OROGENIC GOLD DEPOSITS

ARCHEAN OROGENIC GOLD DEPOSITS ASSOCIATED WITH STRUCTURALLY-CONTROLLED METASEDIMENTARY BELTS OF THE SUPERIOR CRATON

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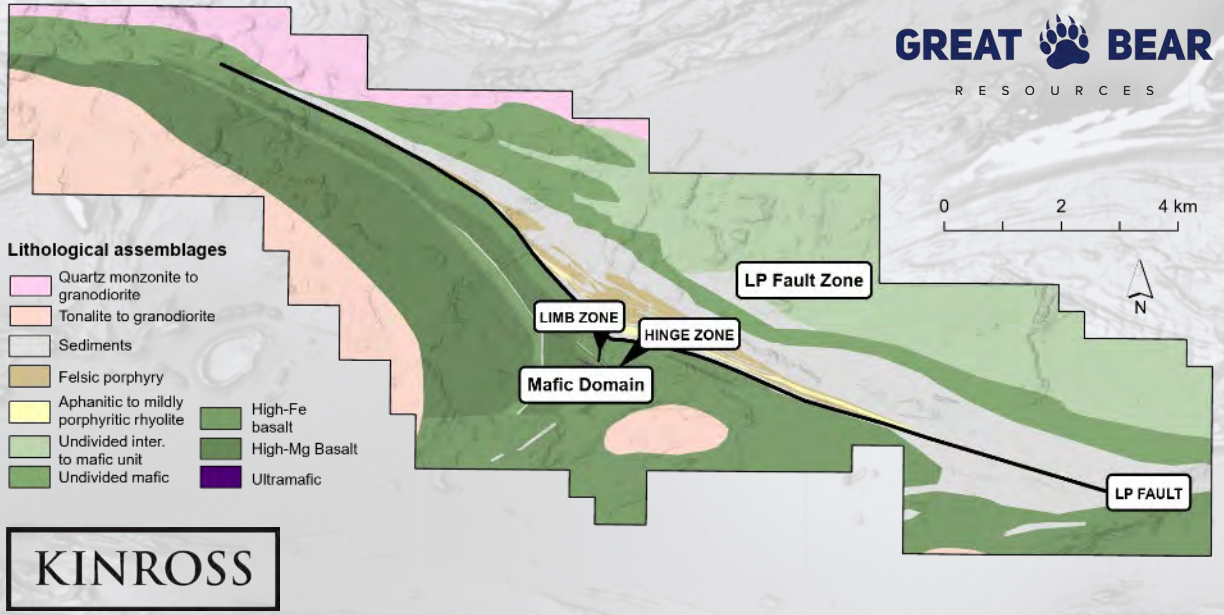

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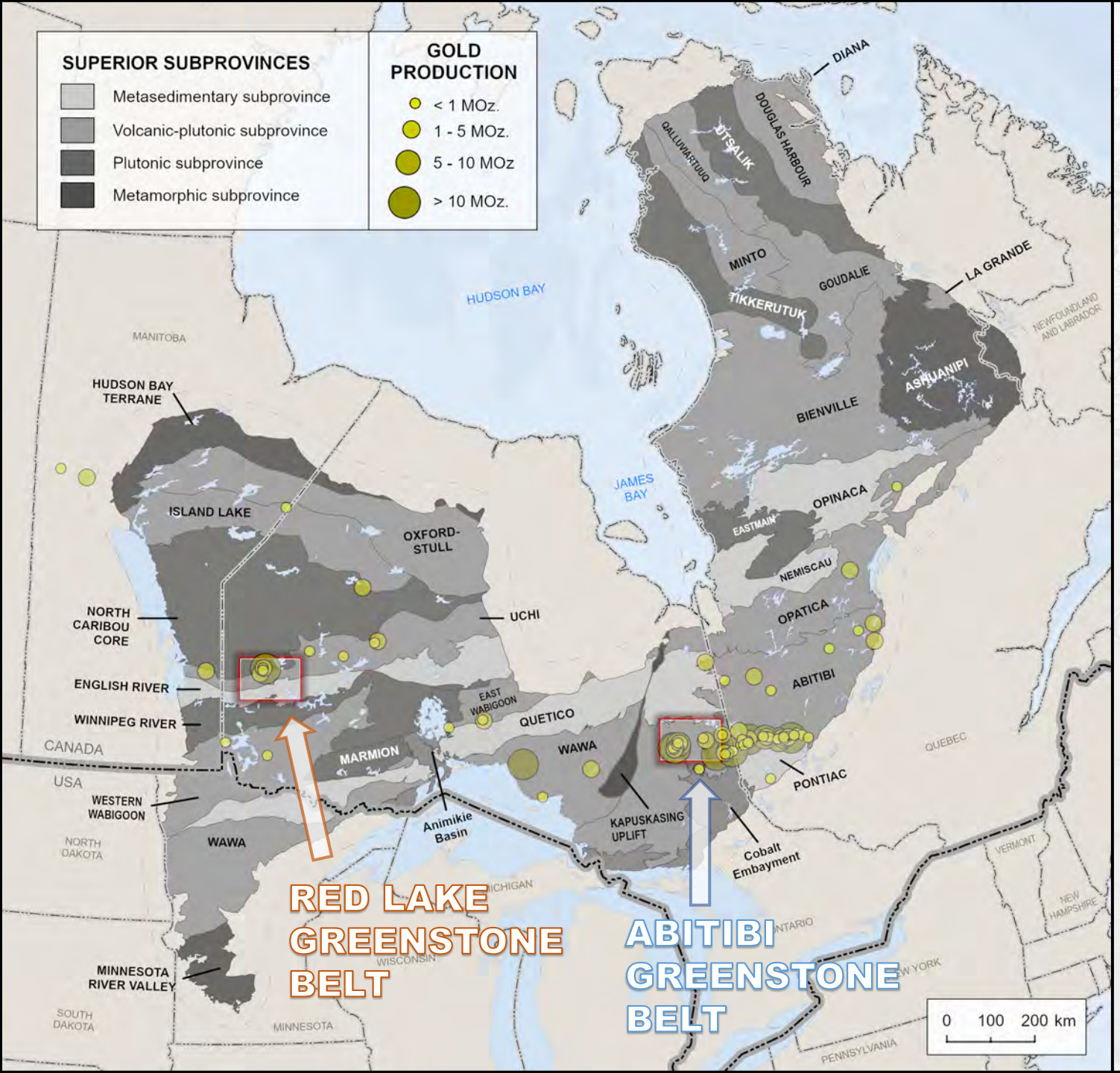

Superior Craton

- Preserves the early formation of continental and oceanic crust and possibly the transition from non-uniformitarian to modern-Earth tectonics.
- Consists of nineteen (19) plutonic volcano-plutonic, metasedimentary, and metamorphic subprovinces.
- Hosts multiple world-class base metal, gold and komatiite-associated Ni-Cu-(PGE) deposits.
- Most notable orogenic gold deposits of the Superior Craton occur in the
  - Abitibi Greenstone Belt
  - Red Lake Greenstone Belt

→ *GIS data for the Superior Craton from Montsion et al. (2018). Gold production values from Gosselin and Dubé (2005).*

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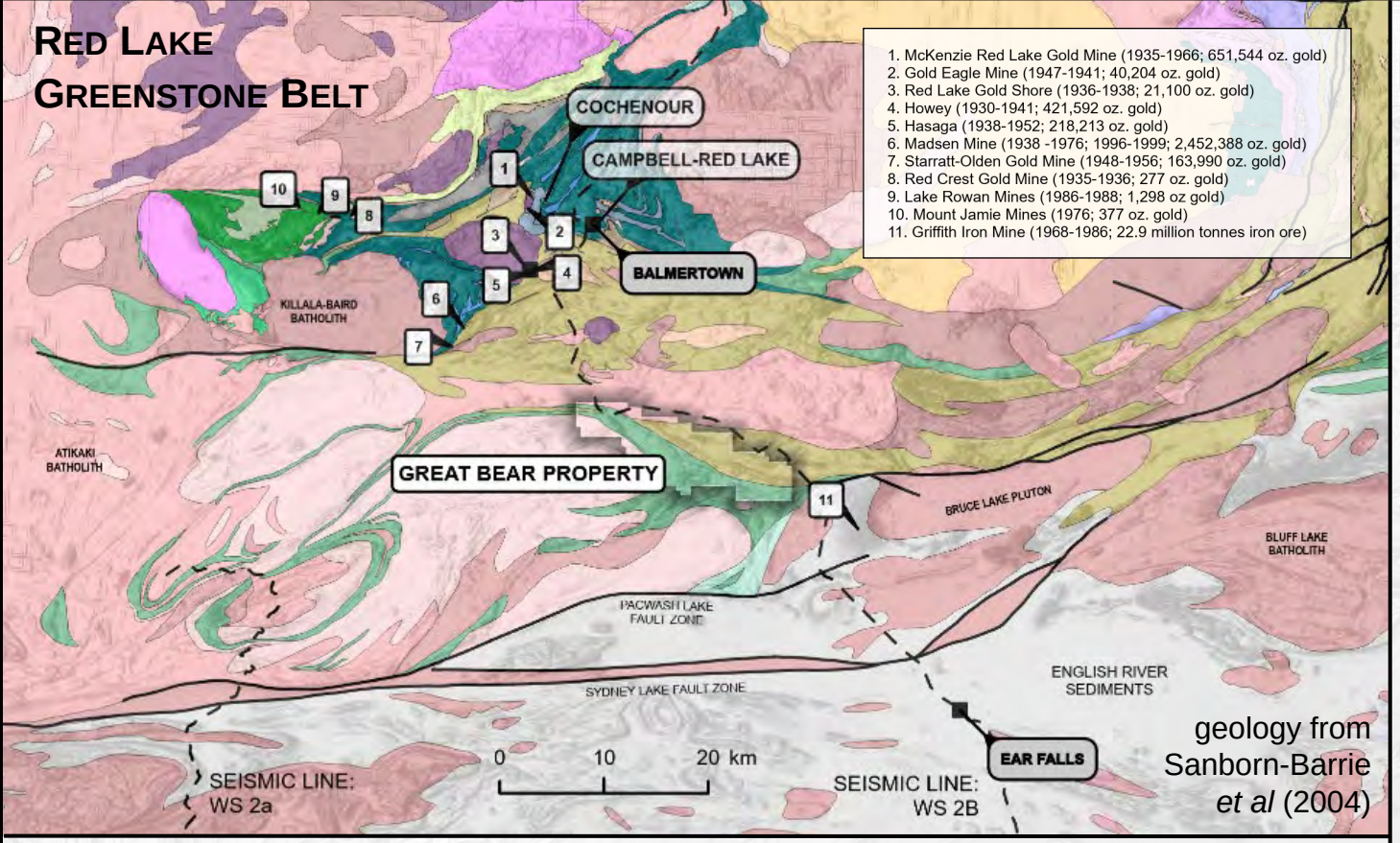

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- One (1) of six (6) major greenstone belts in the Uchi Subprovince:
  - Rice Lake
  - **Red Lake → This talk**
  - Birch–Uchi
  - Meen–Dempster
  - Pickle Lake
  - Lake St. Joseph
- Records a 300 Myr year period of volcanism, intrusive magmatism, sedimentation, and metamorphism attributed to mantle plumes, arc volcanism, intra-arc rifting, and tectonic uplift.
- Hosts some of the largest and richest orogenic gold deposits in Canada (>29.6 million Oz. gold extracted; Lewis et al., 2021).

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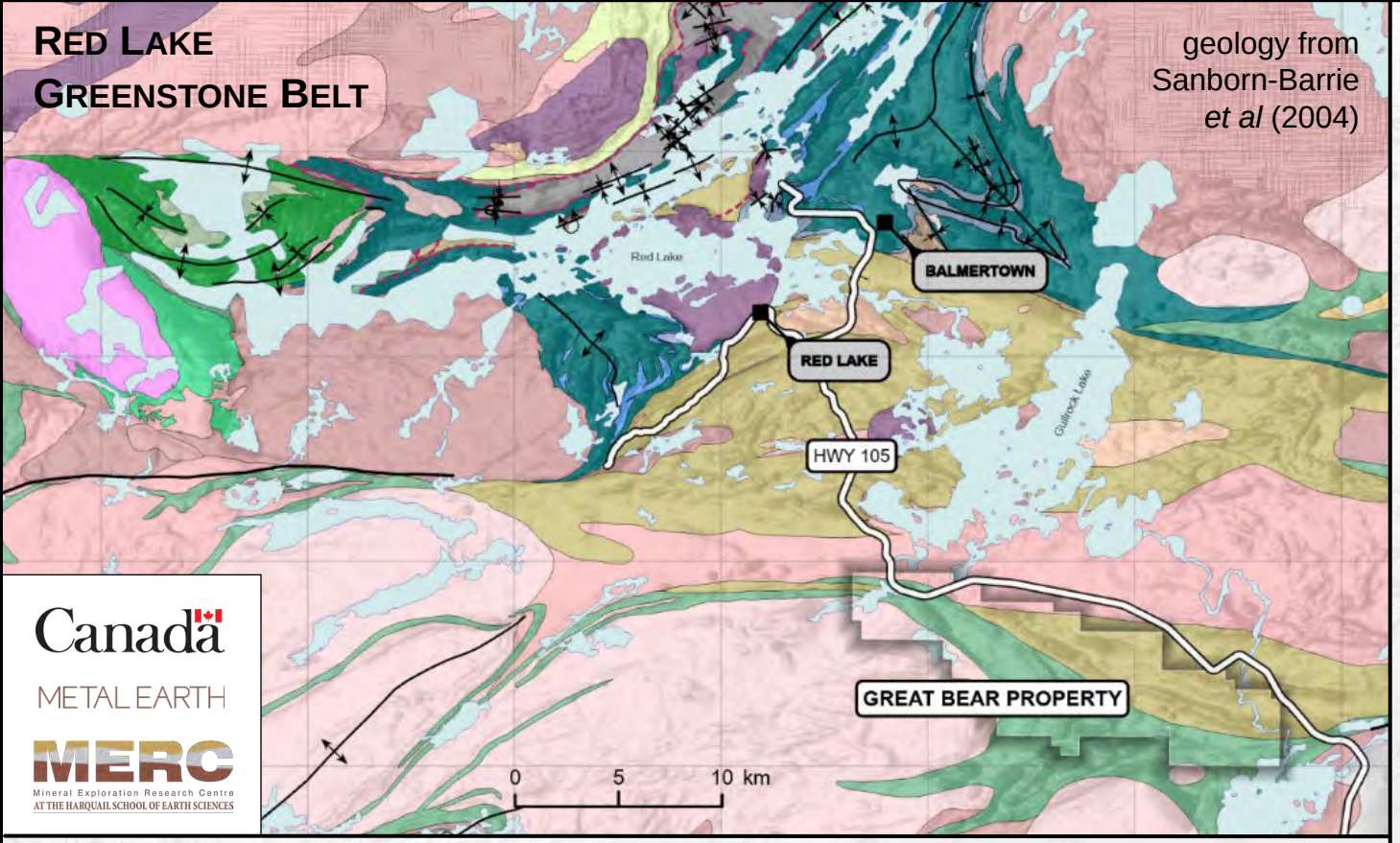

- Exploration has prioritised the Mine Trend between Cochenour to Balmertown, a corridor of E to SE trending D_2 structures that formed during the 2720-2715 Ma Uchian phase of the Kenoran orogeny.
- Major mines within the Mine Trend include the Cochenour and Campbell-Red Lake gold mines (>15 Moz. Au).
- Gold mineralisation within the Mine Trend is principally hosted by tholeiitic and komatiitic metabasalts of the 2.99-2.96 Ga Balmer Assemblage.
- Recent discovery by Great Bear Resources of disseminated gold in the footwall of a crustal-scale fault (LP Fault) located ~25 km SE of the main Red Lake gold camp.

→ **GREAT BEAR PROPERTY**

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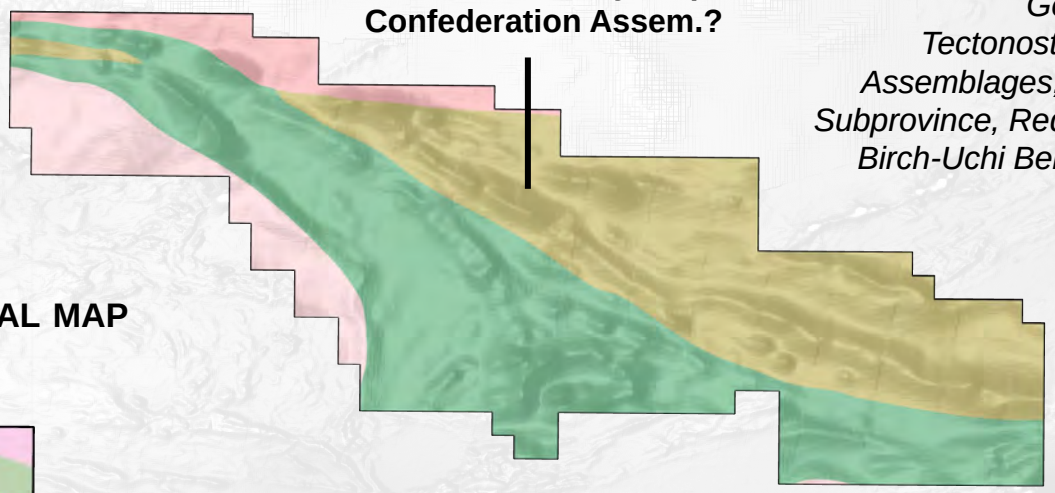
KINROSS

GREAT BEAR
RESOURCES



Sanborn-Barrie et al (2004)
Geology and Tectonostratigraphic Assemblages, East Uchi Subprovince, Red Lake and Birch-Uchi Belts, Ontario

Geology of the Great Bear property

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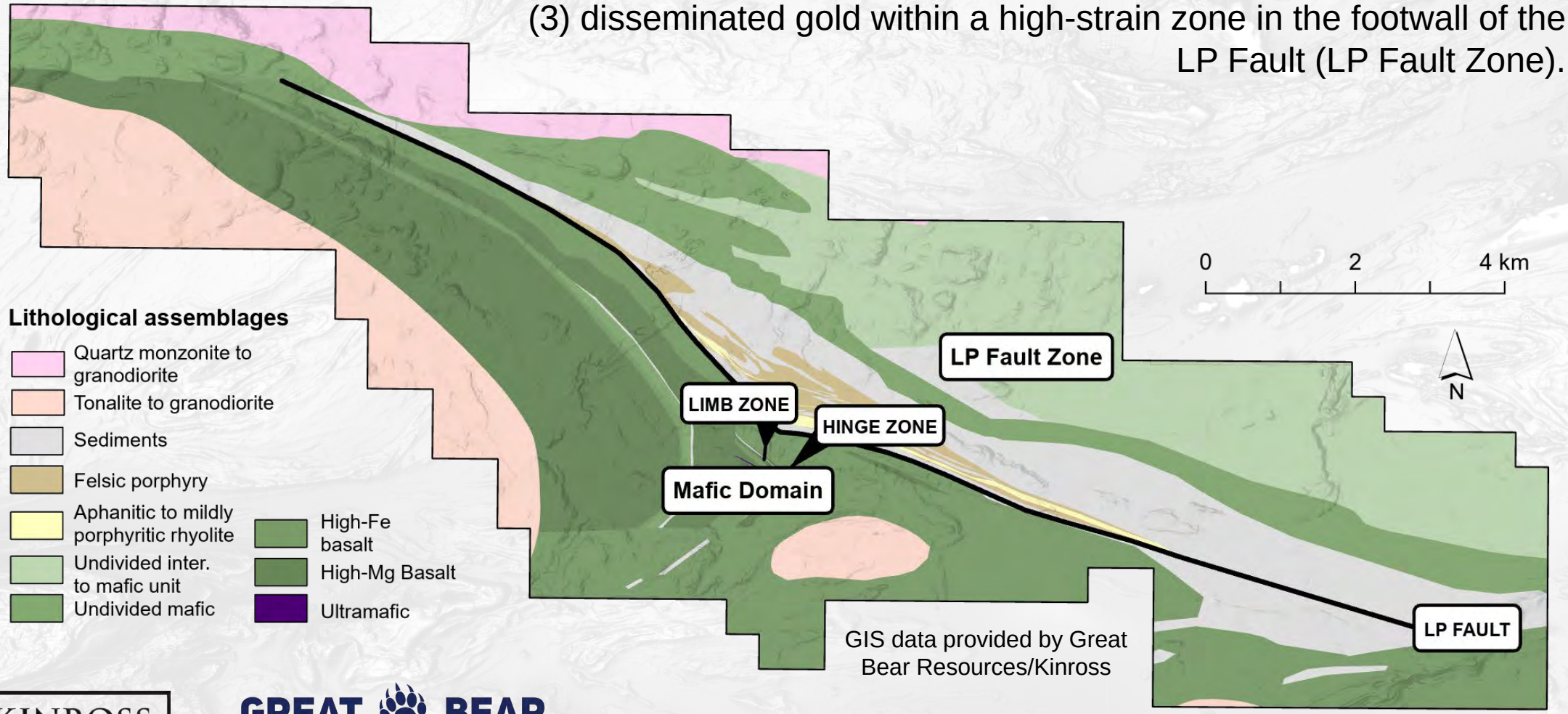
Three key styles of mineralisation within lithologically and compositionally diverse stratigraphy across a crustal-scale fault (LP Fault):

(1) quartz veining in mafic volcanics in the Hinge Zone (Mafic Domain).

(2) silica-sulfide replacement in mafic volcanics in the Limb Zone (Mafic Domain).

(3) disseminated gold within a high-strain zone in the footwall of the LP Fault (LP Fault Zone).



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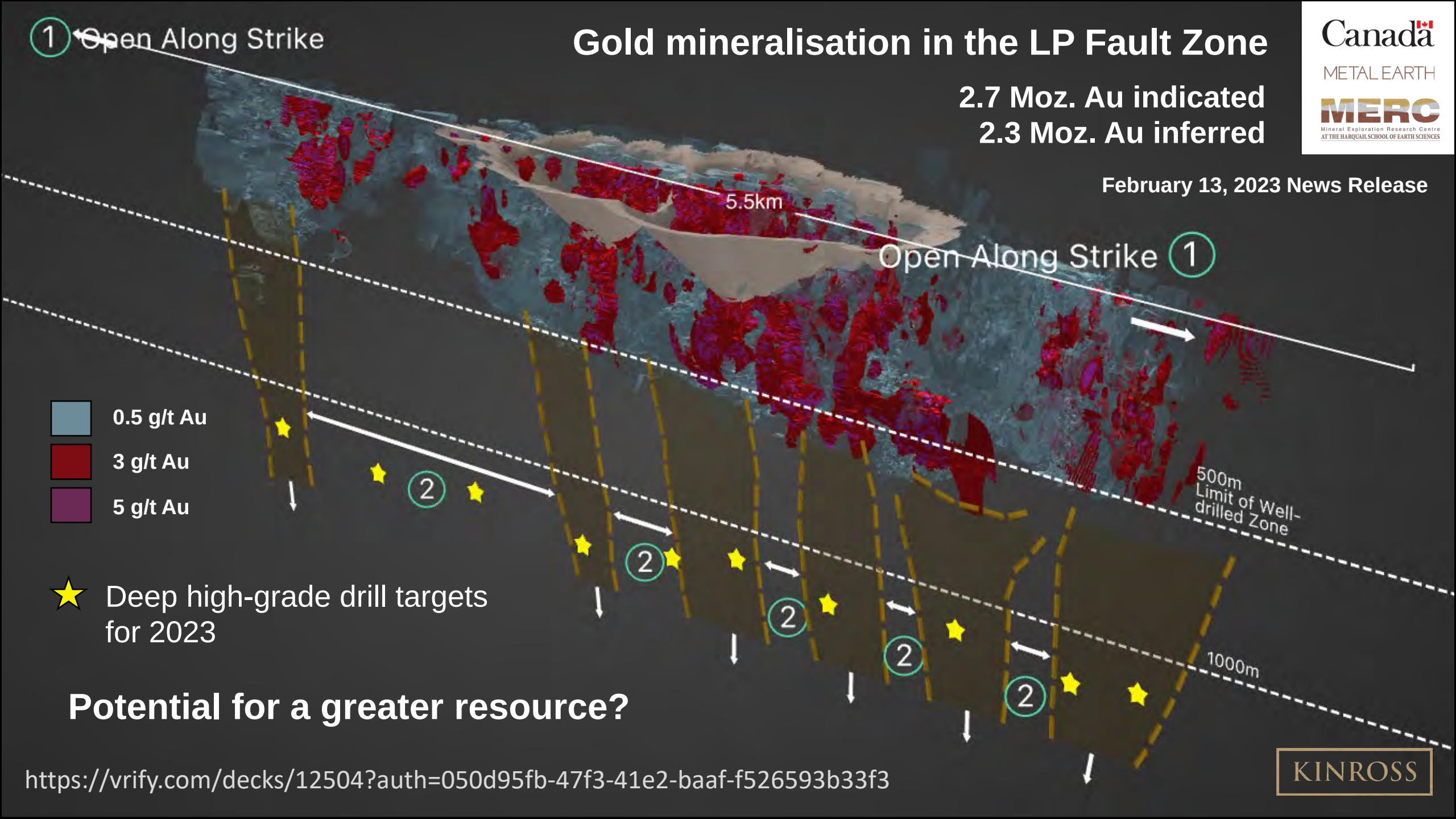
Gold mineralisation in the LP Fault Zone

2.7 Moz. Au indicated
2.3 Moz. Au inferred

February 13, 2023 News Release



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Is the Great Bear deposit a world-class gold deposit?

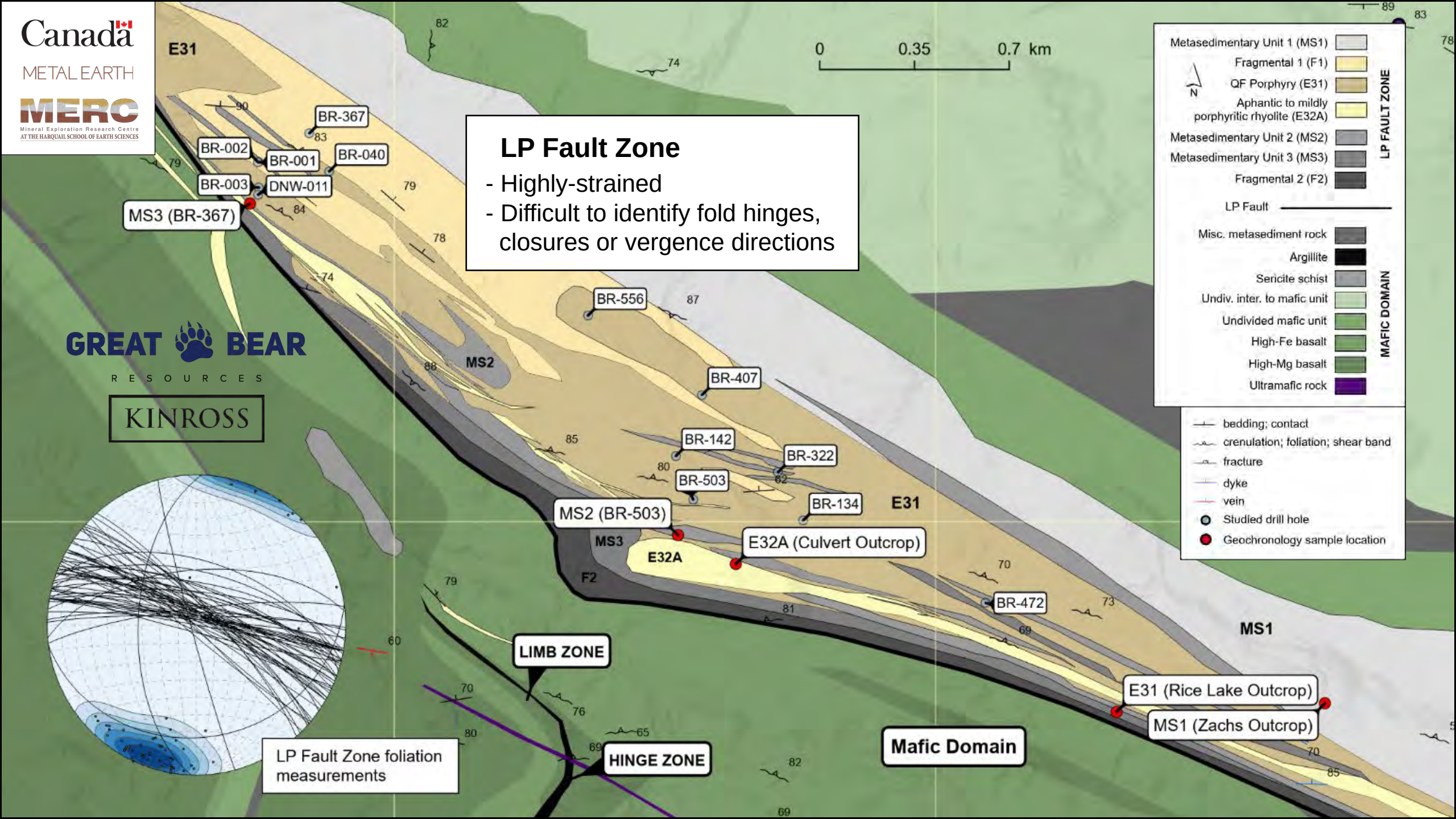
According to Singer (1995) world-class is defined as any gold deposit with >3.2 Moz gold (100 metric tons).

Resource estimates for the LP Fault Zone include:

2.7 Moz. Au indicated +
2.3 Moz. Au inferred
= ~5 Moz. Au

YES????

Exploration to continue…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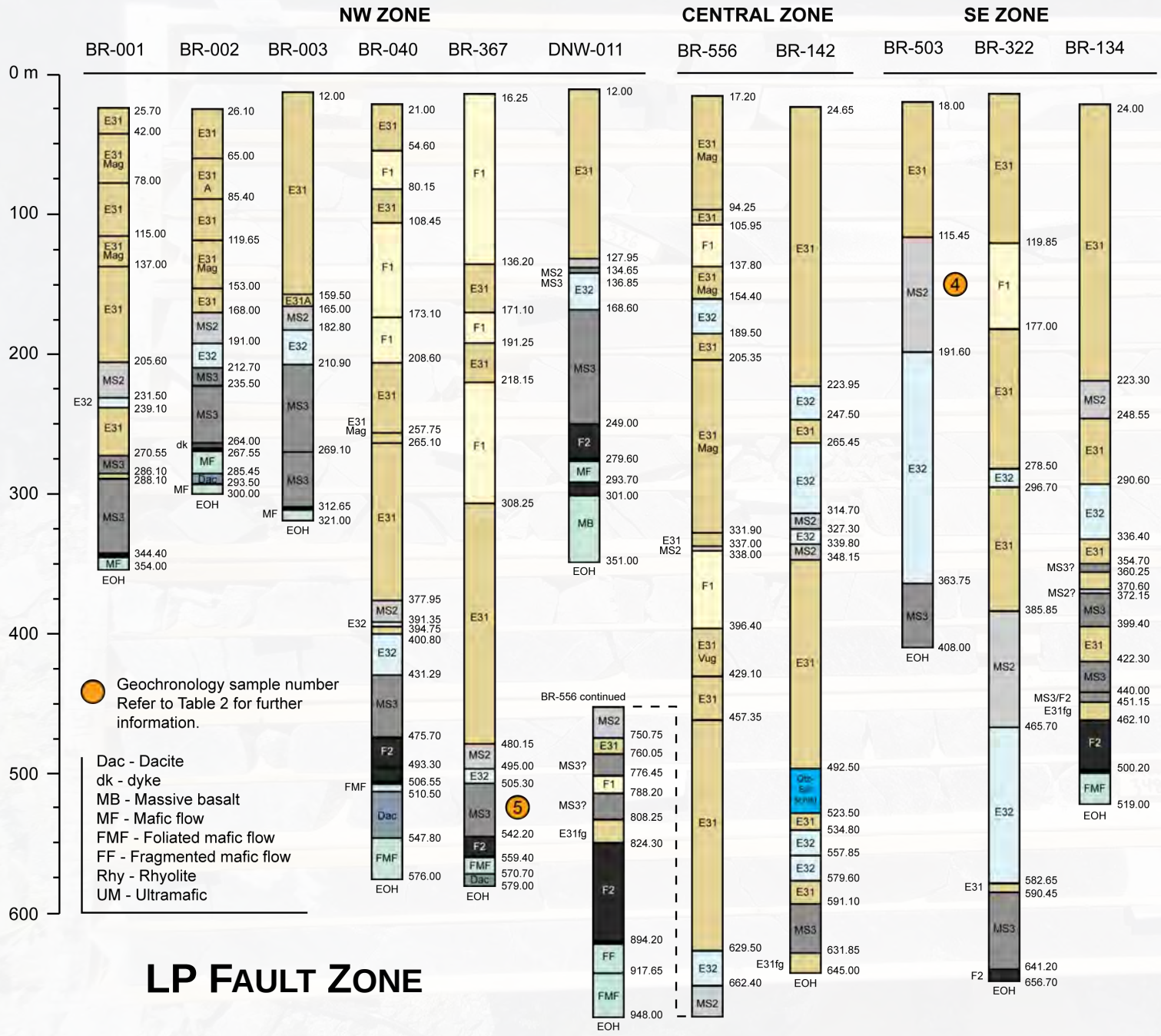
LP Fault Zone
- Highly-strained
- Difficult to identify fold hinges, closures or vergence directions
0 0.35 0.7 km
N
Metasedimentary Unit 1 (MS1)
Fragmental 1 (F1)
QF Porphyry (E31)
Aphantic to mildly porphyritic rhyolite (E32A)
Metasedimentary Unit 2 (MS2)
Metasedimentary Unit 3 (MS3)
Fragmental 2 (F2)
LP FAULT ZONE
LP Fault
Misc. metasediment rock
Argillite
Sericite schist
Undiv. inter. to mafic unit
Undivided mafic unit
High-Fe basalt
High-Mg basalt
Ultramafic rock
MAFIC DOMAIN
bedding; contact
crenulation; foliation; shear band
fracture
dyke
vein
Studied drill hole
Geochronology sample location
E31
BR-367
BR-002
BR-001
BR-040
BR-003
DNW-011
MS3 (BR-367)
BR-556
MS2
BR-407
BR-142
BR-322
BR-503
BR-134
E31
MS2 (BR-503)
MS3
E32A
E32A (Culvert Outcrop)
F2
BR-472
MS1
LIMB ZONE
HINGE ZONE
E31 (Rice Lake Outcrop)
MS1 (Zachs Outcrop)
Mafic Domain
LP Fault Zone foliation measurements



LP FAULT ZONE

Lithostratigraphy

The stratigraphy of the LP Fault Zone is defined by seven (7) key lithofacies:

- Metasedimentary Unit 1 (MS1)
- Fragmental Unit 1 (F1)
- Metasedimentary Unit 2 (MS2)
- Quartz-Feldspar porphyry (E31)
- Altered porphyry (E32A)
- Metasedimentary Unit 3 (MS3)
- Fragmental Unit 2 (F2)

+ multiple mafic dykes and sills

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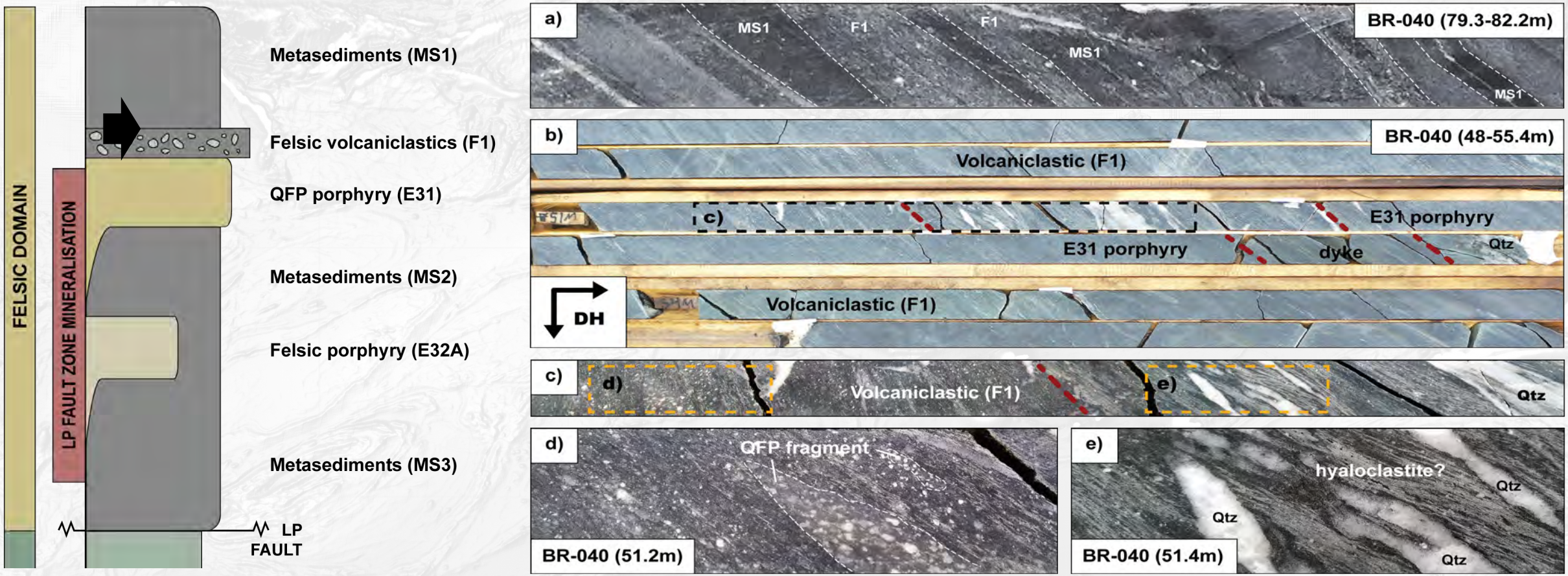

Metasedimentary Unit 1 (MS1) - Thinly-bedded, fine- to medium-grained sediments, with rare graded beds indicating a NE facing direction (away from the LP Fault).

Fragmental Unit 1 (F1) - Poorly-sorted, matrix-supported volcaniclastic deposit, consisting of 4-5 mm-size quartz and feldspar crystals and larger angular to round QFP fragments (derived from E31 QF porphyry in a fine- to medium-grained matrix).

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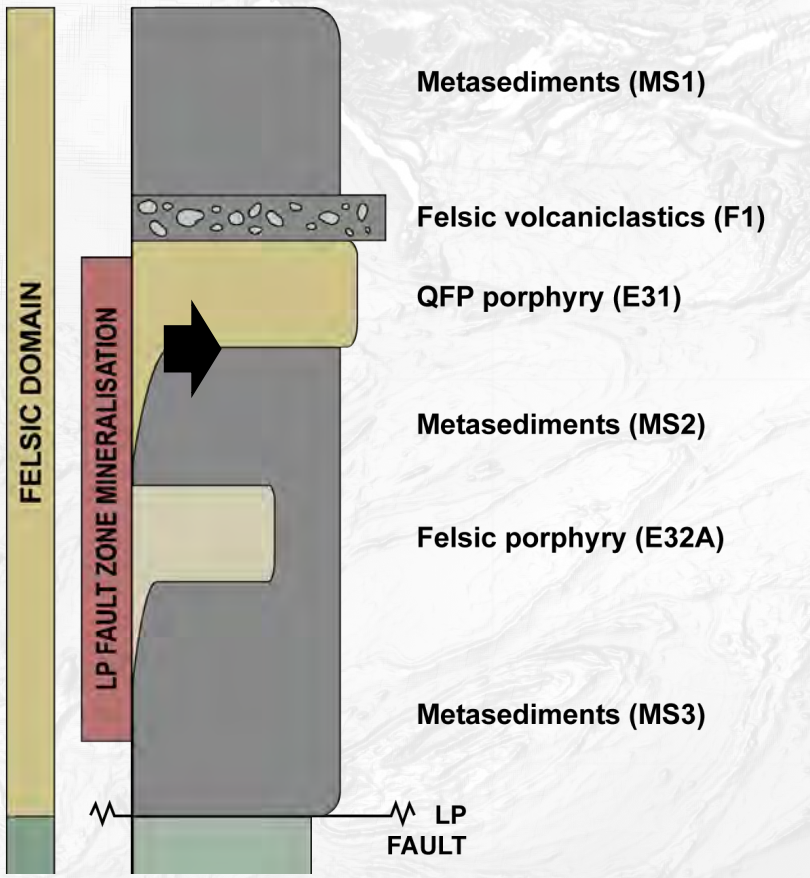

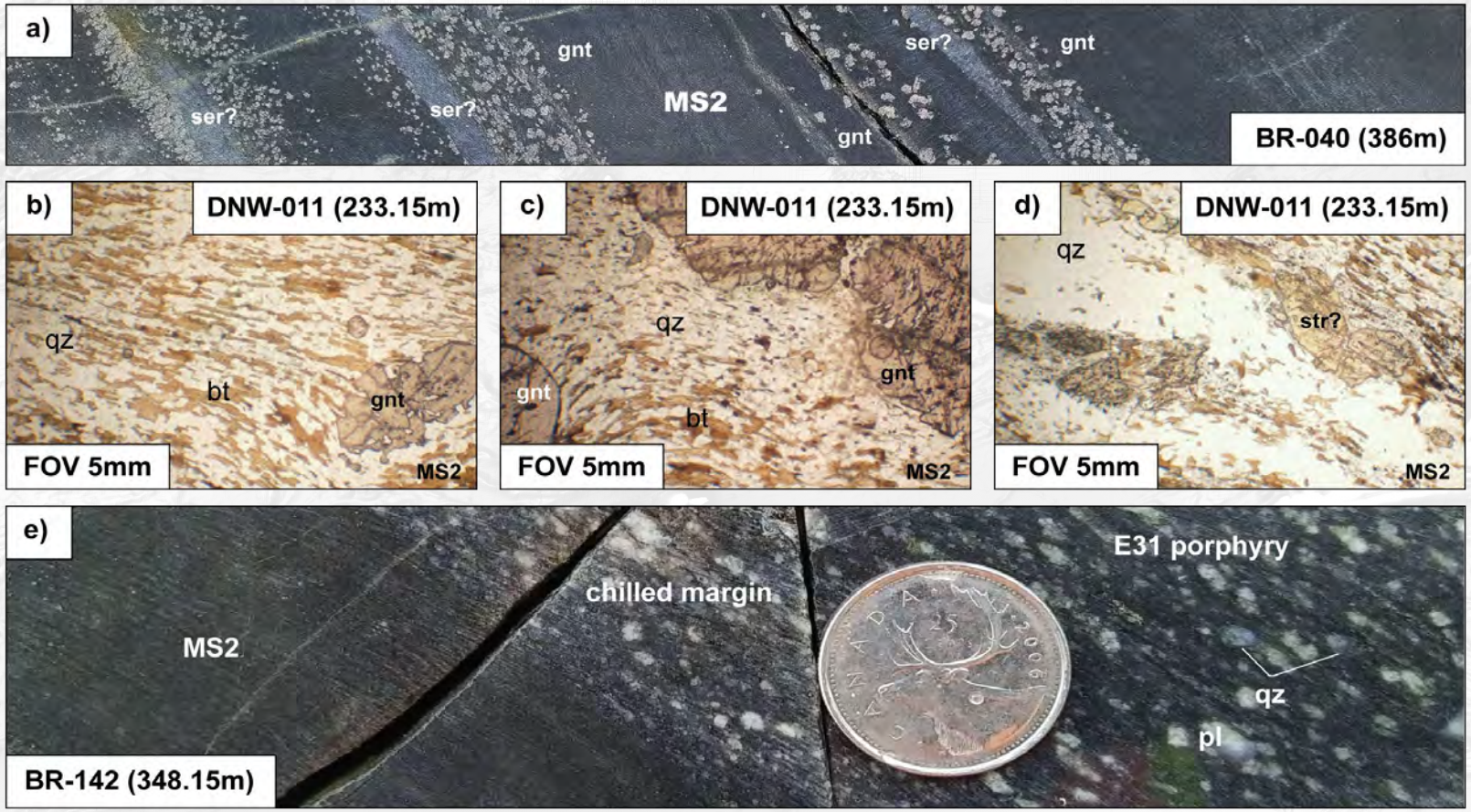

Quartz-Feldspar Porphyry (E31) - Grey to dark grey, medium to strongly foliated porphyry, consisting of generally white feldspars and blue-grey-white quartz in a fine-grained groundmass of quartz, feldspar and biotite.

Metasedimentary Unit 2 - Intensely foliated, massive to thinly-bedded, fine-grained, carbonaceous sediments, with garnet, staurolite, and andalusite porphyroblasts.

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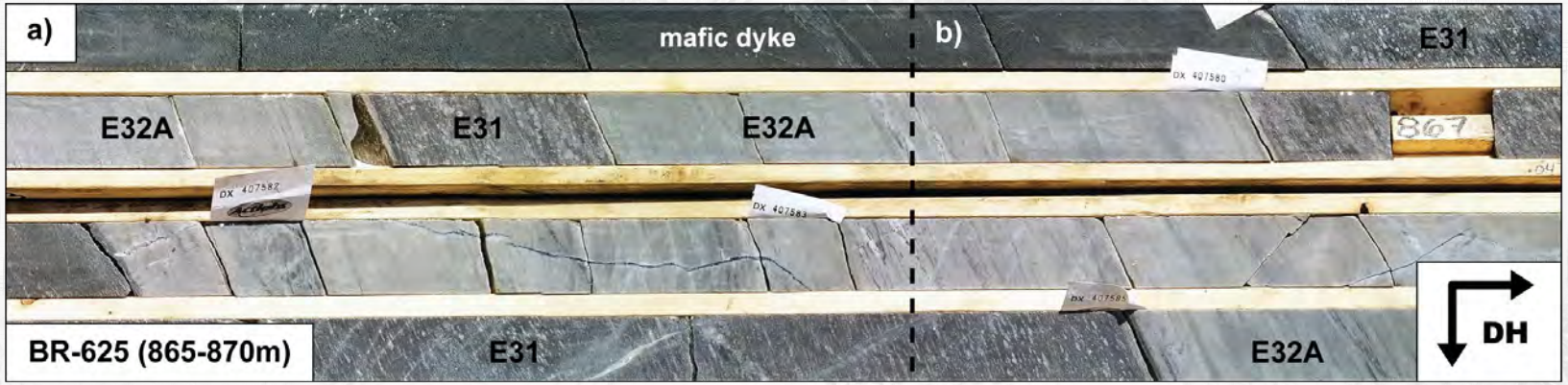

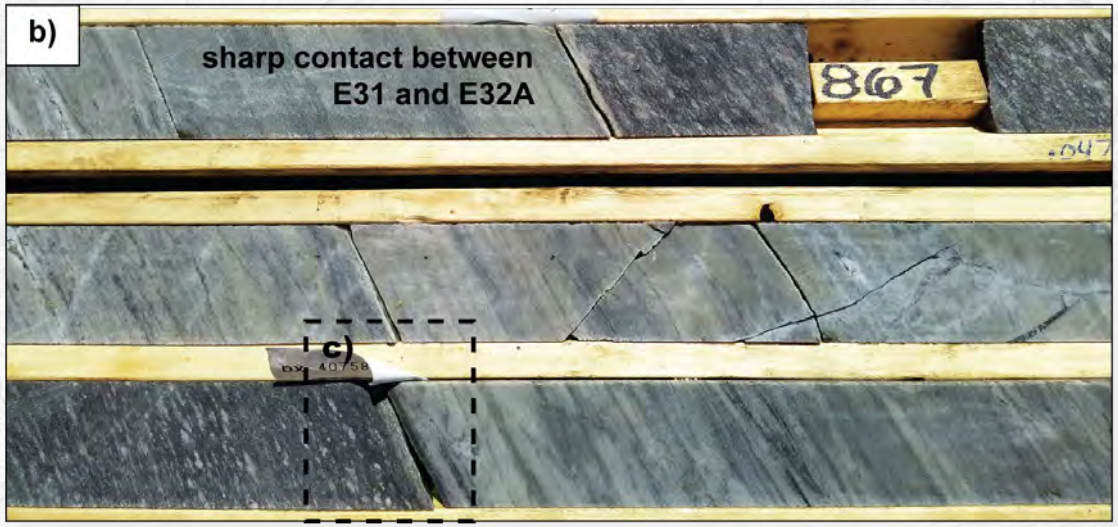

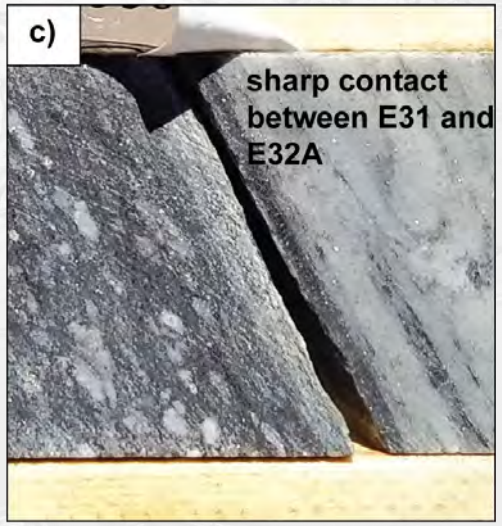

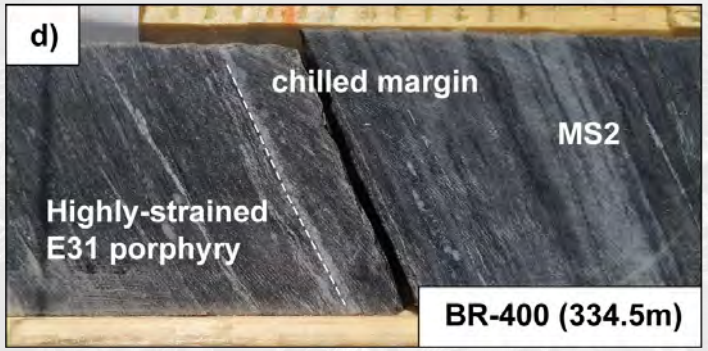

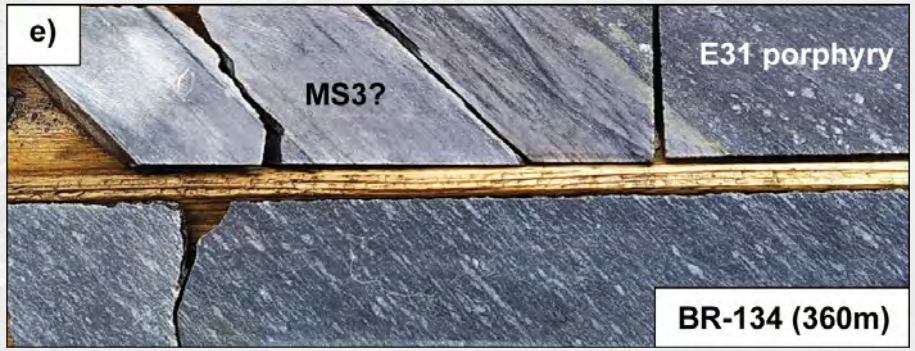

Quartz-Feldspar Porphyry (E31) Grey to dark grey, medium to strongly foliated porphyry, consisting of generally white feldspars and blue-grey-white quartz in a fine-grained groundmass of quartz, feldspar and biotite.

Altered porphyry (E32A)
White to grey, silicified, strongly foliated, aphanitic to mildly porphyritic (minor plagioclase), with secondary quartz, feldspar, muscovite, calcite, and chlorite.

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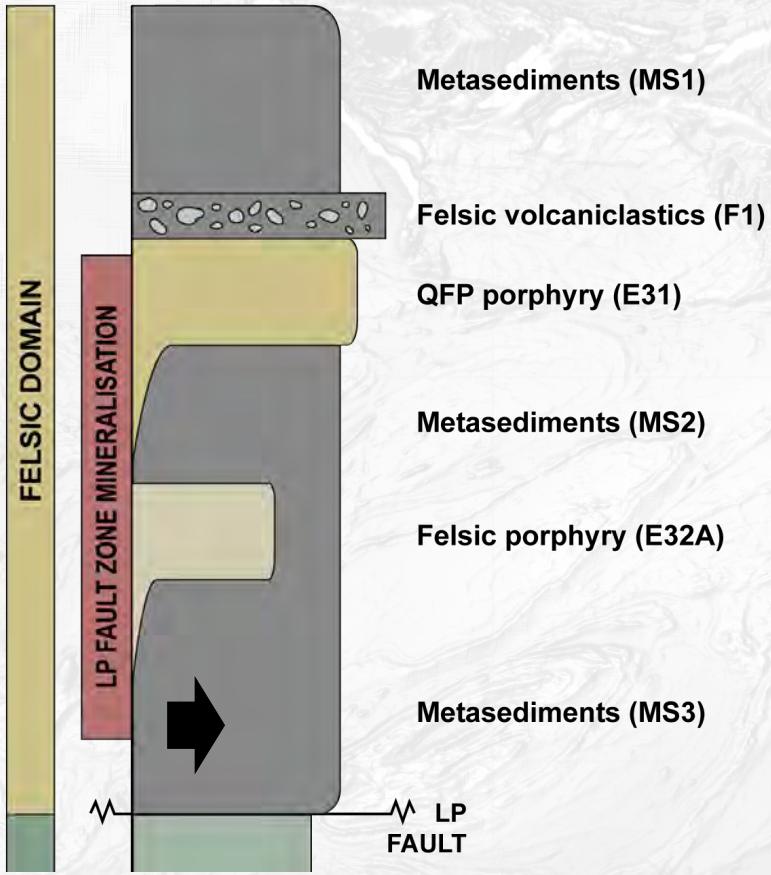

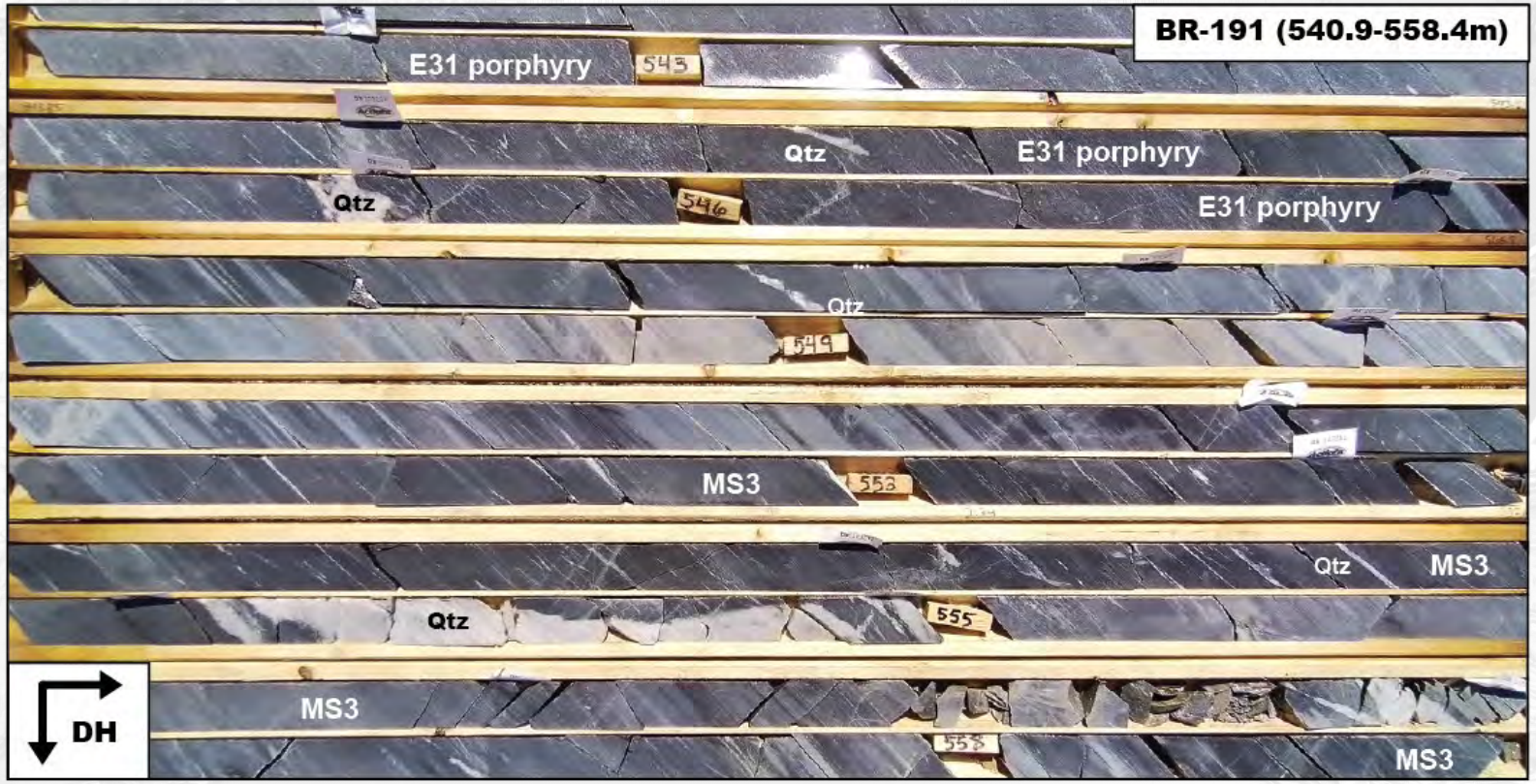

Metasedimentary Unit 3 (MS3) - Moderately to strongly foliated, fine-grained, thinly- to medium-bedded metasediments, with strong sericite alteration.

Fragmental Unit 2 (F2) - Highly-strained unit adjacent to the LP Fault and gradational with MS3, consisting of subangular to round sericitically altered fragments in a fine-grained matrix.
- Pseudobreccia (highly-strained or boudinage component of MS3).

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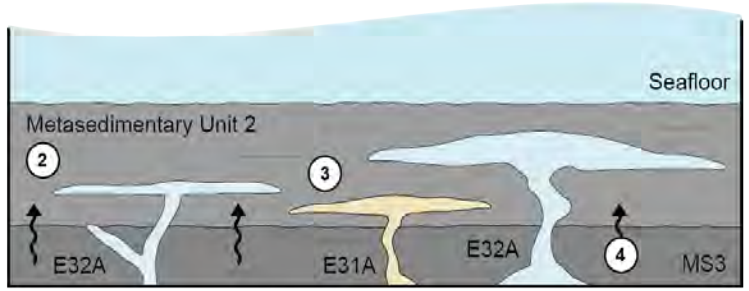
Paleoenvironment

- The metasedimentary units (MS1, MS2, MS3) are part of the one succession that was deposited in a structural basin.

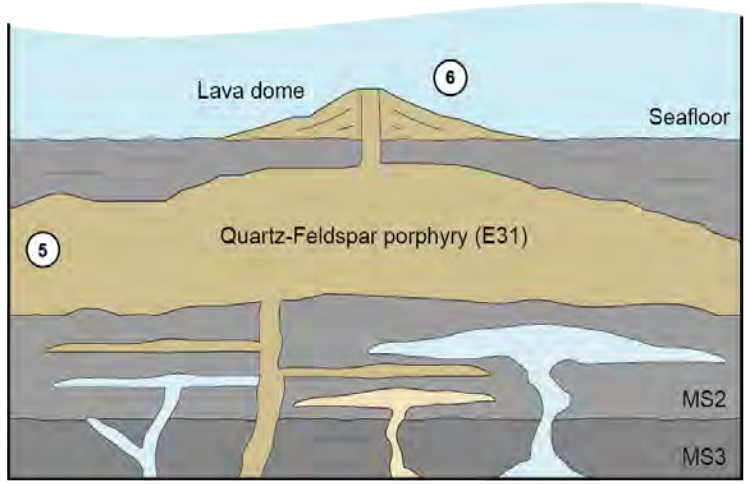
- The E32A and the younger E31 porphyries were emplaced as intrusions. The E31 porphyries also breached the seafloor, producing volcaniclastic deposits (F1).

- The volcaniclastic deposits (F1) were subsequently intruded by additional QF porphyries (E31).

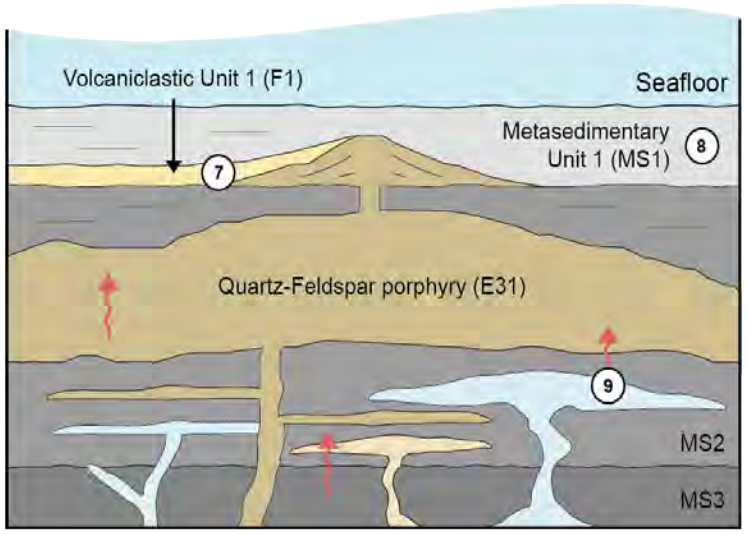
1. Basin development and early deposition of Metasedimentary Unit 3 (MS3).



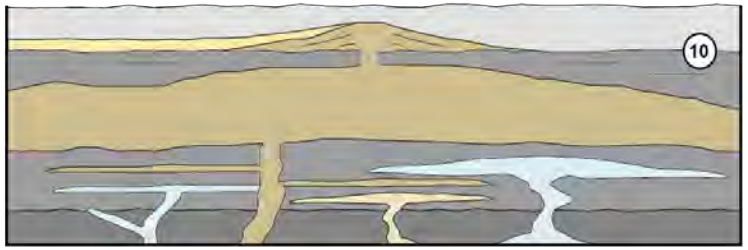
2. Ongoing sedimentation and the deposition of Metasedimentary Unit 2 (MS2).
3. Emplacement of aphantic to mildly porphyric felsic intrusions (E32A and E31A) within the sedimentary package.
4. Widespread silicification/abitization.



5. Intrusion of a quartz-feldspar porphyry (E31).
6. Construction of a submarine lava dome (E31).



7. Quench fragmentation, autobrecciation, and possible collapse of the submarine lava dome, resulting in development of volcaniclastic deposts (F1).
8. Ongoing sedimentation and the deposition of Metasedimentary Unit 1 (MS1).
9. Widespread sericite alteration (<2722 Ma).



10. Transposition and flattening of the stratigraphy associated with the 2720-2715 Ma Uchian phase of the Kenoran orogeny.

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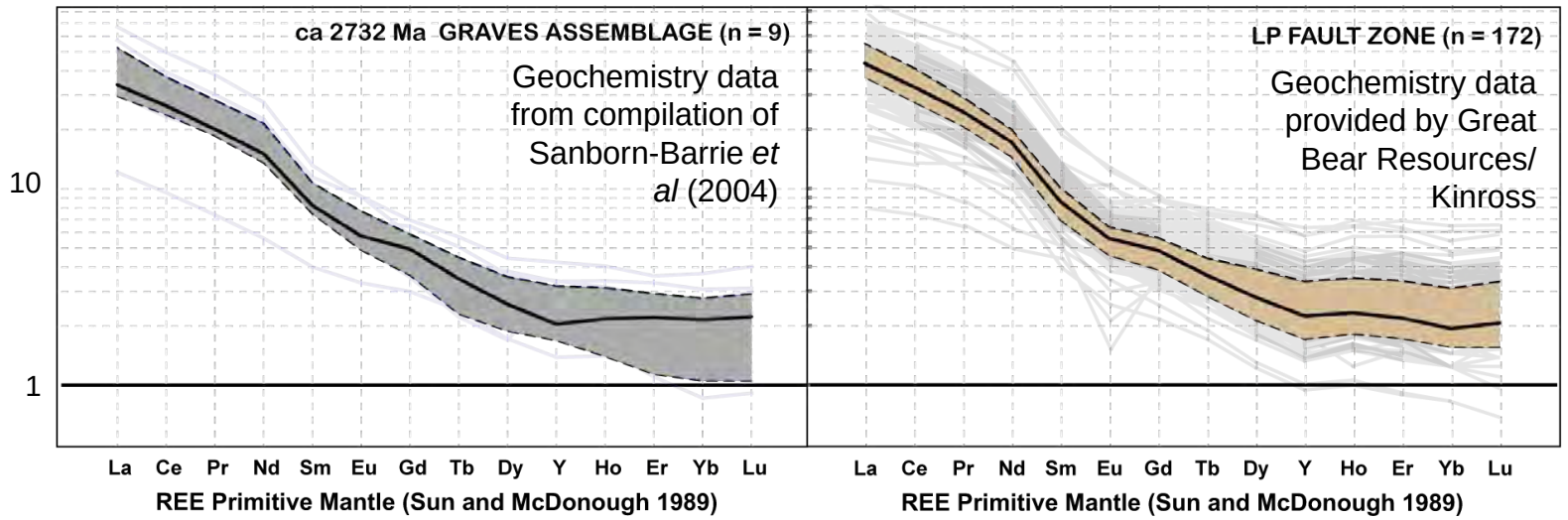
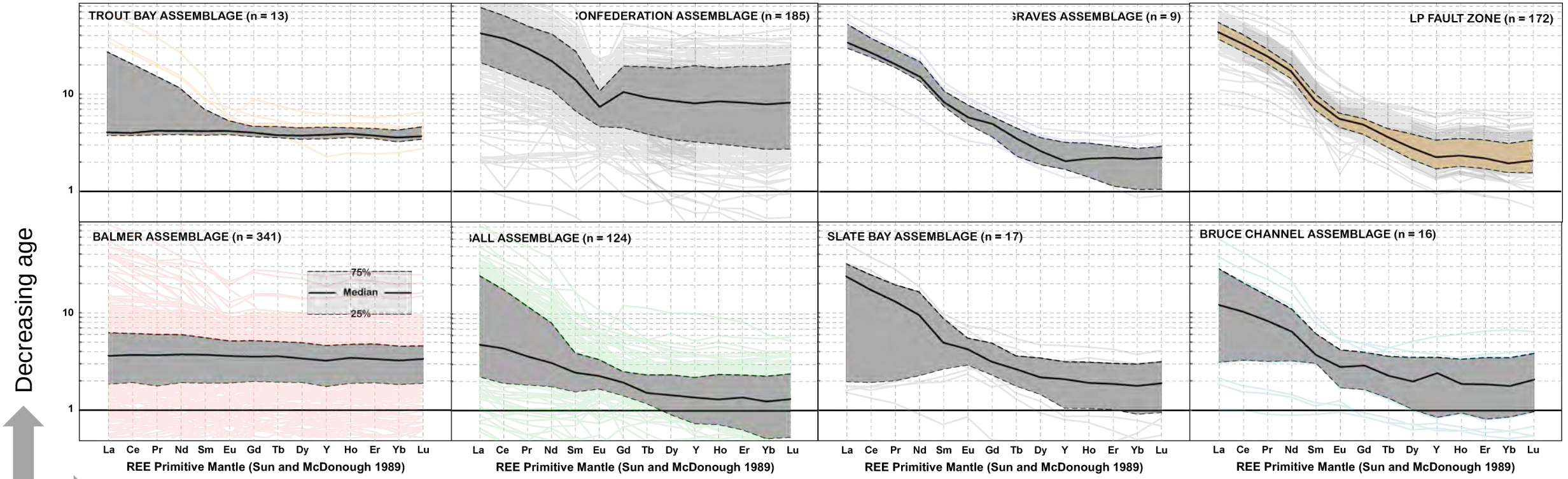
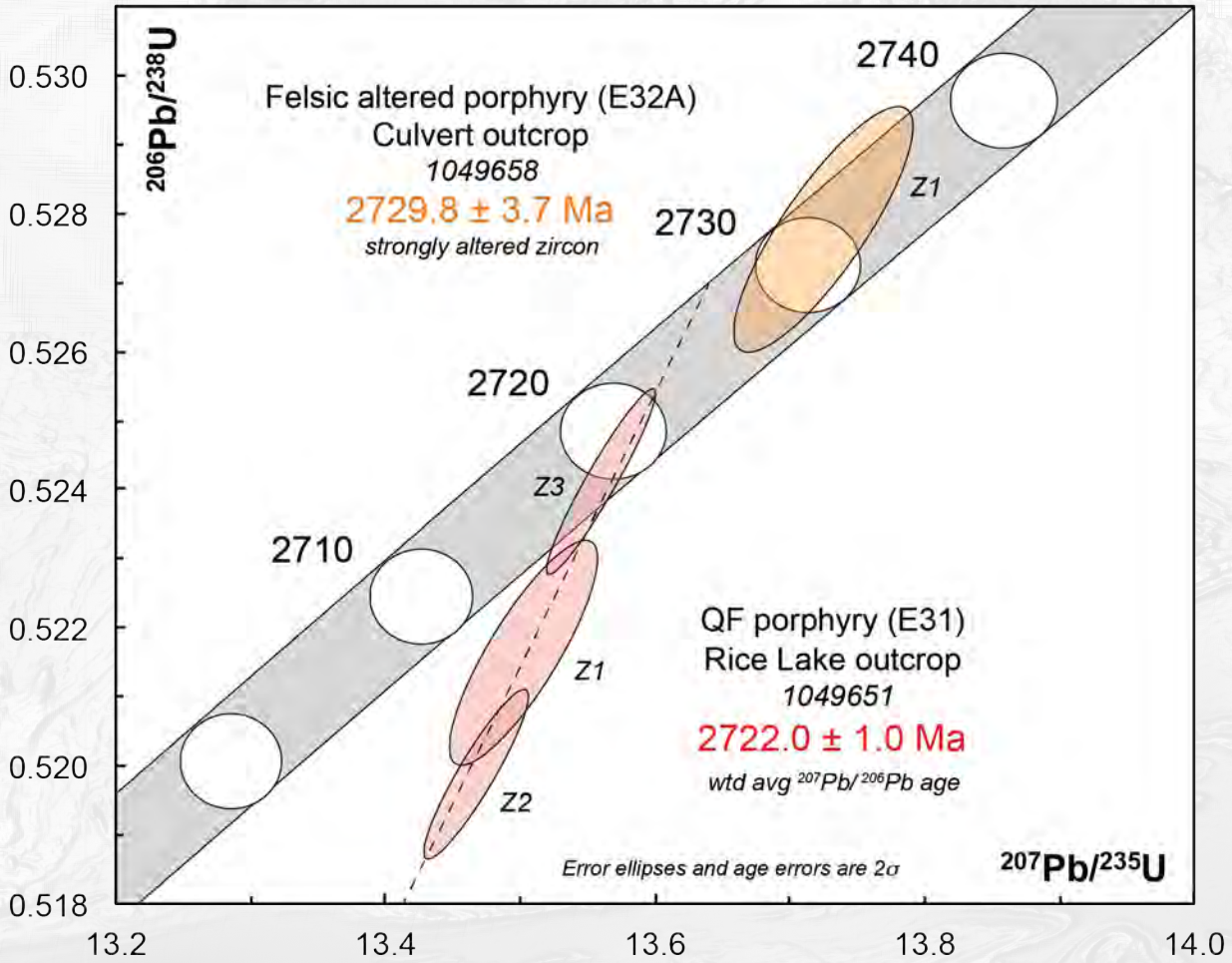
Regional comparison

LP Fault Zone porphyries (E31 + E32A) are compositionally similar to the ca 2732 Ma Graves Assemblage.

Similar age?



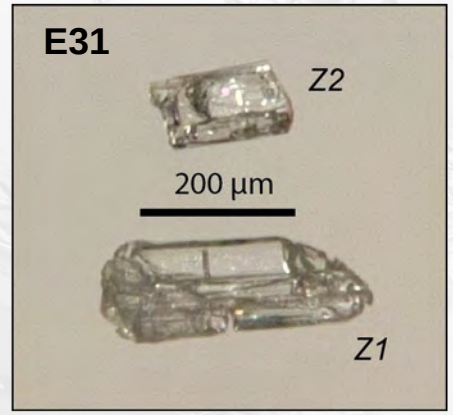




TIMS Geochronology

U-Pb TIMS dating of zircon from the felsic porphyries (E31, E32A) indicate crystallisation ages of 2730-2722 Ma.

- The ages are inconsistent with existing interpretations of the stratigraphy as part of the 2748-2742 Ma McNeely Sequence of the Confederation Assemblage.
- Possible correlation with the 2732 Ma Graves Assemblage or the 2725-2717 Ma St Joseph Suite?



What about the detrital zircon data??

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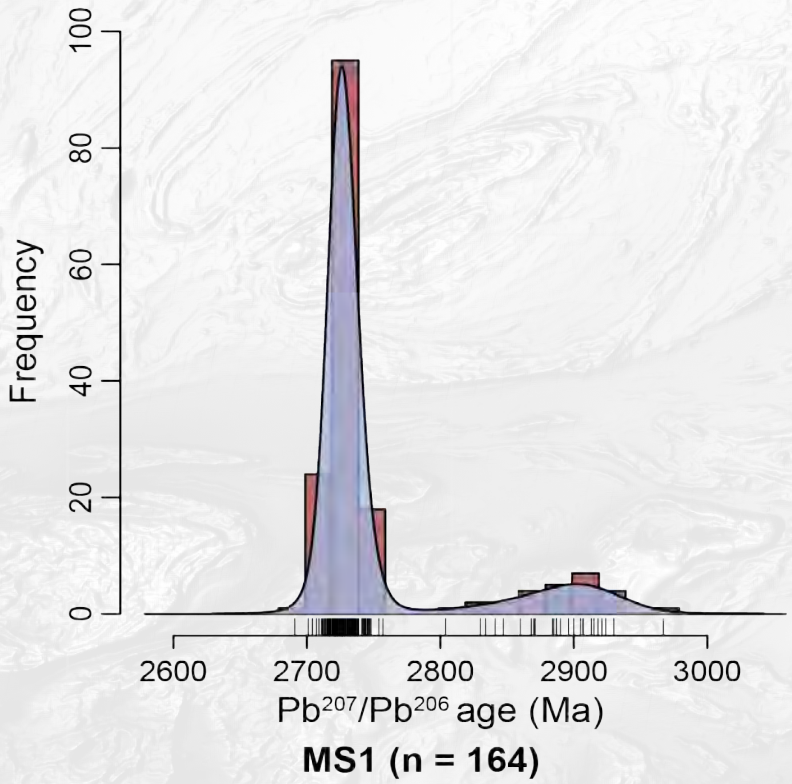
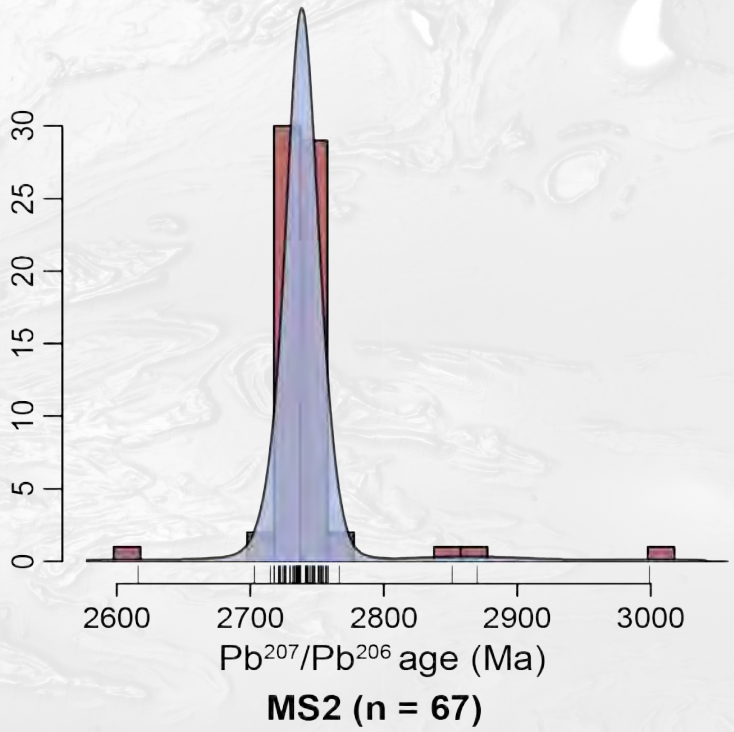
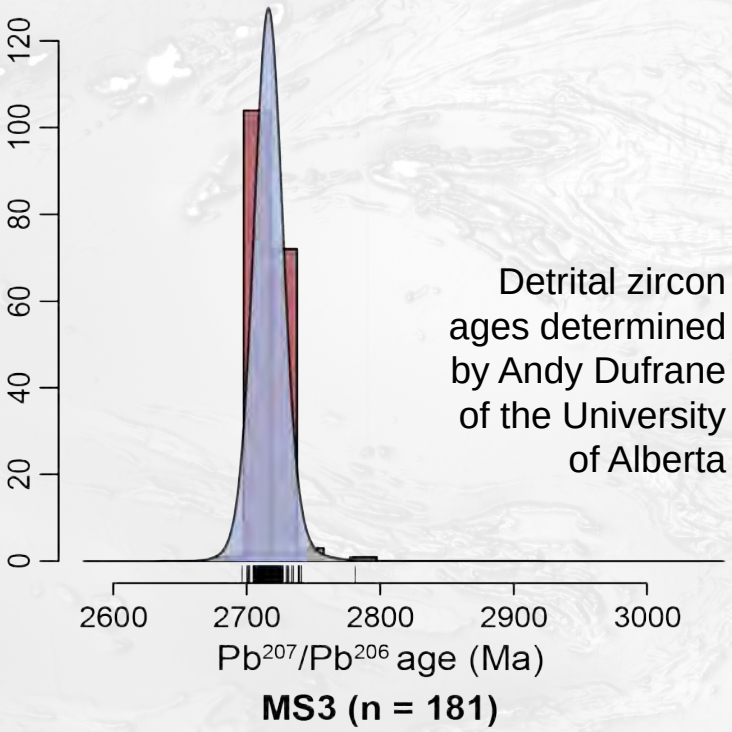
LA-ICPMS Geochronology

U-Pb LA-ICPMS dating of detrital zircon from the metasedimentary succession indicate that the majority of zircons were derived from the felsic porphyries, with clustered aged of ca 2730-2720 Ma.

- Younger (<2720 Ma) detrital zircon ages within MS2 and MS3 likely reflect the local influence of Pb loss associated with deformation, hydrothermal alteration and metamorphism.



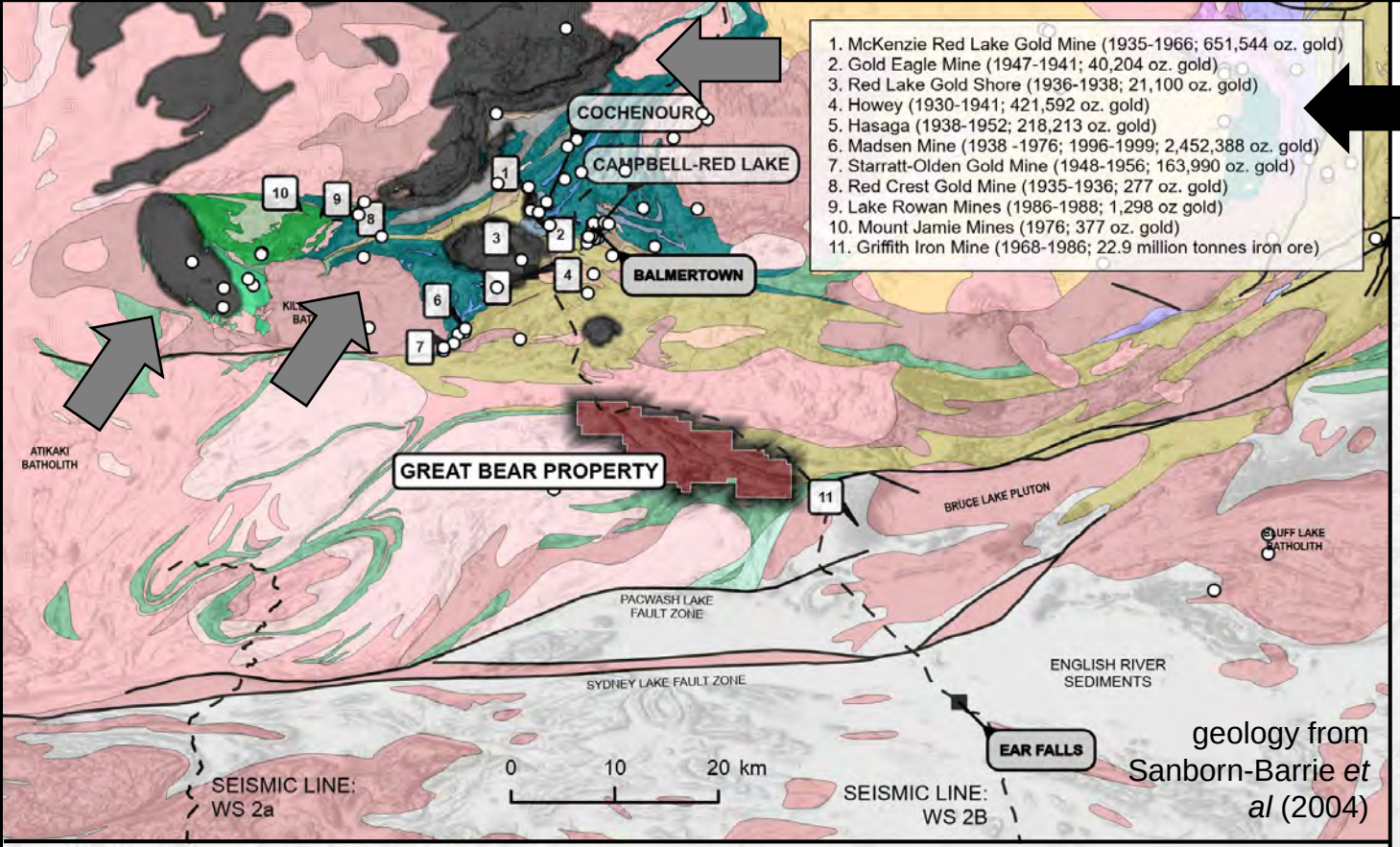


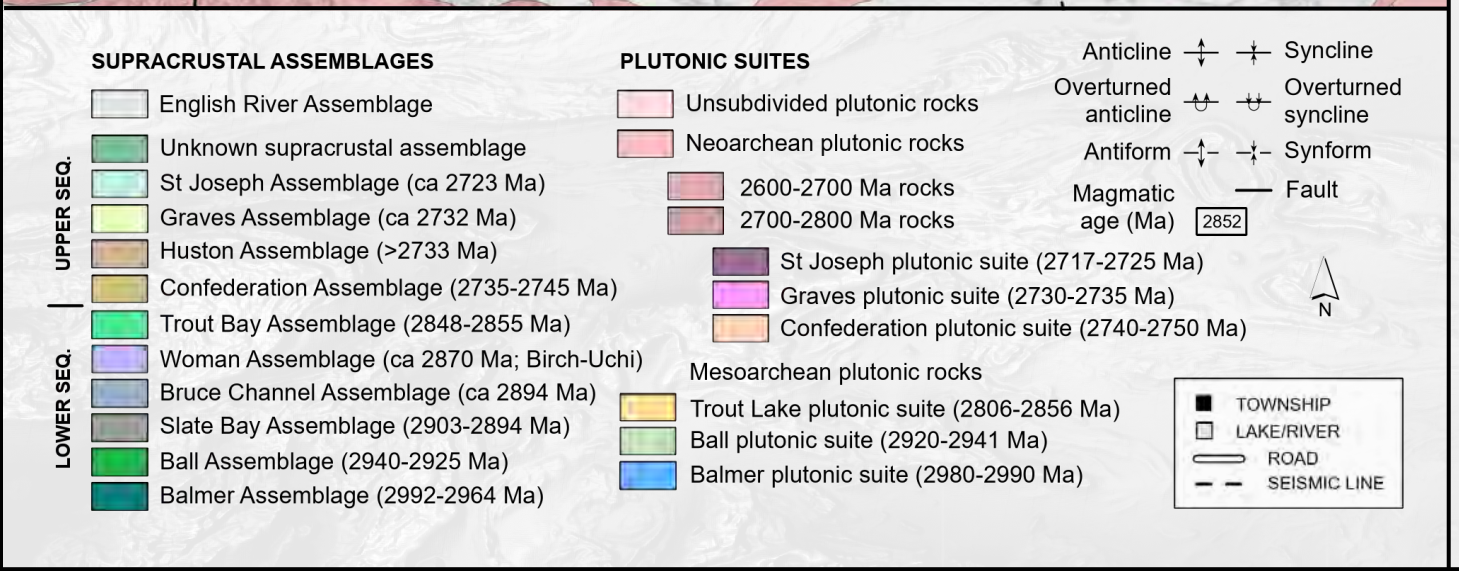


Detrital zircon ages determined by Andy Dufrane of the University of Alberta

2732-2712 Ma assemblages

(Graves Assem. and St Joseph Suite)





- Equivalent aged rocks of the Graves Assemblage and St Joseph Suite occur within and to the NW of the Red Lake gold camp.
  - St Joseph Suite includes the 2720 Ma Abino granodiorite, 2720 Ma McKenzie Island stock, and 2717 Ma Dome Stock.
    - McKenzie Red Lake Gold Mine
    - Gold Eagle Mine
    - Red Lake Gold Shore
- Few known occurrences to the SE of the Red Lake camp.

Is this an accurate reflection of the regional geology or an artifact of limited samples to the SE of the Red Lake camp?

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Significance of 2730-2722 Ma zircon crystallisation ages for mineralisation in the LP Fault Zone?

- Maximum age for mineralisation in the LP Fault Zone is <2722 Ma.

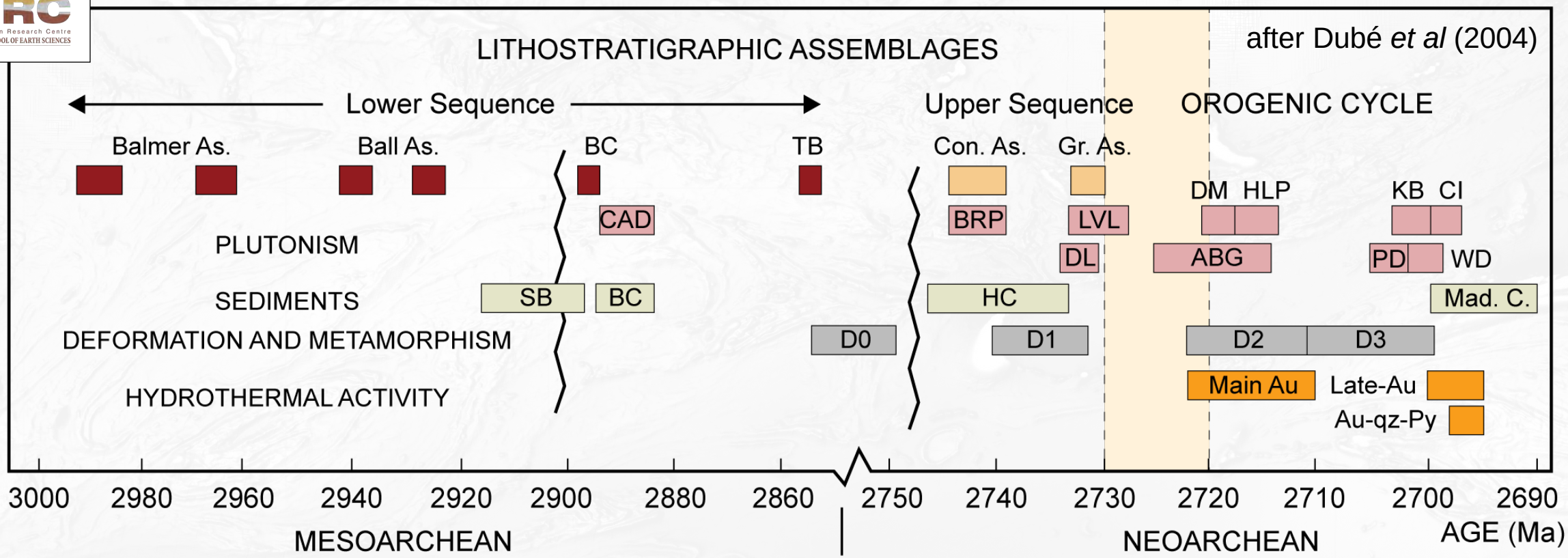
however…..

There are three different styles of mineralisation within the LP Fault Zone:

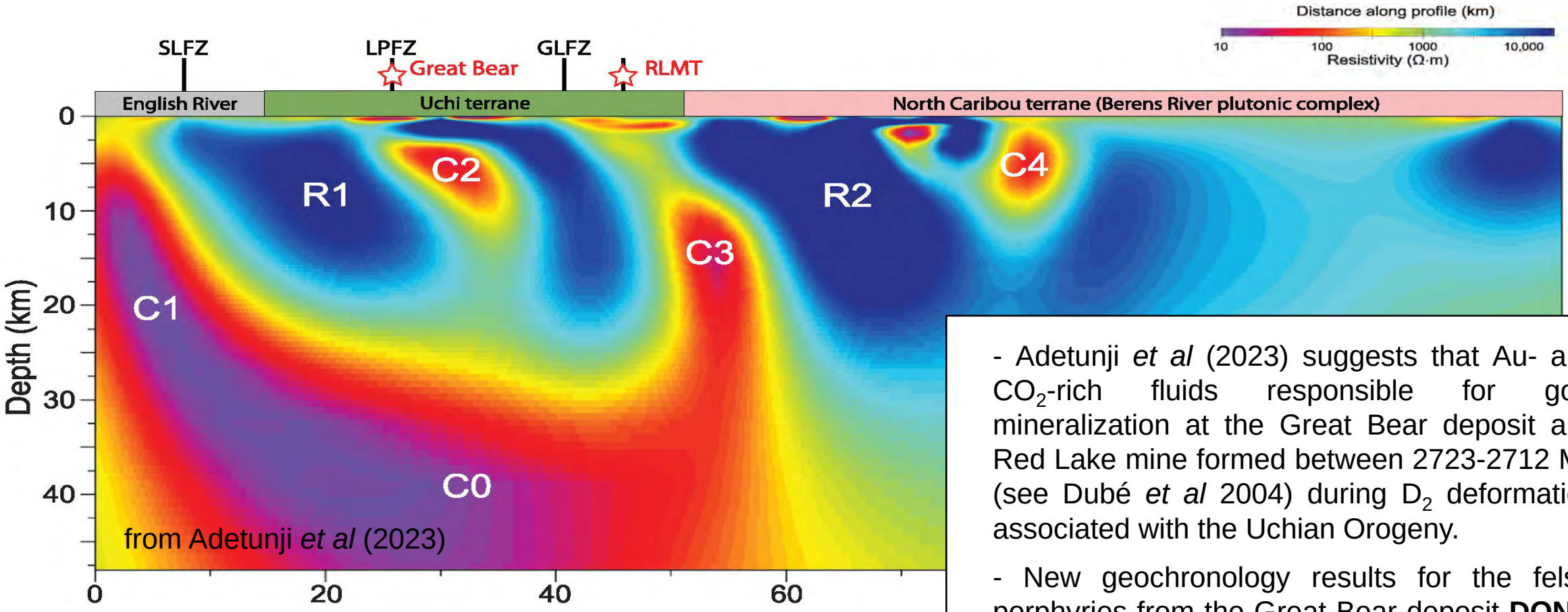
1. Disseminated free gold parallel to the primary NW-SE trending foliation in the host rock.
2. Gold in transposed quartz veins. ⇨ ***Syn-intrusion or Syntectonic?***
3. Free gold in quartz veins oblique to the primary foliation. ⇨ ***Post-tectonic?***

How does this compare with the known timing of mineralisation at the main Red Lake mine?

Summary of events



- Dubé *et al* (2004) suggests the main-stage of gold mineralisation at the Red Lake mine occurred between 2723-2712 Ma, most likely coinciding with the Uchian phase of the Kenoran Orogeny (D_2).
- Late-stage gold mineralisation and remobilisation (quartz-pyrite-tourmaline-vein-type deposits) occurred after 2702 Ma, most likely associated with D_3 amphibolite-facies metamorphism and post-orogenic intrusions (Dubé *et al* 2004).



Magnetotellurics (MT)

- Adetunji *et al* (2023) suggests that Au- and CO_2-rich fluids responsible for gold mineralization at the Great Bear deposit and Red Lake mine formed between 2723-2712 Ma (see Dubé *et al* 2004) during D_2 deformation associated with the Uchian Orogeny.

- New geochronology results for the felsic porphyries from the Great Bear deposit **DON'T** disprove this model.

Is there potential for the discovery of other major gold deposits within the RLGB?

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LP Fault Zone vs. Red Lake mining camp

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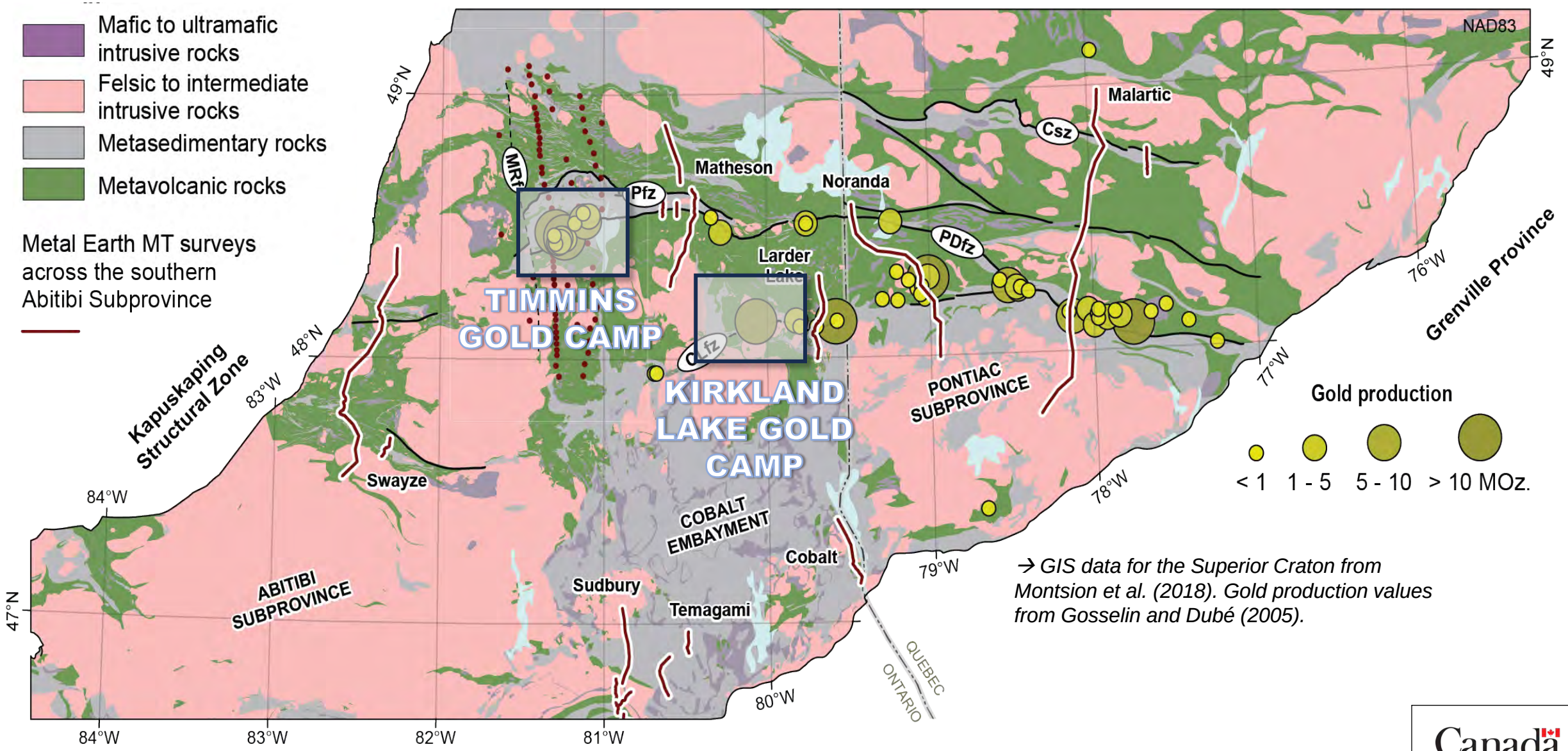
Similarities

- Both deposits are located adjacent to major unconformities and crustal-scale faults.
- Both deposits are located adjacent to sedimentary belts.
- Both deposits are hosted within a zone of predominantly NW-SE structures.
  - SE trending 'Mine Trend' in the Red Lake gold camp.
- Mineralisation at both deposits was likely associated with the 2723-2712 Ma Uchian phase of the Kenoran Orogeny (D_2)???

Differences

- Hosted by different lithostratigraphic assemblages.
  - 2.99 Ga Balmer Assemblages vs. 2.73-2.72 Ga Graves Assemblage/St Joseph Suite.
- Different primary styles of mineralisation.
  - Widespread shallow disseminated gold in the LP Fault Zone at the Great Bear property vs. gold-bearing quartz-carbonate veins at the Campbell-Red Lake deposit.

IMPLICATIONS FOR GOLD EXPLORATION?



→ *GIS data for the Superior Craton from Montsion et al. (2018). Gold production values from Gosselin and Dubé (2005).*

Major gold deposits of the Abitibi Subprovince

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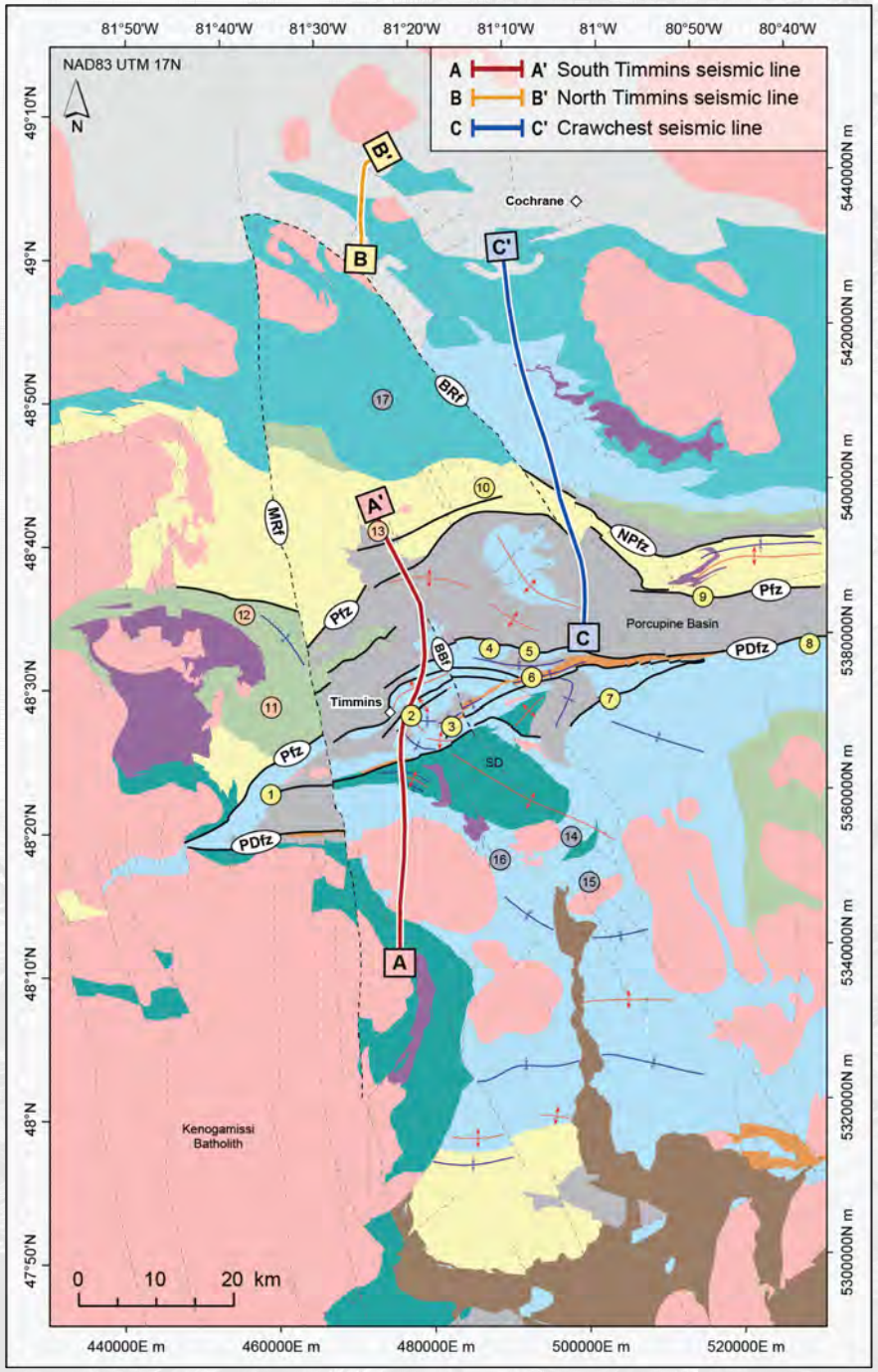


Lithostratigraphic framework

PC Proterozoic cover (<2500 Ma)

Intrusions

FI Felsic to intermediate intrusions (2750-2682 Ma)

MI Synvolcanic ultramafic to mafic intrusions (2750-2700 Ma)

Sedimentary rocks

Tm Timiskaming Assemblage (2676-2669 Ma)

P Porcupine Assemblage (2690-2685 Ma)

SG Scapa Group (<2697 Ma)

Volcanic rocks

BR Blake River Assemblage (2704-2696 Ma)

T Tisdale Assemblage (2710-2704 Ma)

KM Kidd-Munro Assemblage (2719-2710 Ma)

SR Stoughton-Roquemaure Assem. (2723-2720 Ma)

D Deloro Assemblage (2730-2724 Ma)

Structures

Archean faults — Late faults

Anticline — Syncline

Gold (Au) deposits

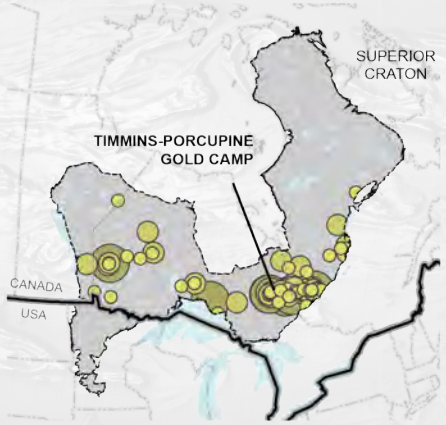
1. West Timmins mine
2. Hollinger mine
3. Dome mine
4. Bell Creek mine
5. Hoyle Pond mine
6. Pamour mine
7. Night Hawk Peninsula mine
8. Taylor mine
9. Clavos mine
10. Bradshaw mine

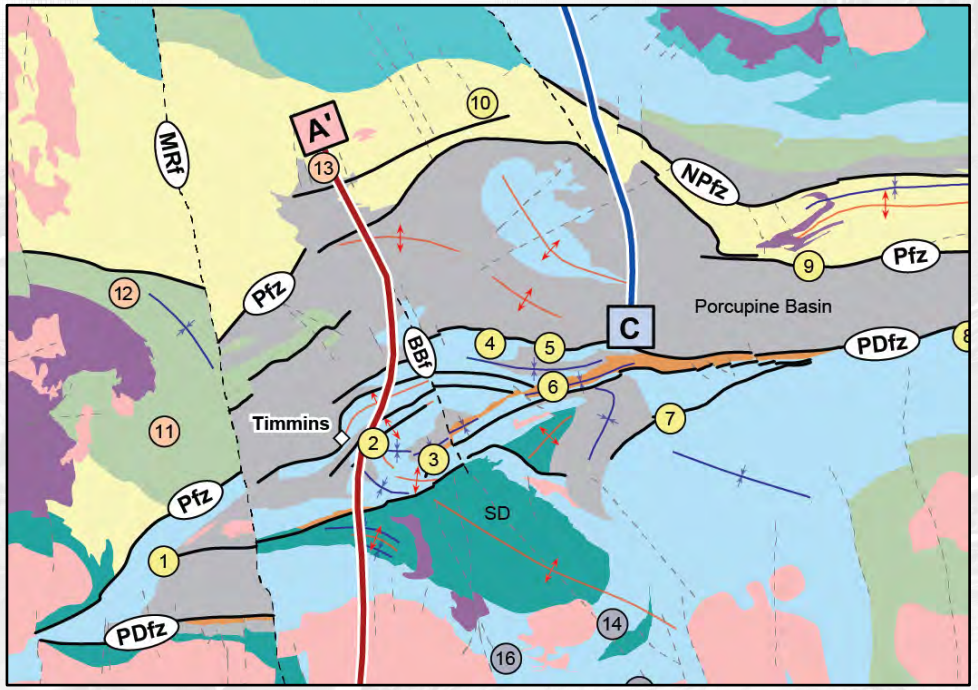
VMS deposits

11. Genex mine
12. Kam Kotia mine
13. Kidd Creek mine

Ni-Cu deposits

14. Langmuir mine
15. Premier mine
16. Redstone mine
17. Crawford deposit





Timmins Gold Camp

- Multiple world-class-giant gold deposits associated with the Porcupine- Destor fault zone (75-100+ Moz. Au).
- World class VMS deposits
- Multiple Ni-Cu-PGE deposits

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Deloro Assemblage (2730-2724 Ma)

calc-alkaline andesite pillows with breccia

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Tisdale Assemblage (2710-2704 Ma)

variolitic, strained, mafic pillow lavas

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Tisdale Assemblage (2710-2704 Ma)

quartz-carbonate alteration (ankerite) of ultramafic-mafic metavolcanic flows with multiple generations of veins

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Angular unconformity

greywacke of the Porcupine Assemblage (2690-2685 Ma) vs. conglomeratic deposits of the Timiskaming Assemblage (2676-2669 Ma).

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Timiskaming Assemblage (2676-2669 Ma)

polymictic conglomerate with fuchsite-altered ultramafic clasts, sulfidized clasts, quartz feldspar porphyry, and mafic volcanic clasts.

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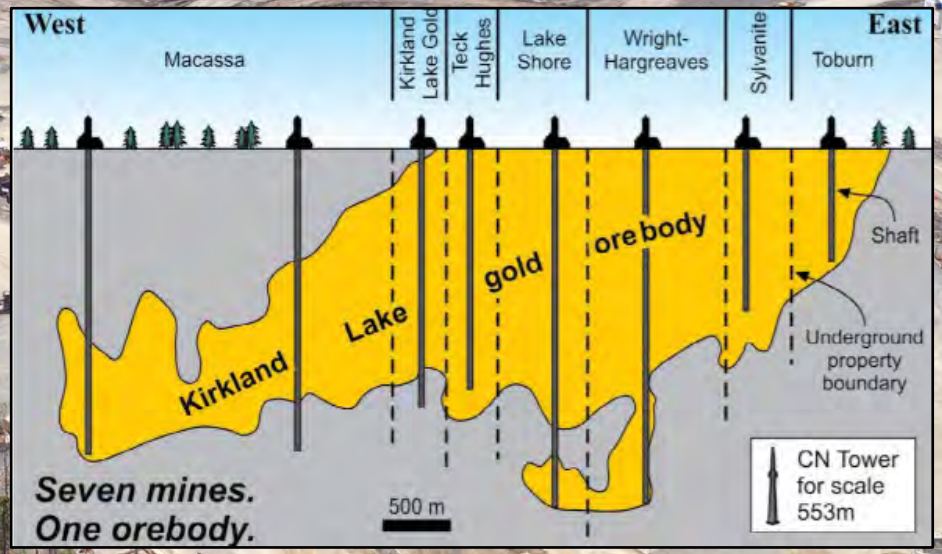
Macassa Mine, Kirkland Lake



41+ Moz. Au produced

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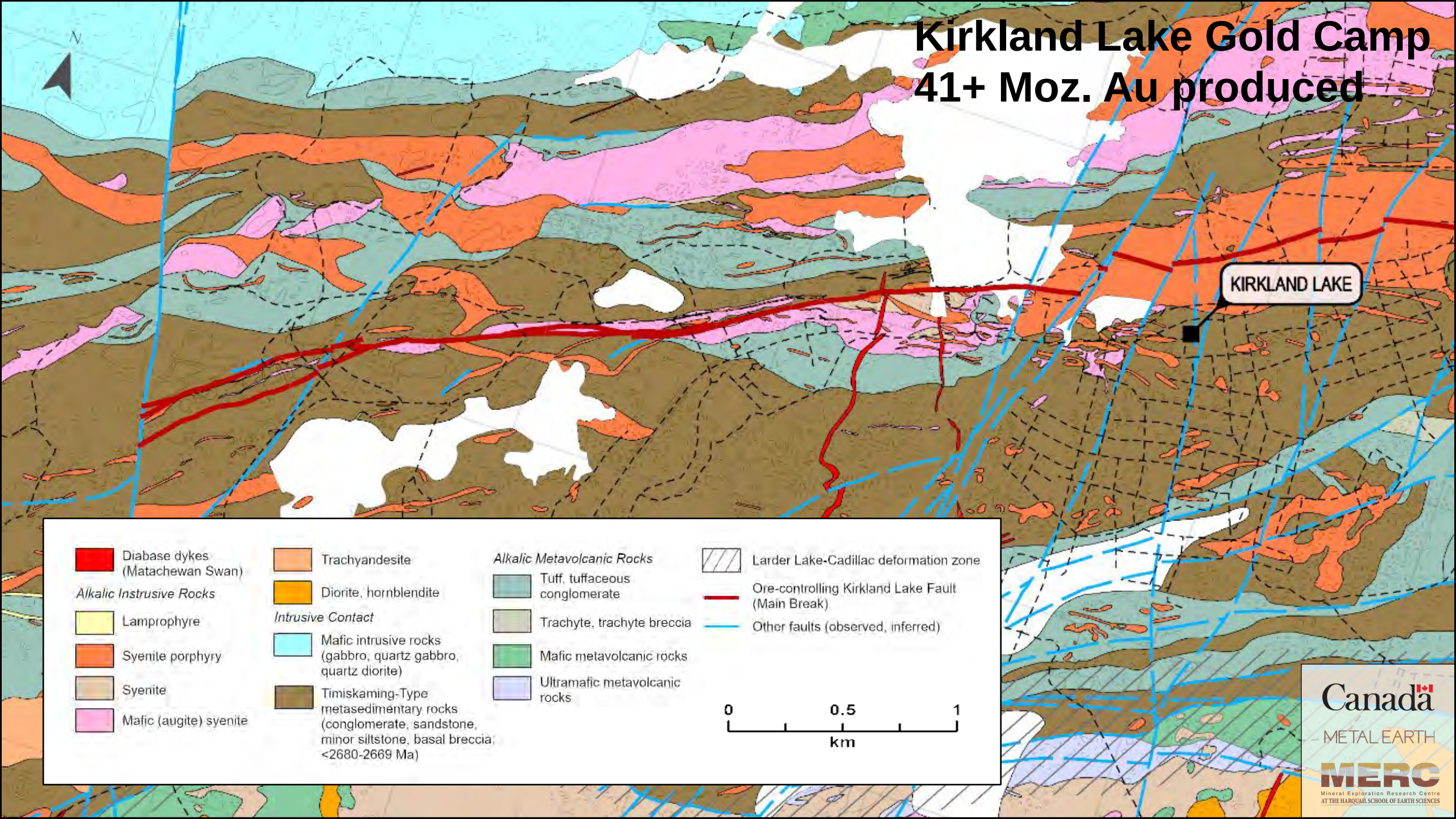
Kirkland Lake Gold Camp
41+ Moz. Au produced
N
KIRKLAND LAKE
Diabase dykes (Matachewan Swan)
Alkalic Instrusive Rocks
Lamprophyre
Syenite porphyry
Syenite
Mafic (augite) syenite
Trachyandesite
Diorite, hornblendite
Intrusive Contact
Mafic intrusive rocks (gabbro, quartz gabbro, quartz diorite)
Timiskaming-Type metasedimentary rocks (conglomerate, sandstone, minor siltstone, basal breccia; <2680-2669 Ma)
Alkalic Metavolcanic Rocks
Tuff, tuffaceous conglomerate
Trachyte, trachyte breccia
Mafic metavolcanic rocks
Ultramafic metavolcanic rocks
Larder Lake-Cadillac deformation zone
Ore-controlling Kirkland Lake Fault (Main Break)
Other faults (observed, inferred)
0
0.5
1
km
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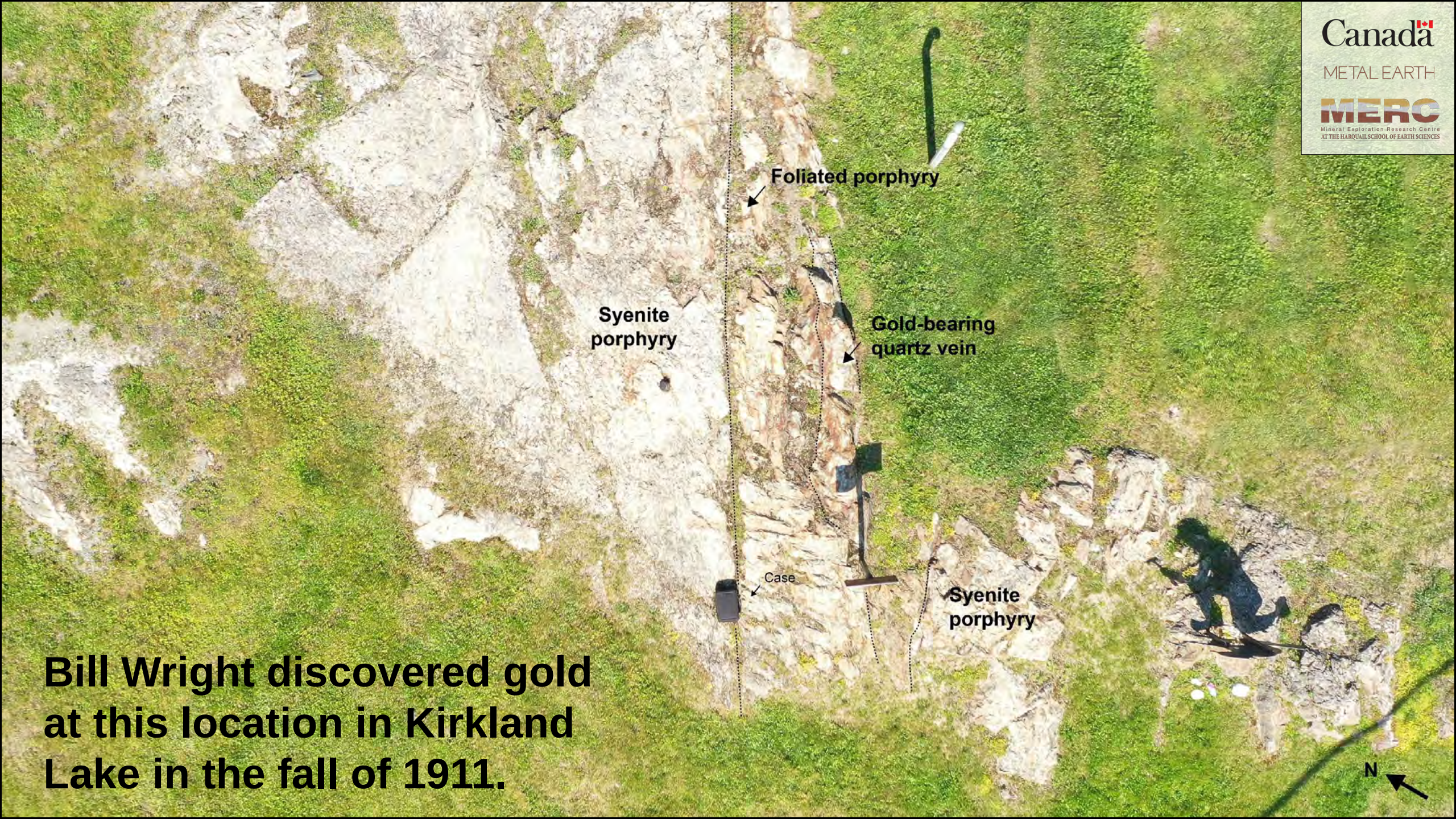
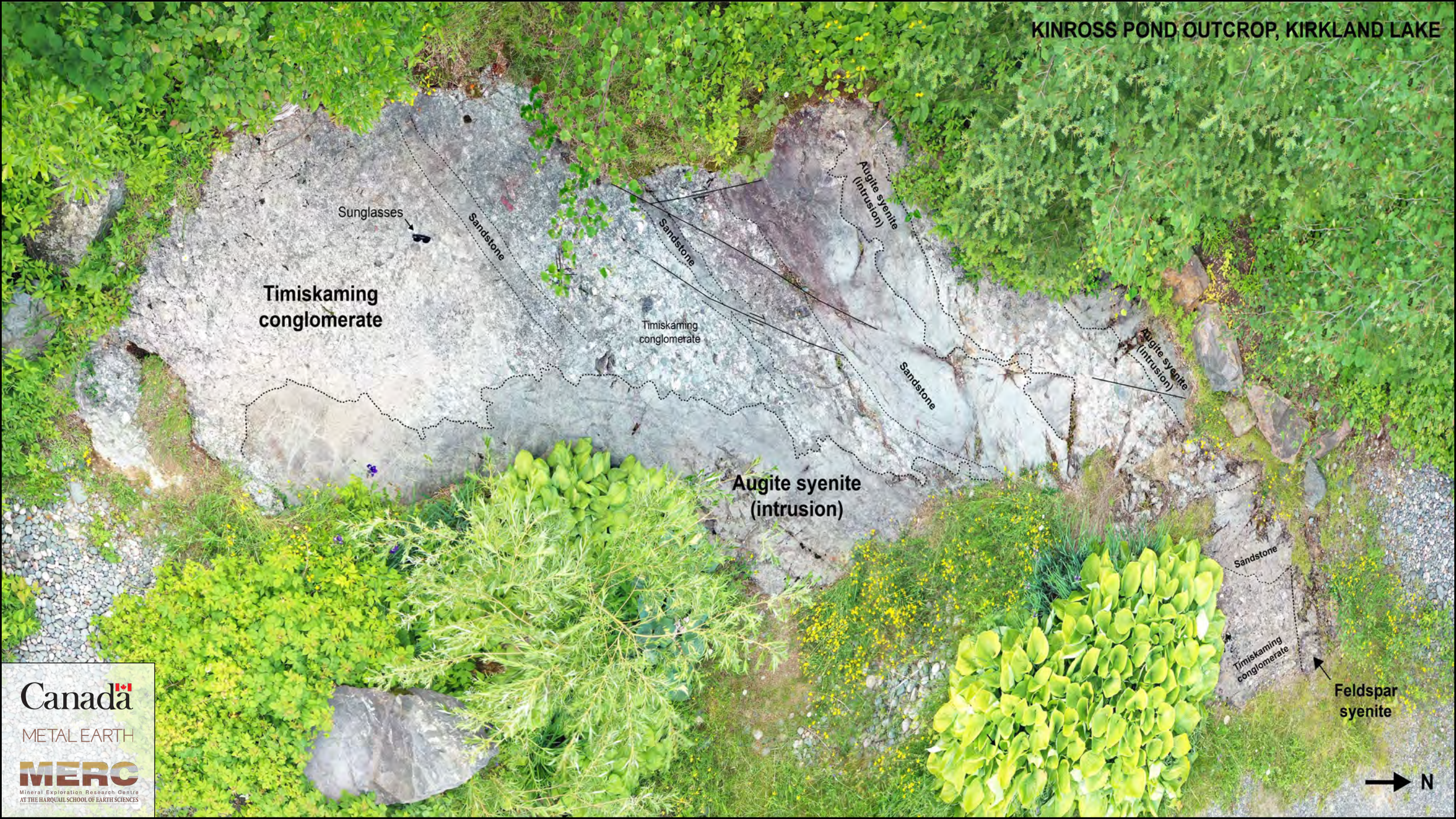


Bill Wright discovered gold at this location in Kirkland Lake in the fall of 1911.


KINROSS POND OUTCROP, KIRKLAND LAKE
Sunglasses
Sandstone
Timiskaming conglomerate
Sandstone
Augite syenite (intrusion)
Timiskaming conglomerate
Sandstone
Augite syenite (intrusion)
Augite syenite (intrusion)
Sandstone
Timiskaming conglomerate
Feldspar syenite
N
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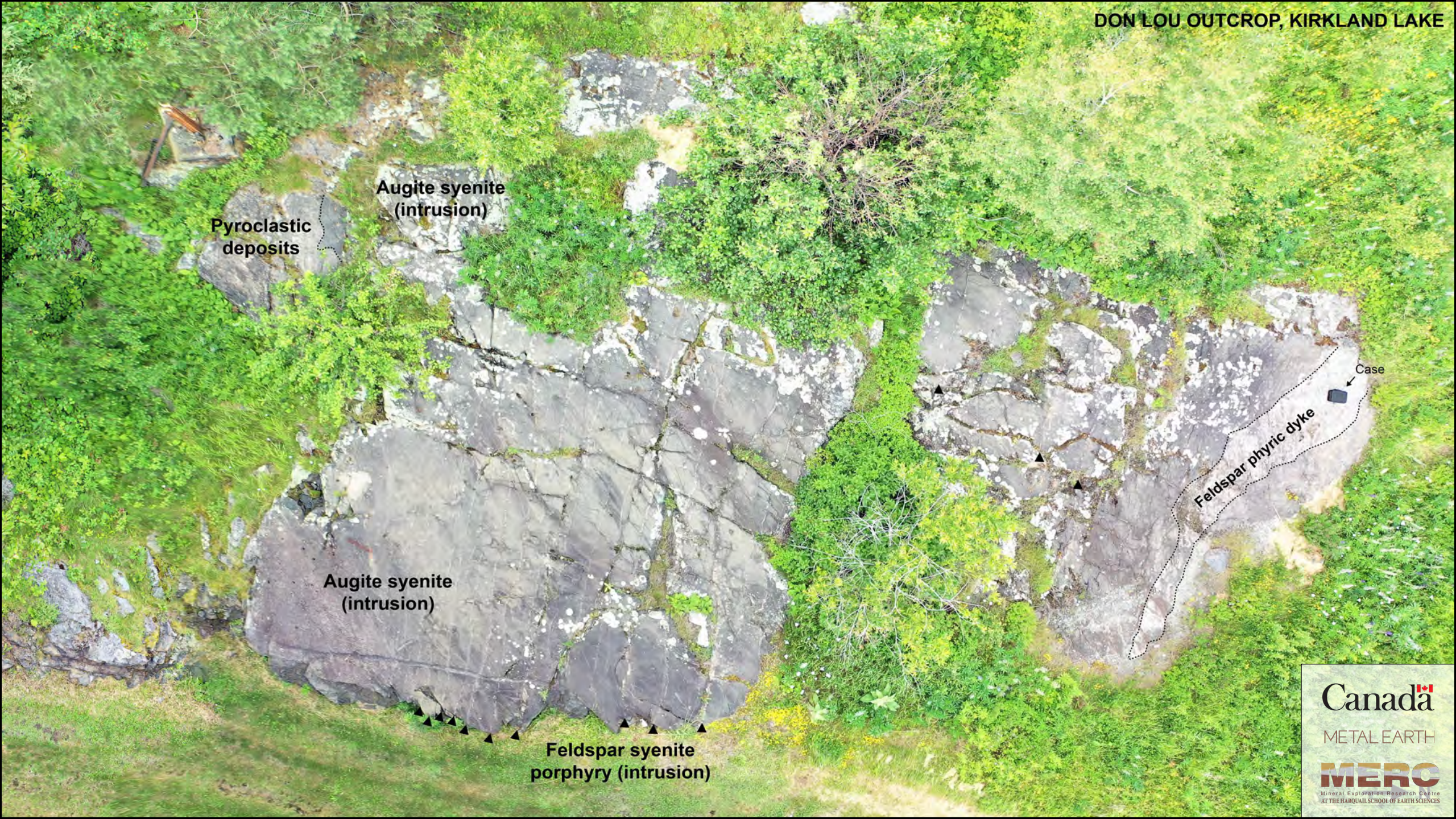
DON LOU OUTCROP, KIRKLAND LAKE
Augite syenite (intrusion)
Pyroclastic deposits
Case
Feldspar phyric dyke
Augite syenite (intrusion)
Feldspar syenite porphyry (intrusion)
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QUESTIONS?

GREAT BEAR
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ACKNOWLEDGMENTS

The entire team at Great Bear Resources/Kinross, particularly Emily Gorner, Dylan Langille, Rick Greenwood, Graham Long, and Juan Carlos Ordóñez Calderón

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