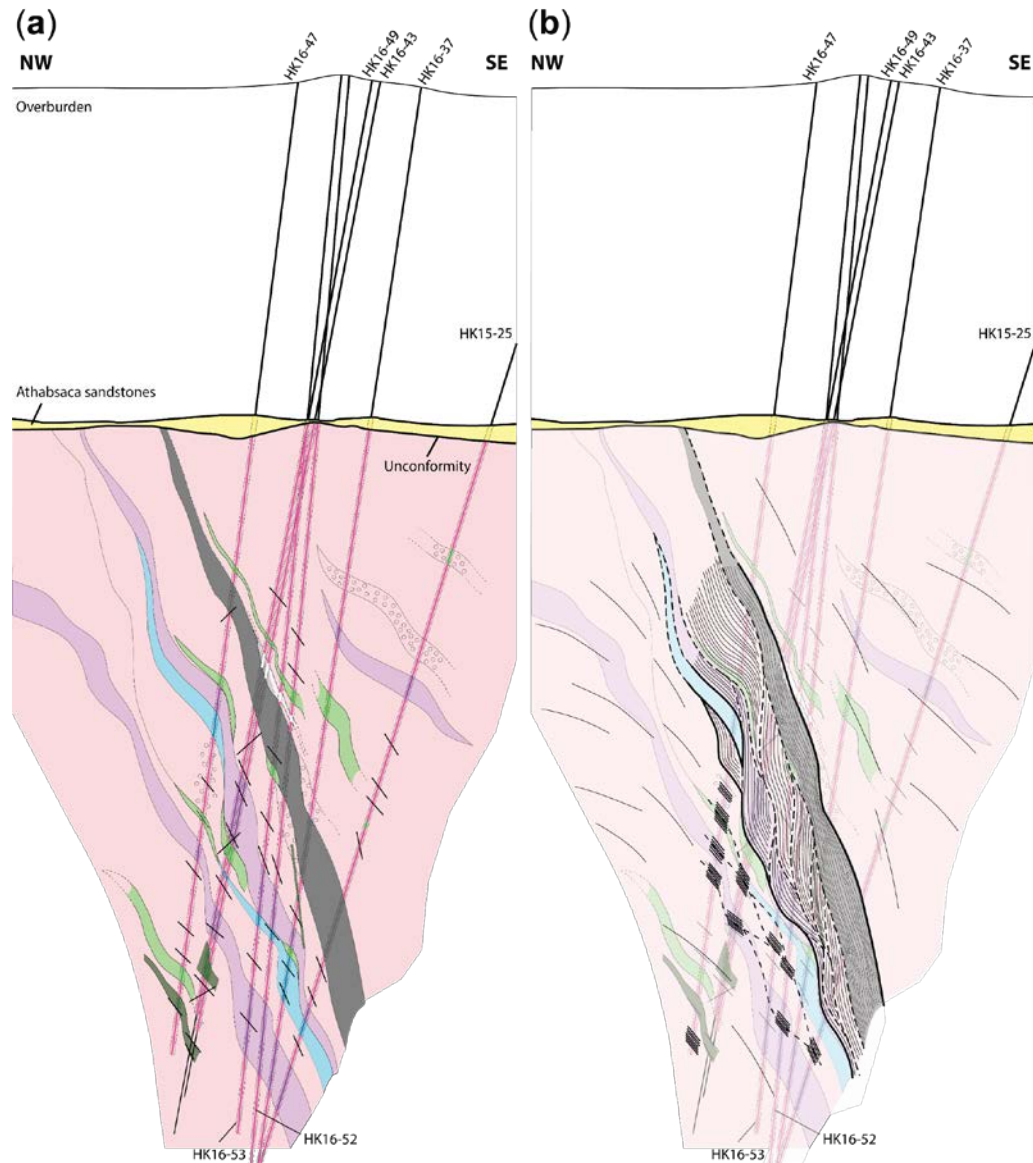
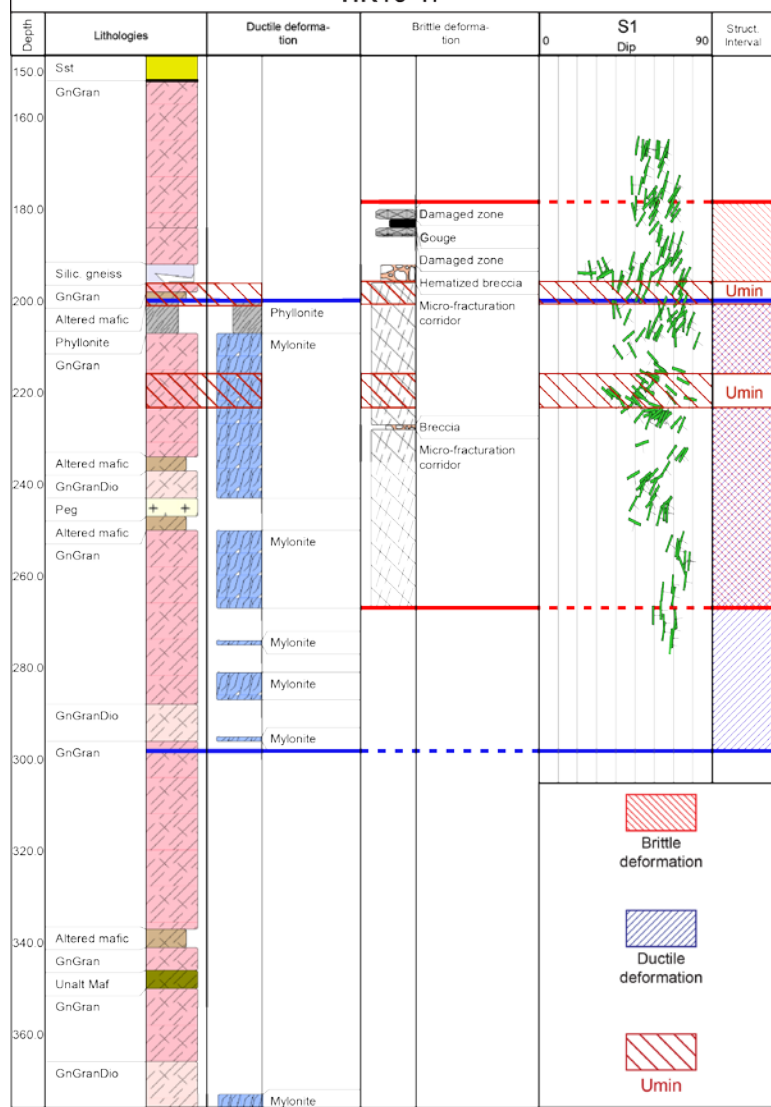
- Phyllonite
- Mylonitic orthogness
- Ductile-brittle shear zone
- Shear fold-like deformation
- Foliation

Brittle structures:

- Extent of the micro-fracturation
- Hematized grey-quartz breccia
- Argilized fault zone
- Isolated damaged zone
- Oriented data
- Uranium mineralization

0 50m

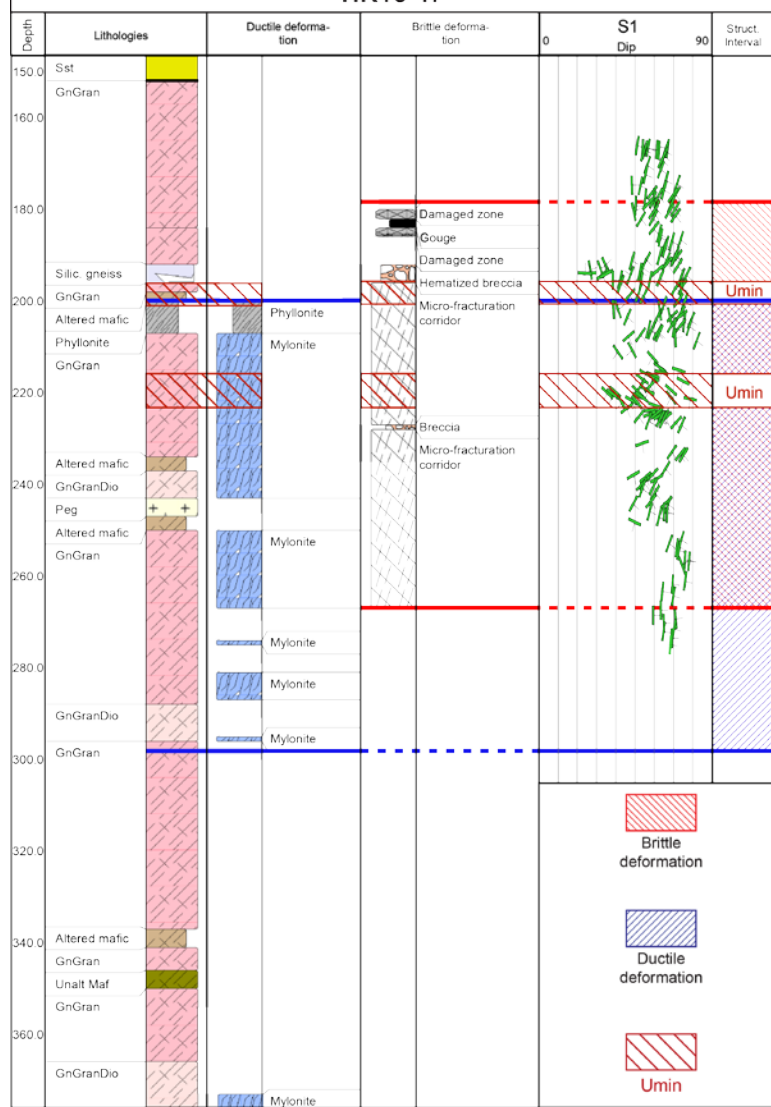
HK16-47



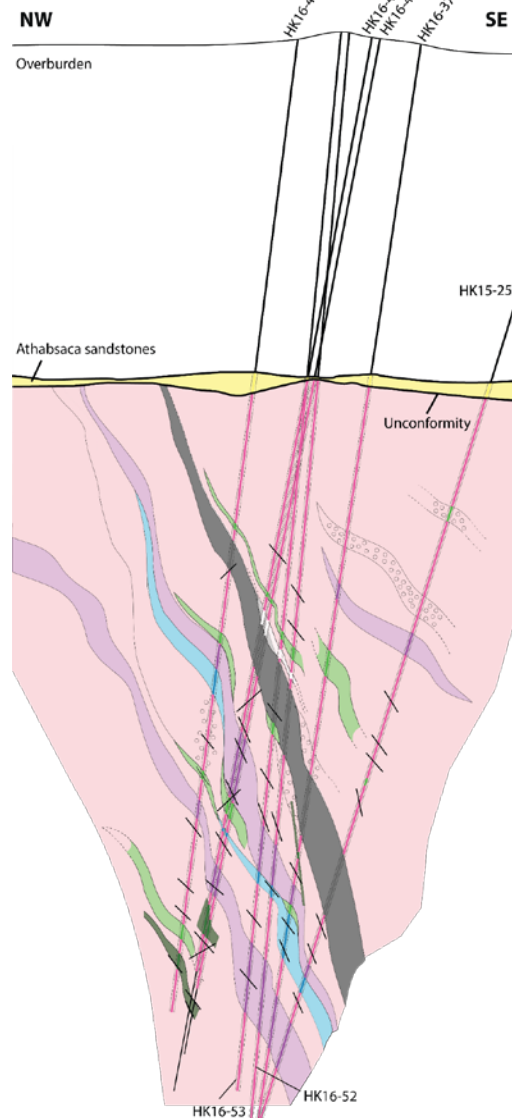
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0 50m

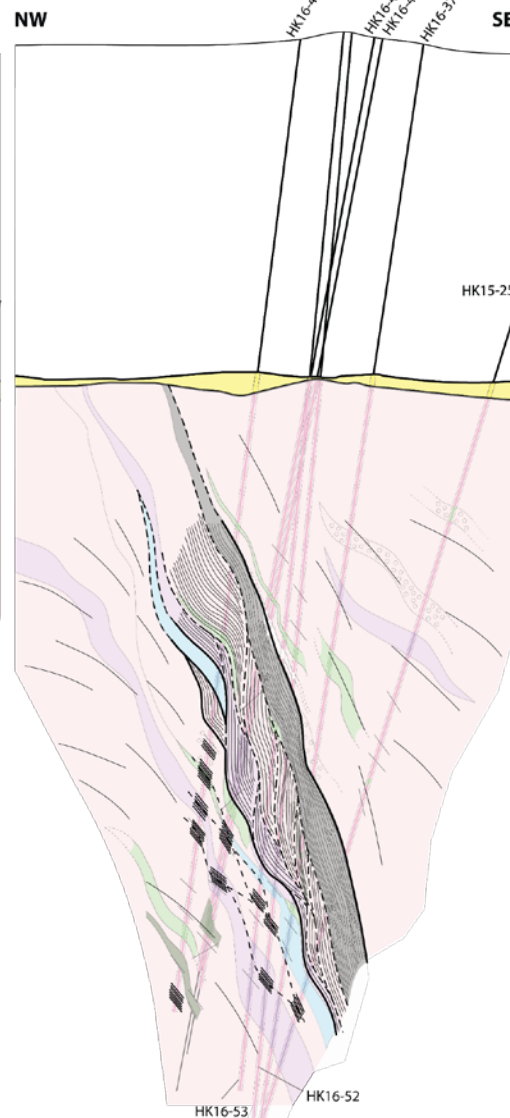
HK16-47



(a)



(b)

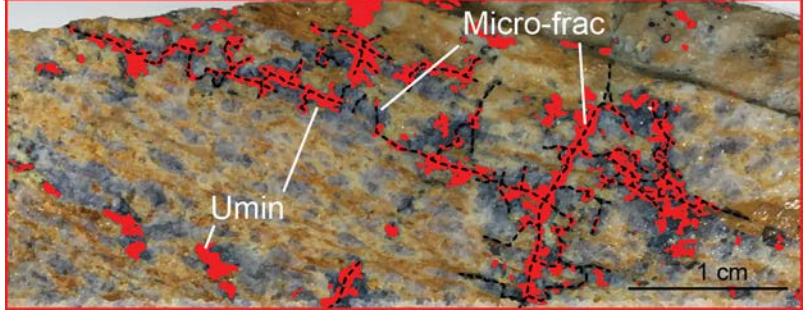
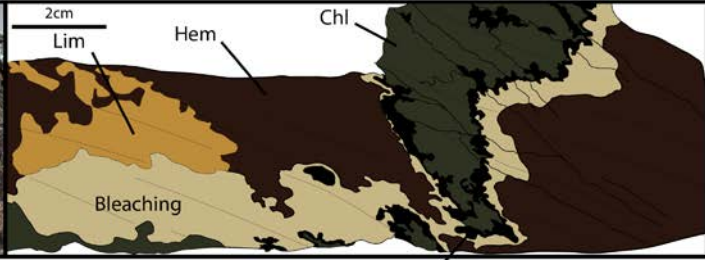
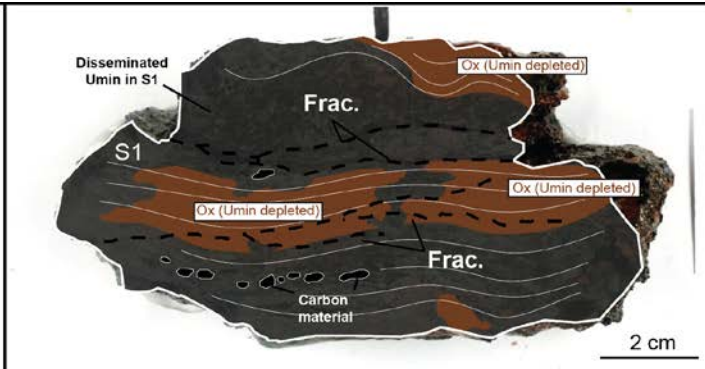
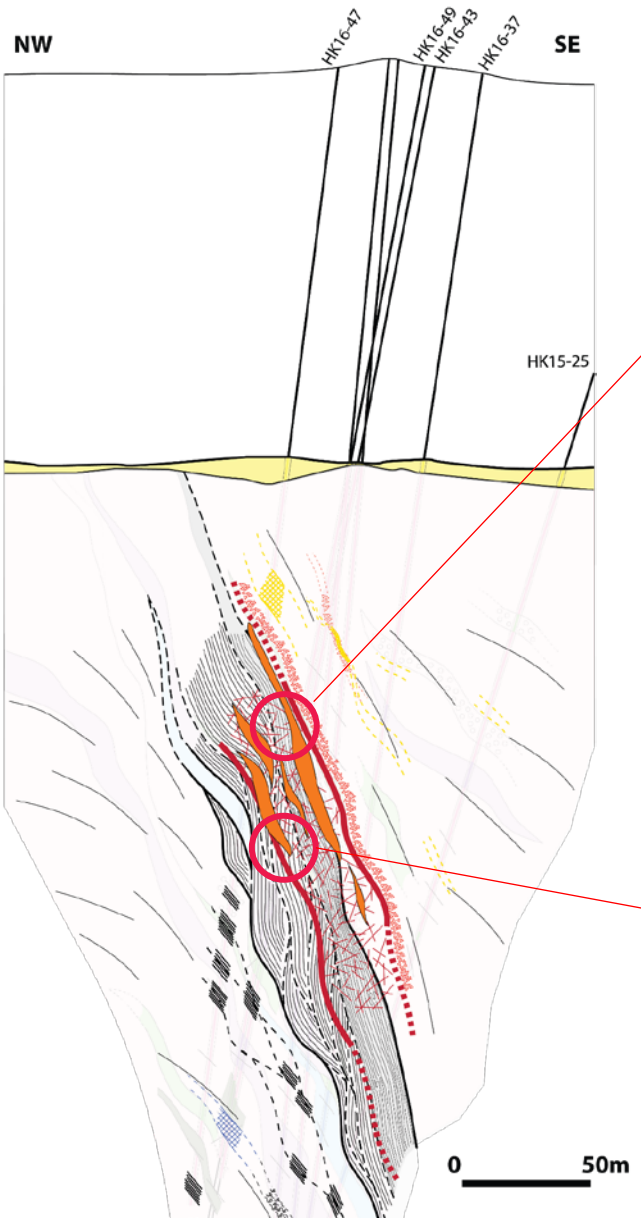


(c)



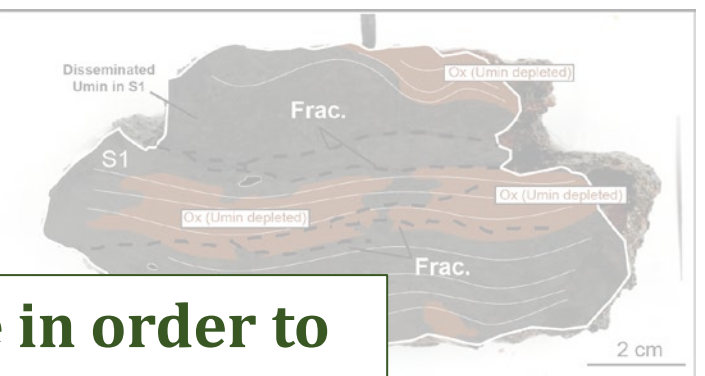
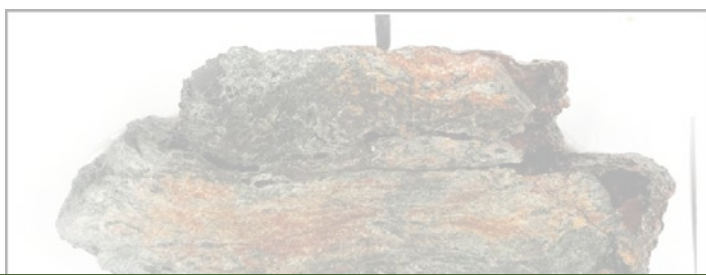
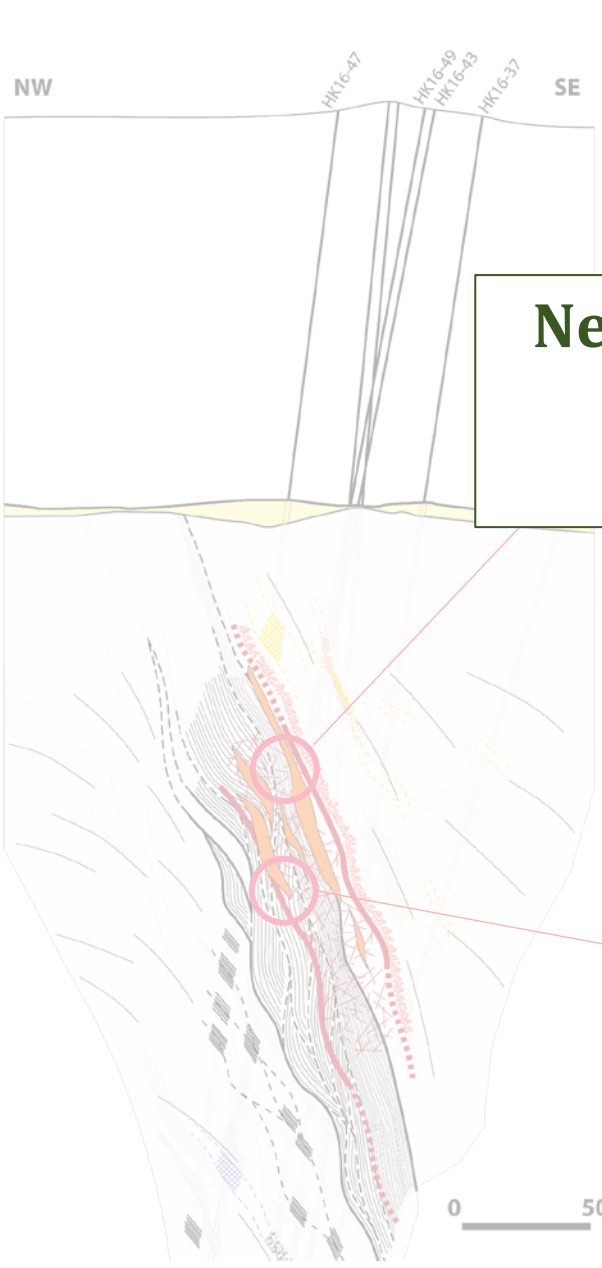
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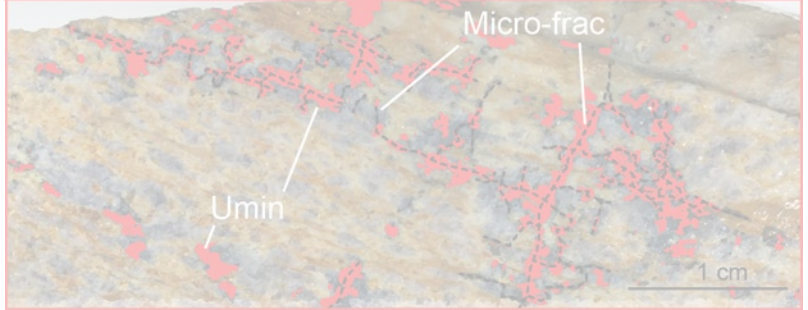
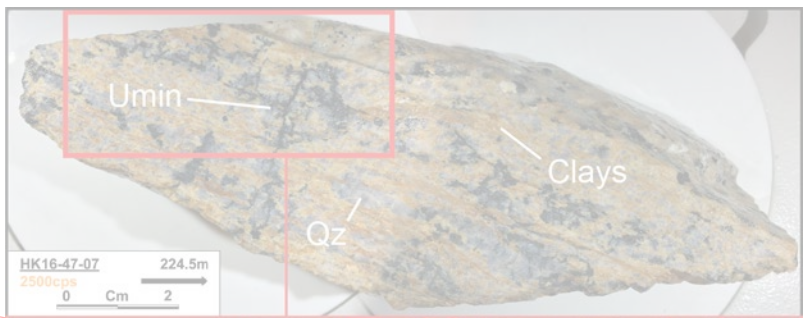


Main structural traps:

- Foliation: disseminated Umin
- Fractures: mili to micrometric, difficult to observe at the scale of the hand sample

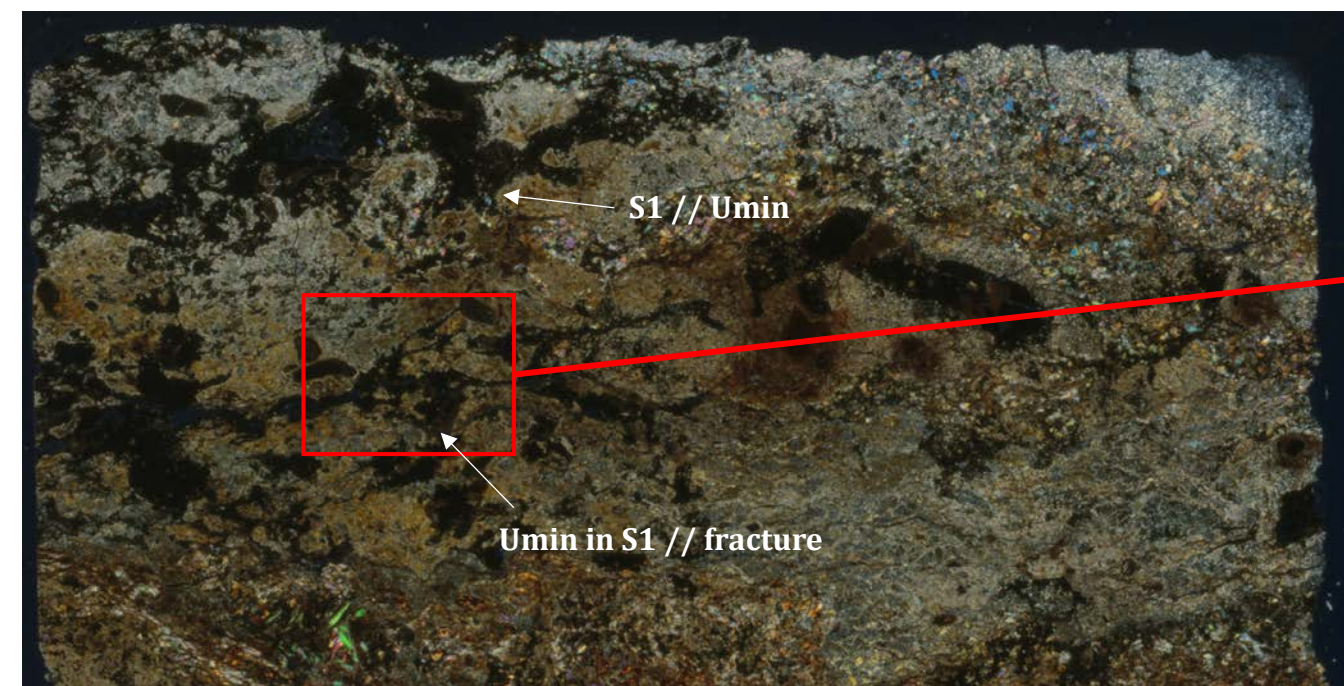
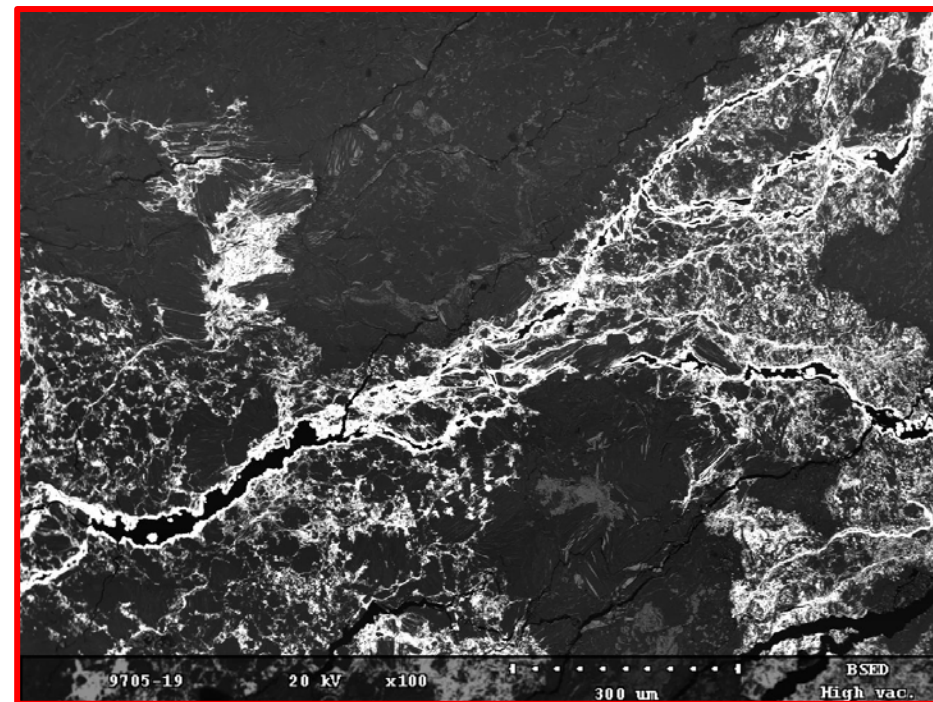
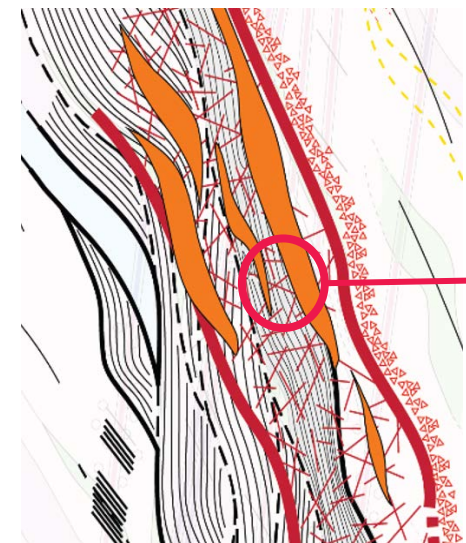


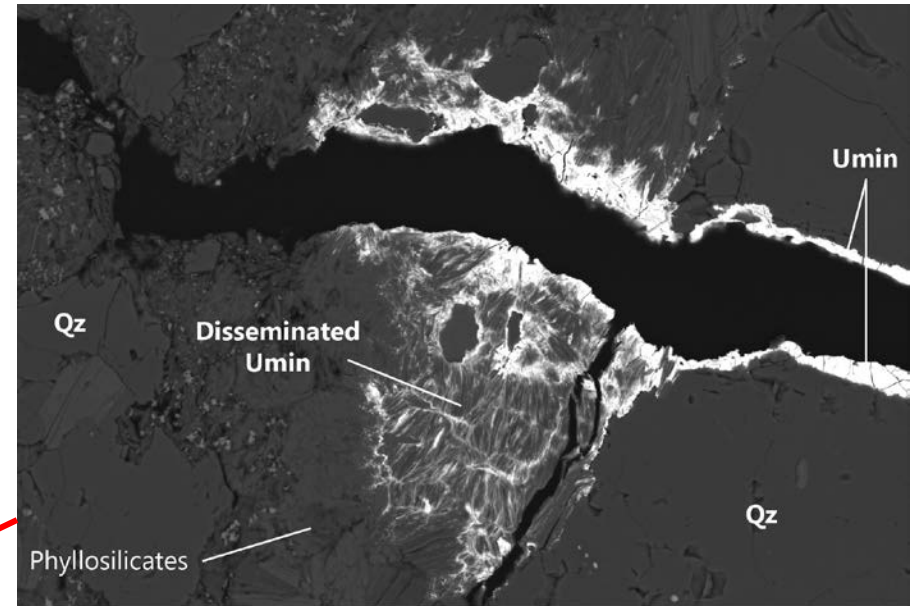
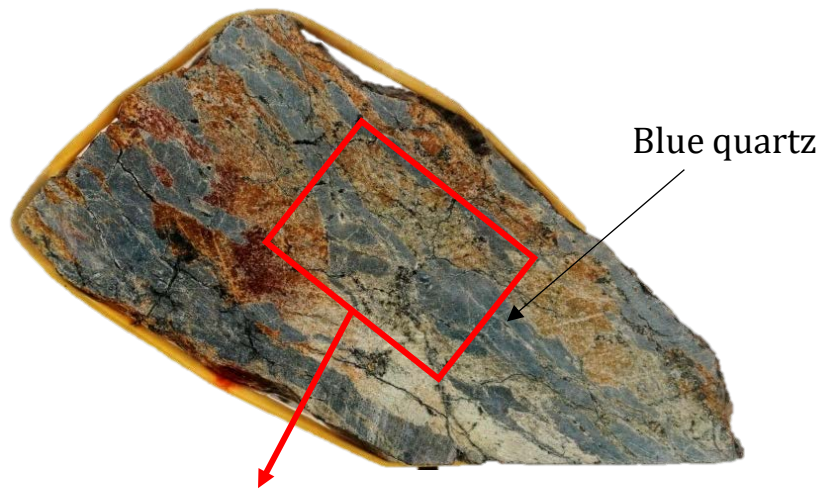
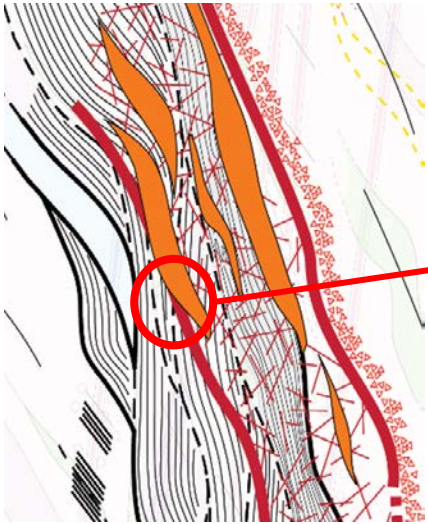
Need to switch to the microscale in order to get further information about micro-structures



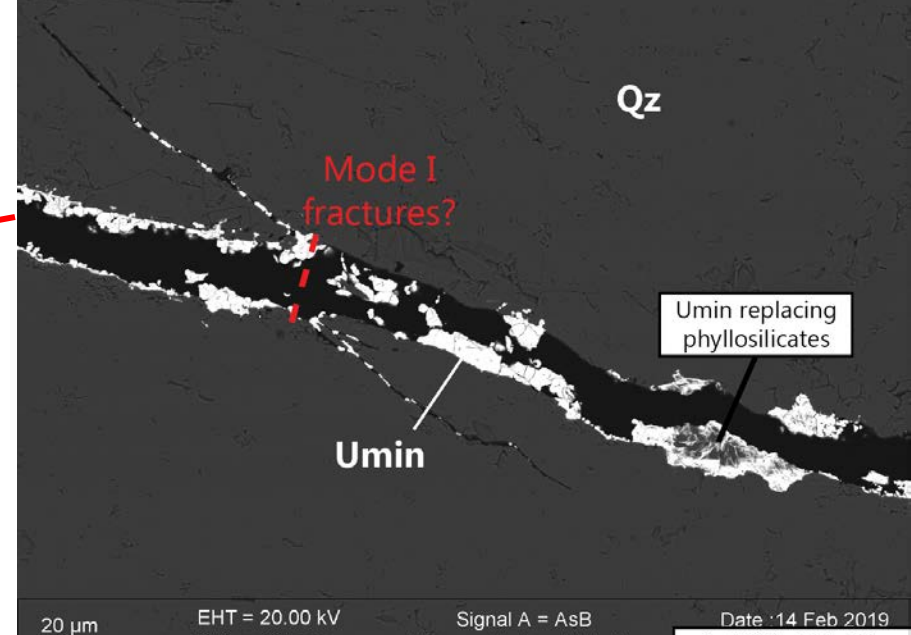
Main structural traps:

- Foliation: disseminated Umin
- Fractures: mili to micrometric, complex to observe at the scale of the hand sample

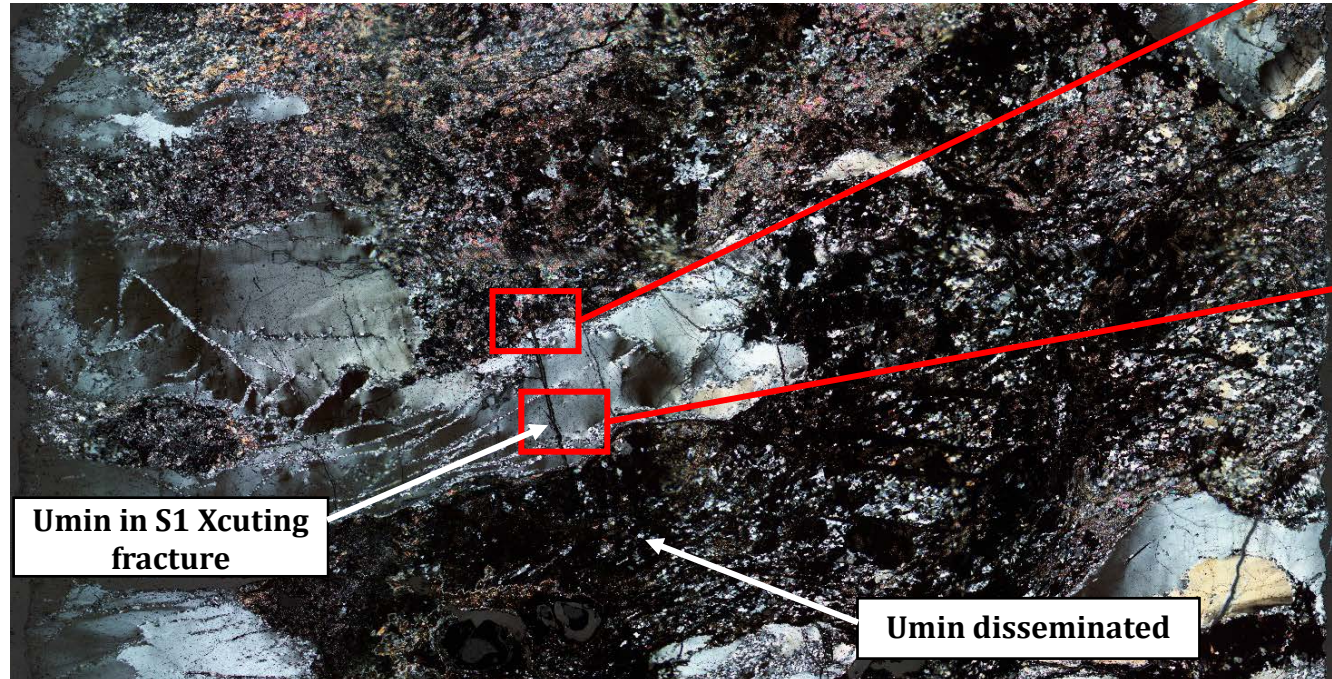




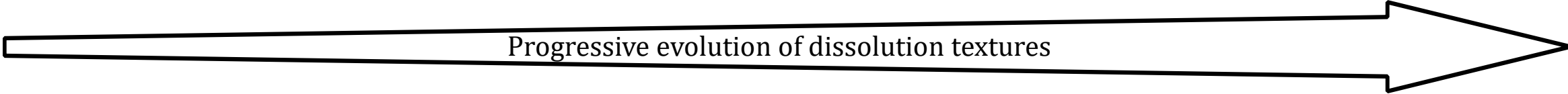
10 μ m
 EHT = 20.00 kV
 WD = 9.3 mm
 Signal A = AsB
 Vacuum Mode = High Vacuum
 Date : 14 Feb 2019
 Mag = 370 X



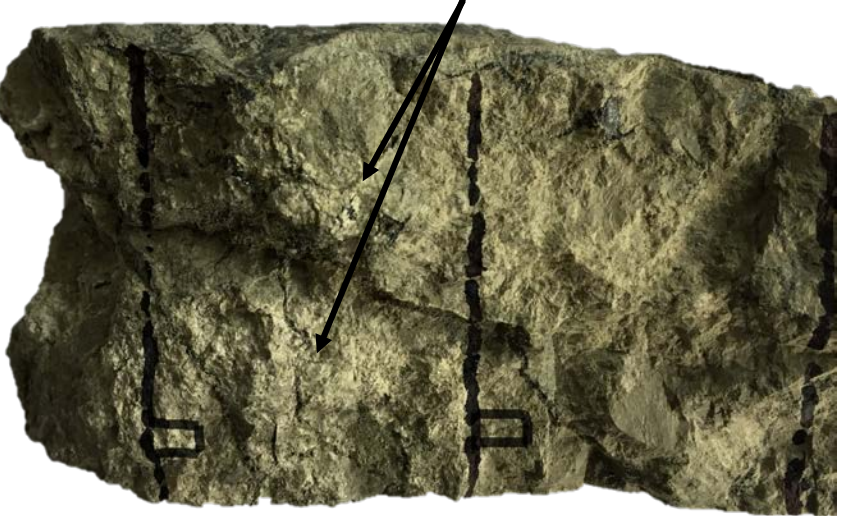
20 μ m
 EHT = 20.00 kV
 Signal A = AsB
 Date : 14 Feb 2019



Progressive evolution of dissolution textures

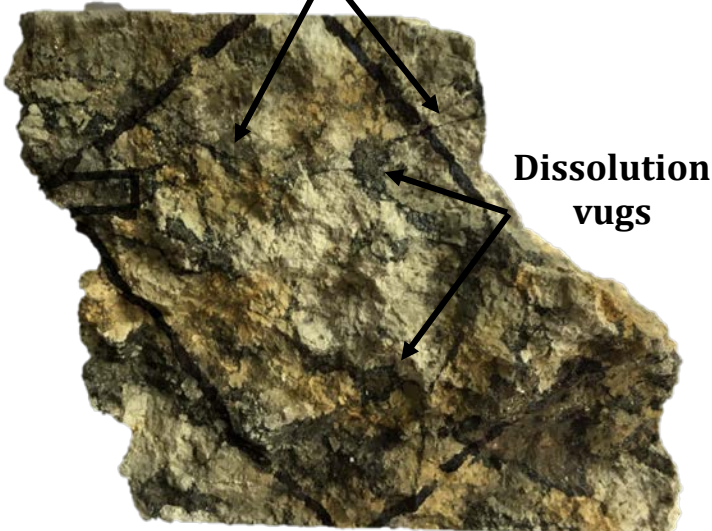


Micro-veins



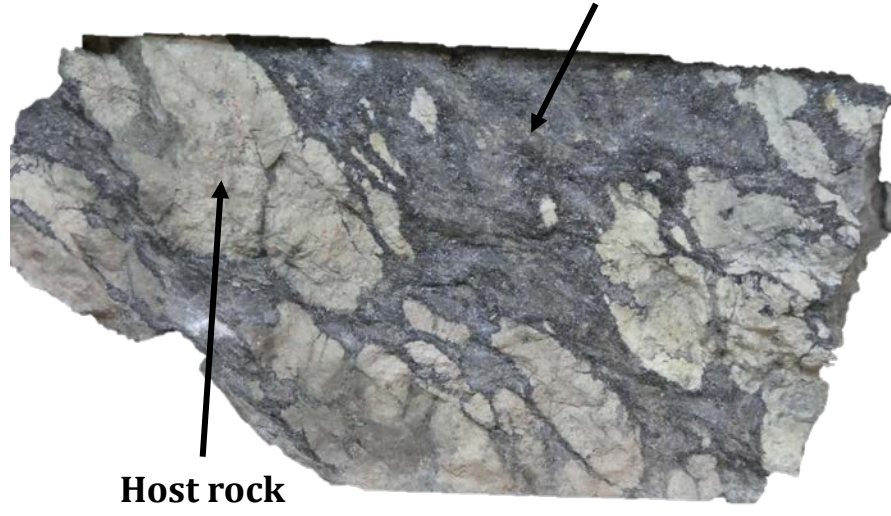
Isolated veinlets with dark infill (chlorite)

Micro-veins



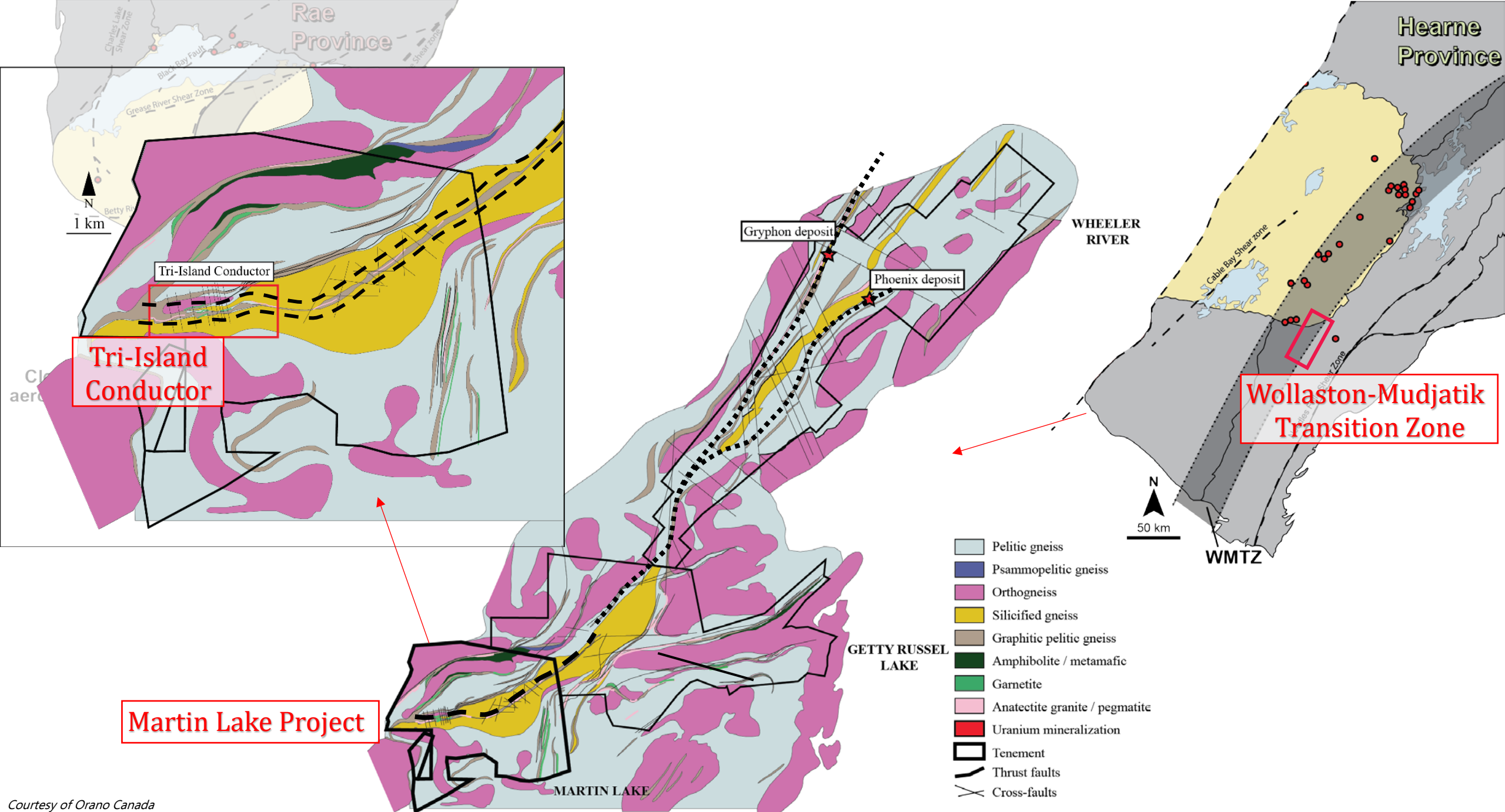
Connected veinlets driving dissolution of the host rock

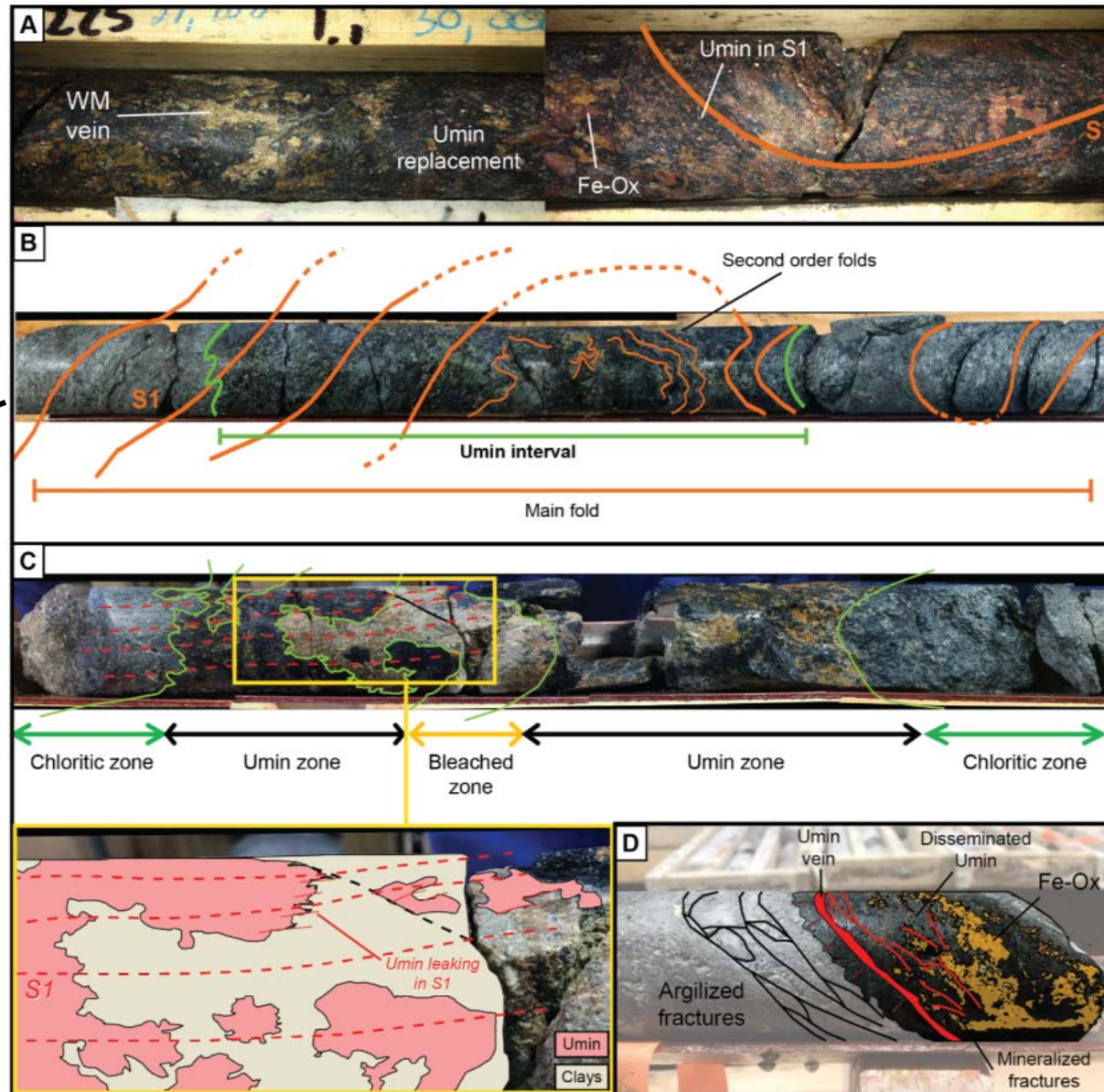
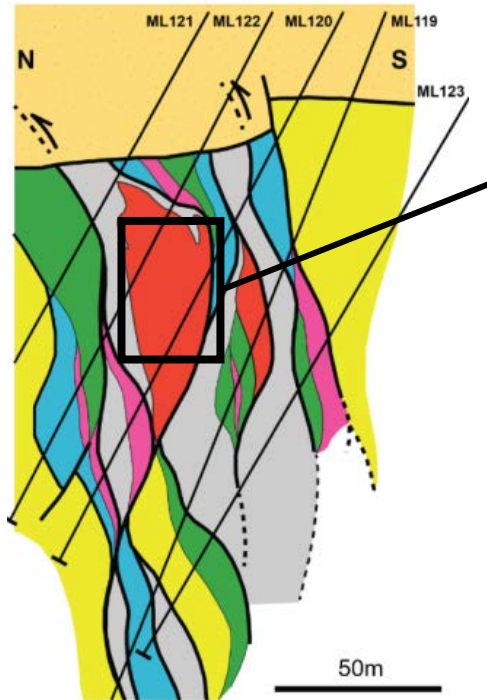
Chlorite



Isolated host-rock clasts in dark matrix (chlorite)





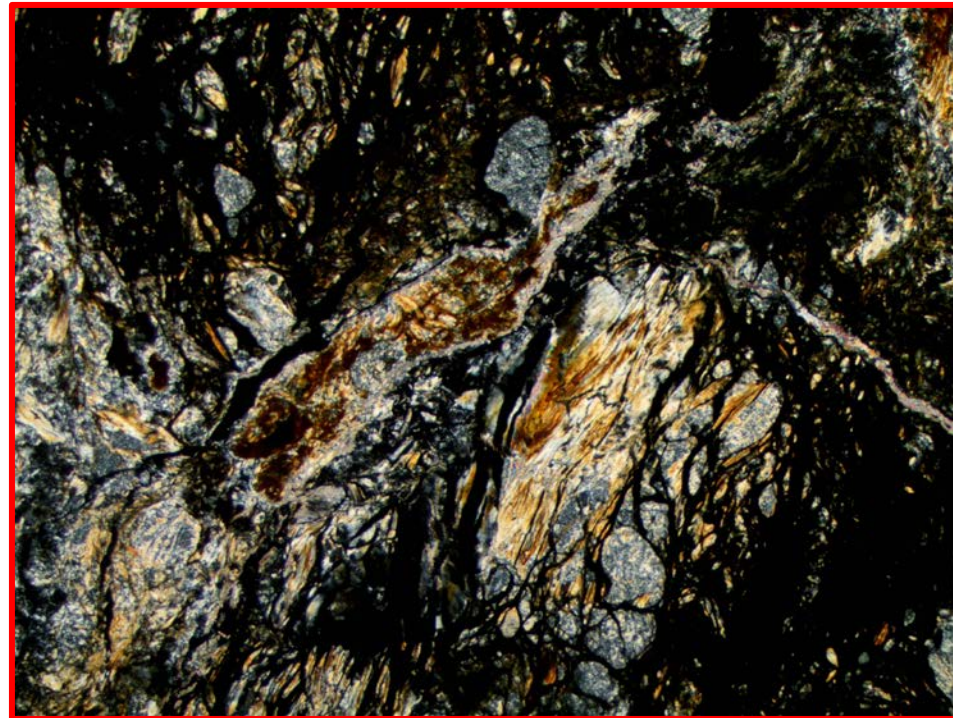
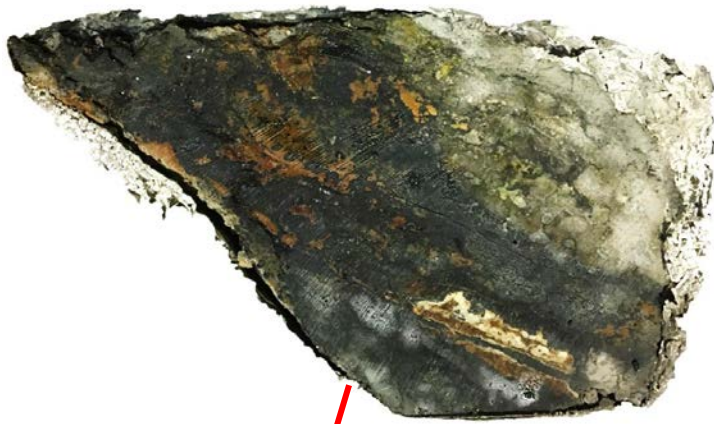


Main structural traps:

- Massive mineralization **replacing** the host rock
- **Local inversion** in foliation dip
- **Lack of major brittle** structure running through the basement

Mineralization disseminated along foliation and ductile structures (folds) ✓

Local mineralized micro-fractures, often S1 // ✓

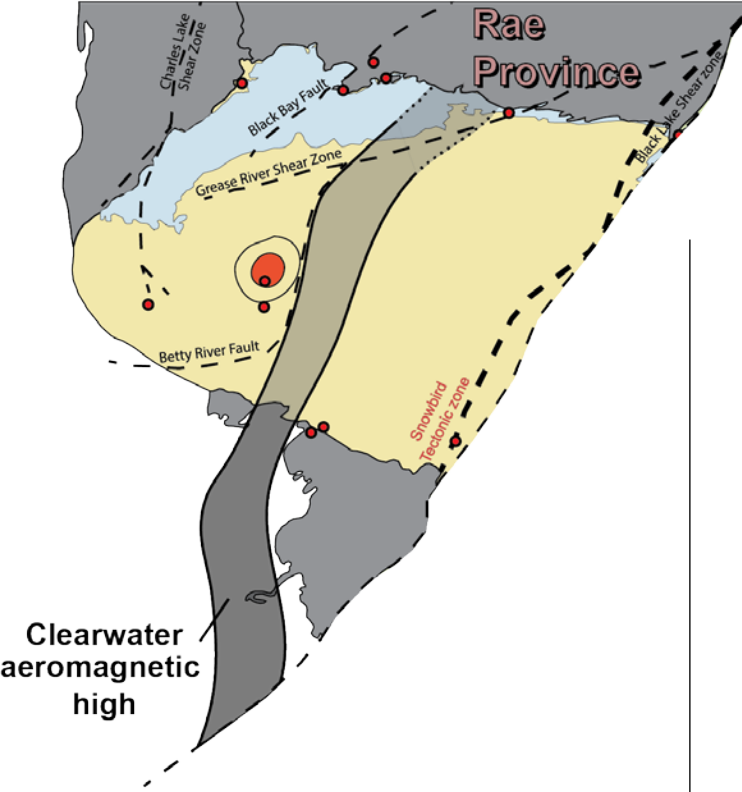


Observations at the microscale:

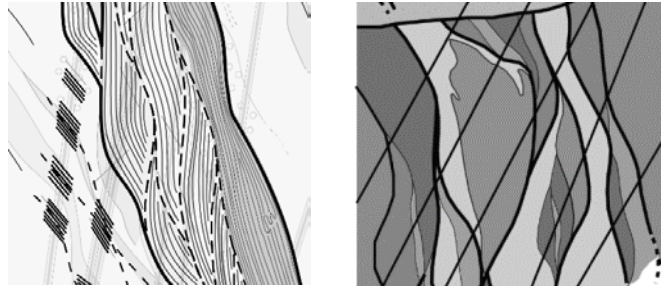
- Strong clay alteration (chlorite and illite)
- Umin disseminated **in micro-veins**
- Veins forming an **anastomosed network**

Microscopic mineralized veins ✓

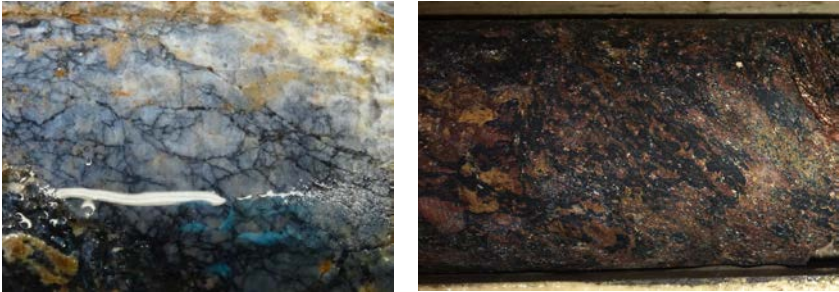
Veins geometry following the metamorphic fabric ✓



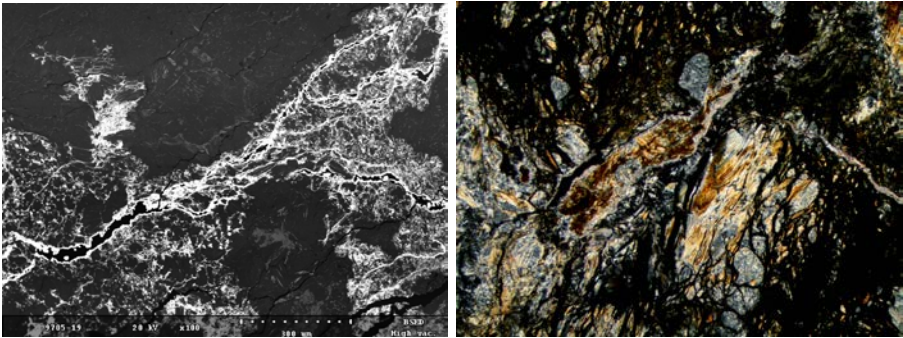
GEOLOGICAL FEATURES SHARED BY THE PLC AND THE WMTZ



Strongly deformed and altered ductile shear zone

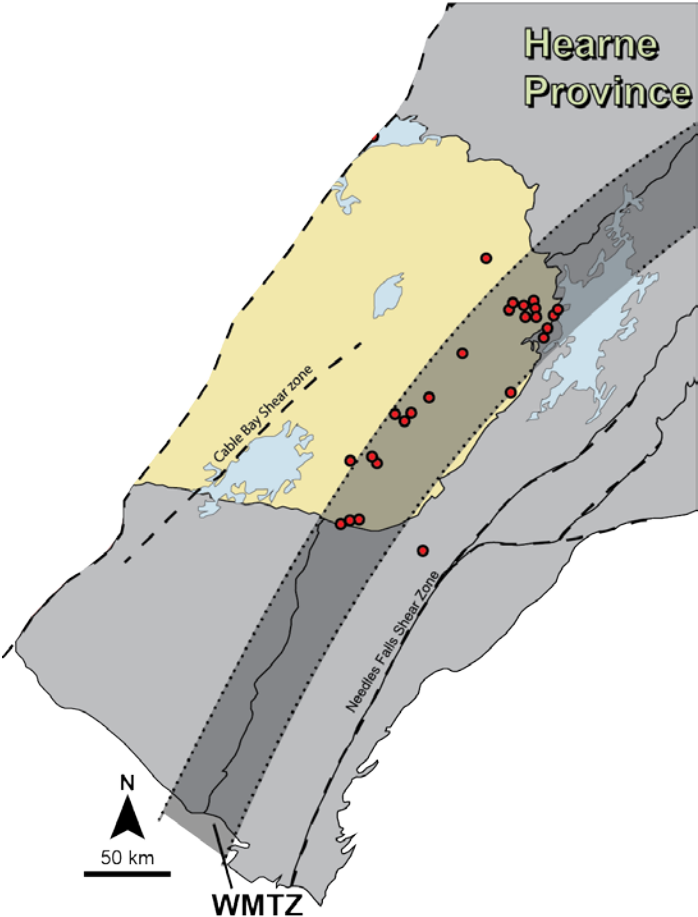


Umin associated to small fractures and disseminated in S1

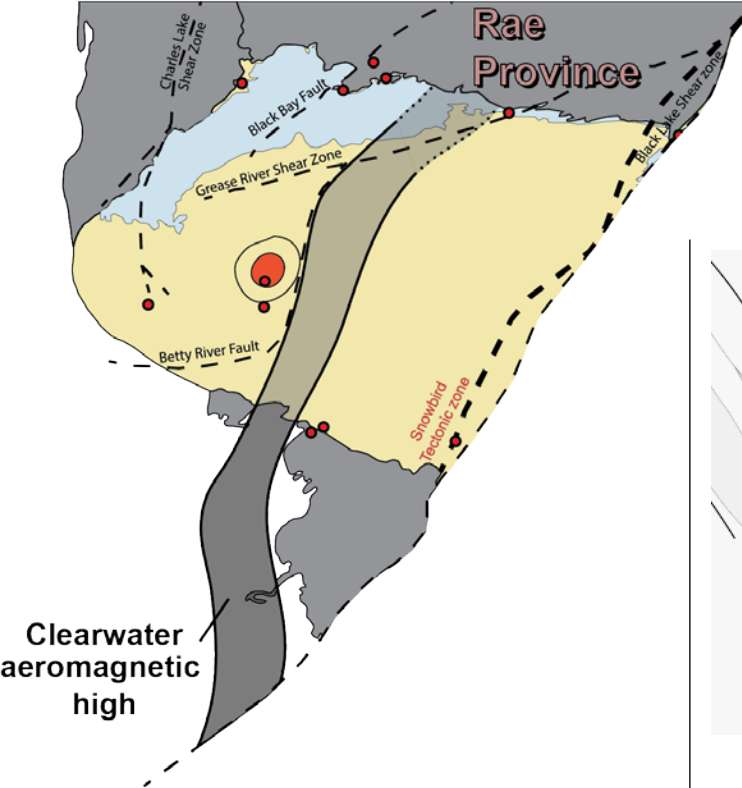


Well-developed microscale fracture network

- East Athabasca
- Pelitic-derived basement
- East-West conductive trend

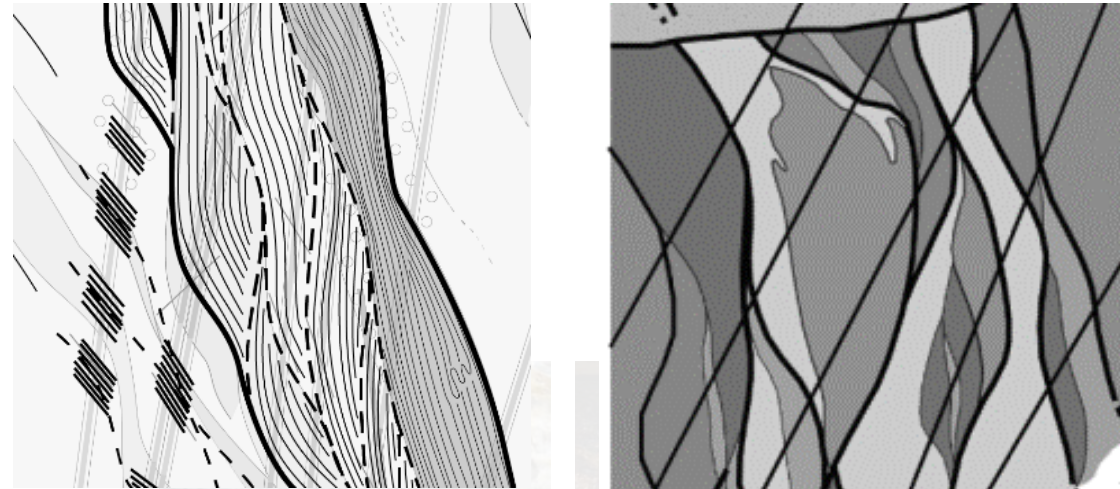


- West Athabasca
- Orthogneiss basement
- NE-SW conductive trend



GEOLOGICAL FEATURES SHARED BY THE PLC AND THE WMTZ

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- East-West conductive trend

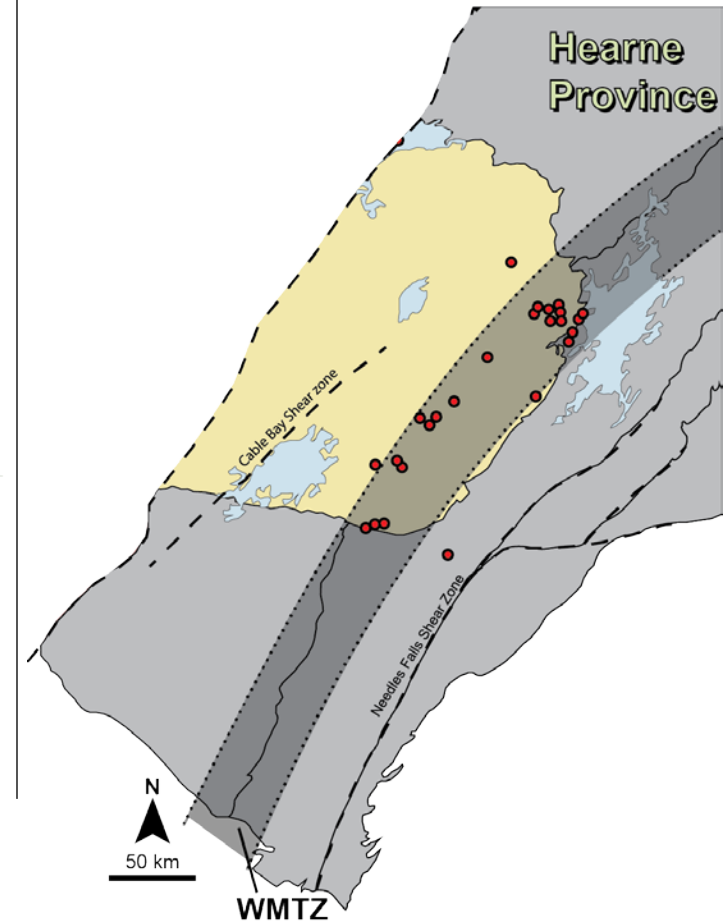


Strongly deformed and altered ductile shear zone

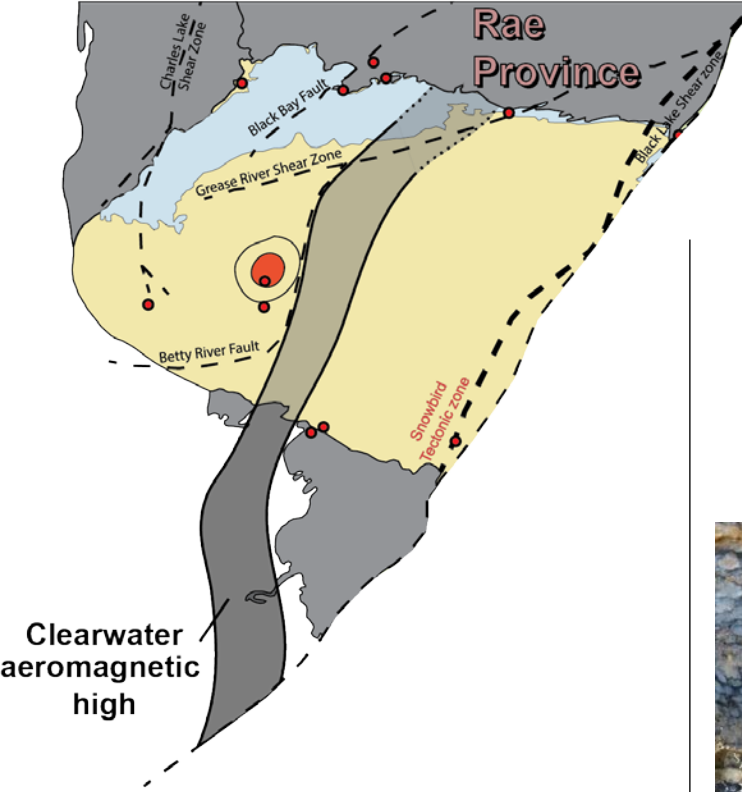
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Well-developed microscale fracture network



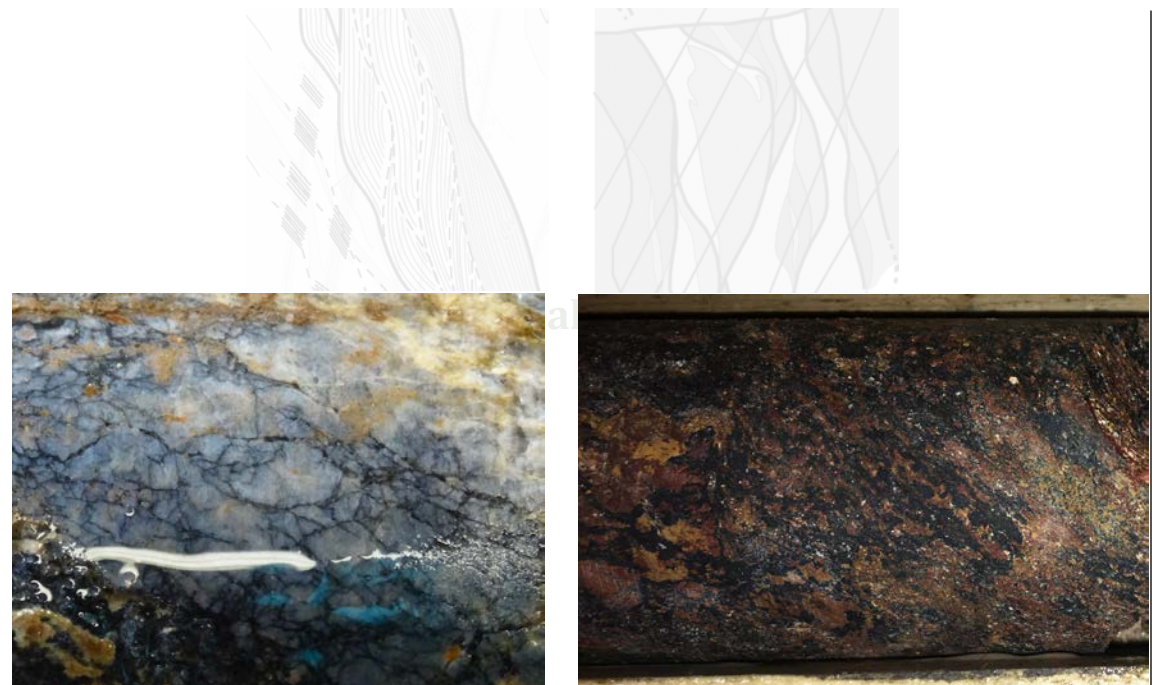
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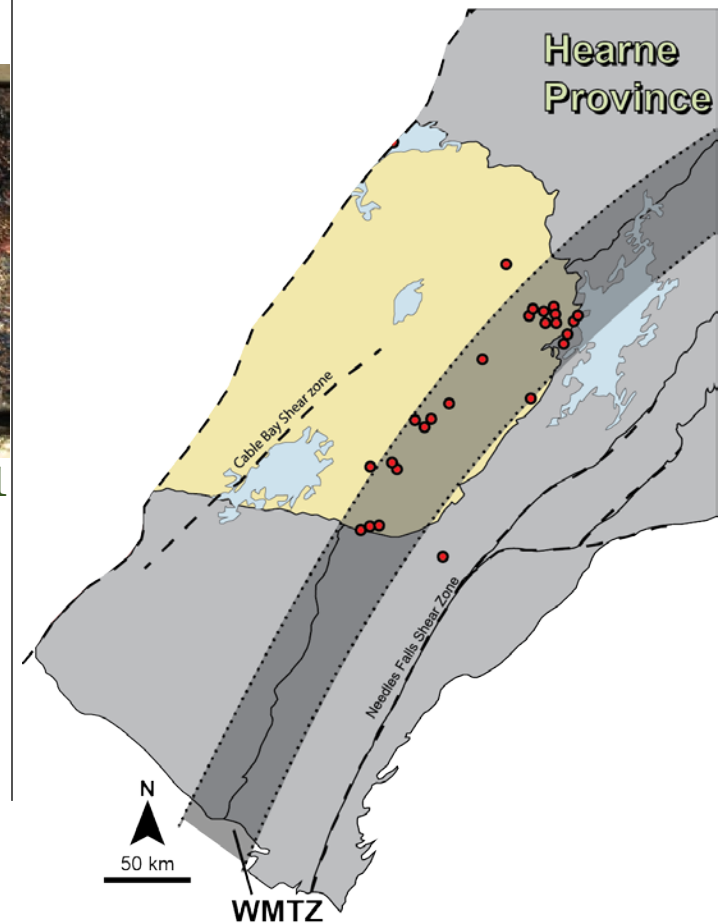
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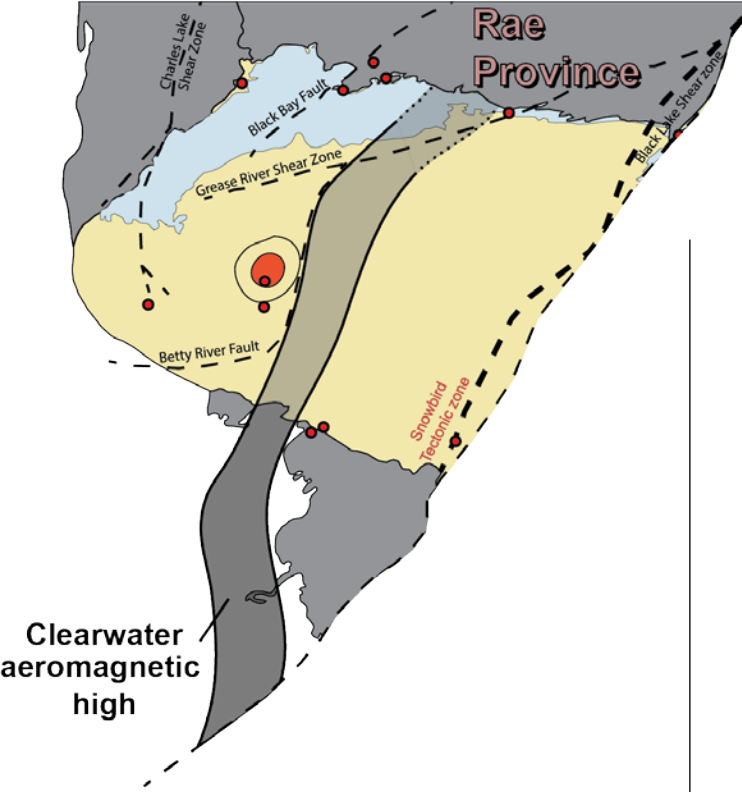


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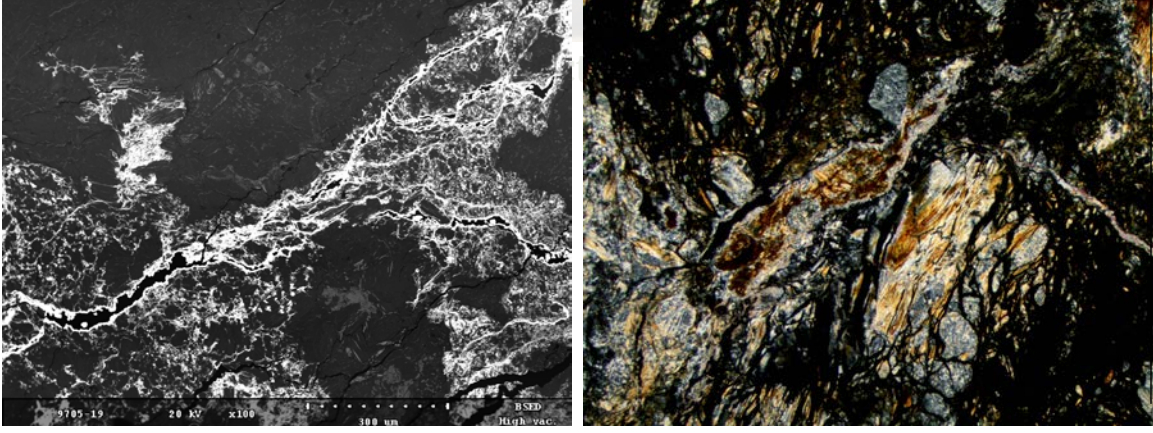
Well-developed microscale fracture network





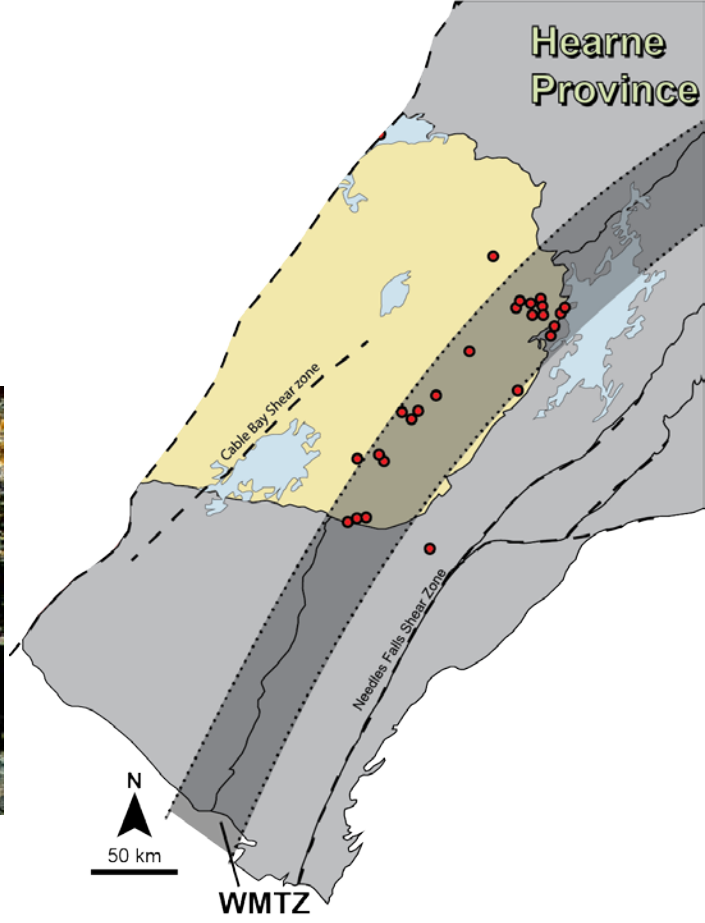
GEOLOGICAL FEATURES SHARED BY THE PLC AND THE WMTZ

Strongly deformed and altered ductile shear zone



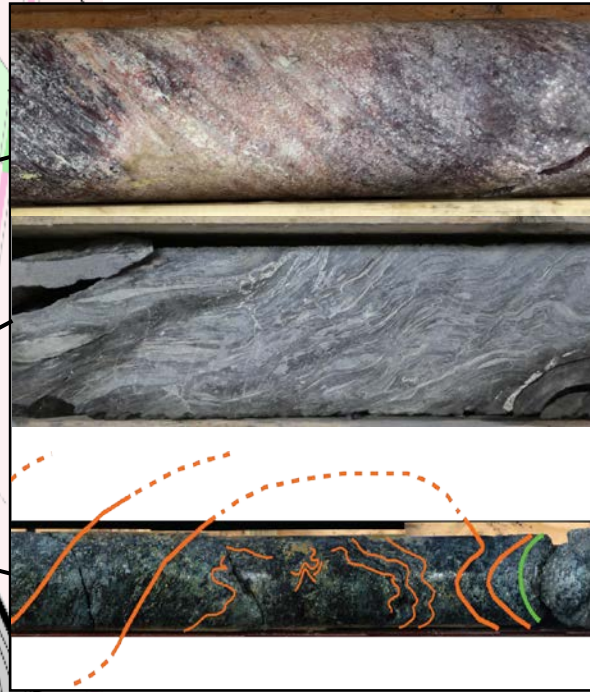
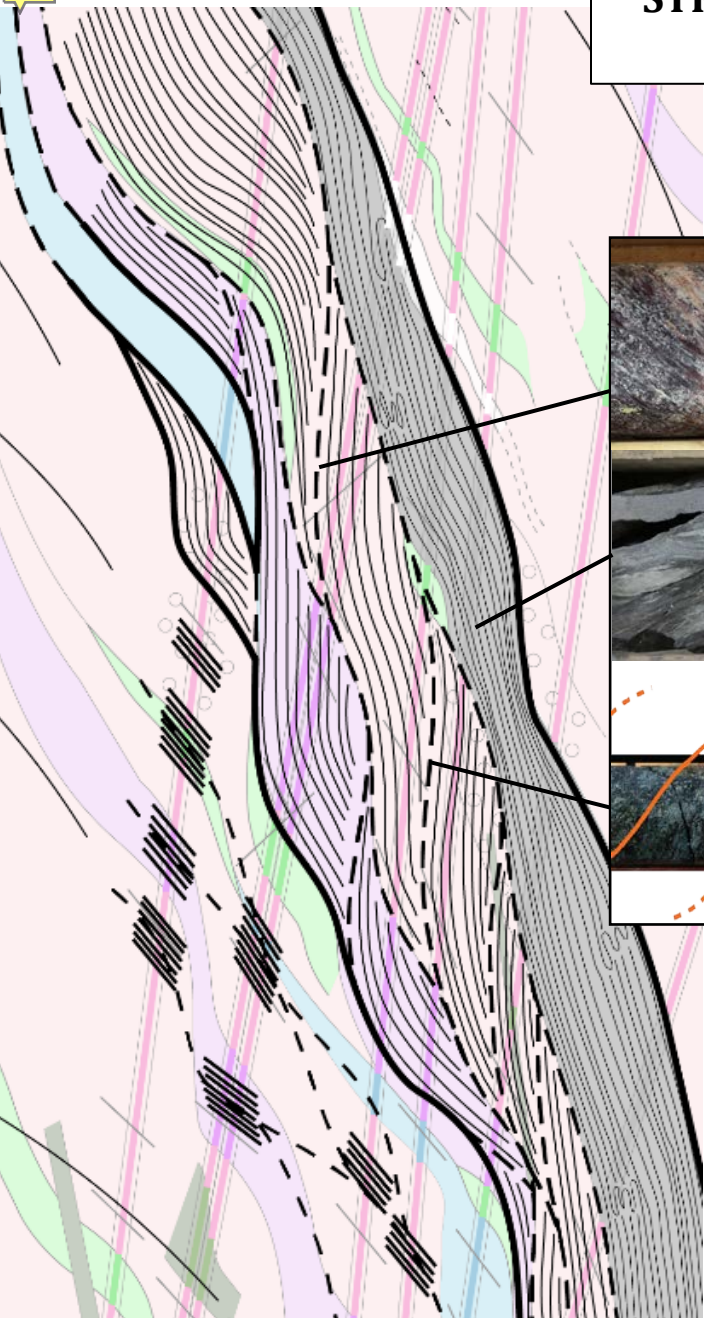
Well-developed microscale fracture network

- East Athabasca
- Pelitic-derived basement
- East-West conductive trend

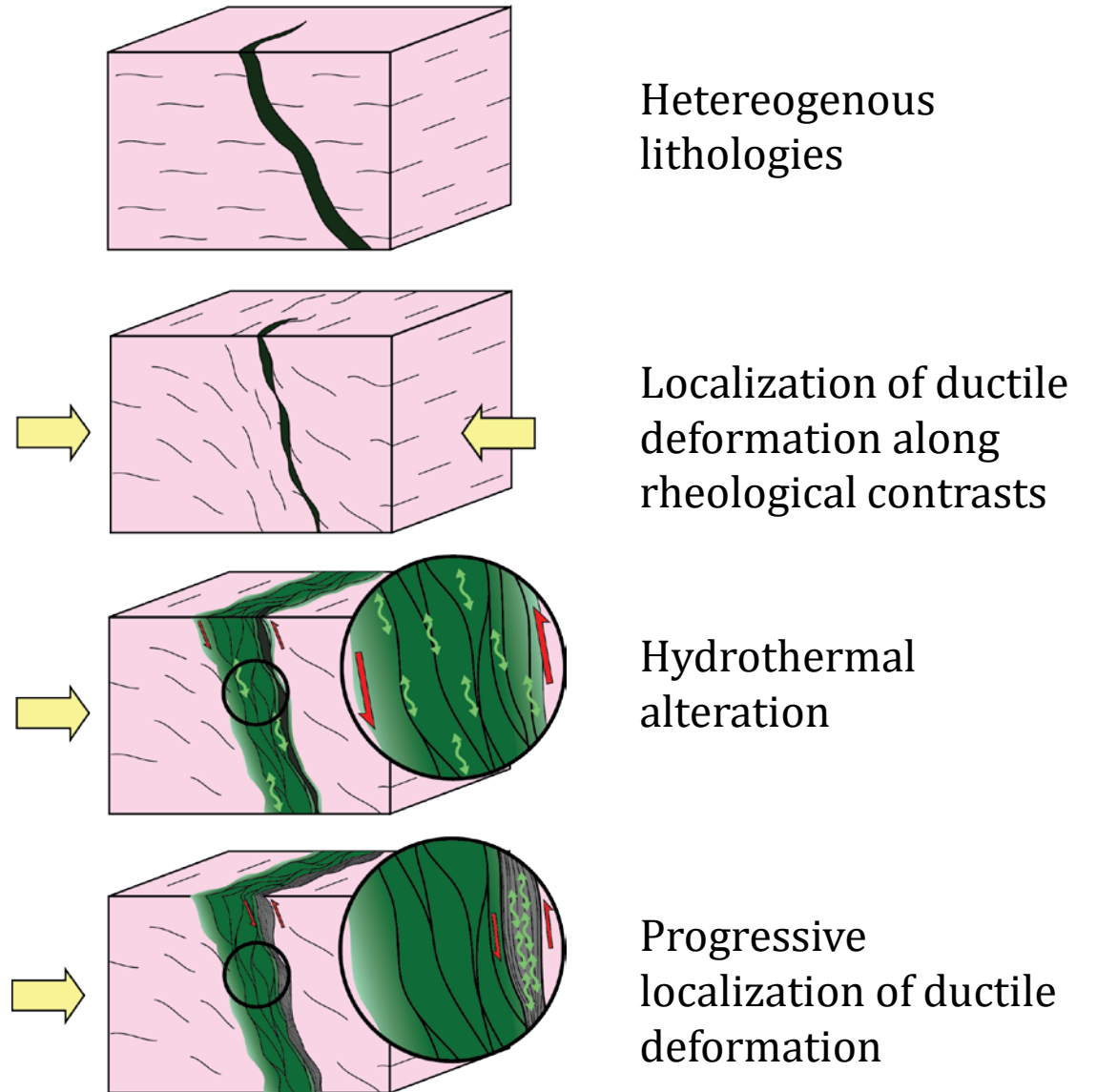


- West Athabasca
- Orthogneiss basement
- NE-SW conductive trend

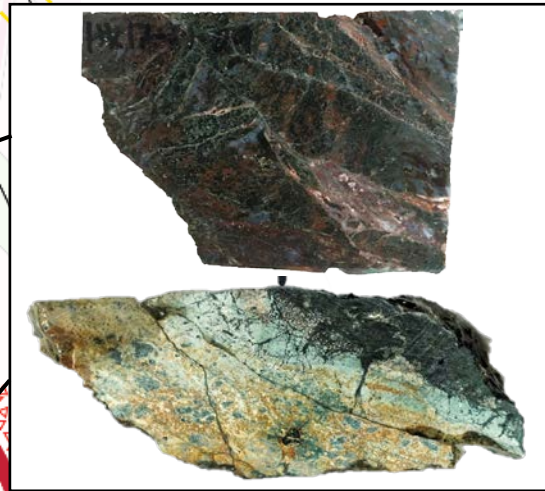
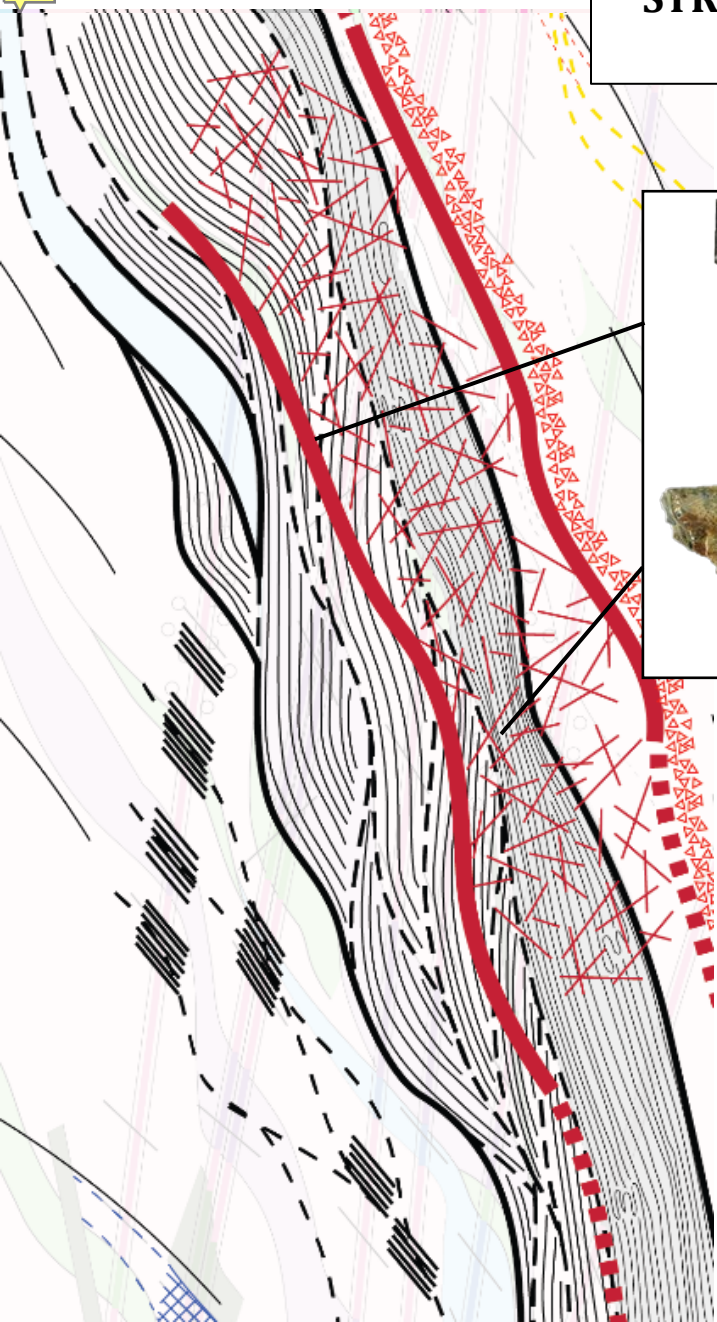
STRUCTURAL EVOLUTION OF A BASEMENT DUCTILE SHEAR ZONE FROM THE ATHABASCA BASIN: DUCTILE INHERITAGE



Mylonites



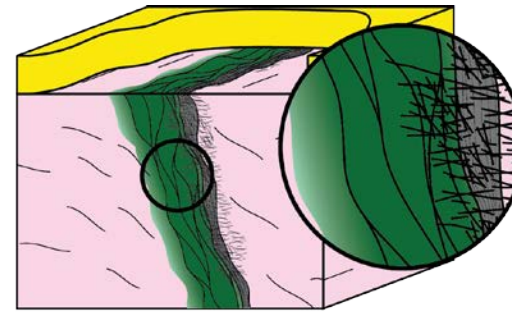
STRUCTURAL EVOLUTION OF A BASEMENT DUCTILE SHEAR ZONE FROM THE ATHABASCA BASIN: BRITTLE REACTIVATION



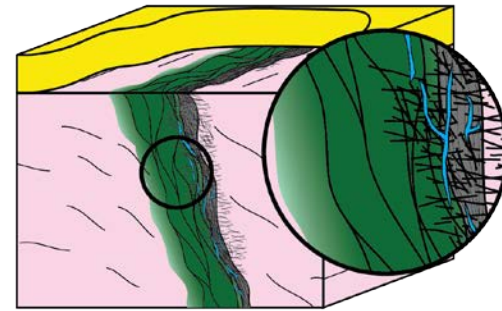
Fracturing



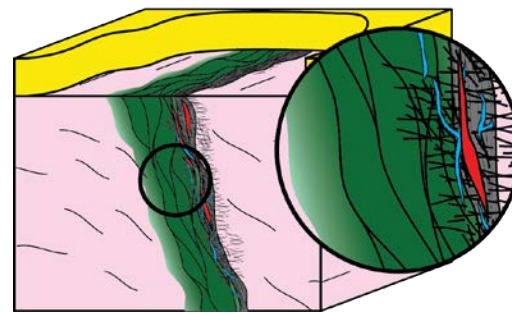
Dissolution



Fracturing along strong anisotropies



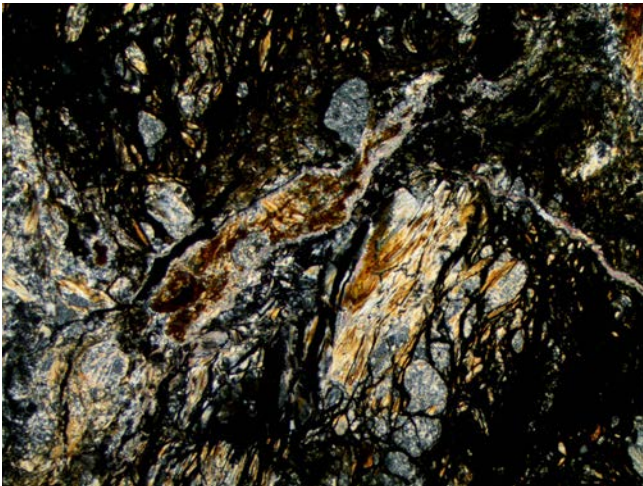
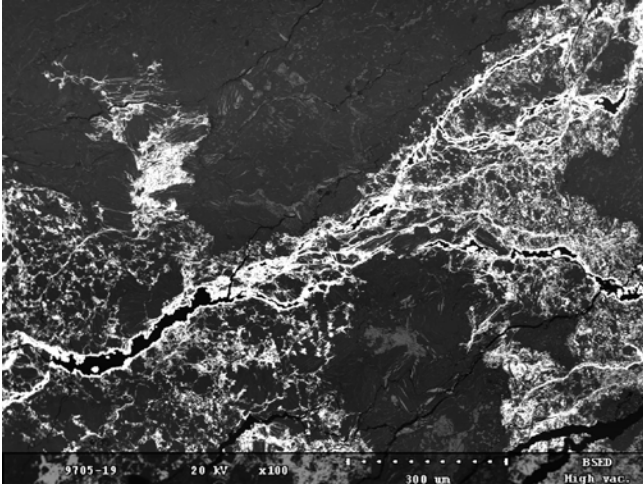
Hydrothermal alteration and porosity enhancement



Mineralization localized by the matured porosity network

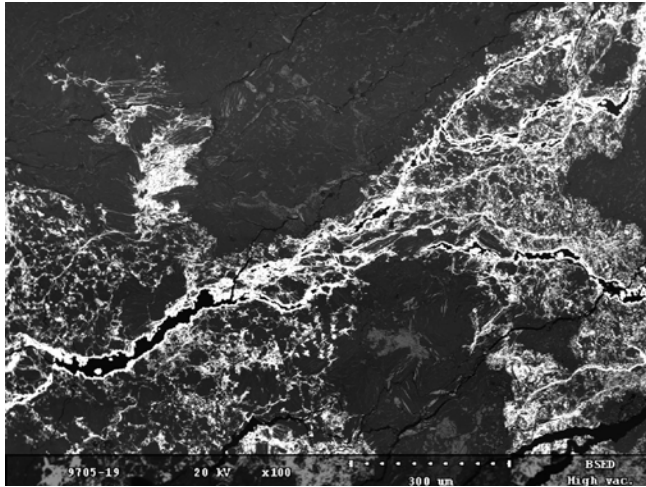
➤ **Different geological domains,
similar deformation mechanisms:**

- Altered and deformed shear zone
- Corridor of micro-fractures
- Strong dissolution evidences



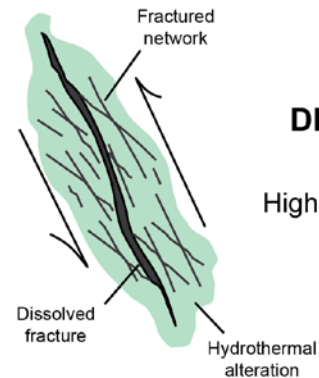
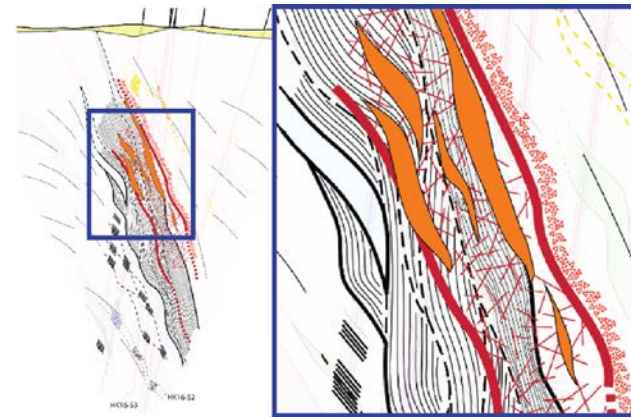
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➤ **Favorable porosity network: Damaged zone enhanced by late hydrothermal circulation:**

- Combination of microfractures along metamorphic fabric and dissolution processes

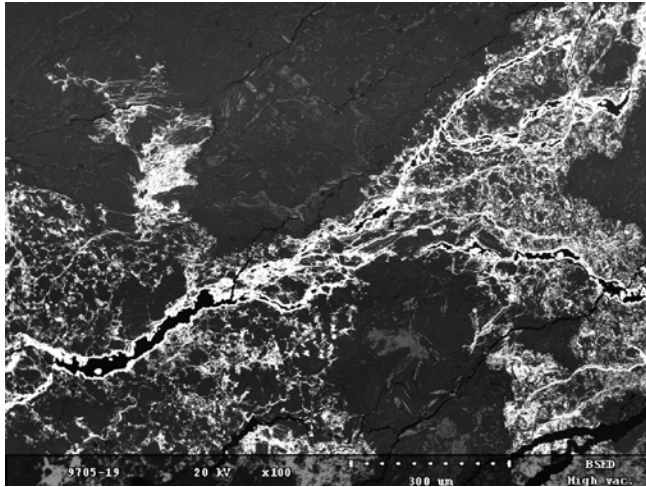


DISTRIBUTED CONDUIT

High % Damage zone
Low % Core

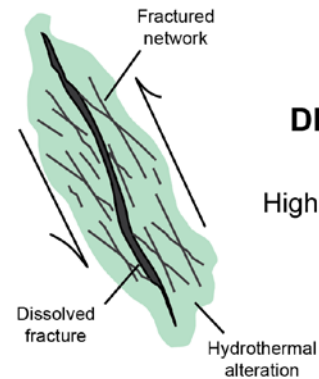
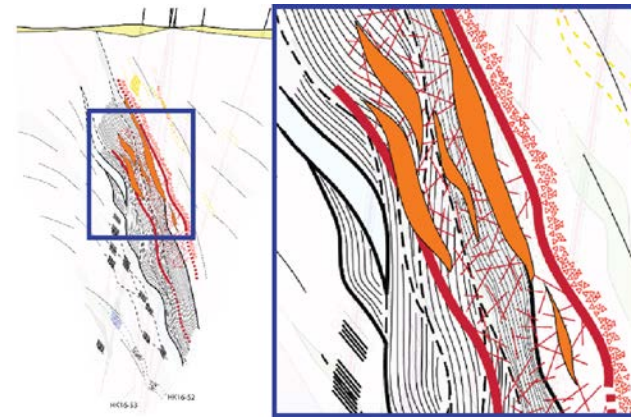
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➤ **Polyphased deformation and alteration history:**

- Deformation focusing along rheological contrasts...
- ... enhanced by hydrothermal and retromorphic alteration
- Brittle reactivation along these contacts
- Mineralization in the porosity network

