

Dating Geologic Processes:

EMPA Accessory Phase Characterization, Dating, and P-T-t-D- Analysis

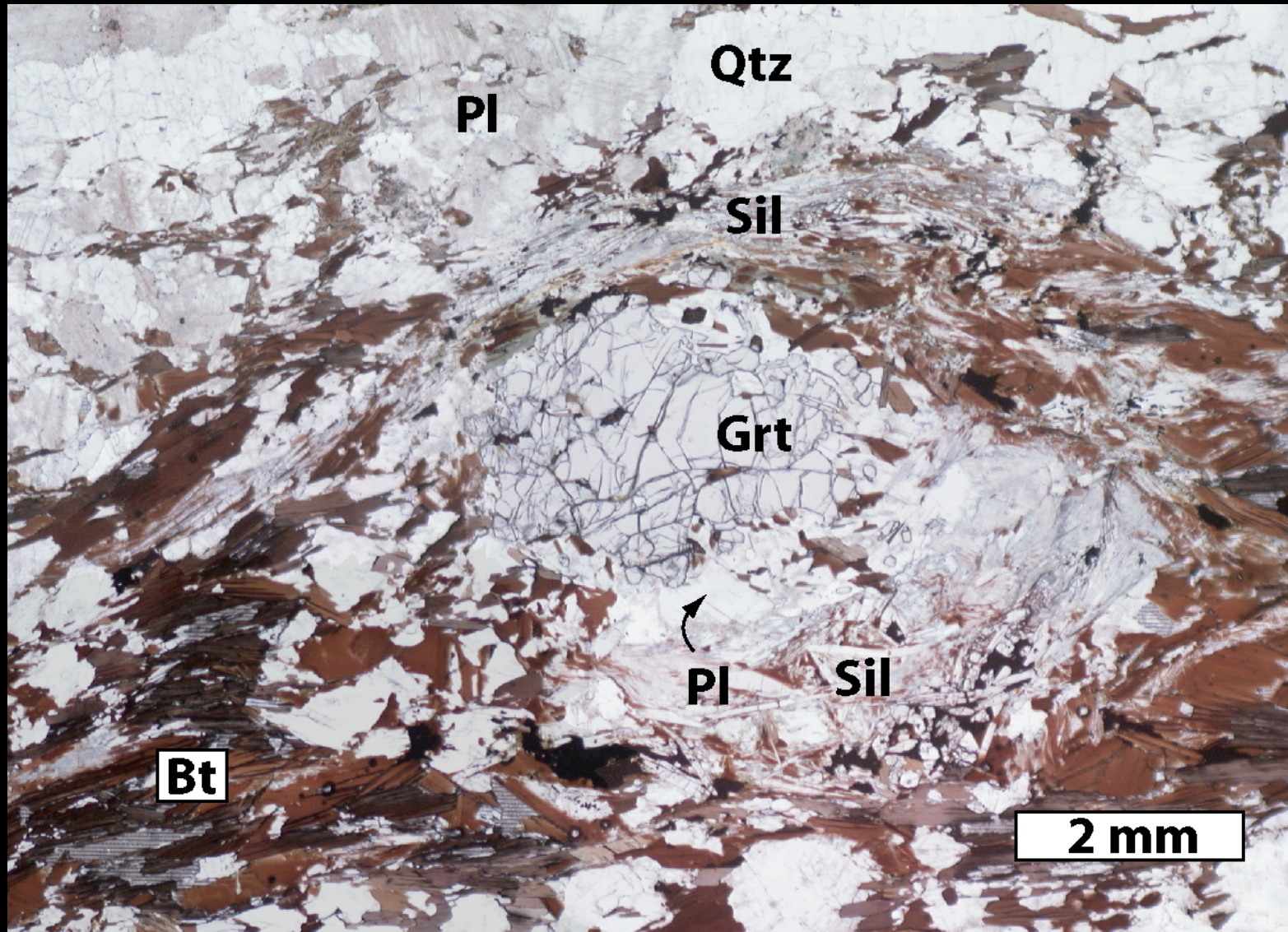


M.L. Williams

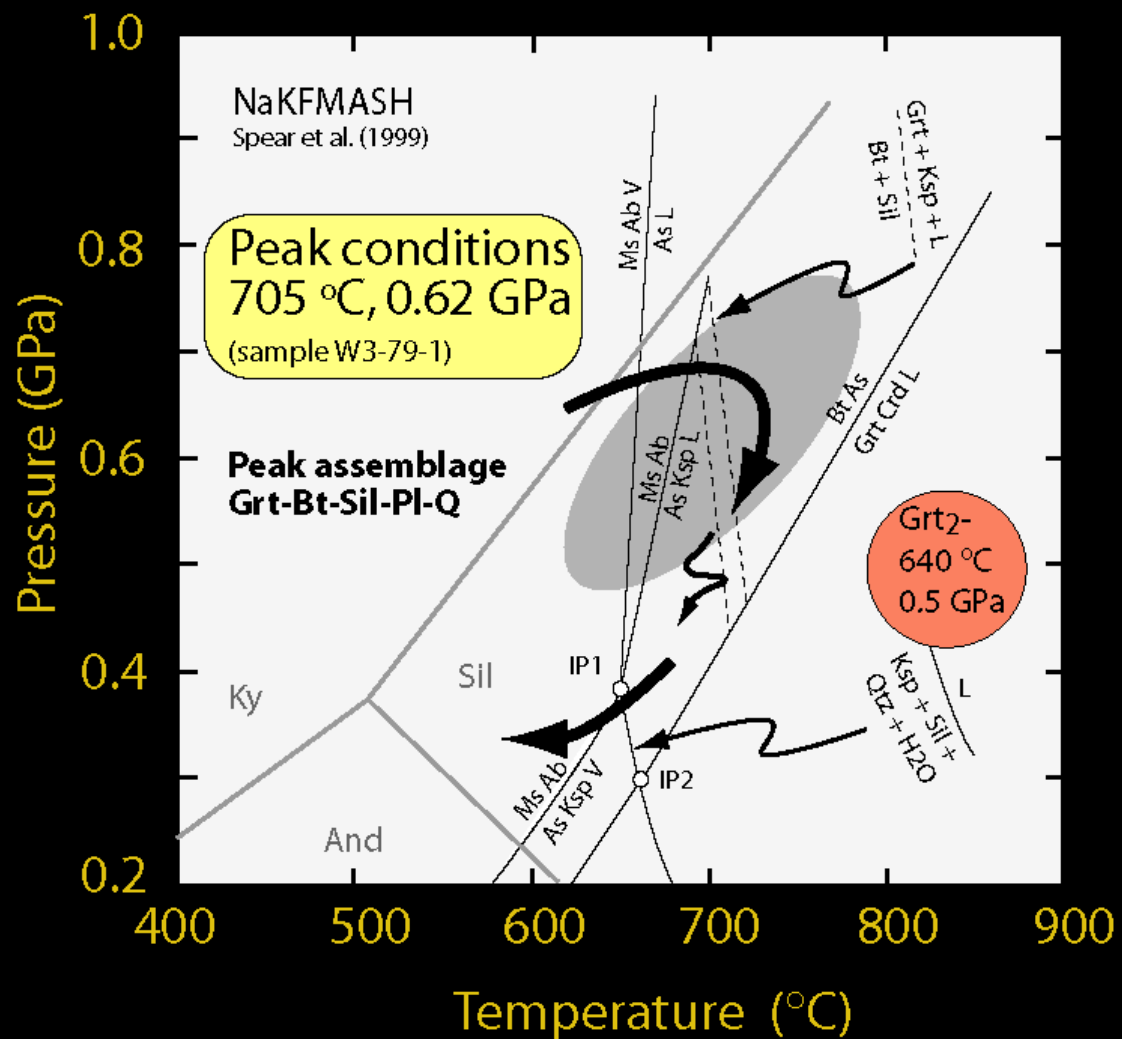
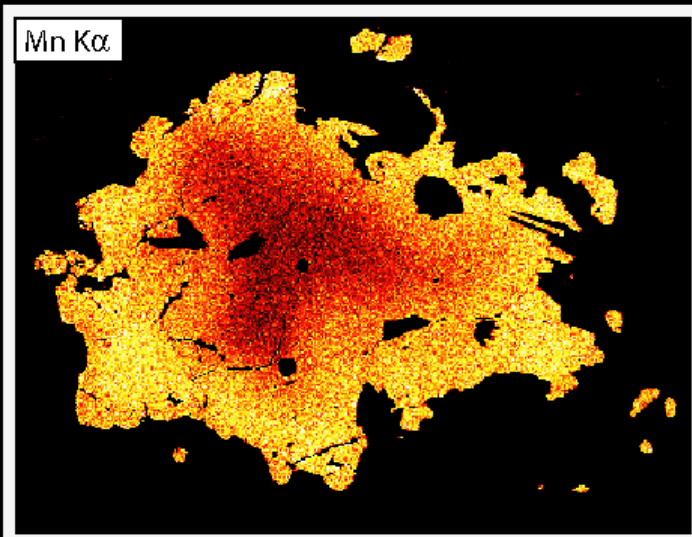
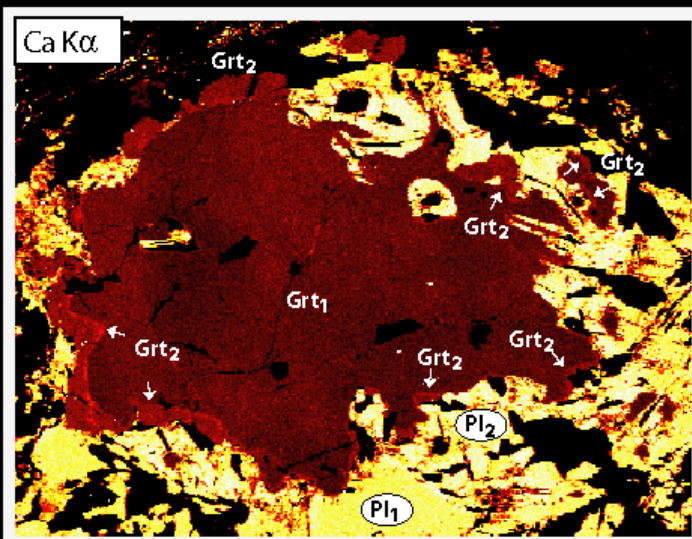
Univ. of Massachusetts-Amherst



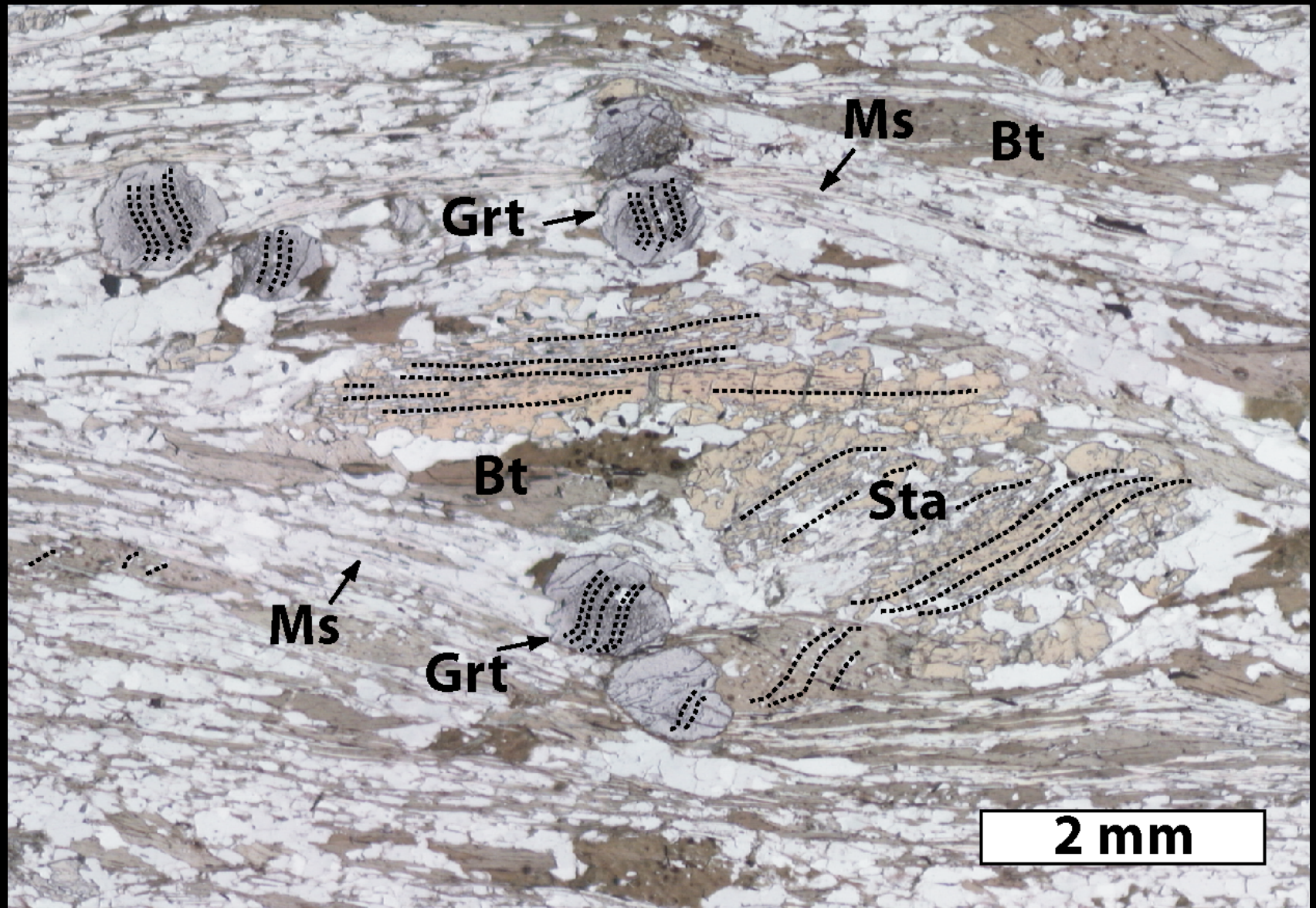
Grand Canyon (mile 78-81)



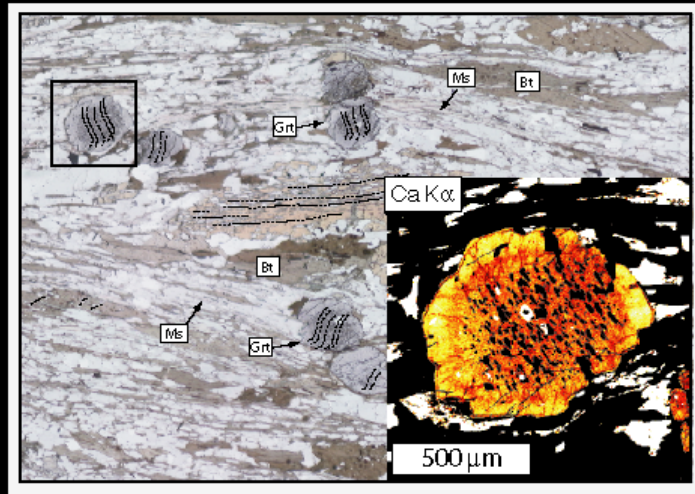
Grand Canyon (mile 78-81)



Grand Canyon (mile 81-87)



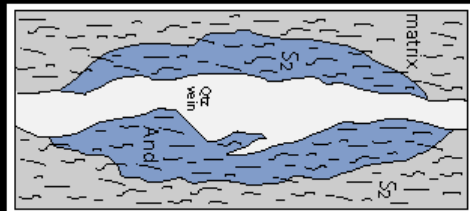
Clear Creek Block (mile 81-87)



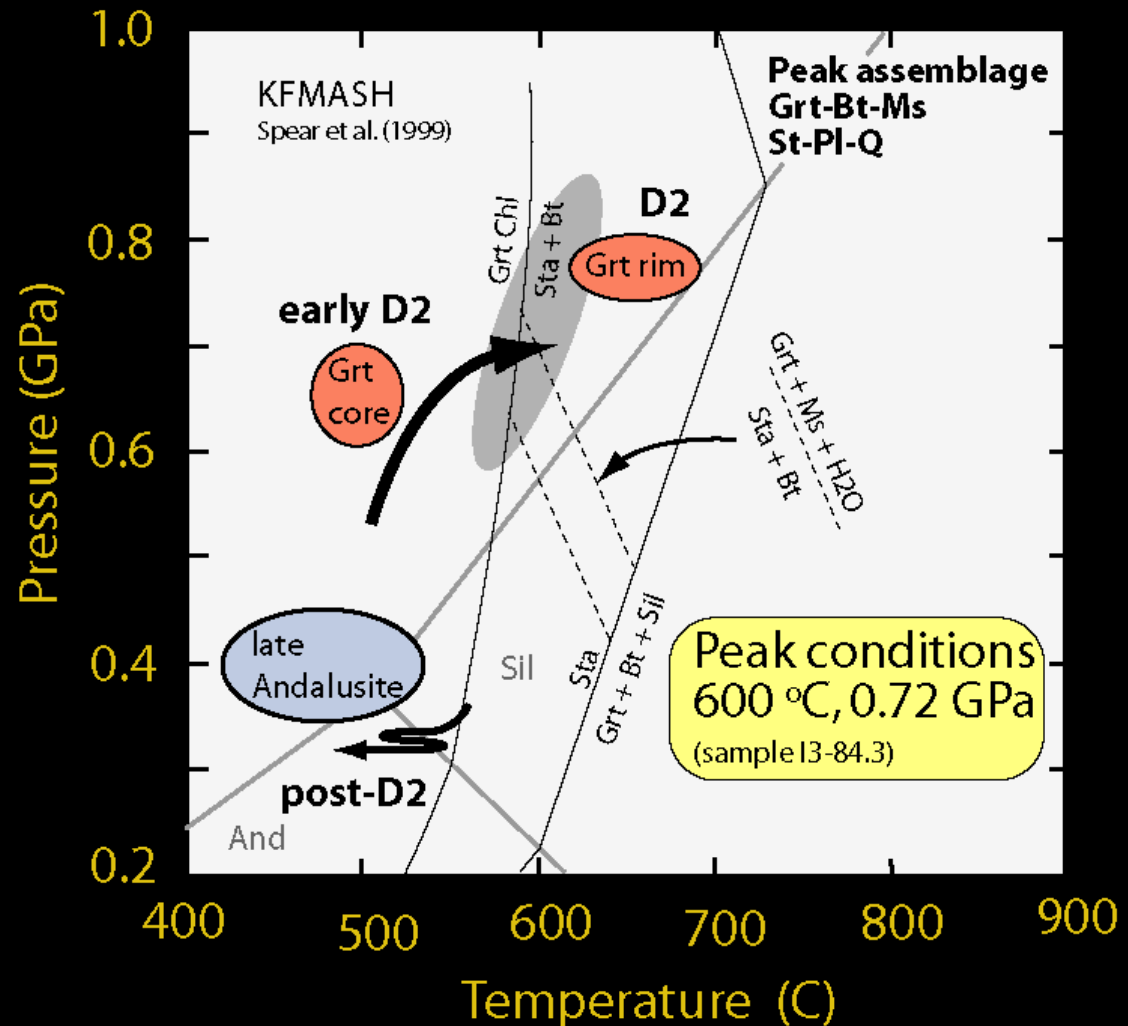
**Late Post - D2
Andalusite**

NW

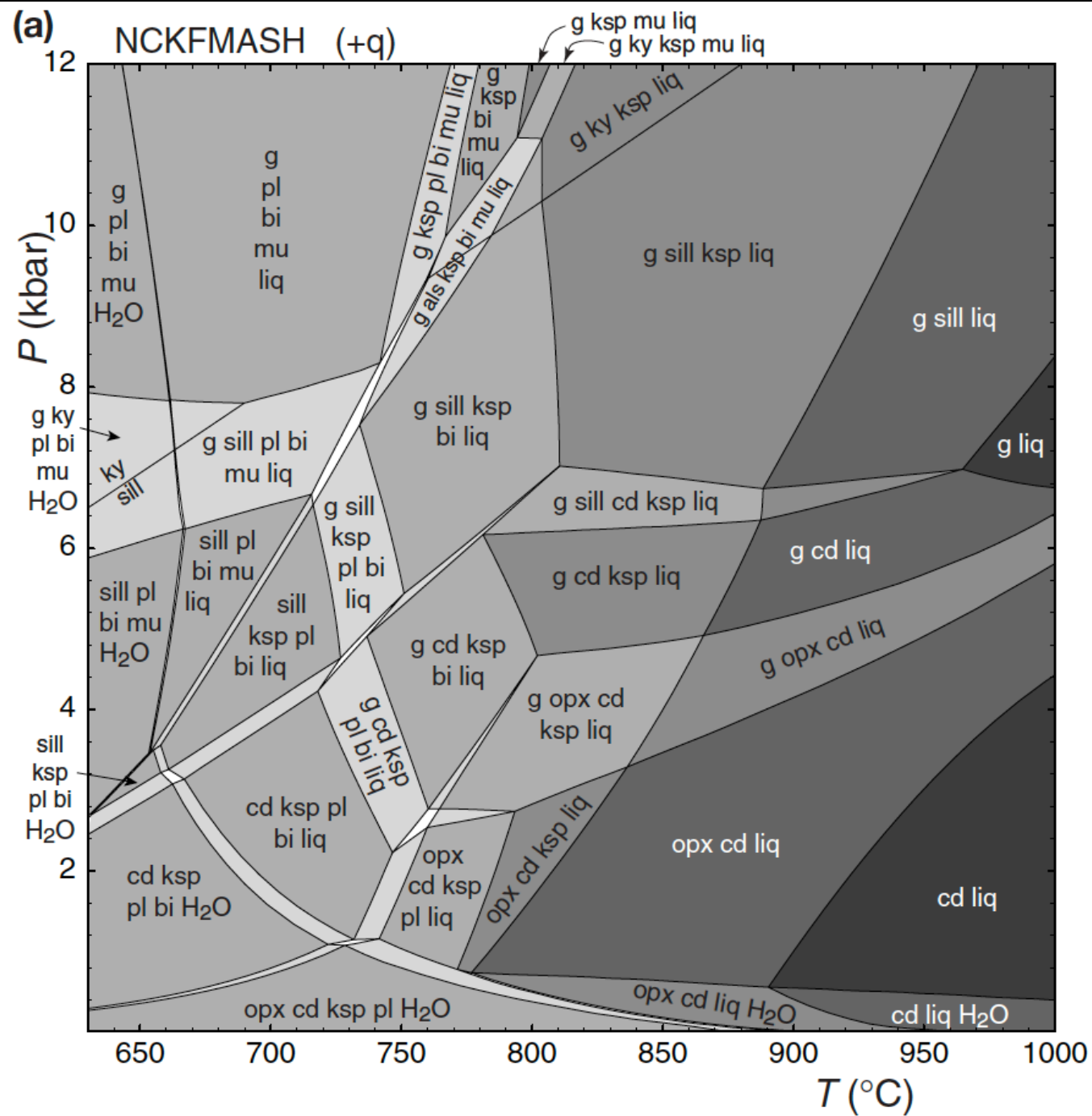
5 cm



SE



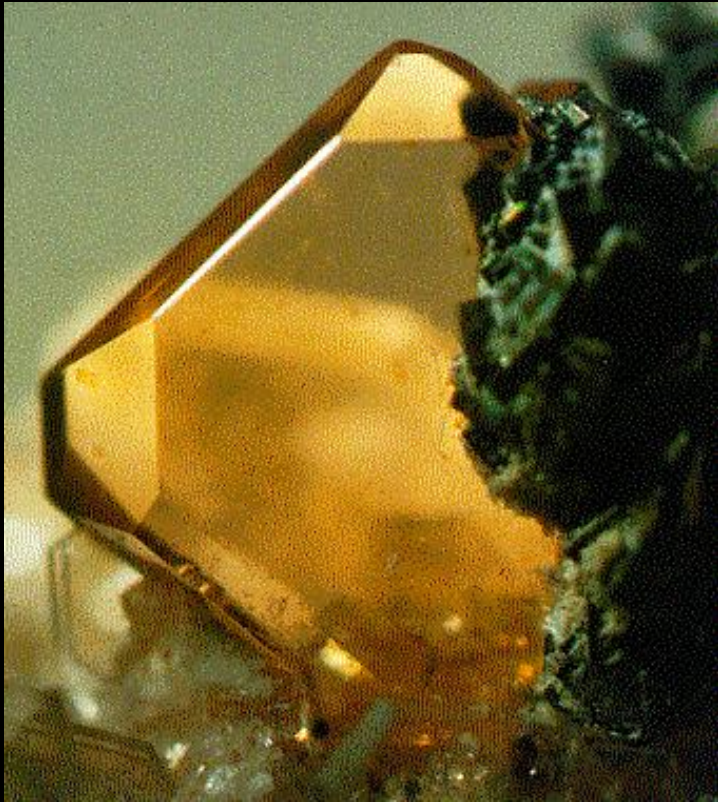
Pseudosection





Monazite geochronology

Monazite: (LREE) PO_4



Common accessory phase in igneous, metamorphic and sedimentary rocks...

Major REE's: Ce, La, Nd

Minor elements: Y, Si, Ca, Sm, Eu, Gd, Pr

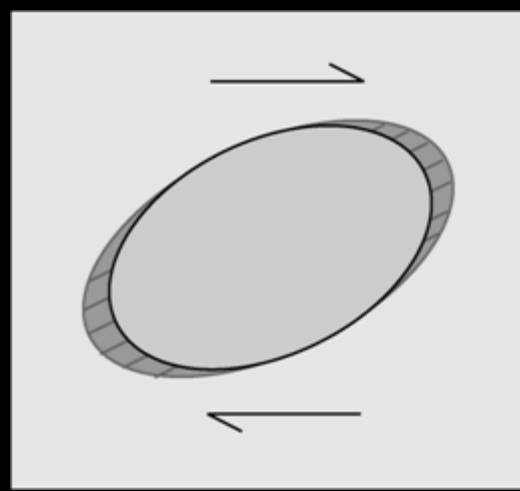
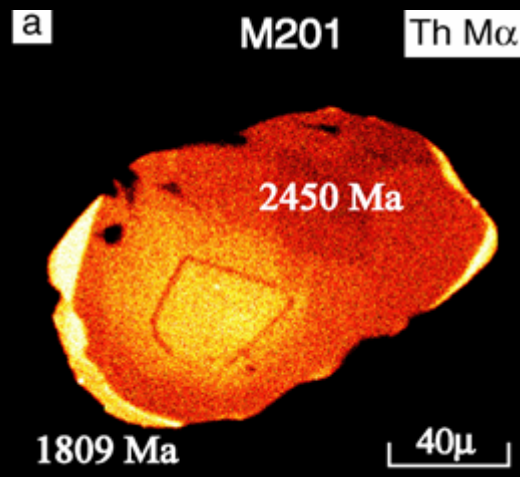
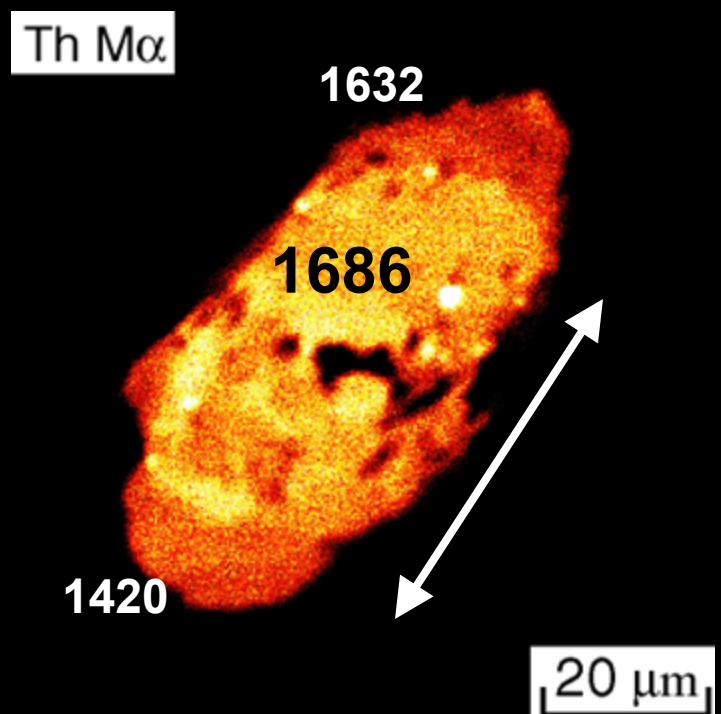
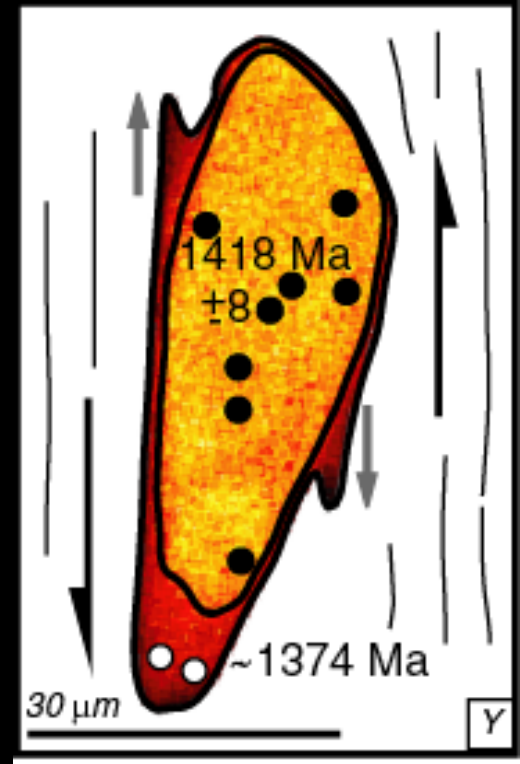
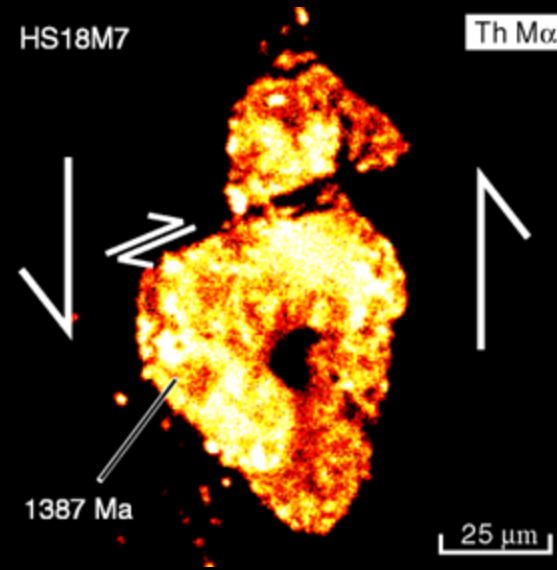
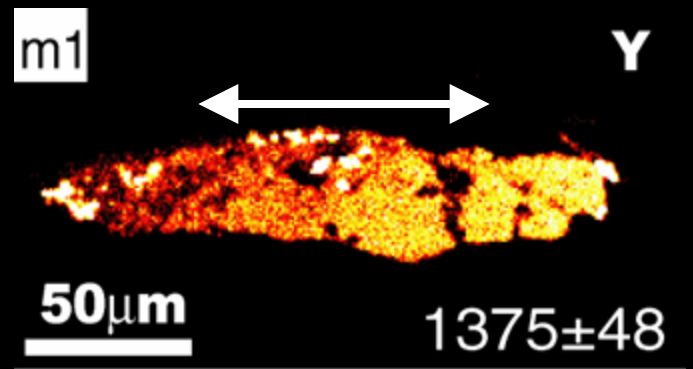
Th : 100's of ppm → 10's of wt%

U : 10's of ppm → Several wt%

Pb : Very little "common" Pb
(ppb → several ppm)



Timing Deformation

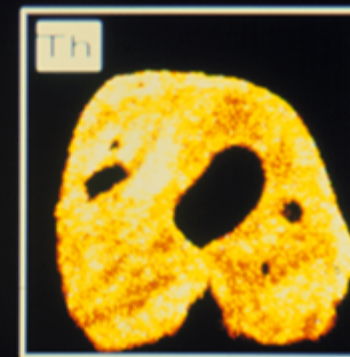
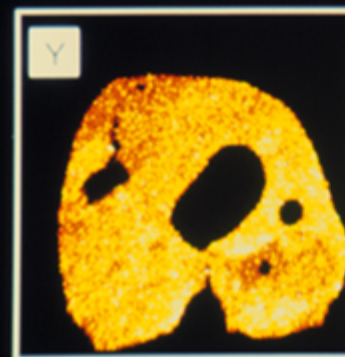




CB 4 Monazite 1



CB 4 Monazite 5



1700 $\pm$ 15 my

Crazy Basin Pluton, AZ

Reaction-dating

Pyle and Spear, 2003

Shaw et al. (2001)

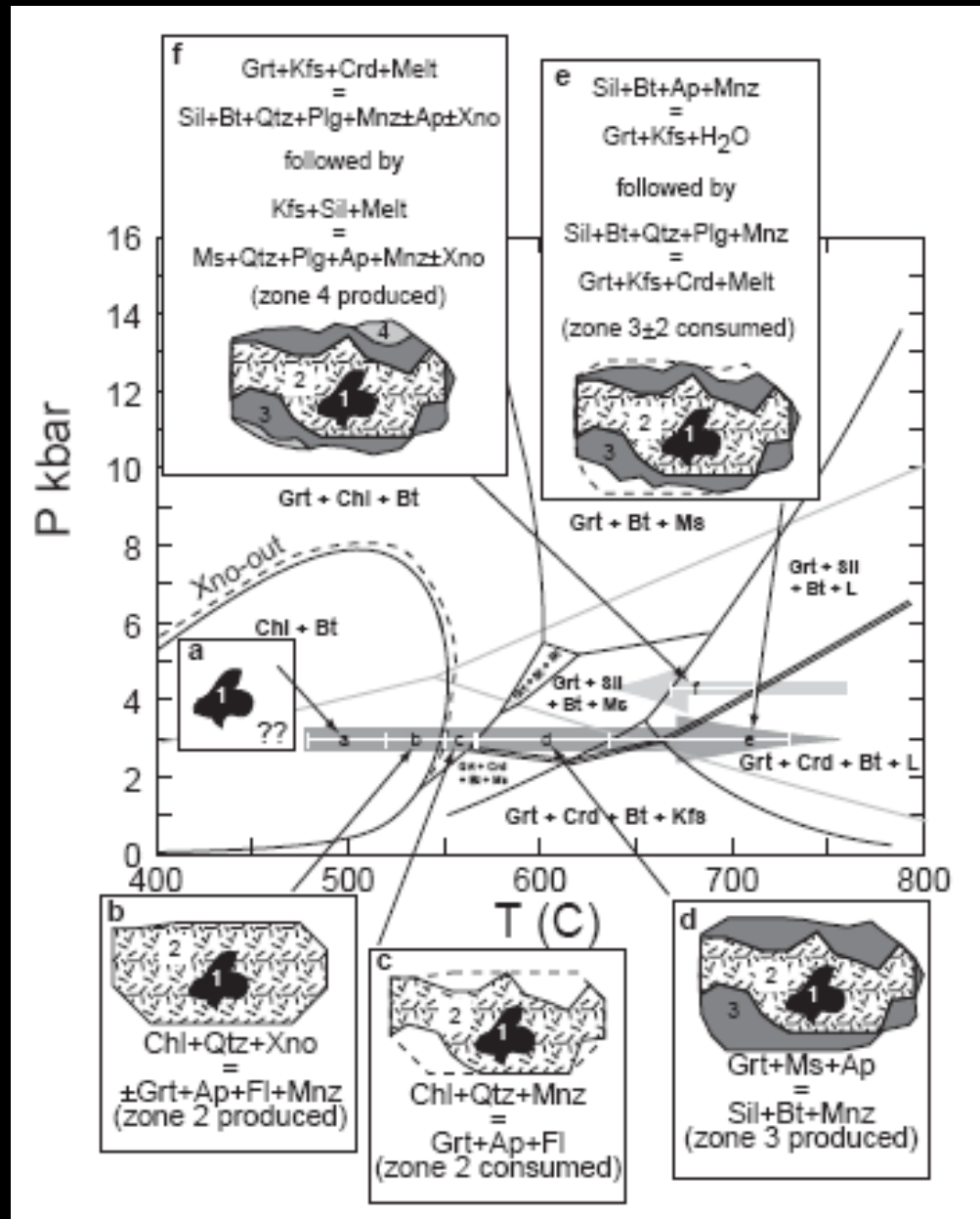
Wing and Ferry (2003)

Foster et al. (2004)

Kohn et al. (2005)

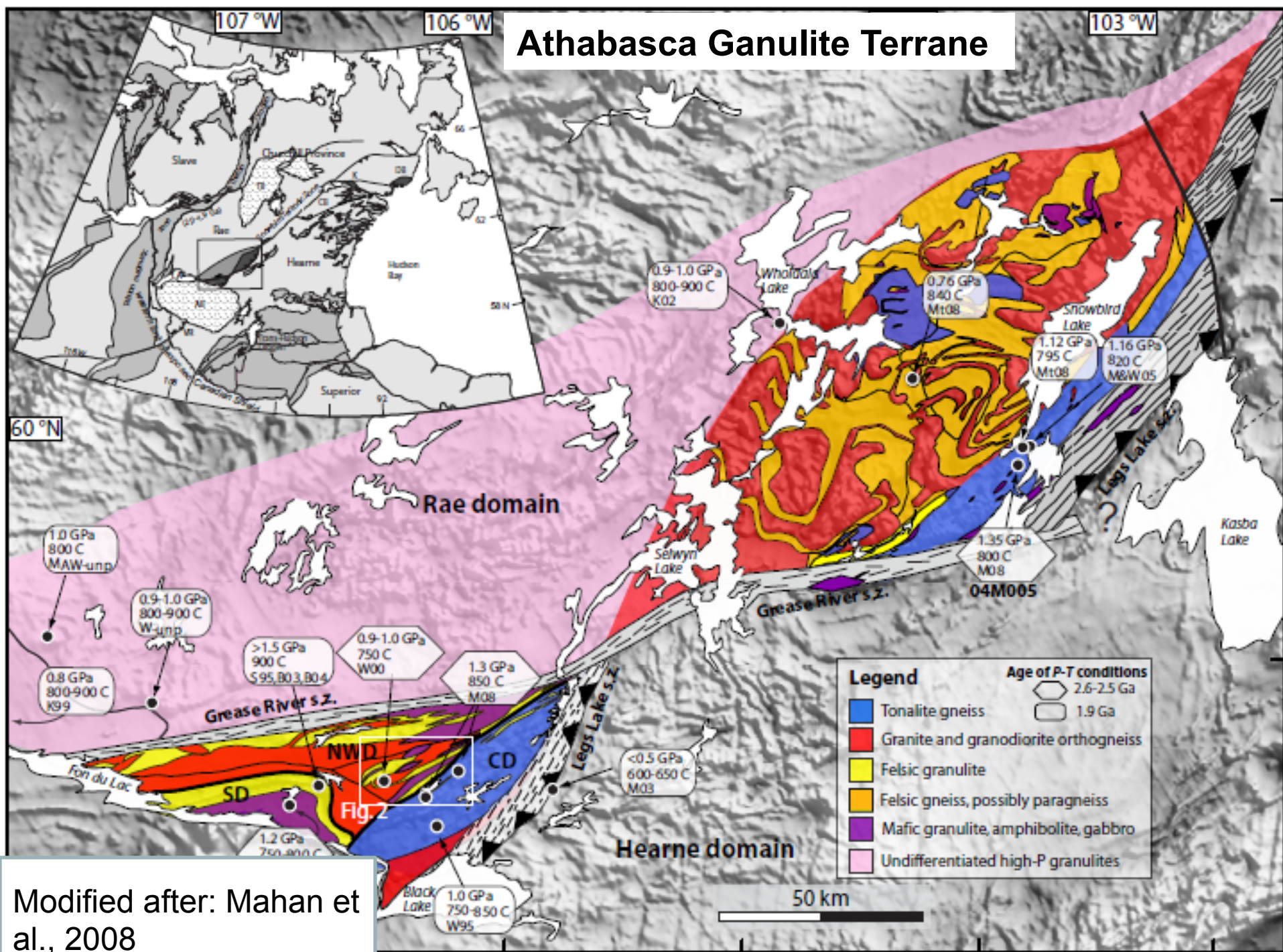
Caddick et al. (2007)

McFarlane, et al. (2005)

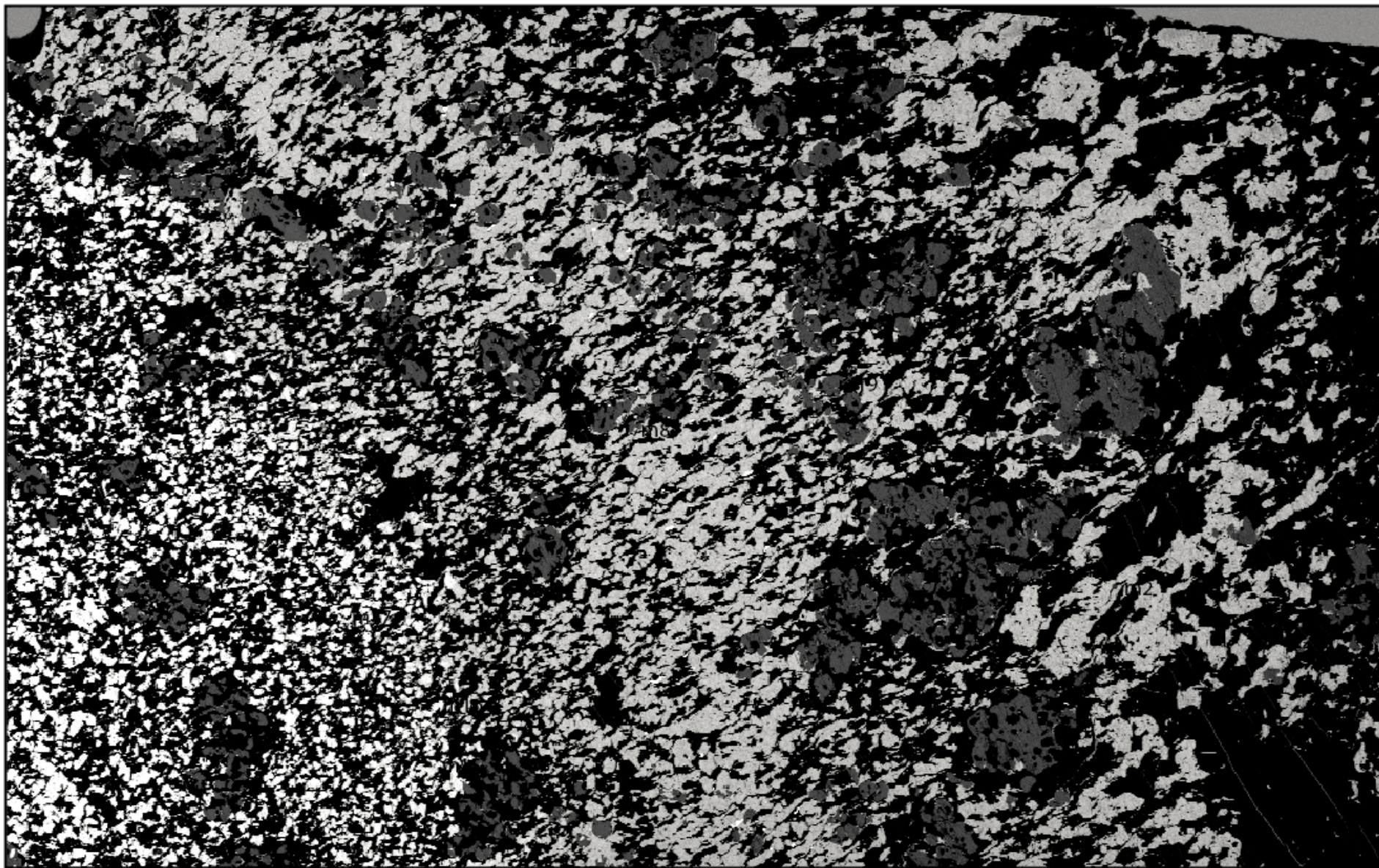




Athabasca Ganulite Terrane

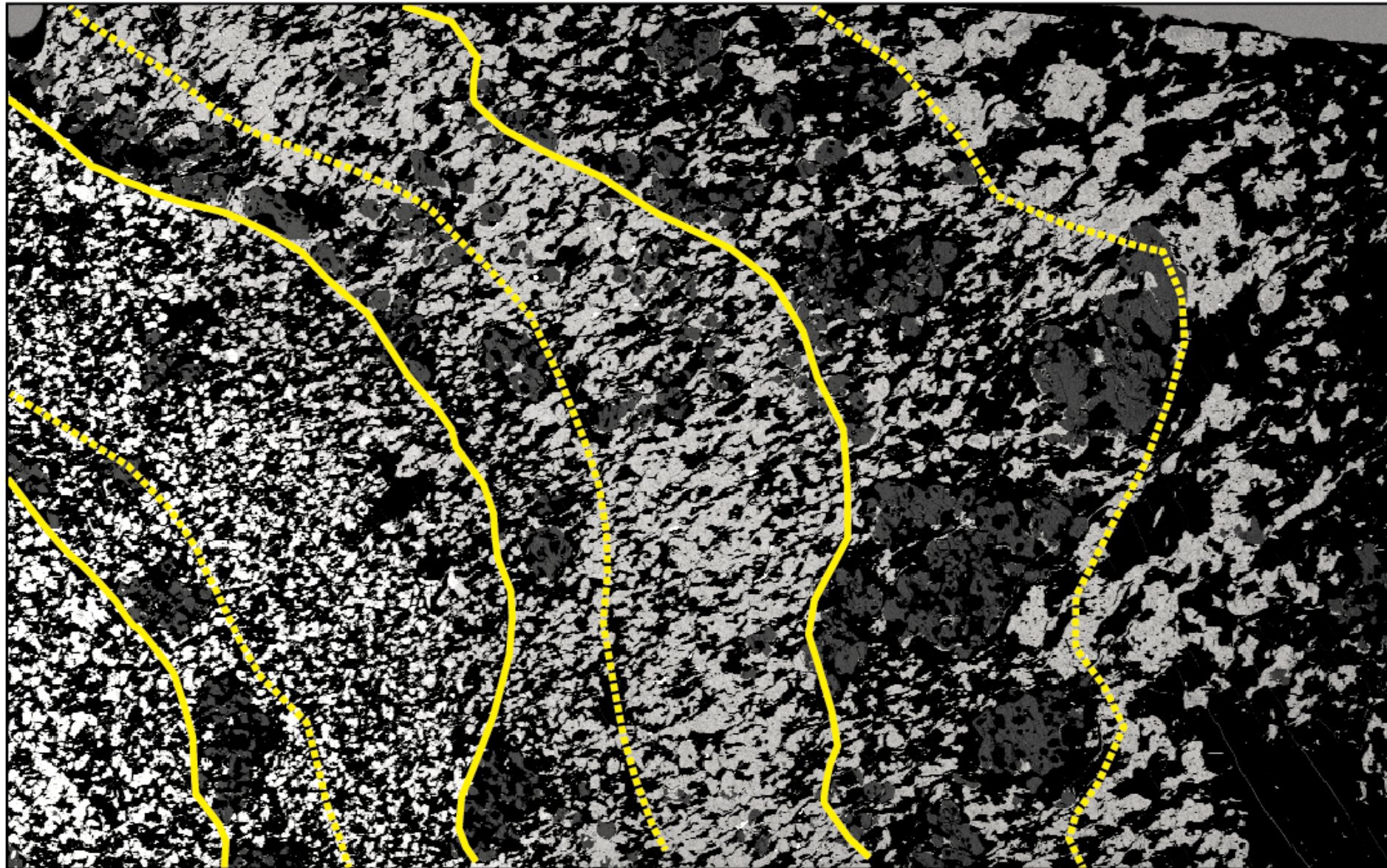


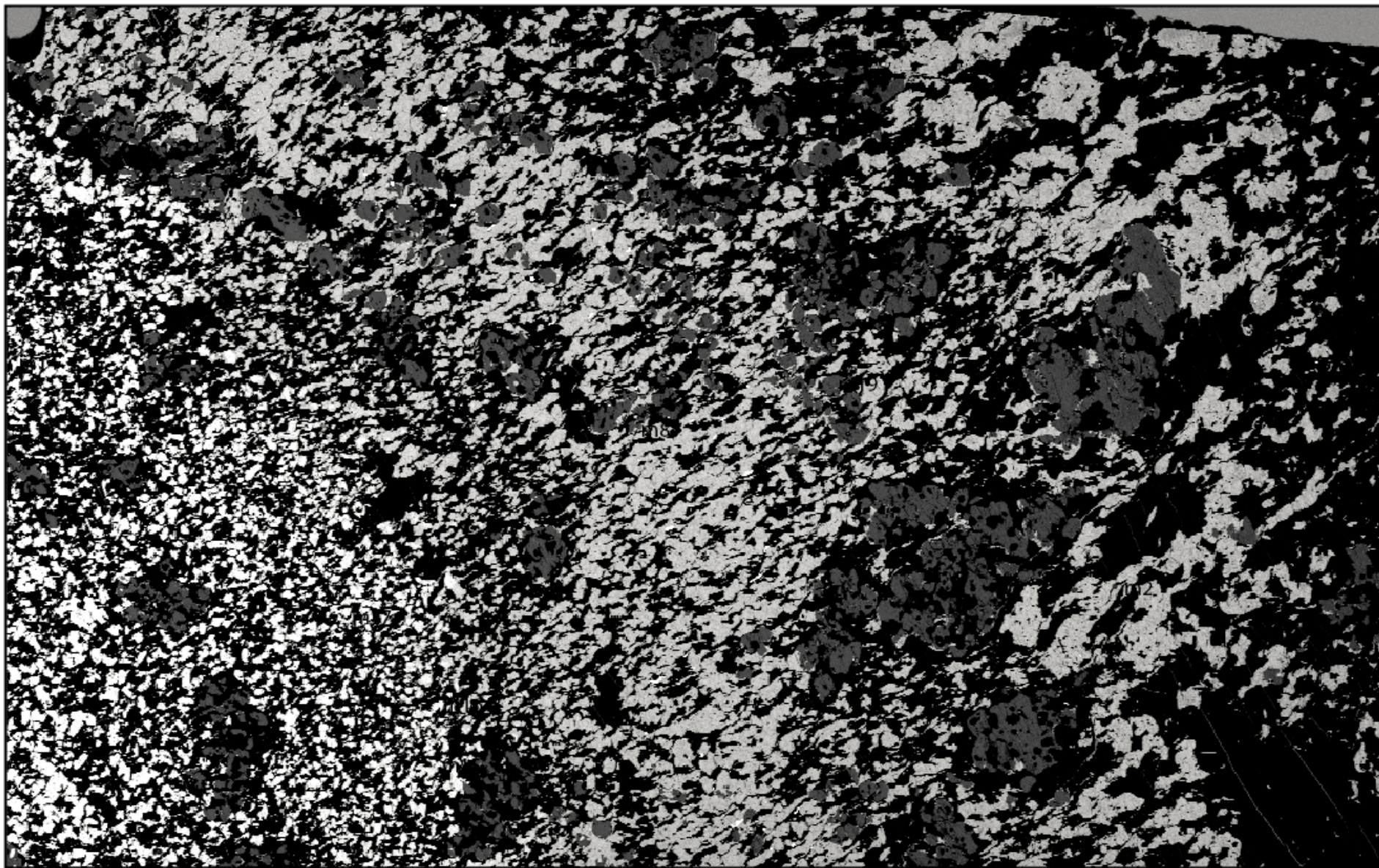
Modified after: Mahan et al., 2008



07W-032B

Ca K α

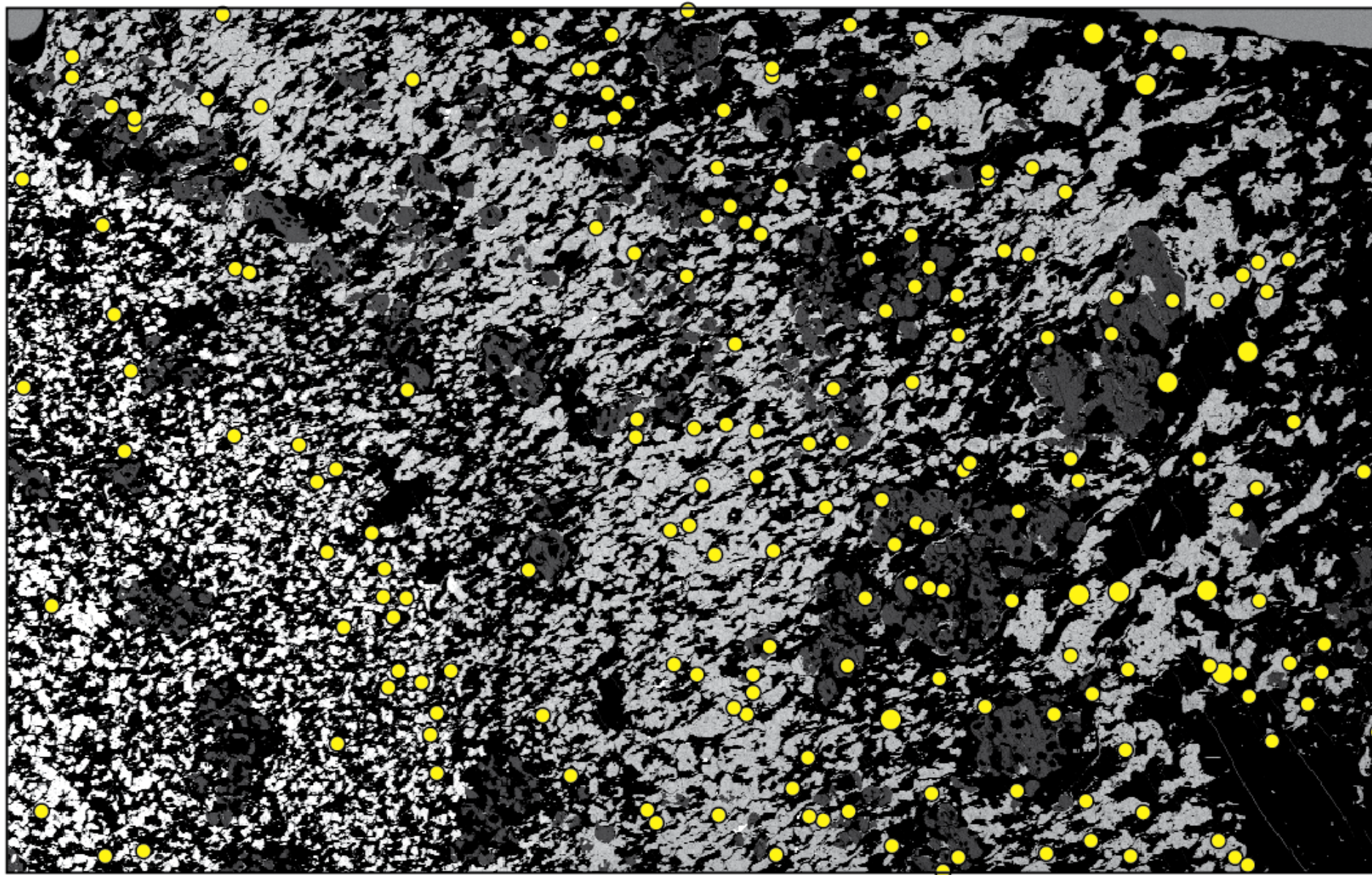




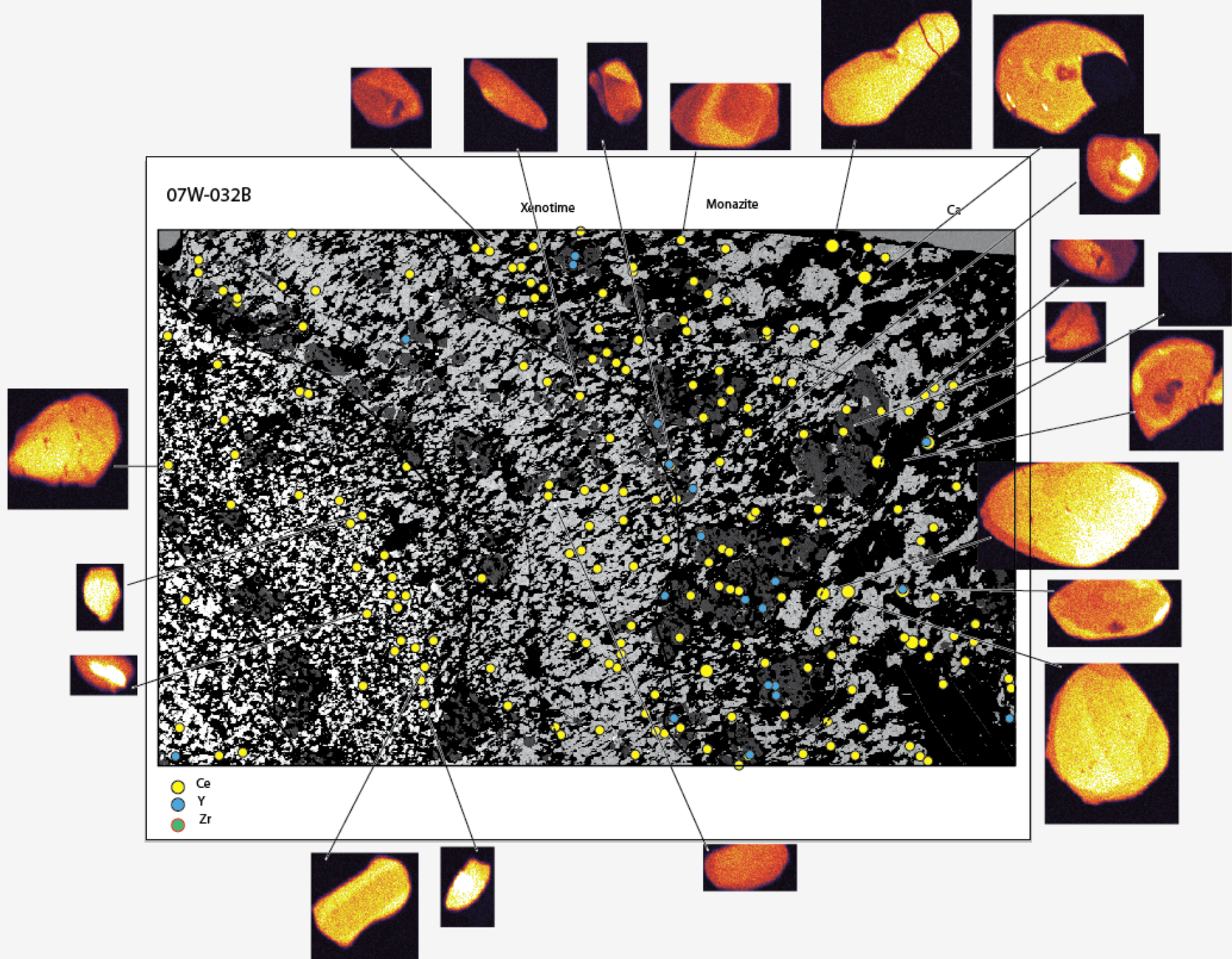
07W-032B

Monazite

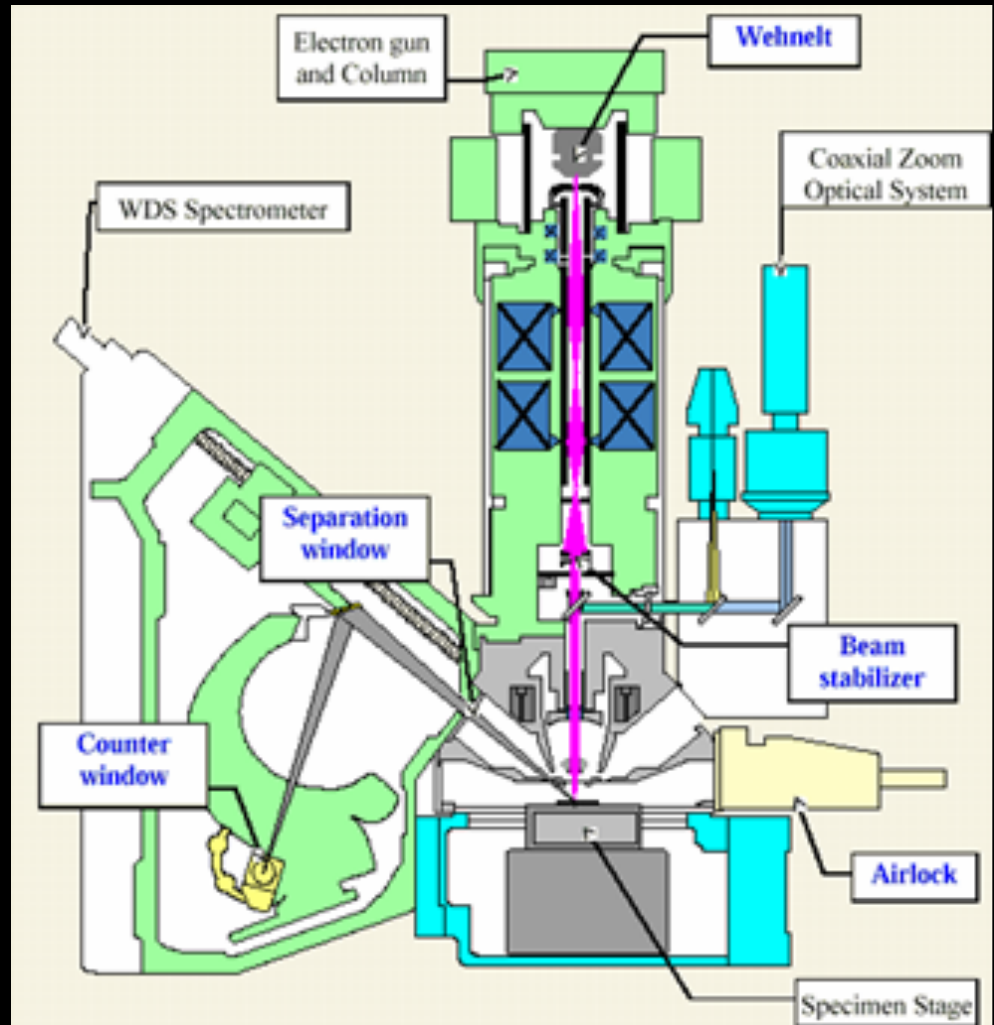
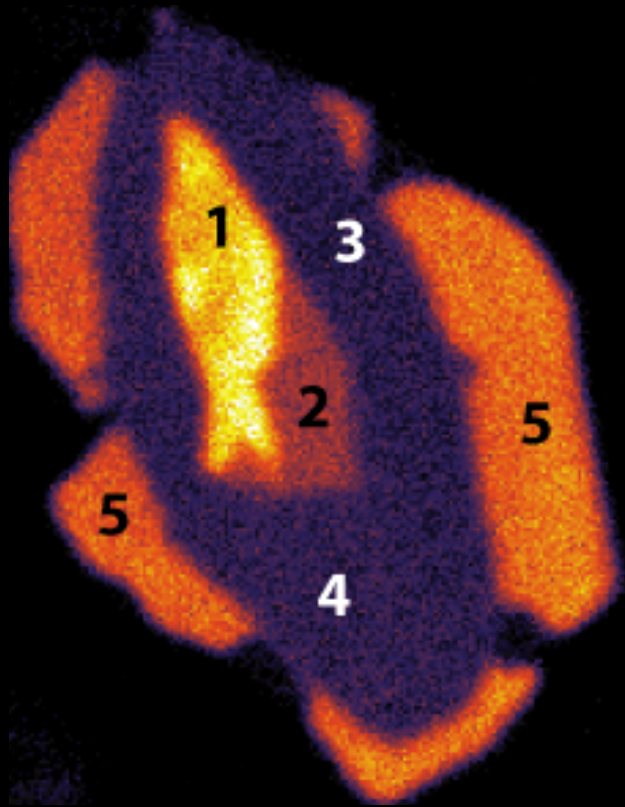
Ca



● Ce

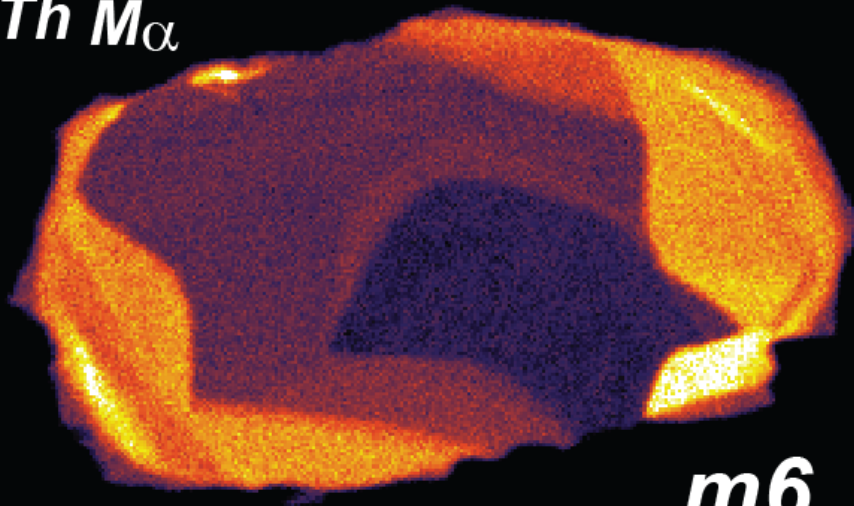


Monazite: (LREE) PO₄

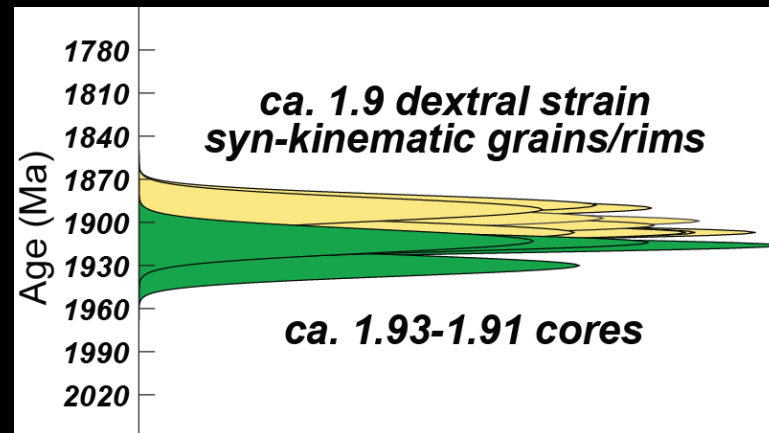


Microprobe optimized for Trace-element Analysis

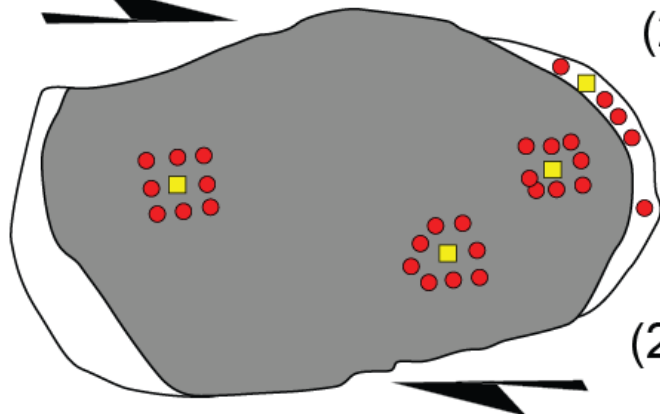
Th M_α



m6



Syn-kinematic rim: **1901 $\pm$ 12 Ma**
(2- σ , MSWD=1.2)



Core:
1915 $\pm$ 16 Ma
(2- σ , MSWD=0.40)

- = background collection point
- = trace element analysis point

20 μ m

Multipoint Background

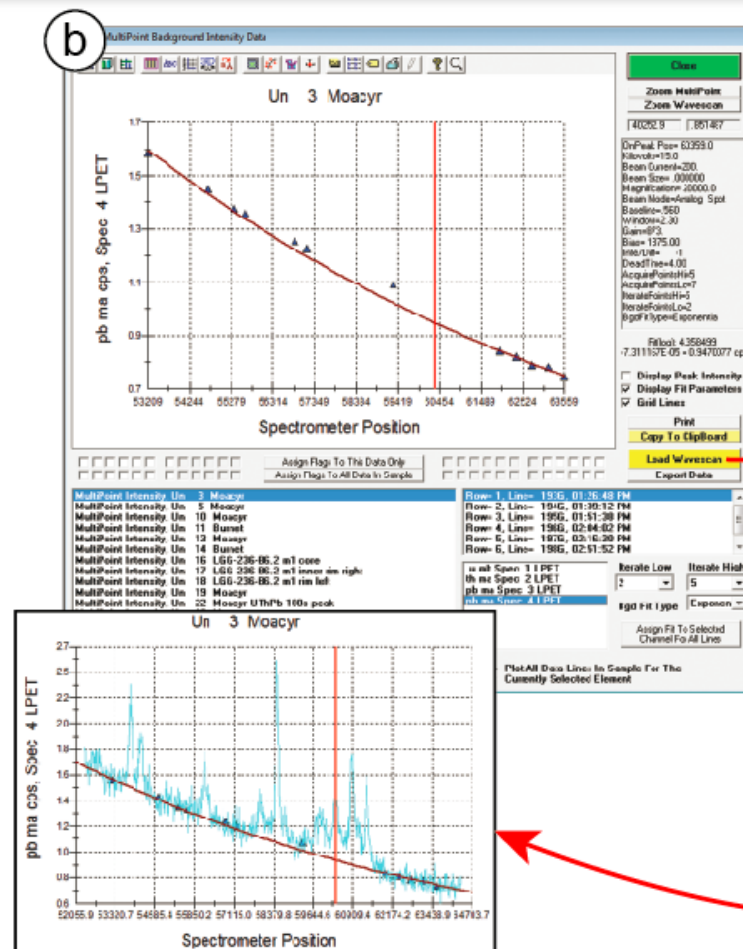
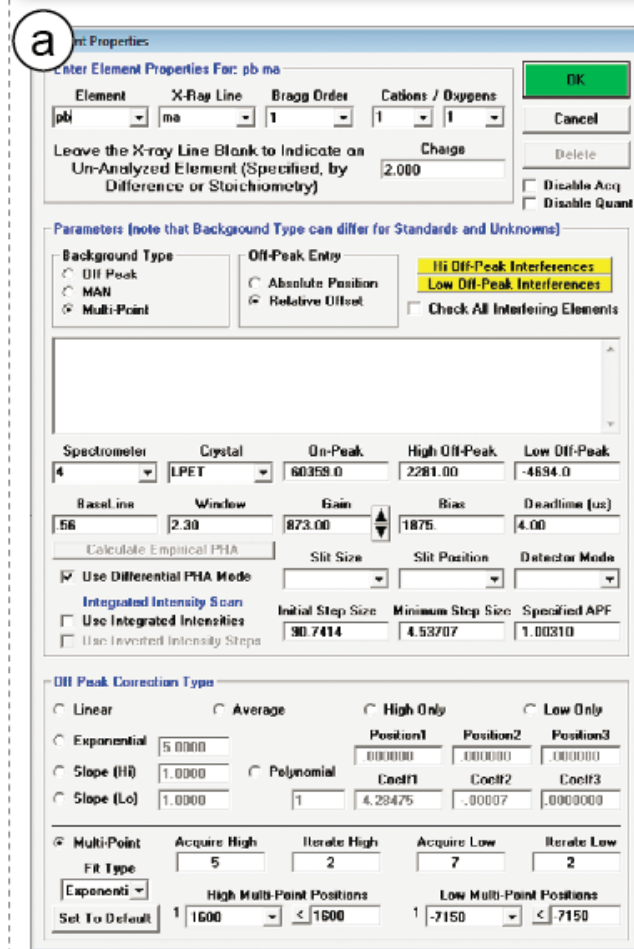
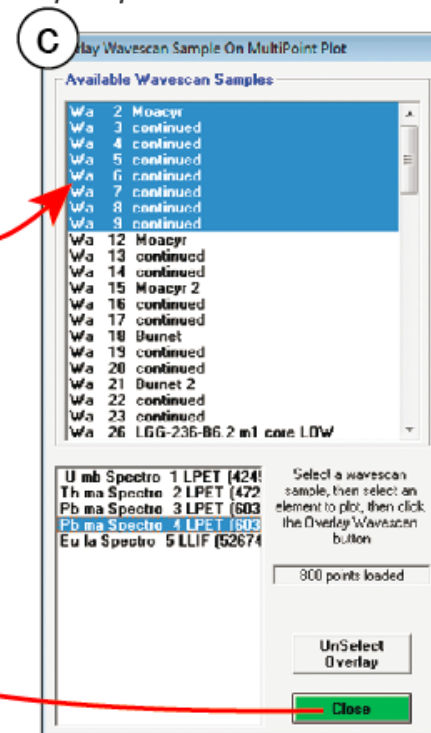
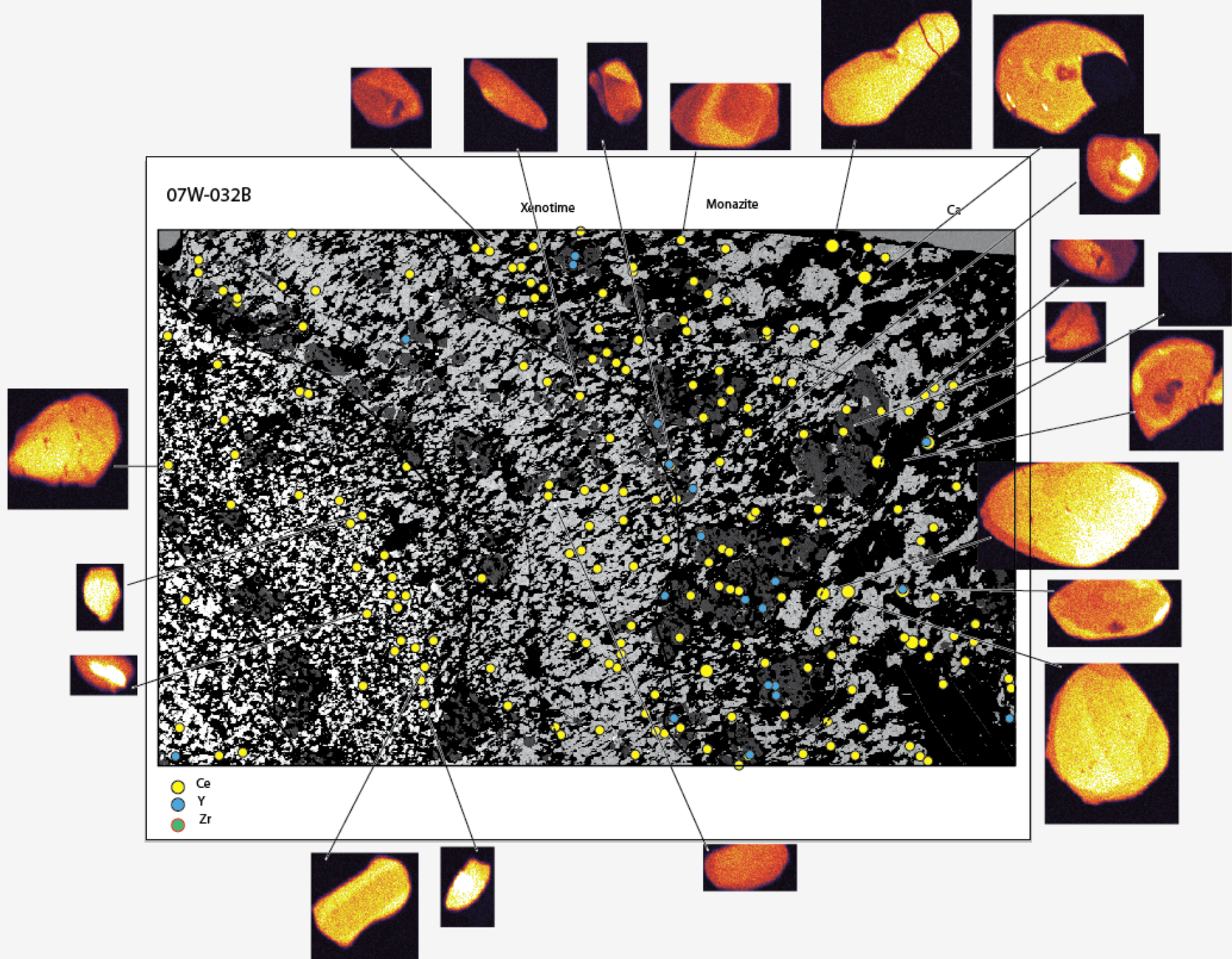
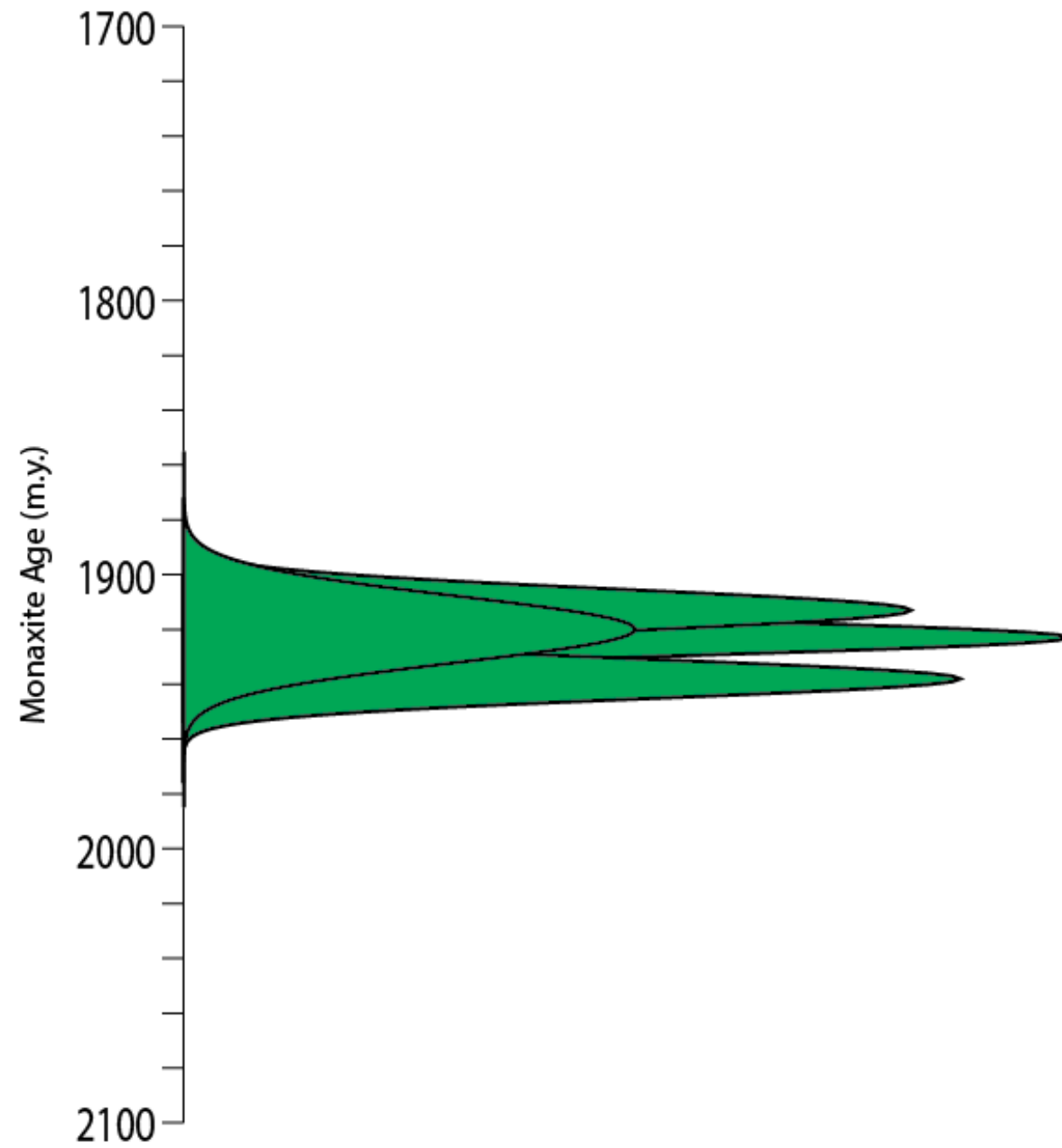


Fig. 3: Windows used in Probe for EPMA for the setting of multipoint background measurement, and example of result treatment: a) Element properties window; b) Display multipoint background intensity data; c) Overlay wavescan sample on multipoint plot.

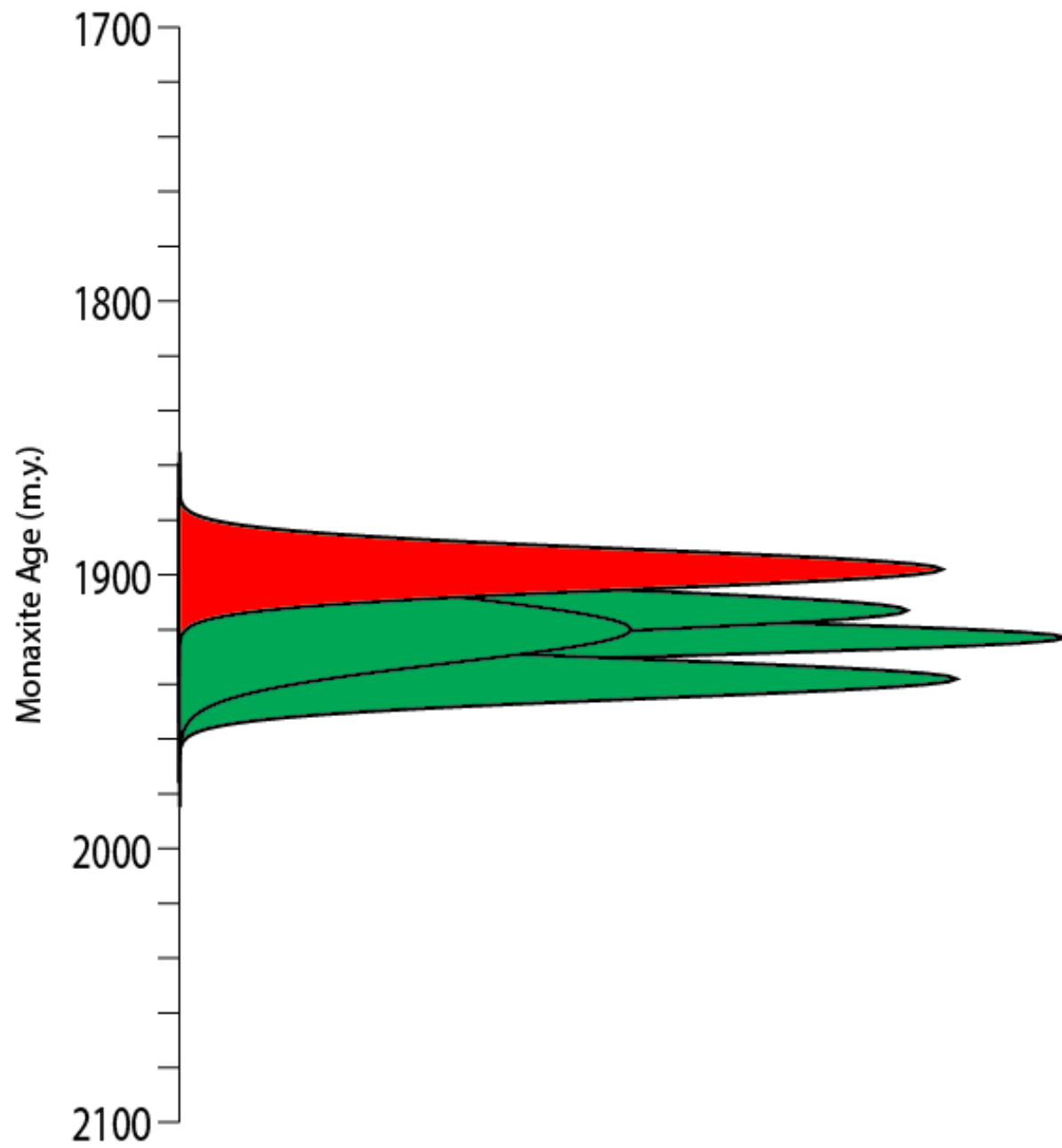




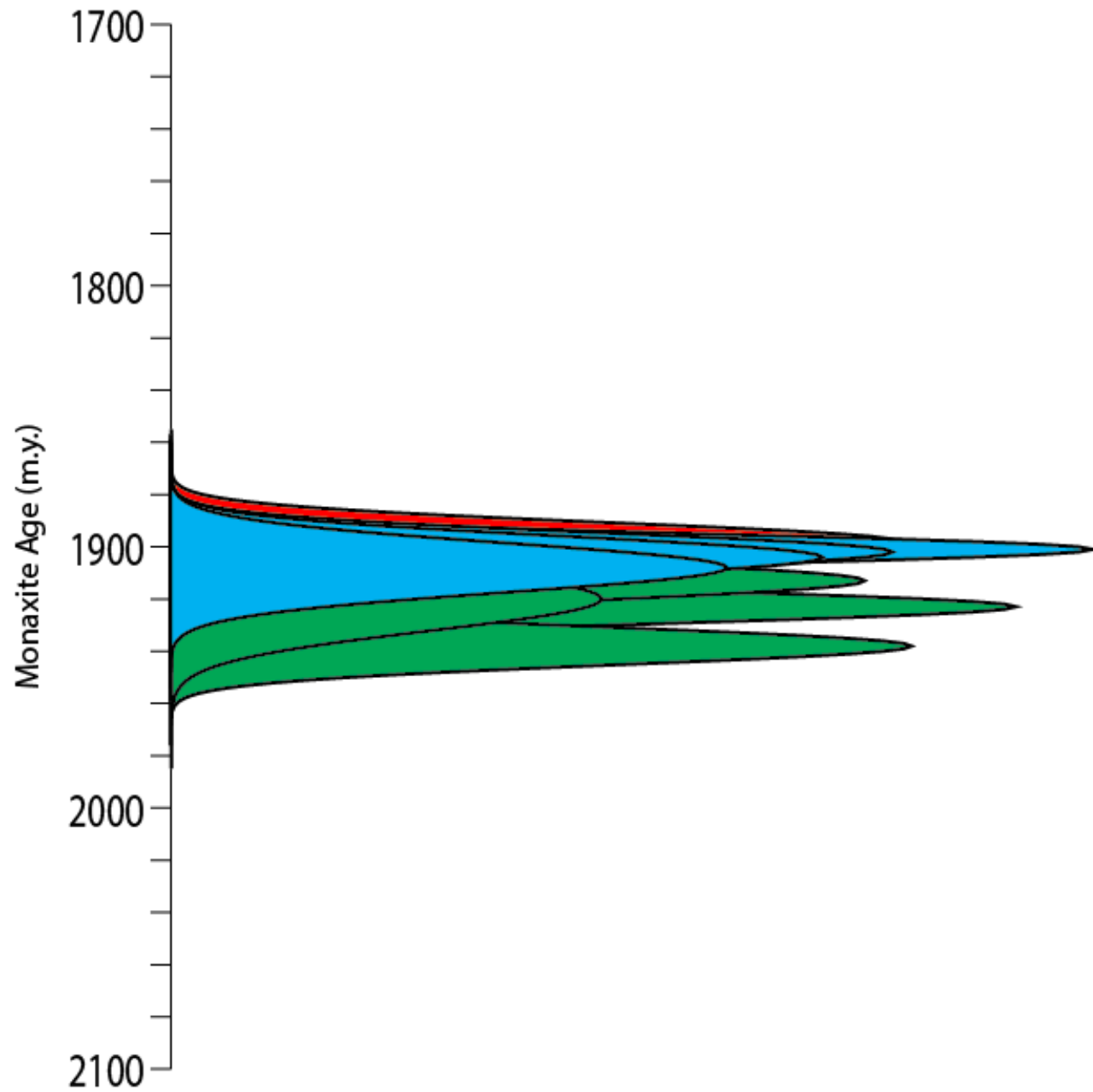
07W-032-All



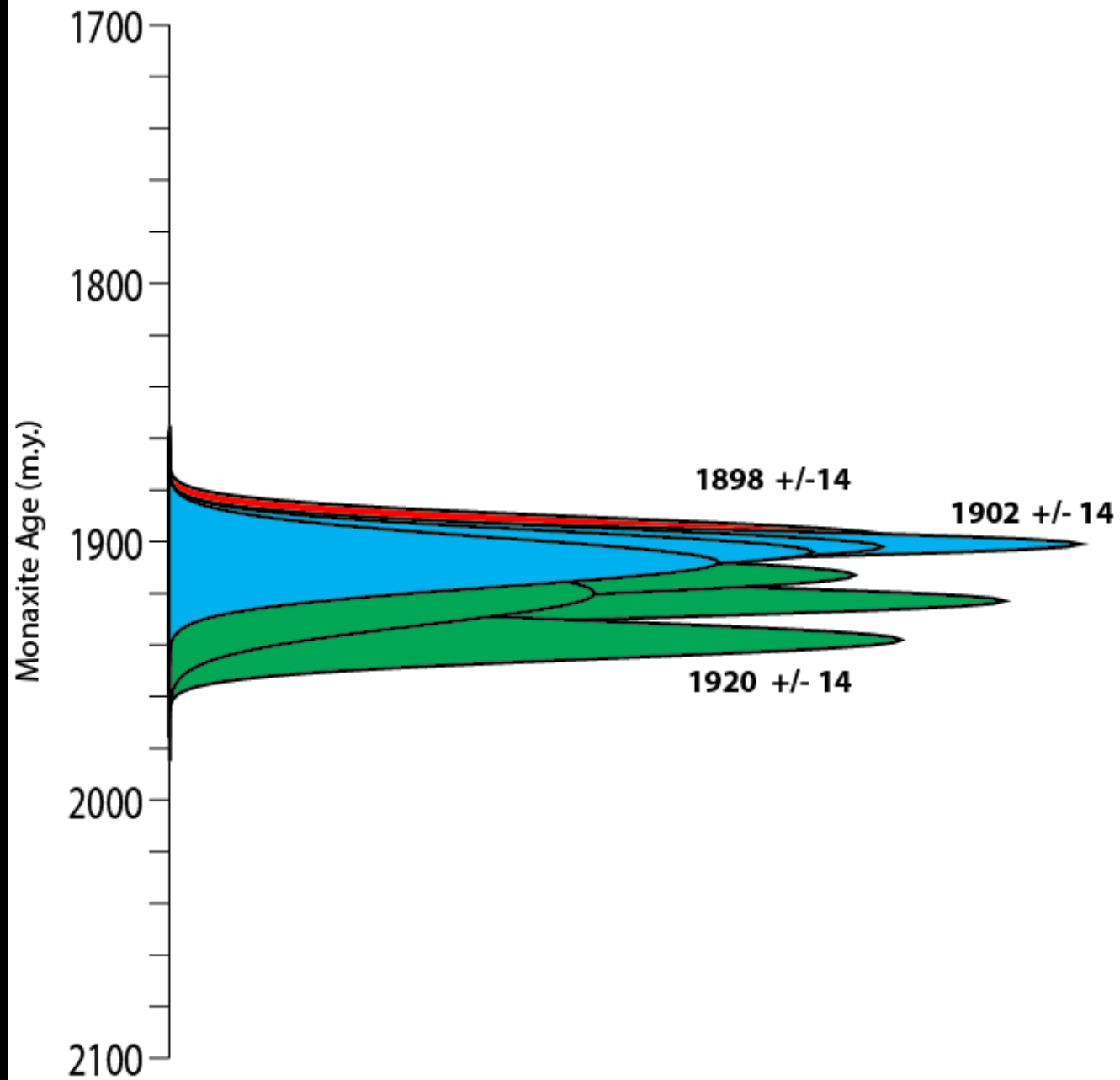
07W-032-All

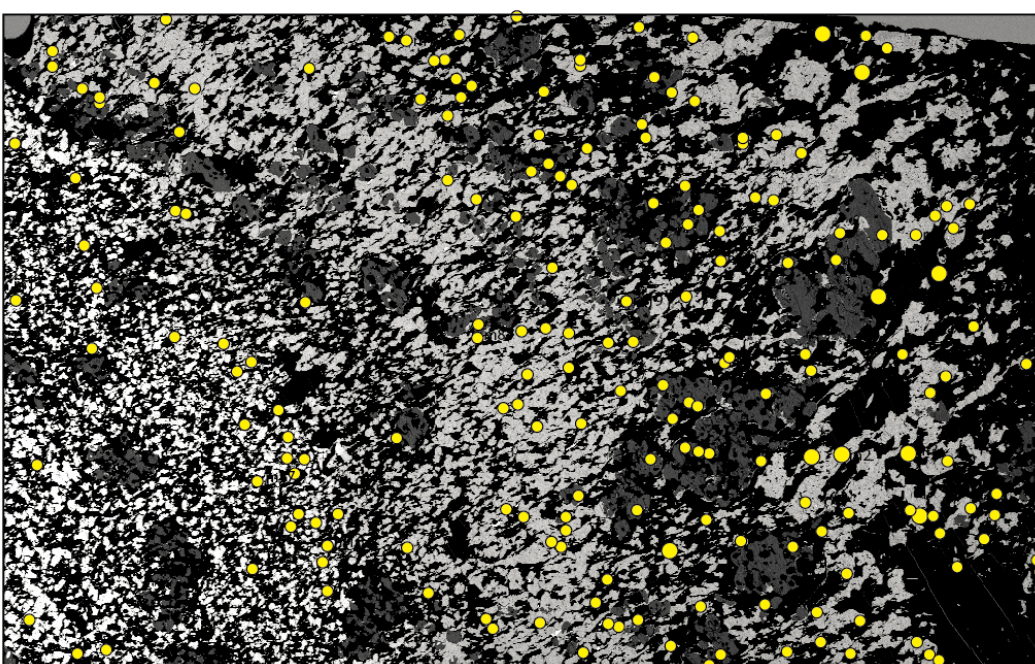


07W-032-All

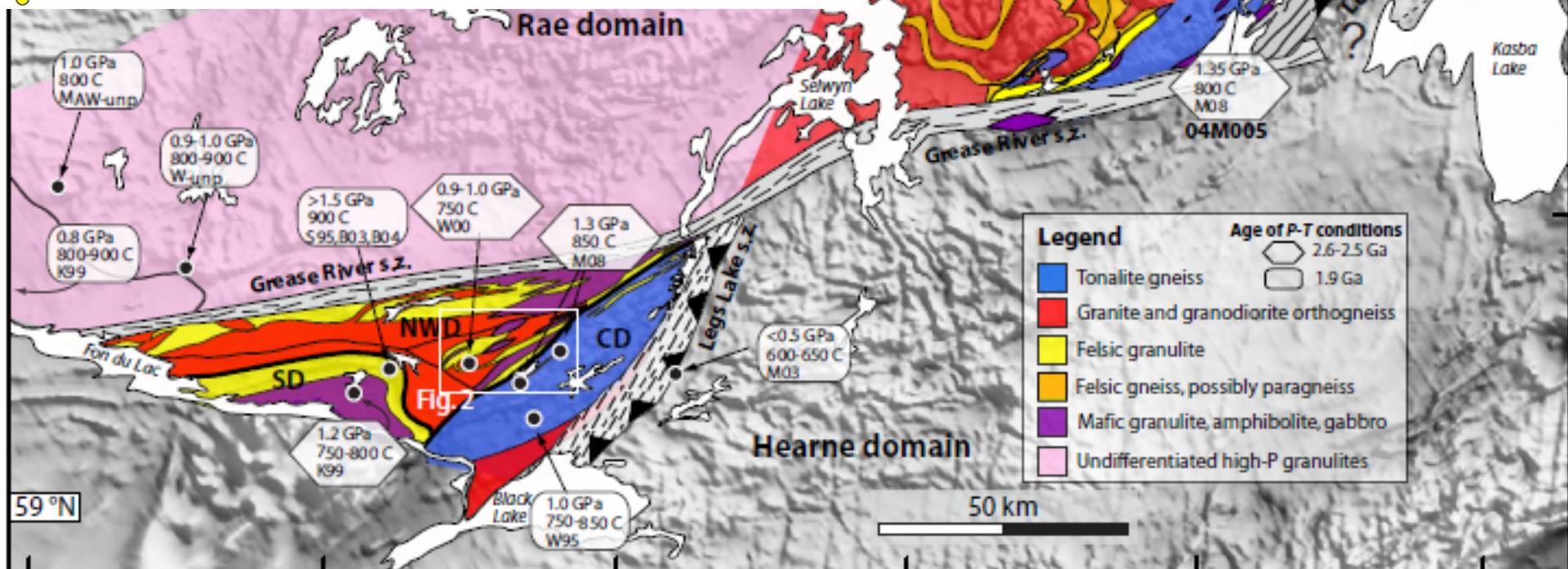


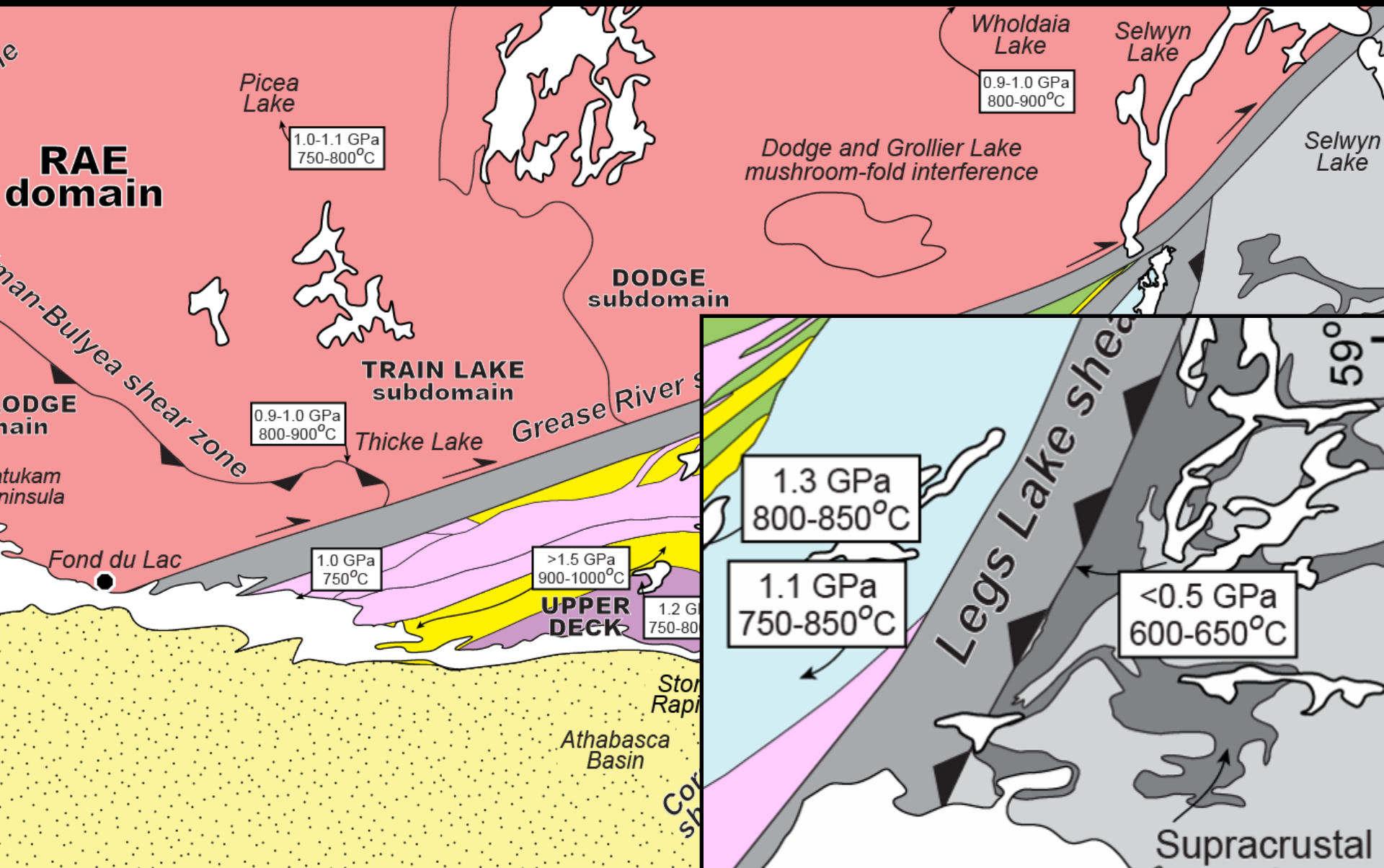
07W-032-All



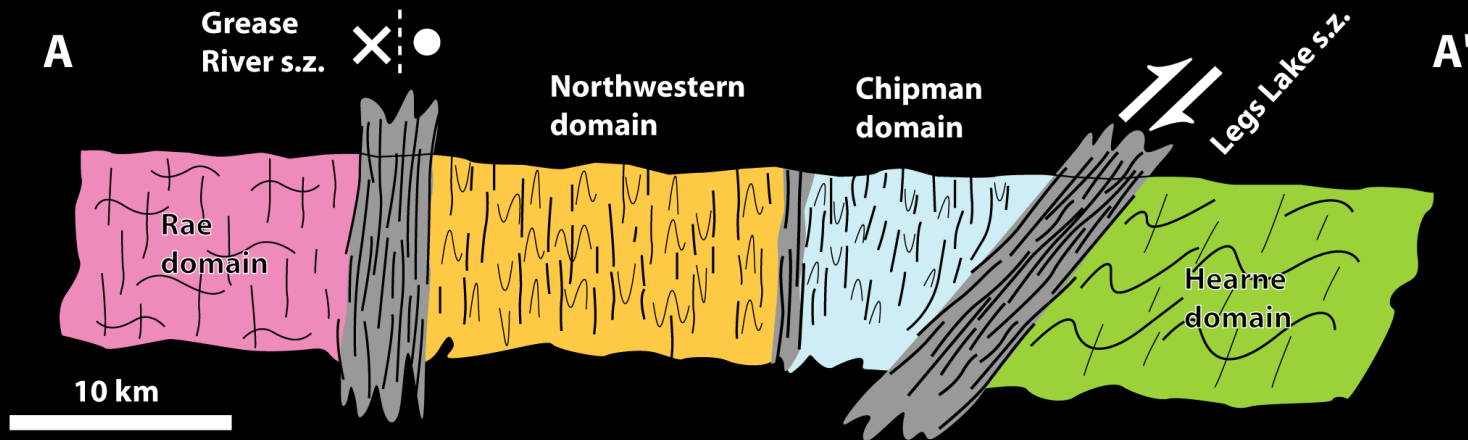
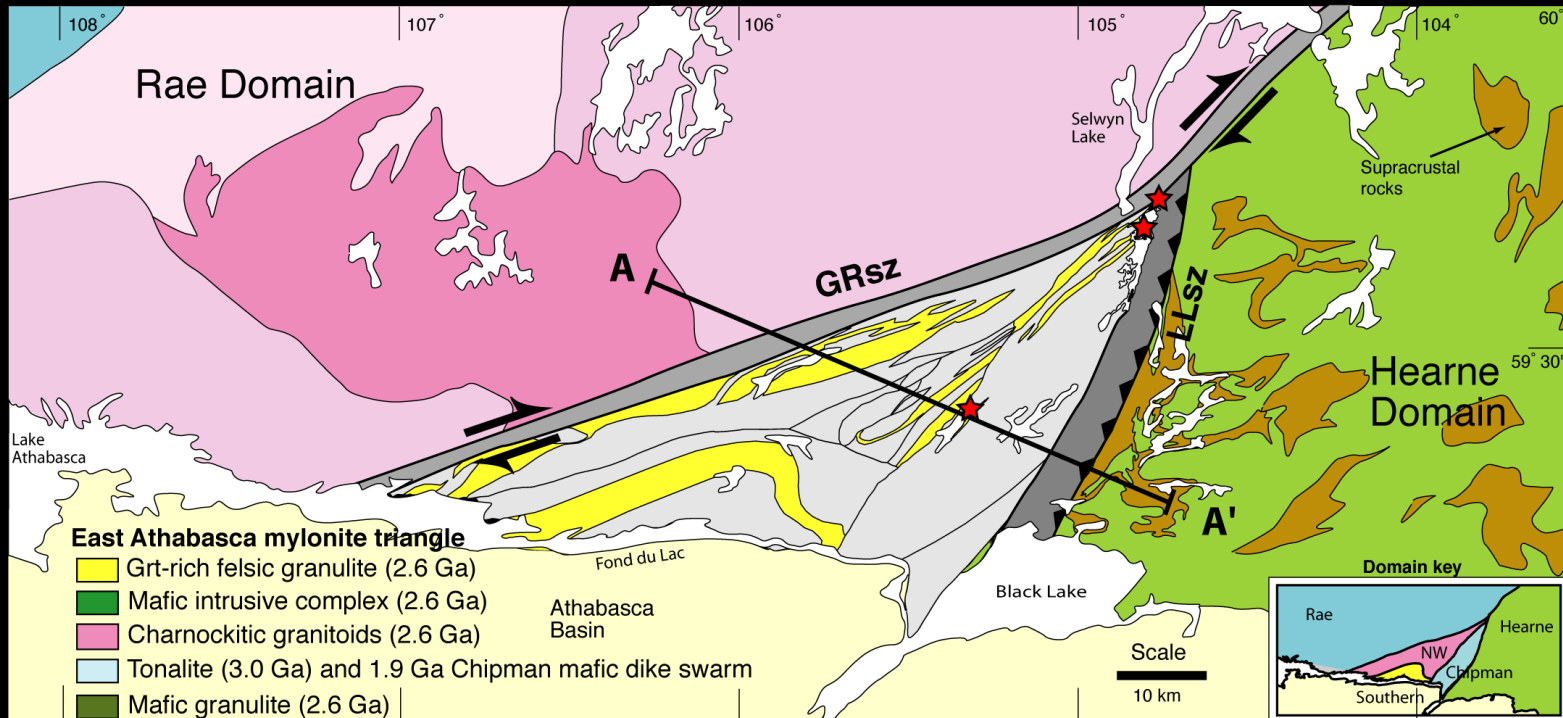


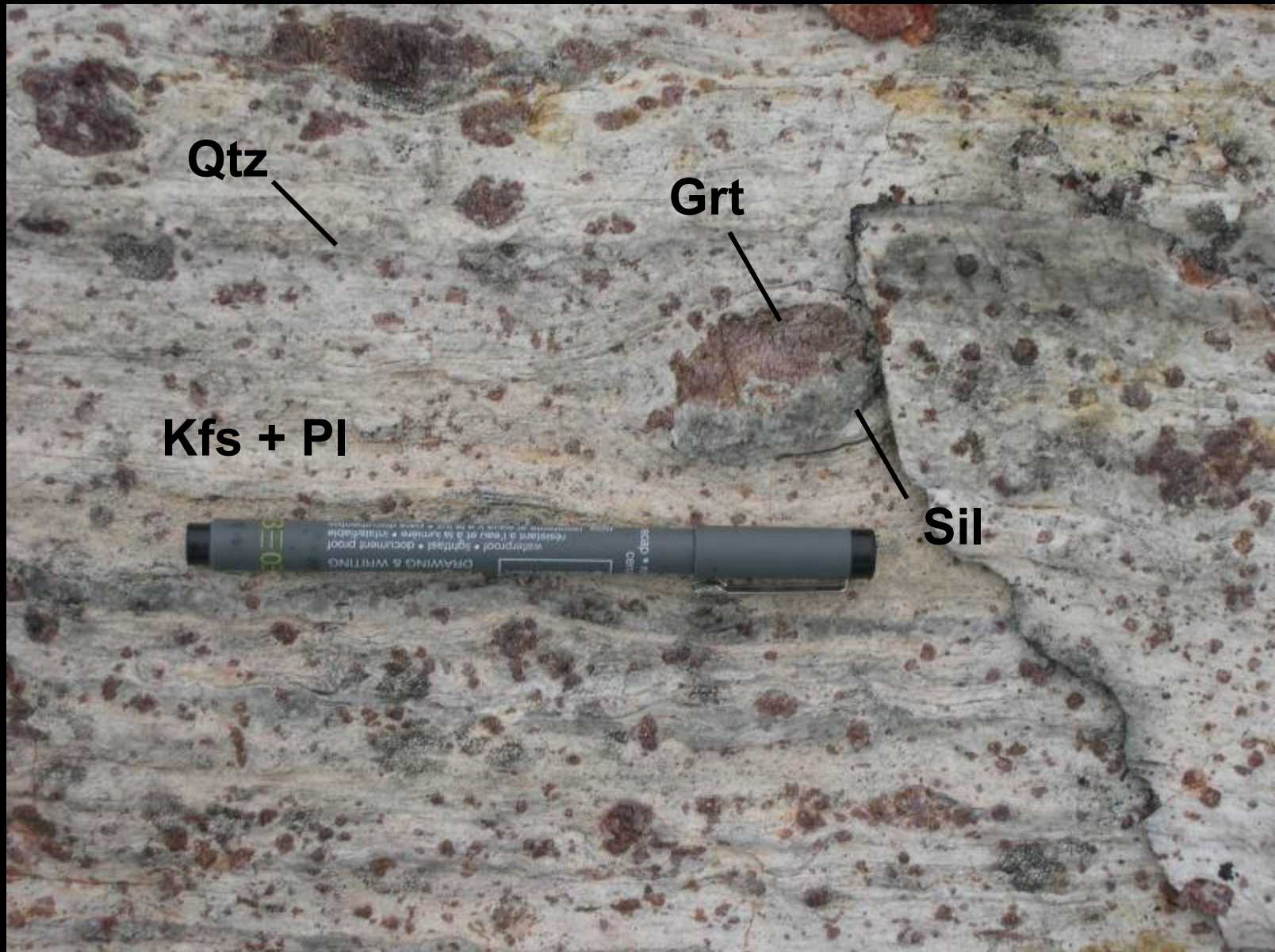
● Ce





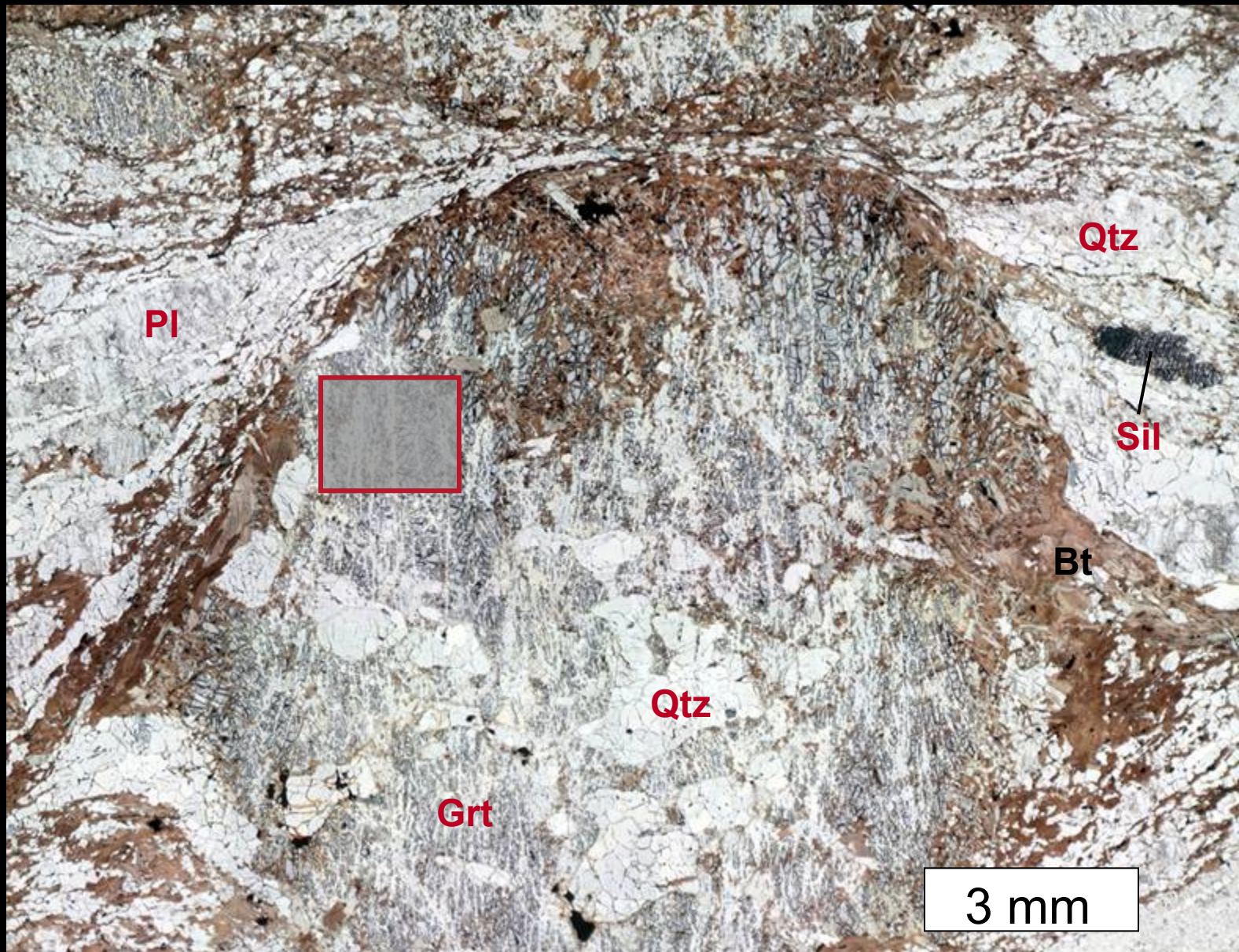
Grt-rich felsic granulites

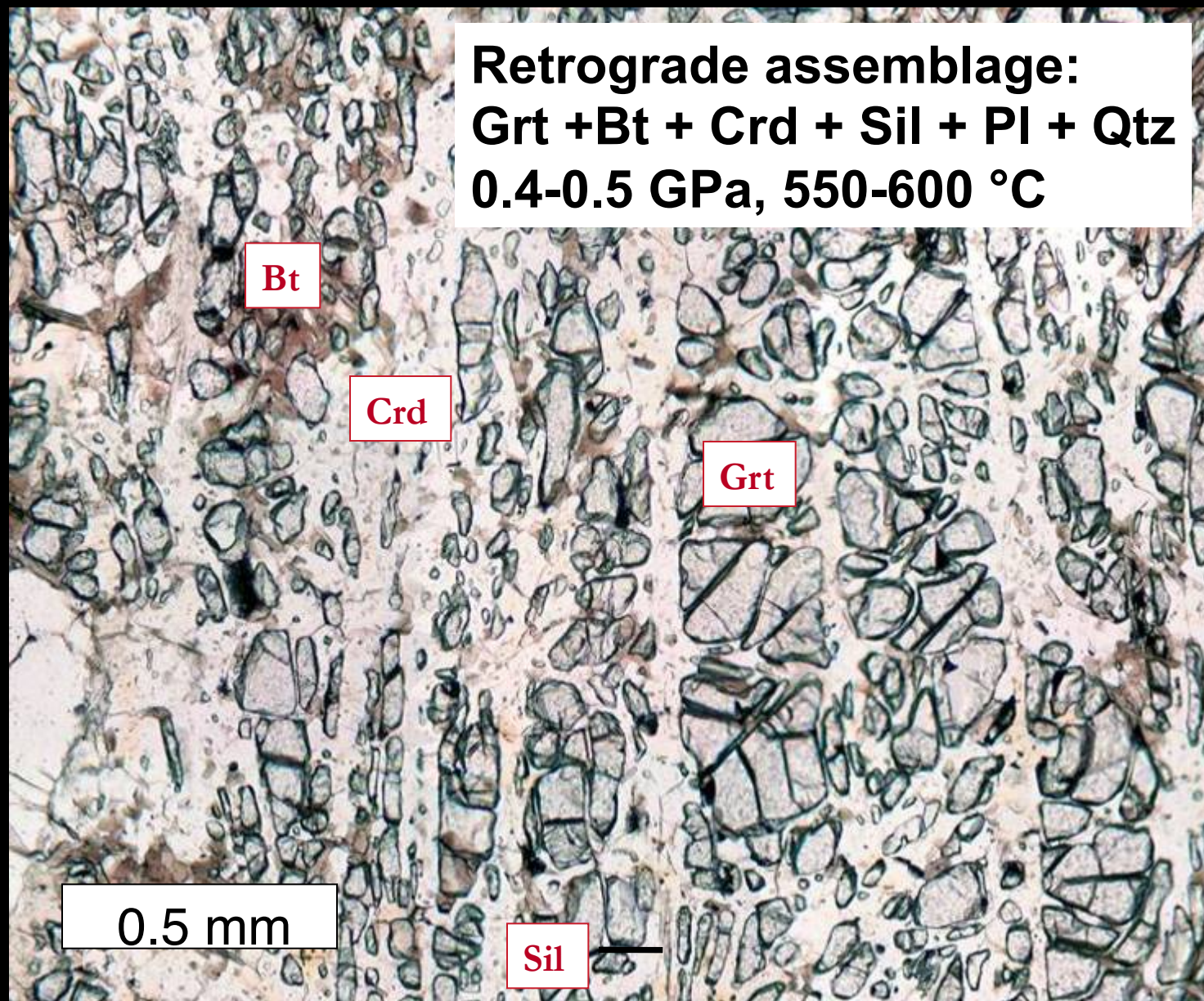




Legs Lake shear zone -

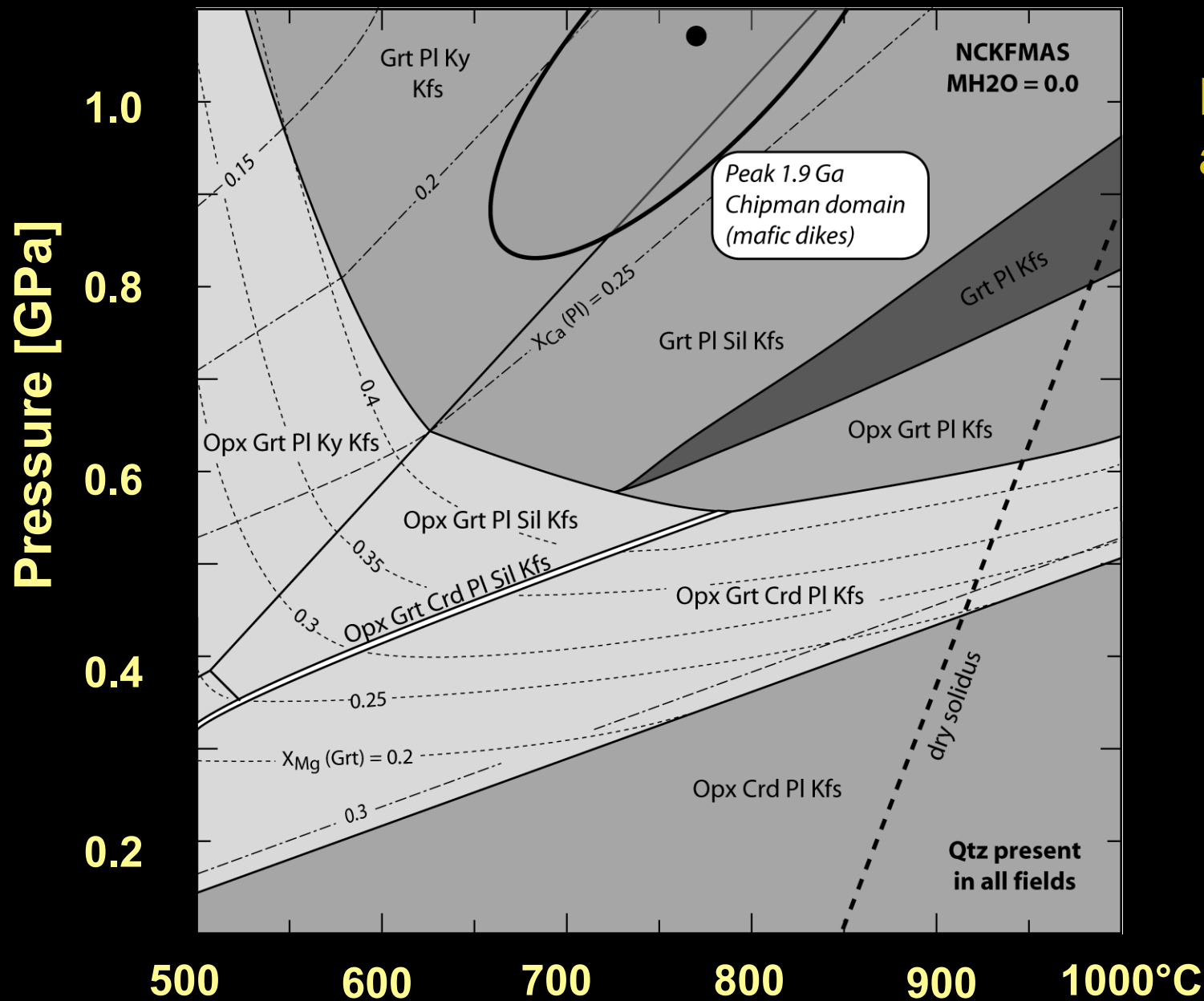
Hydrated felsic granulites





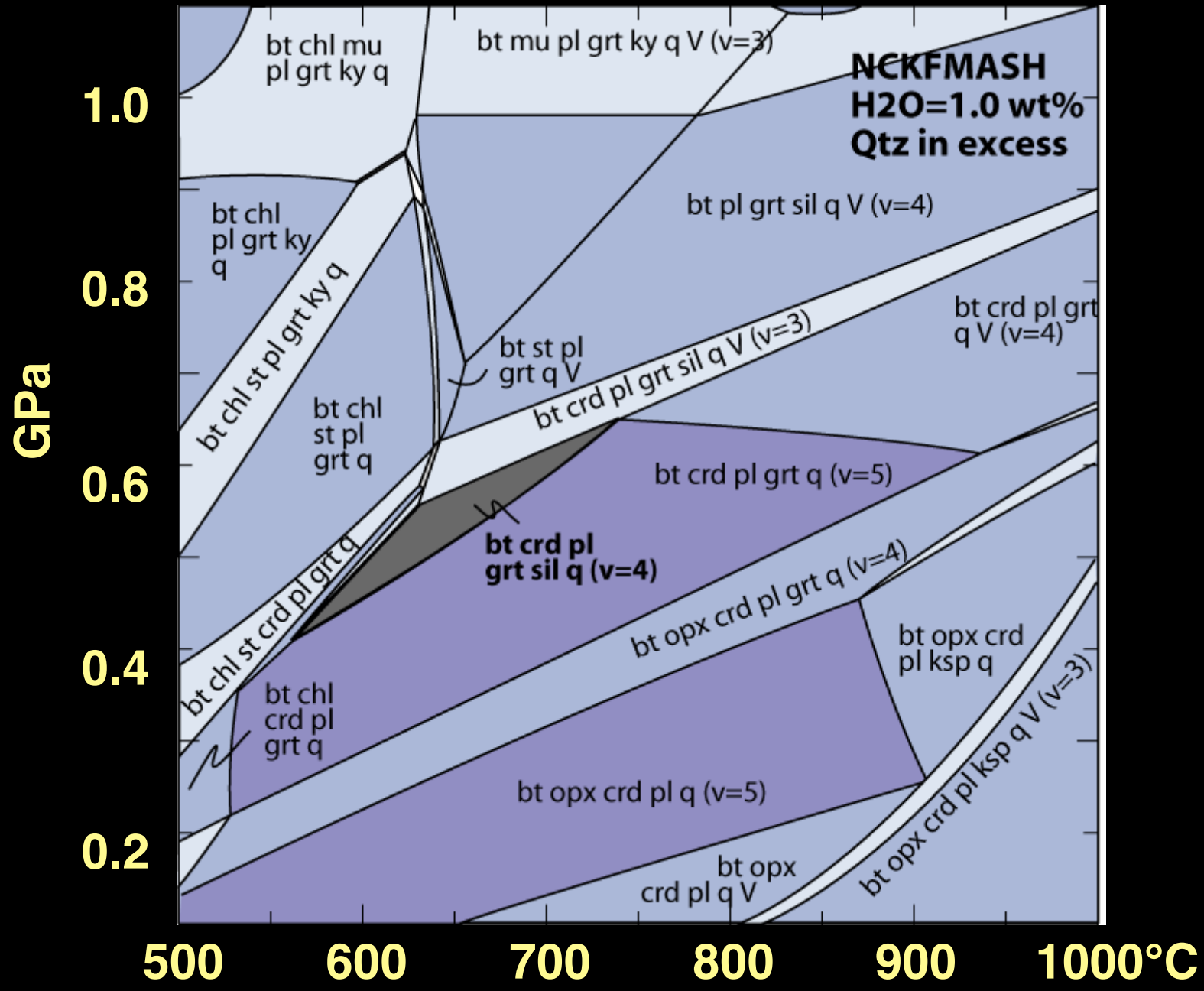
Anhydrous felsic granulites -

P-T pseudosection

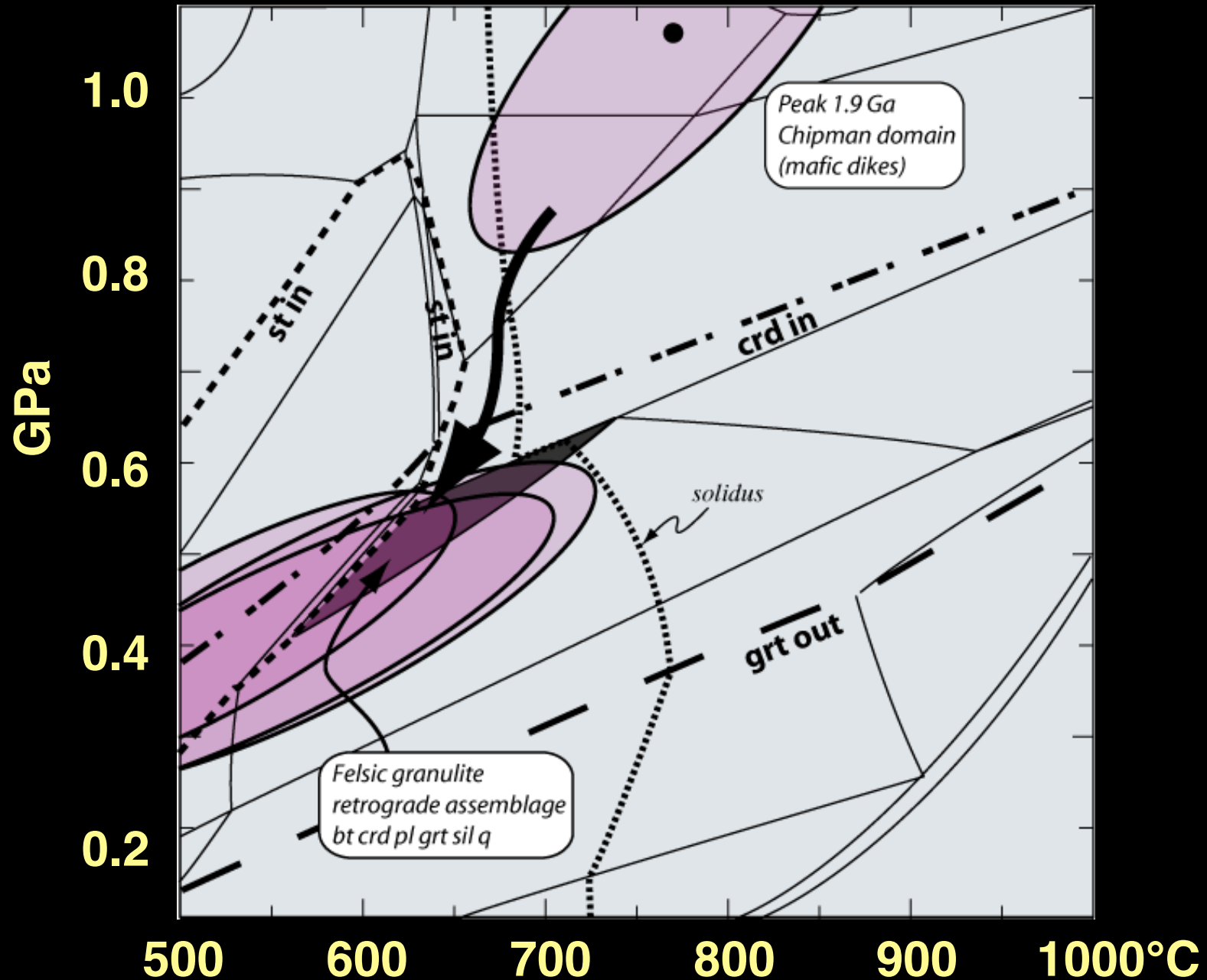


No H₂O added

Pseudosection – hydrous felsic granulite

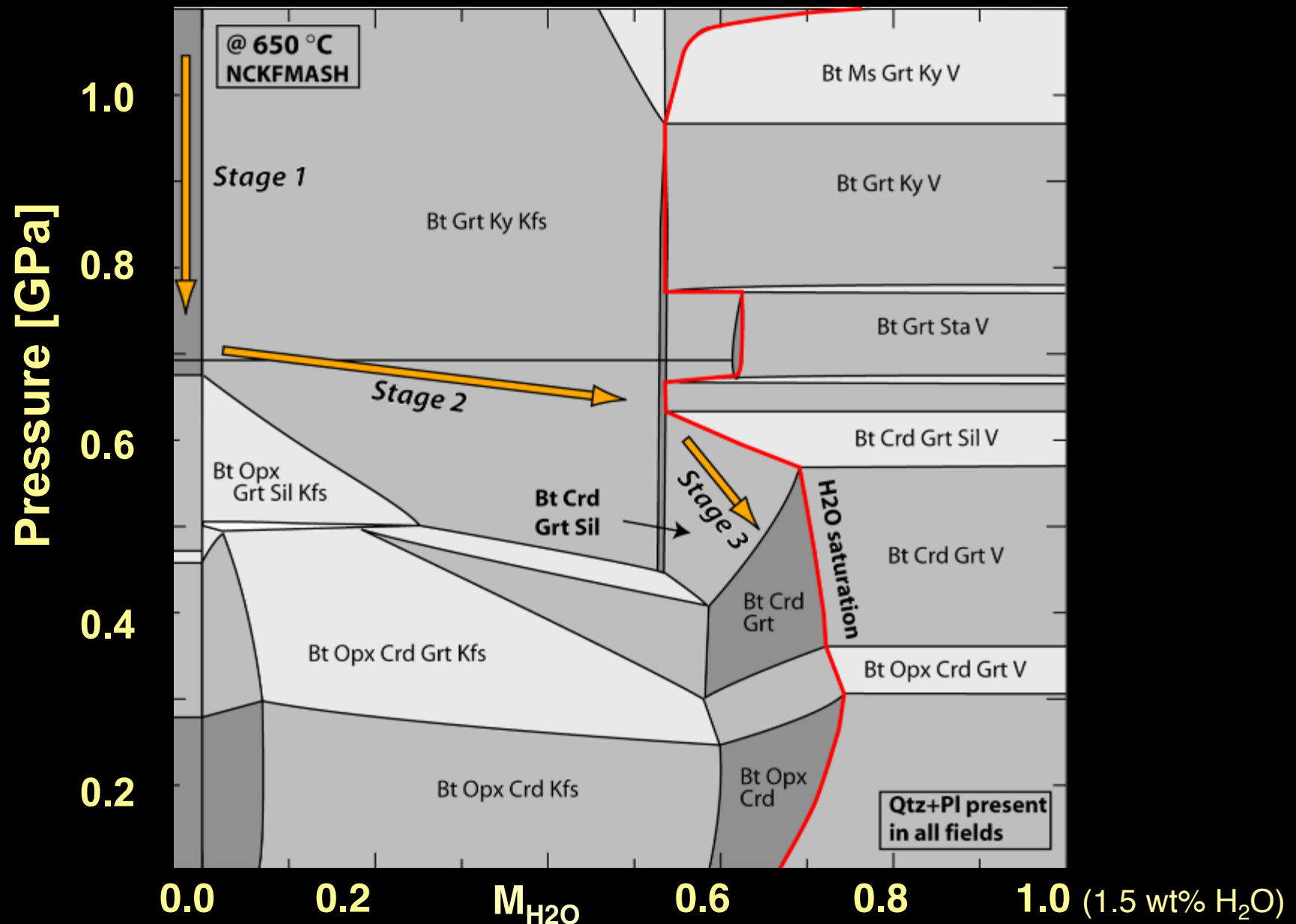


P-T pseudosection for hydrated felsic granulite



Felsic granulites -

P-MH₂O pseudosection



Mn K α - background

● Monazite

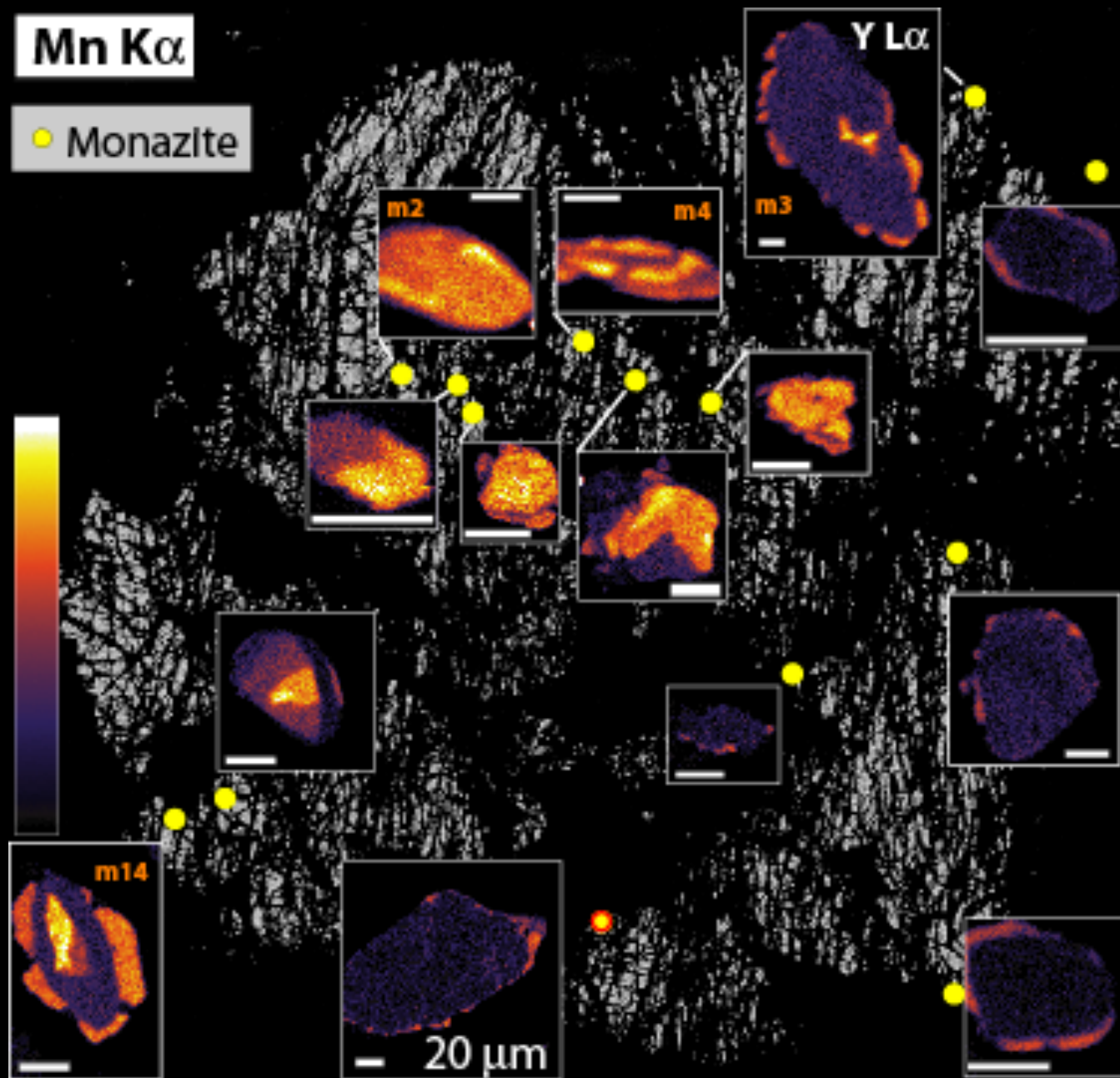
4 mm



S32D-2 Garnet

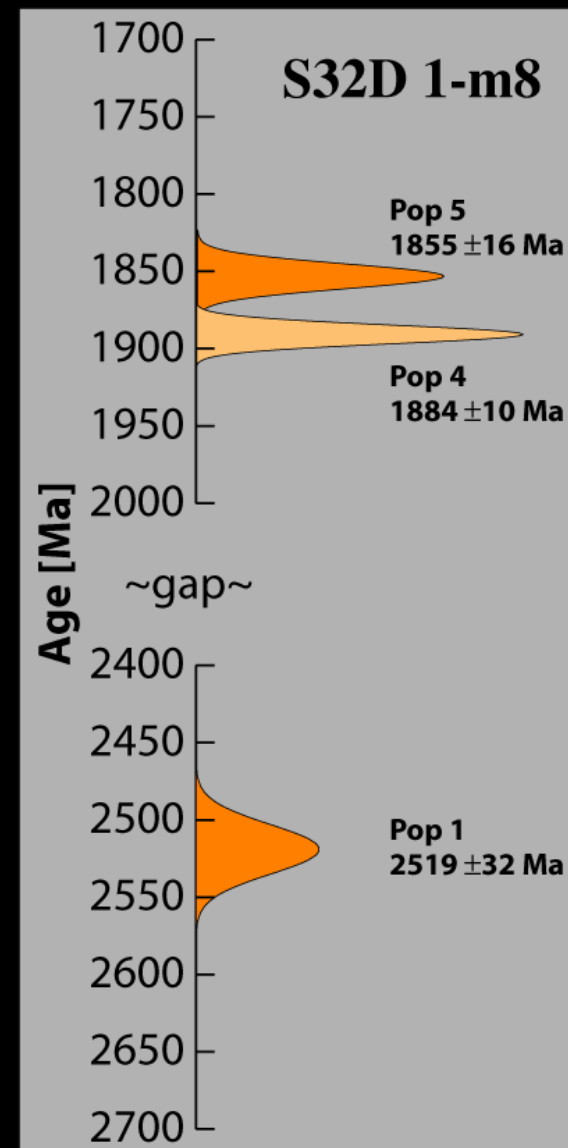
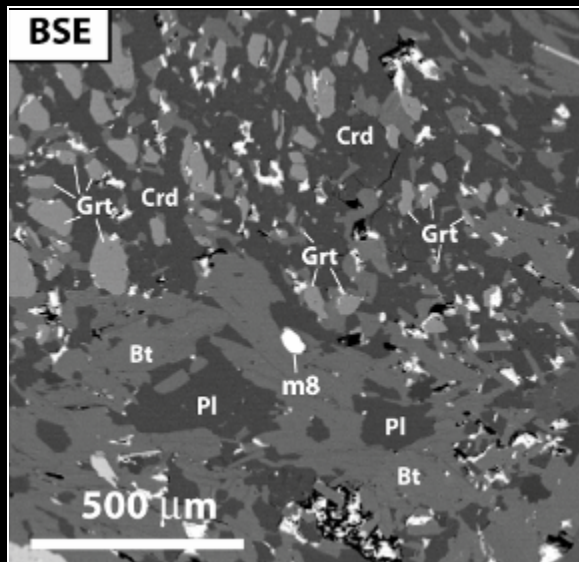
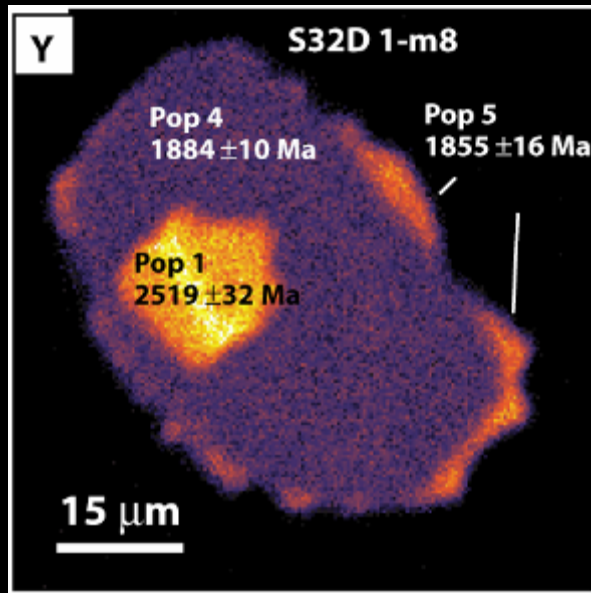
Mn K α

● Monazite



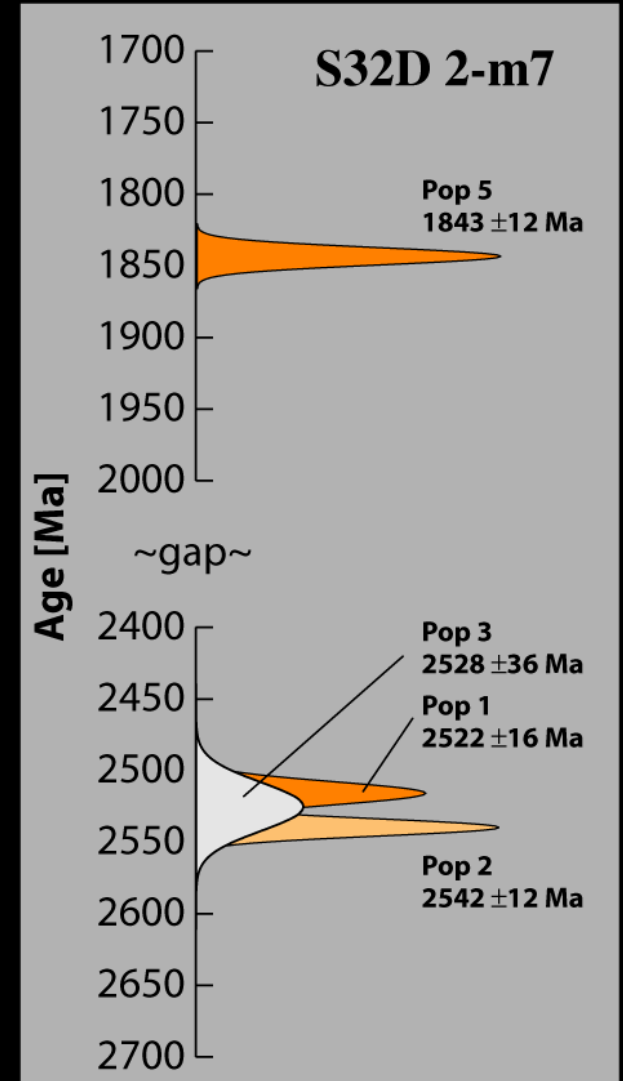
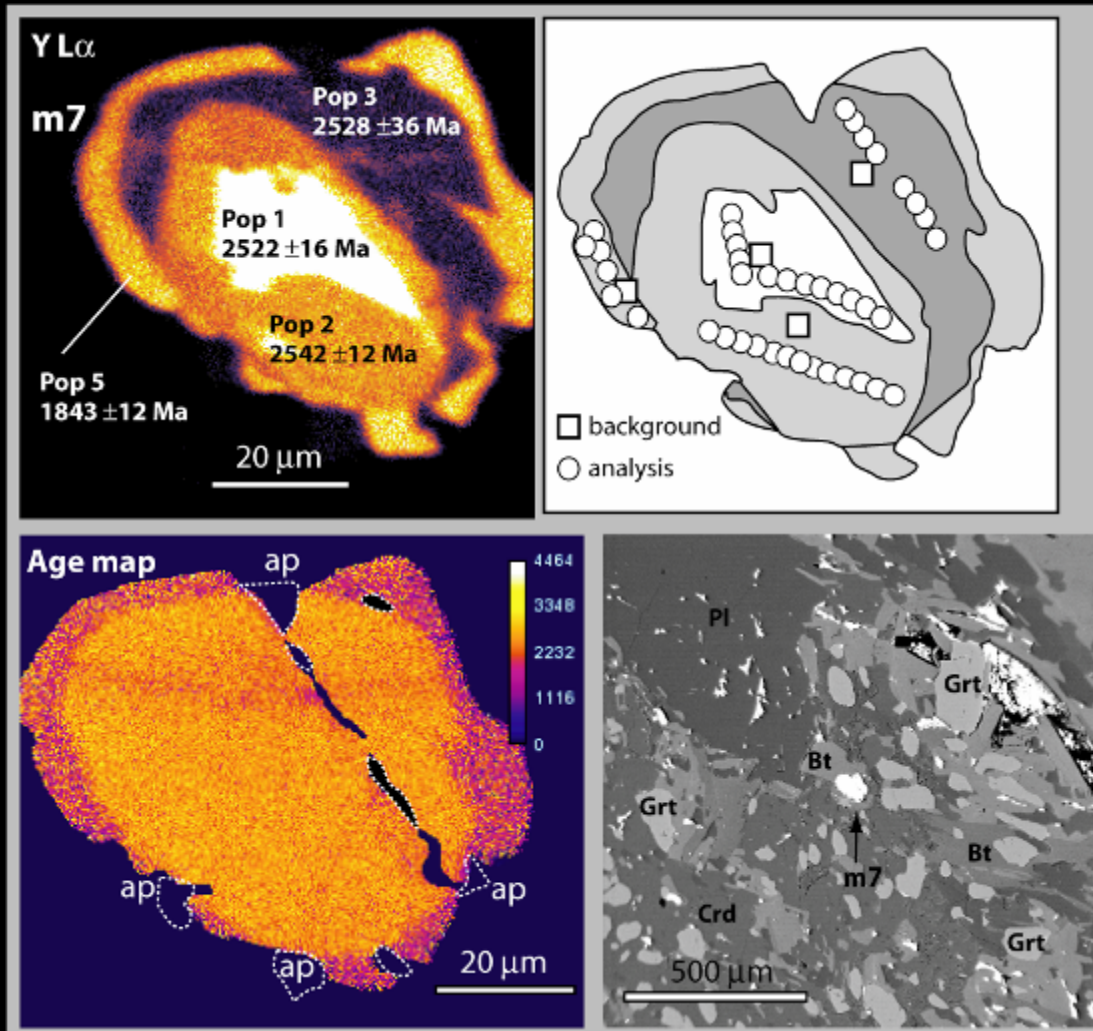
Felsic granulites -

Monazite dating results



Felsic granulites -

Monazite dating results



Felsic granulite evolution

Major metamorphic and deformation events

Granulite-facies metamorphic event

Granulite-facies metamorphic event

LLSz deformation (amphibolite-facies)

GRsz deformation (lower amphibolite- to greenschist-facies)

Time scale

2.6-2.5 Ga

1.9 Ga

1.85 Ga

1.80 Ga

Stage description

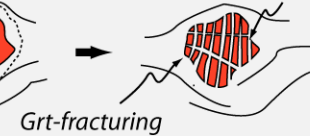
Grt-growth, anhydrous peak assemblage

Stage 1 - initial decompression (anhydrous)

Stage 2 - initial H₂O infiltration

Stage 3 - continued decompression (hydrated)

Garnet evolution

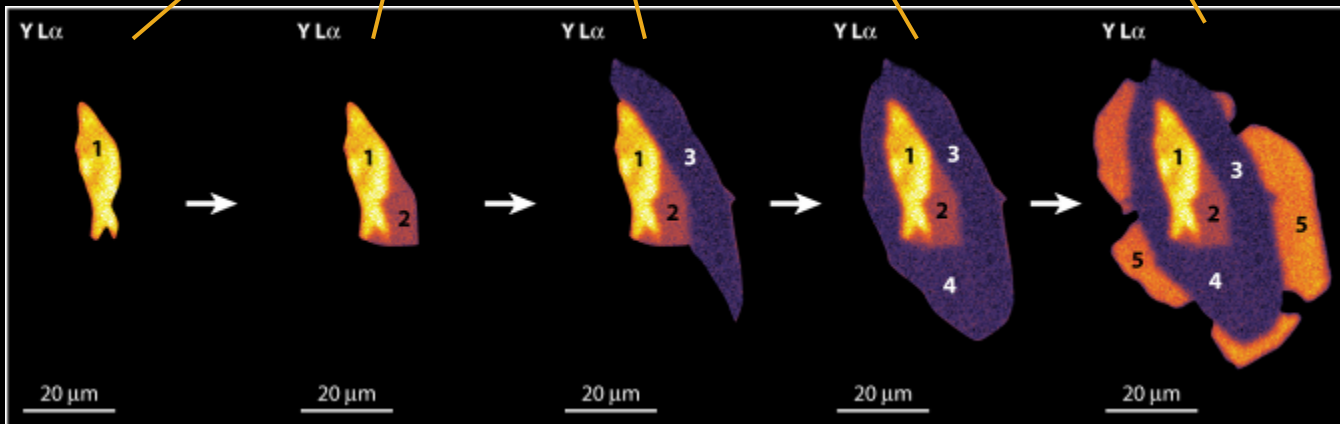


Dominant Retrograde Rxn's

$\text{Grt} + \text{Kfs} + \text{H}_2\text{O} \rightarrow \text{Bt} + \text{Sil}$

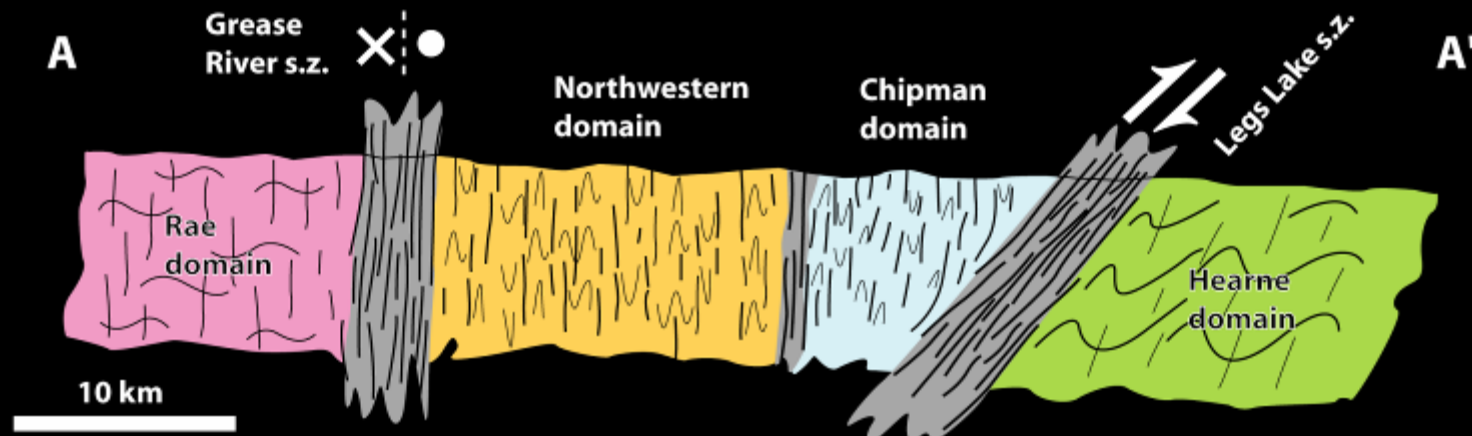
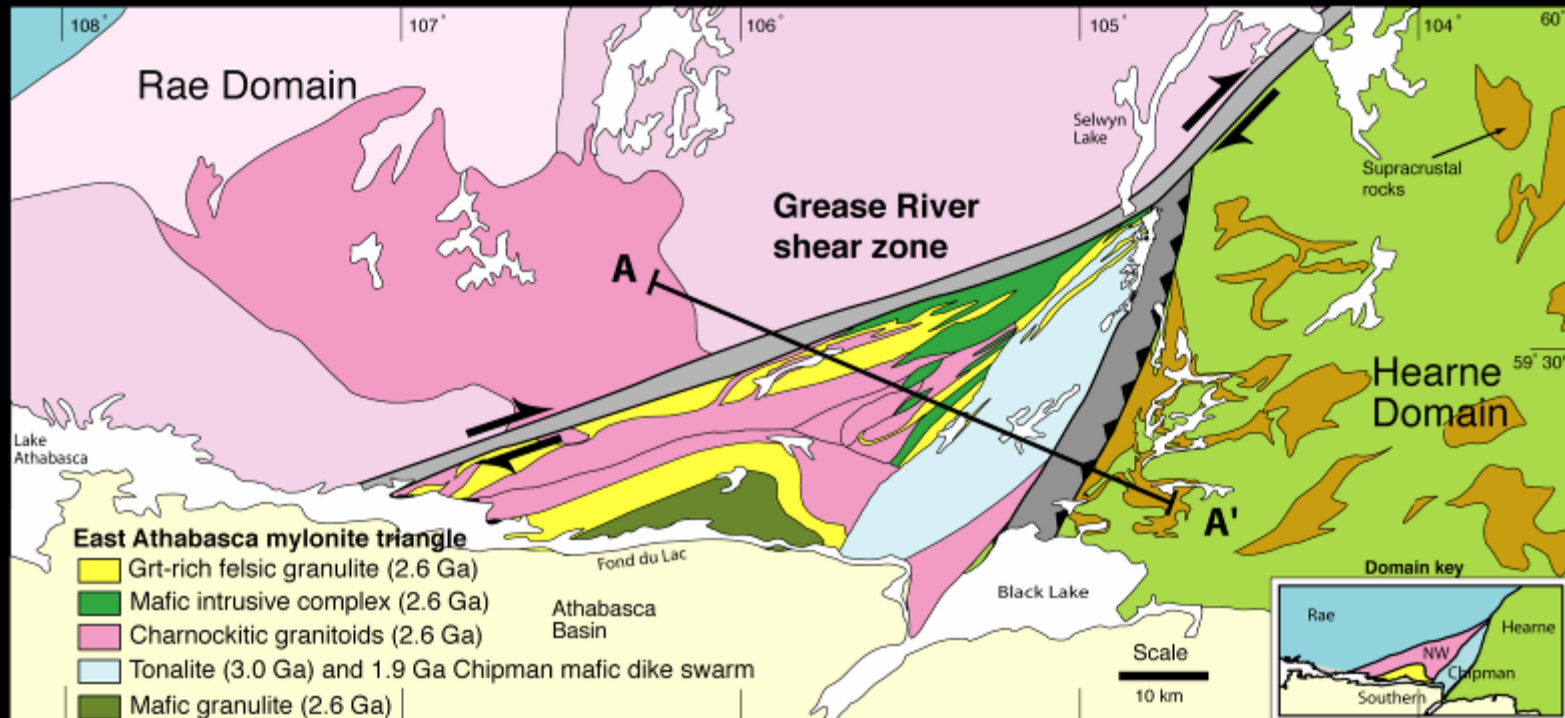
$\text{Grt} + \text{Sil} + \text{H}_2\text{O} \rightarrow \text{Crd}$

Monazite growth events



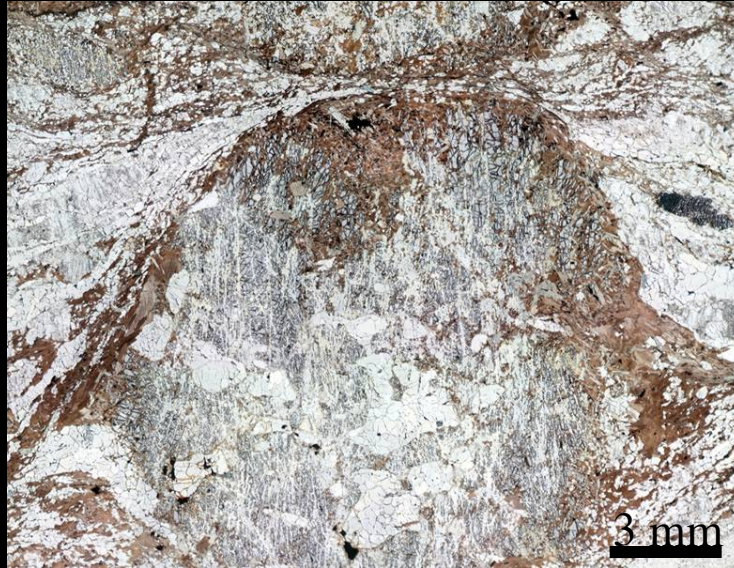
East Lake Athabasca region -

Grease River shear zone

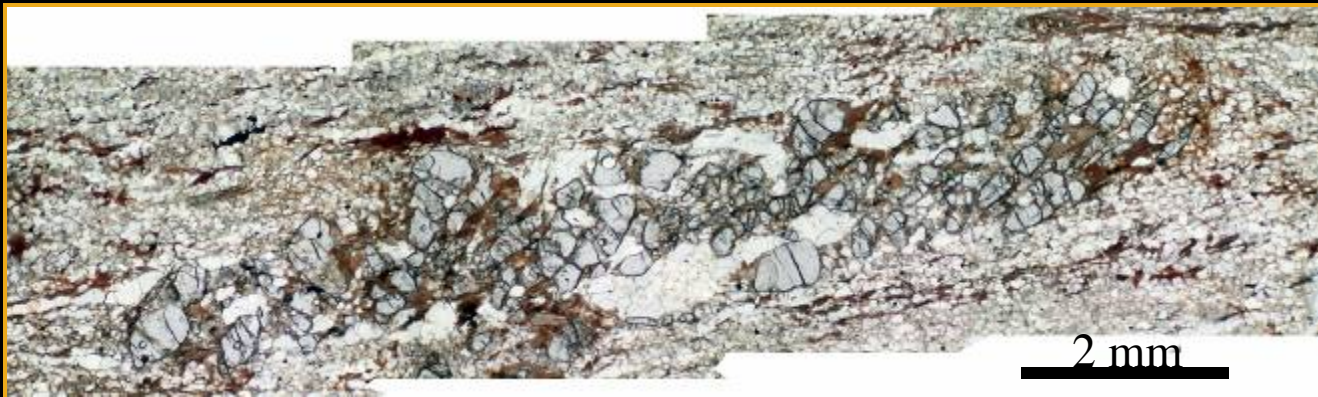


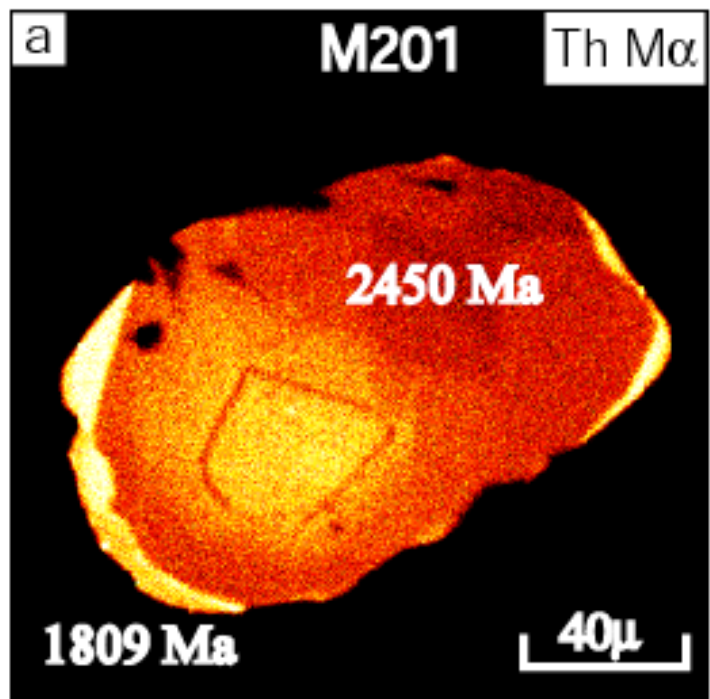
Felsic granulites

Legs Lake shear zone

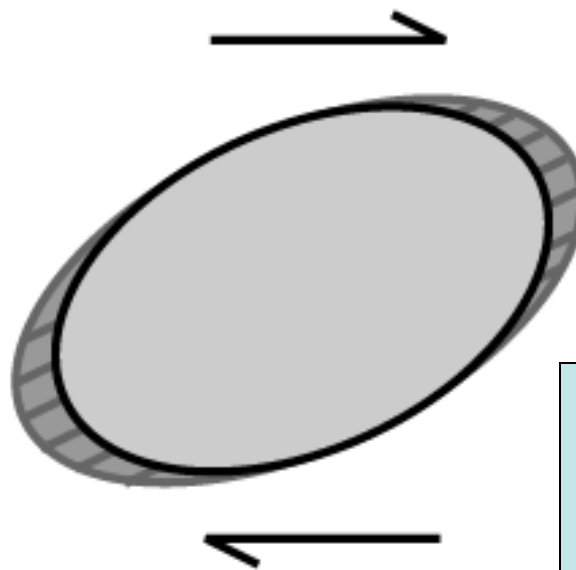


Grease River shear zone



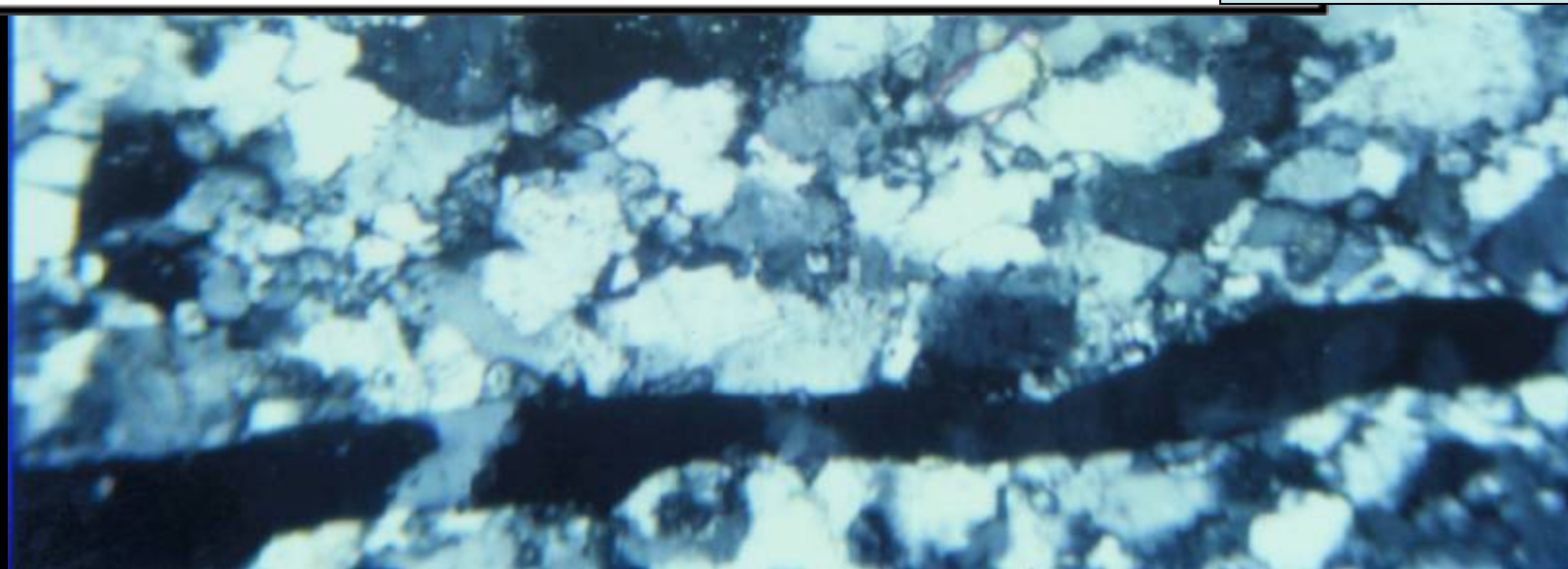


b



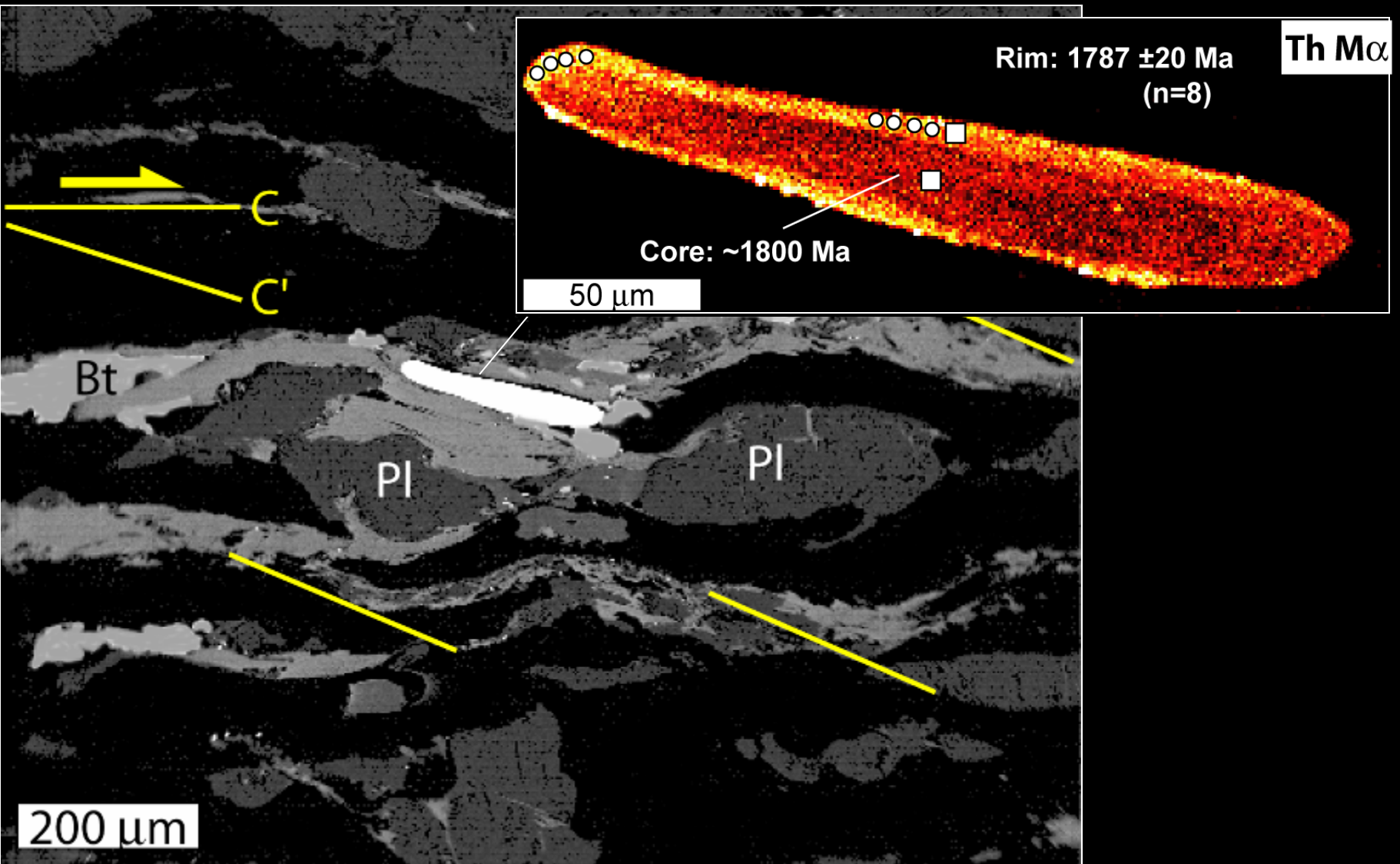
C

S



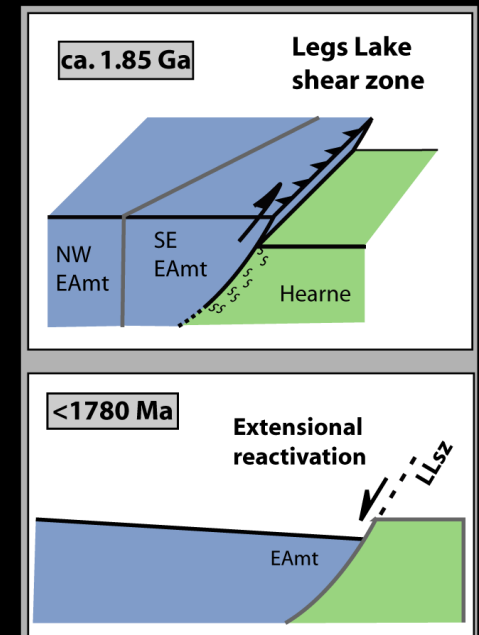
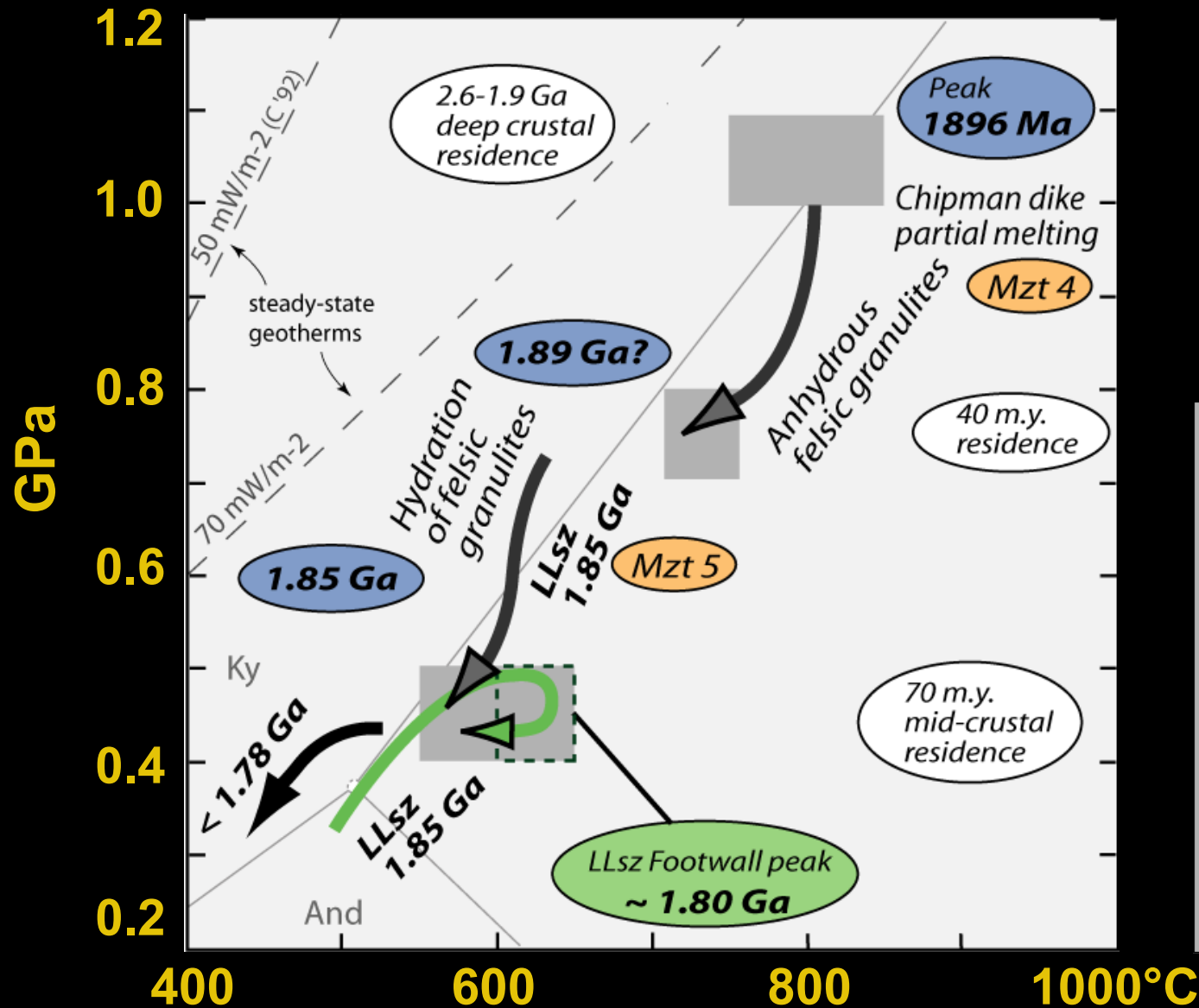
Grease River shear zone -

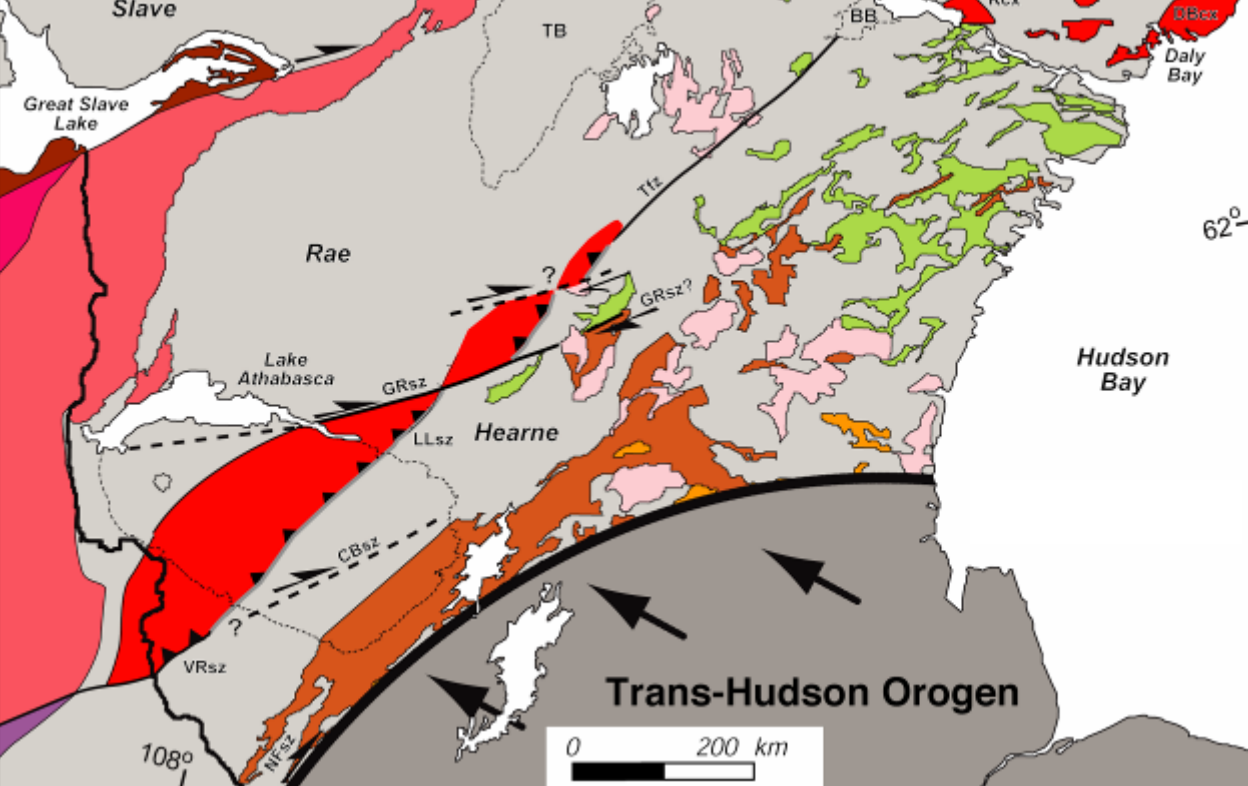
Syn-kinematic monazite



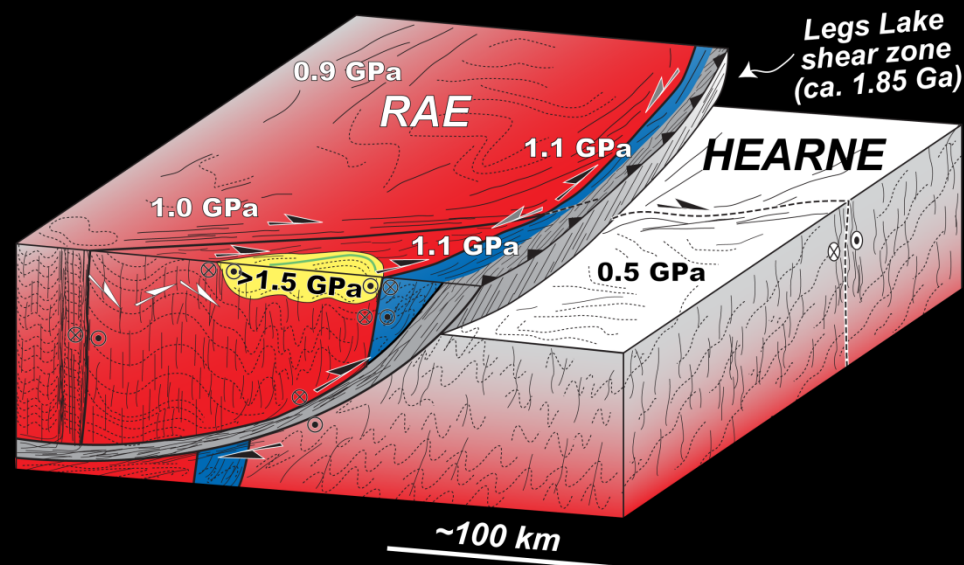
Chipman domain/Legs Lake s.z. -

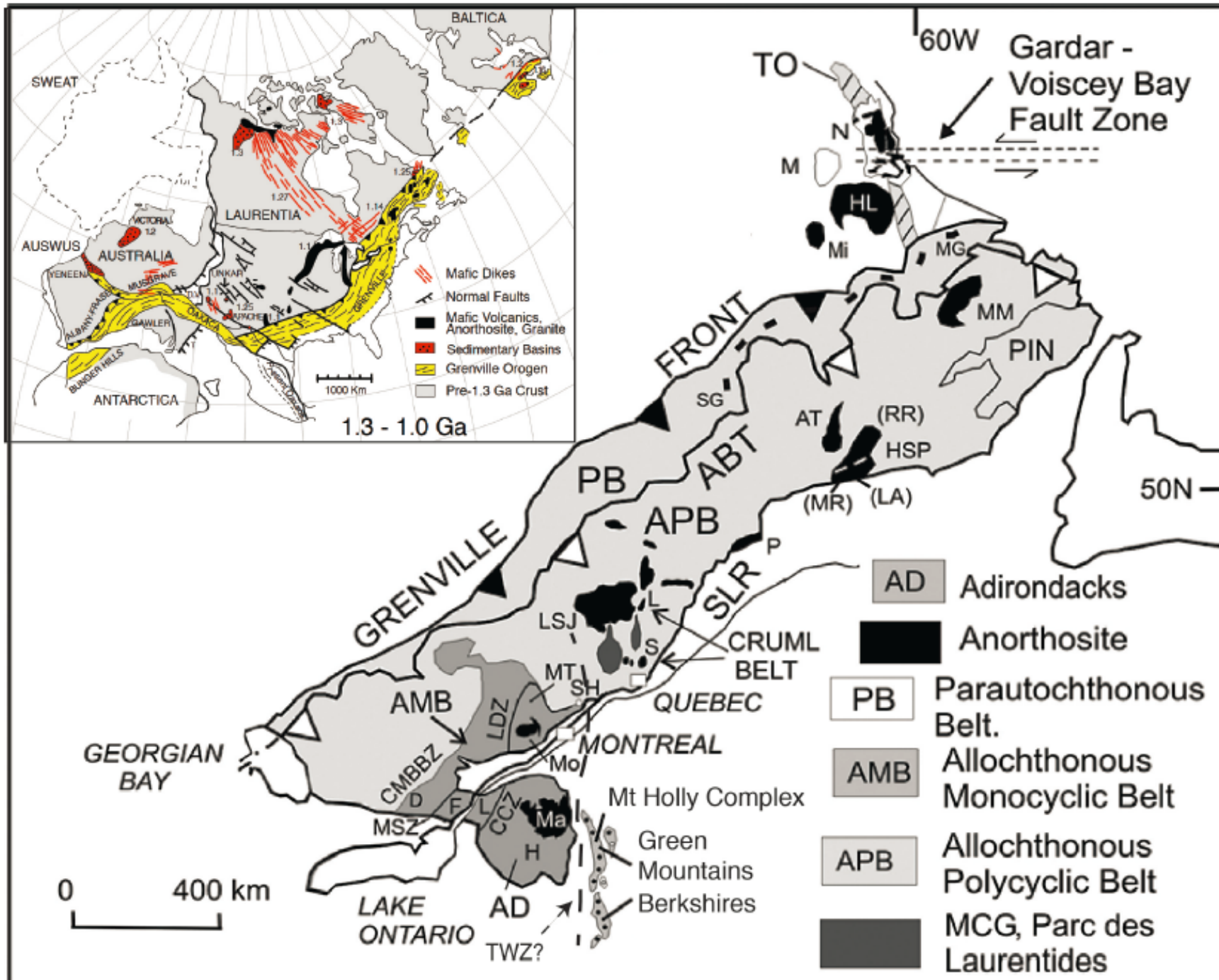
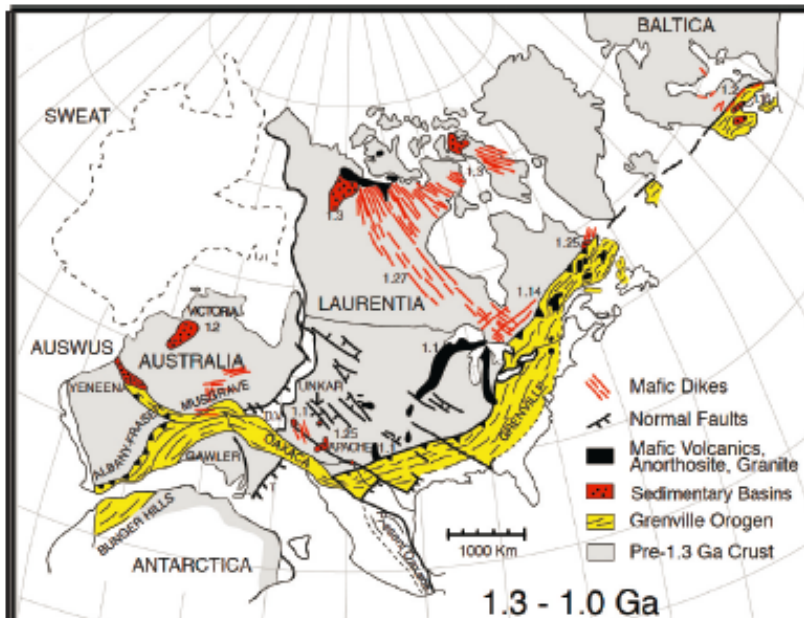
P-T-t-D paths

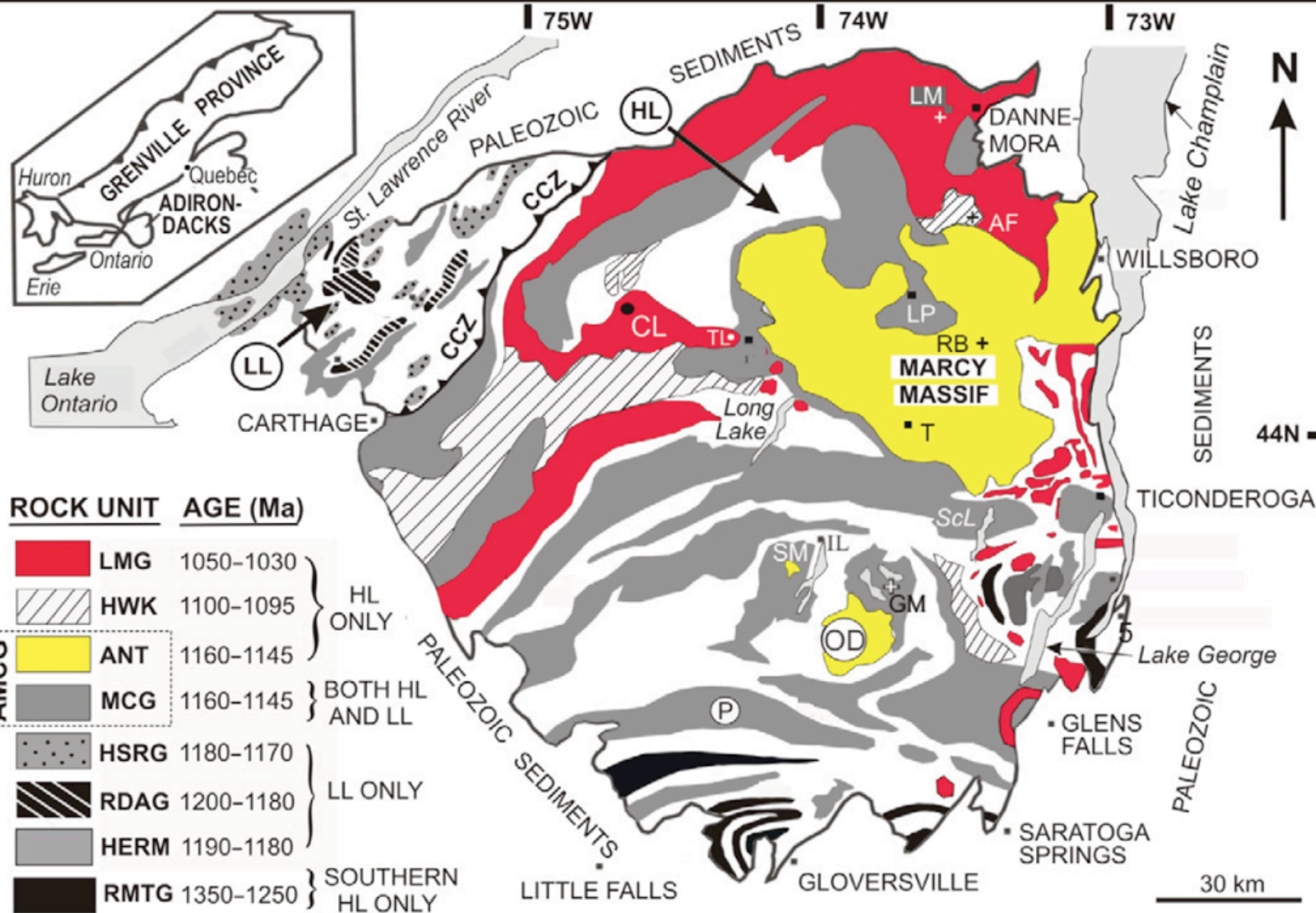




1850-1800 Ma





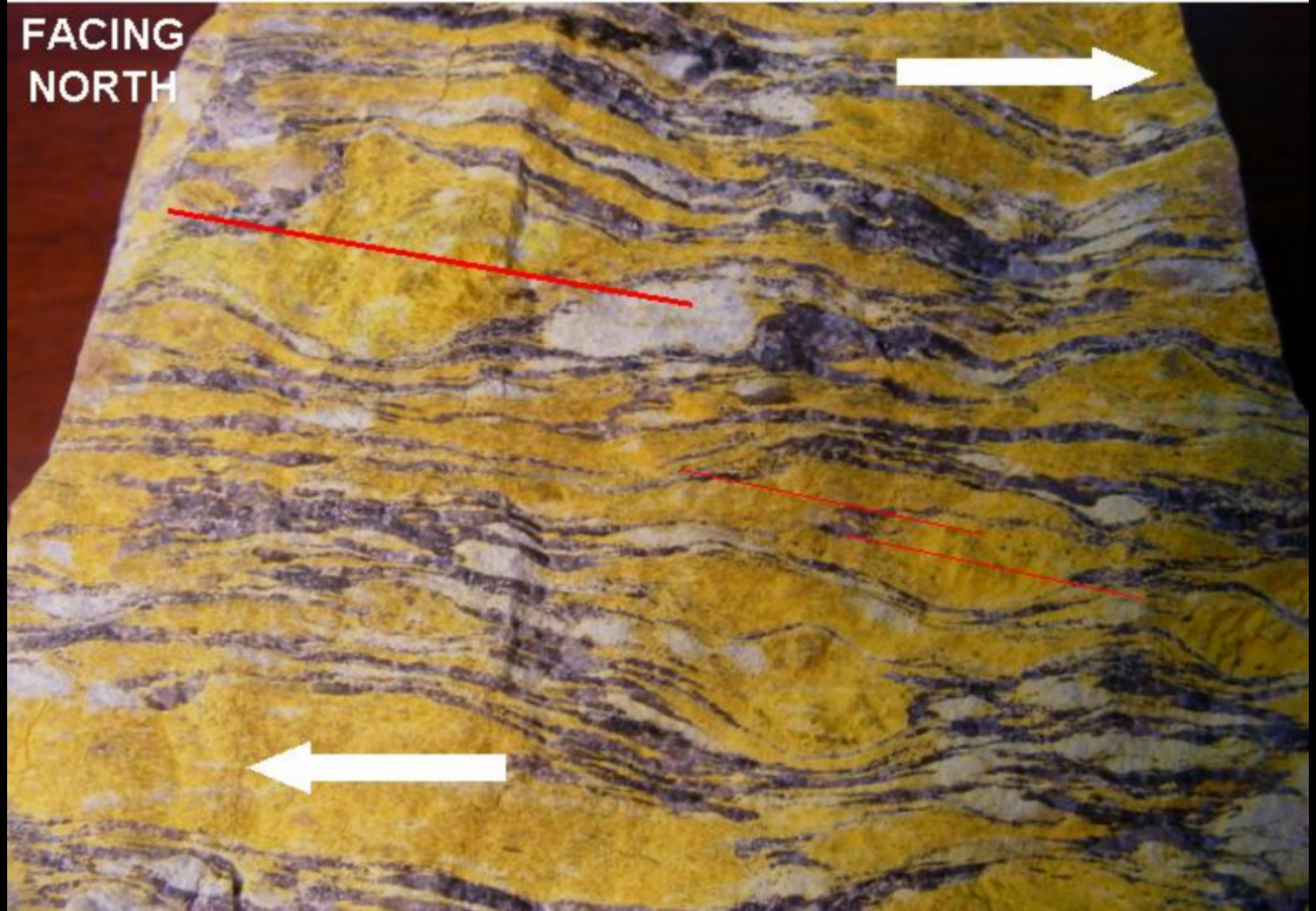


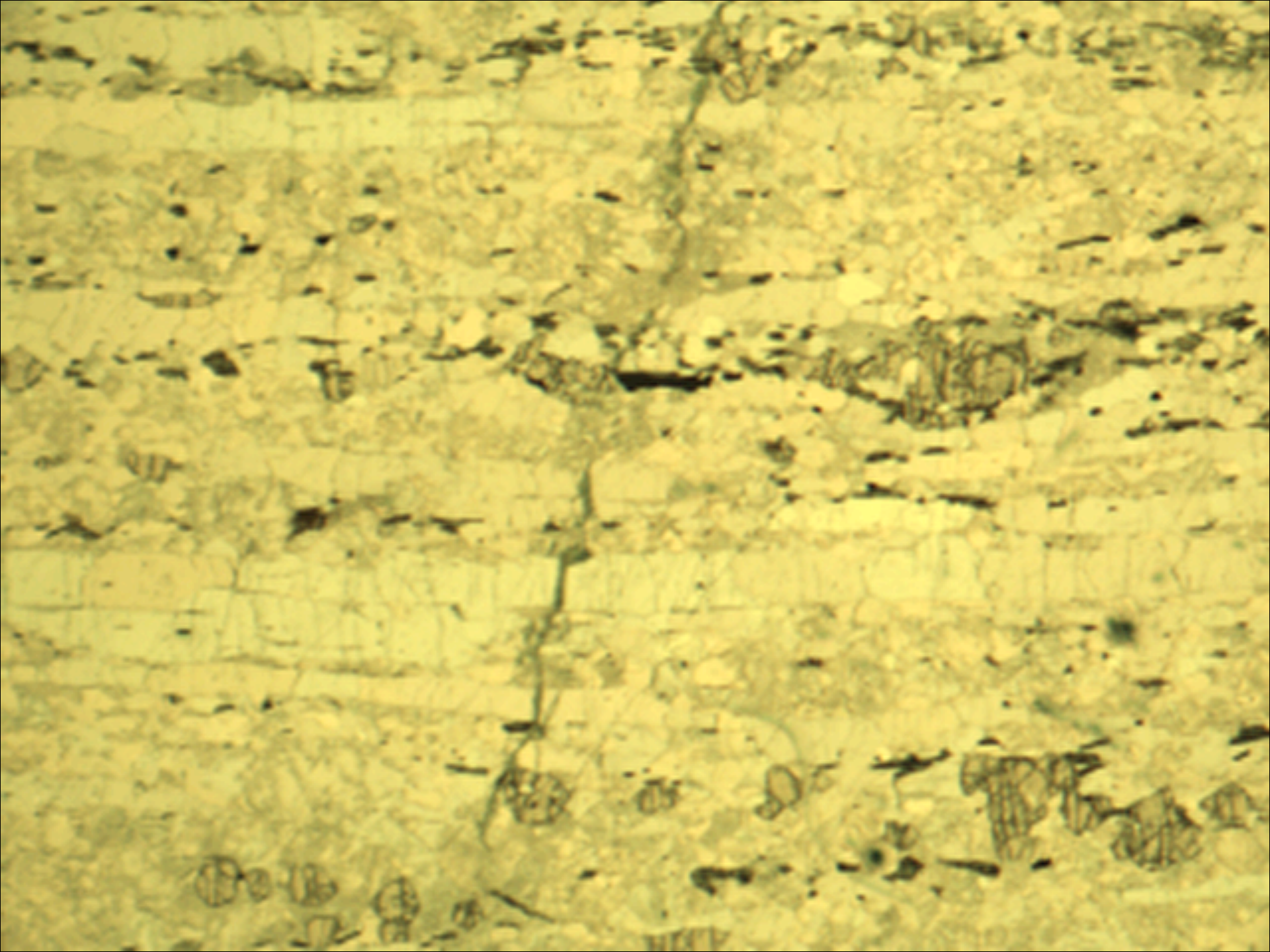
**LIN: PLUNGES AT 15°
ALONG S°40E**

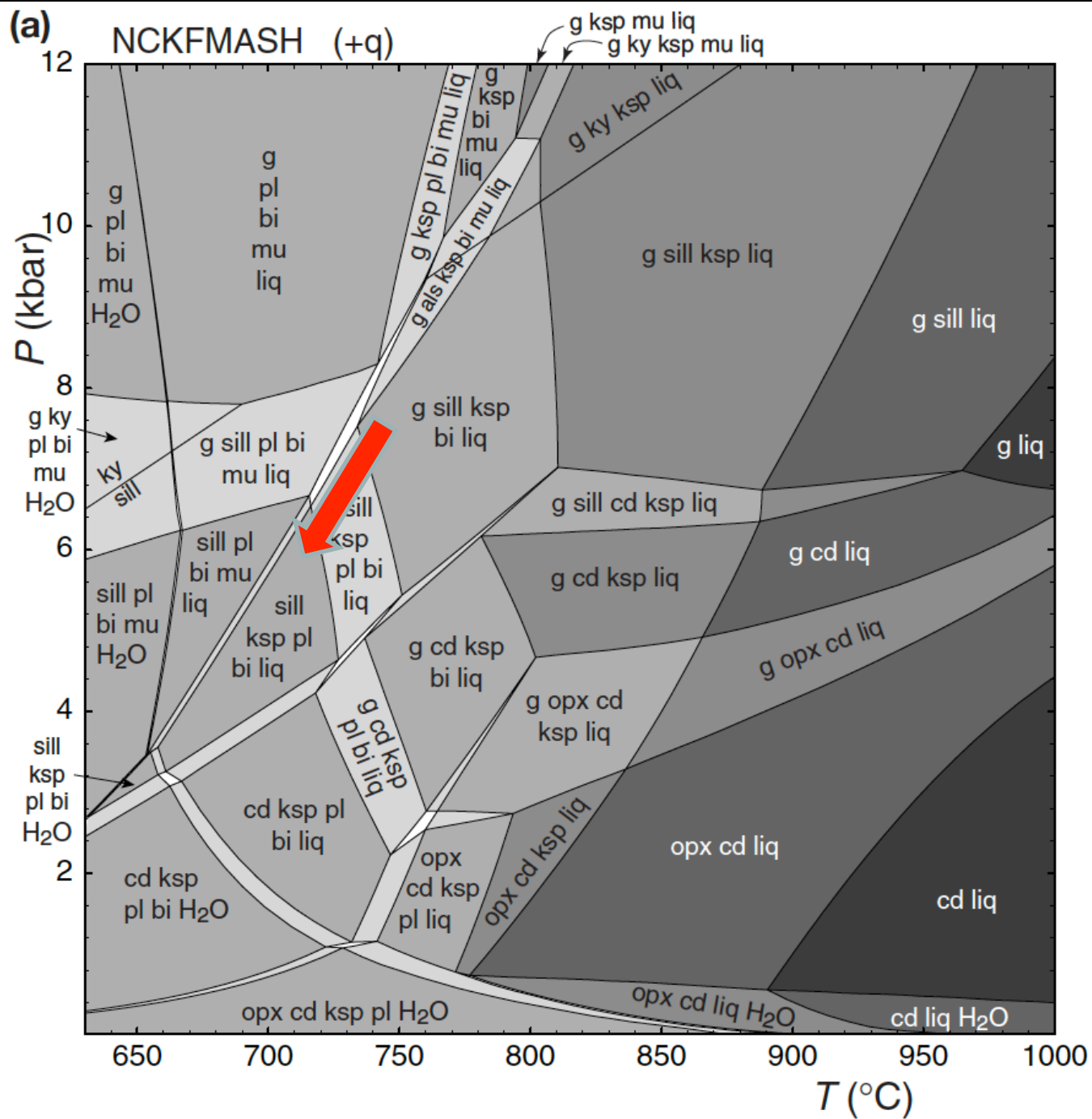


DEXTRAL, TOP SIDE DOWN TO EAST, PLUNGE 15°, S40°E

FACING
NORTH

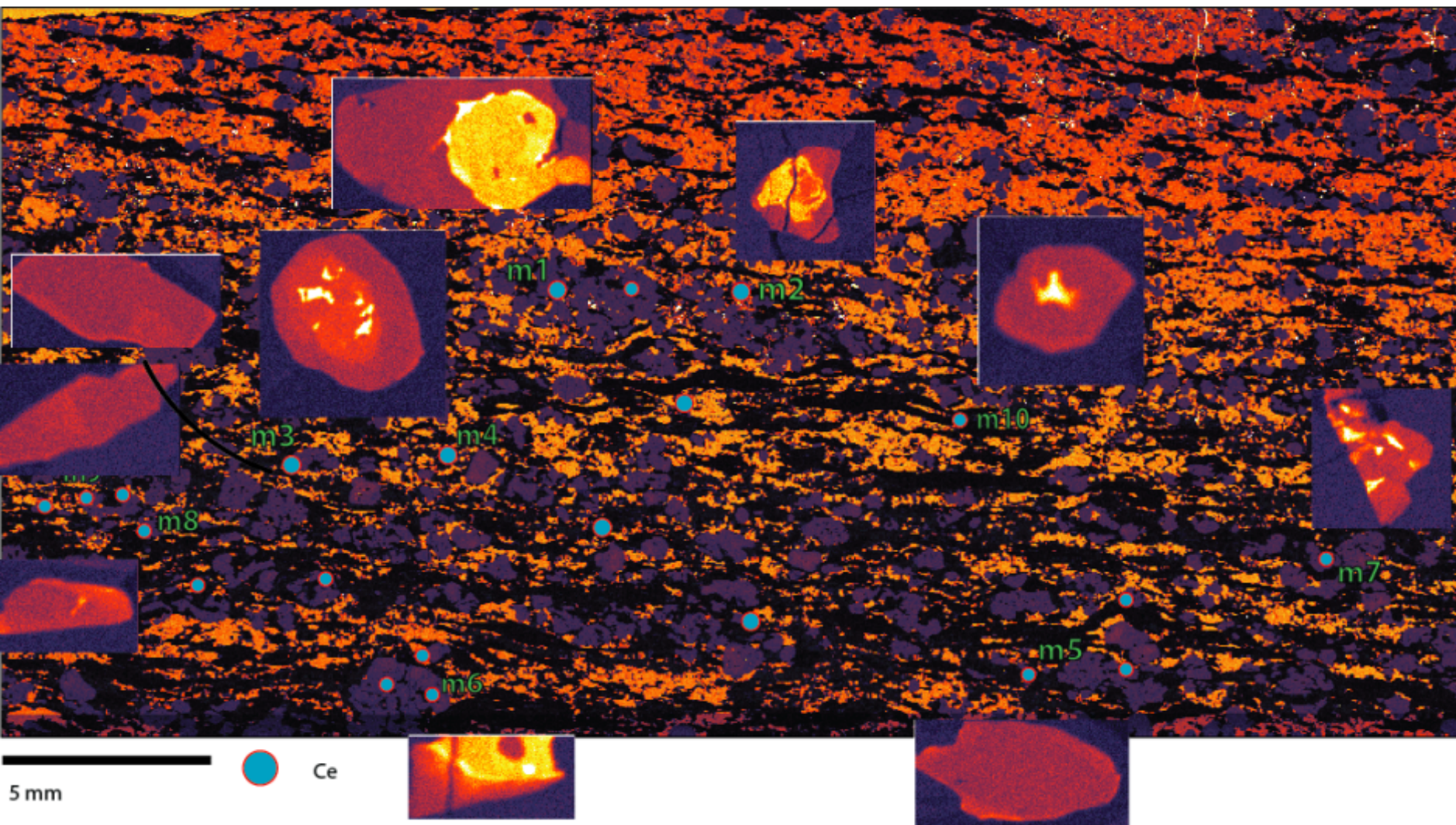


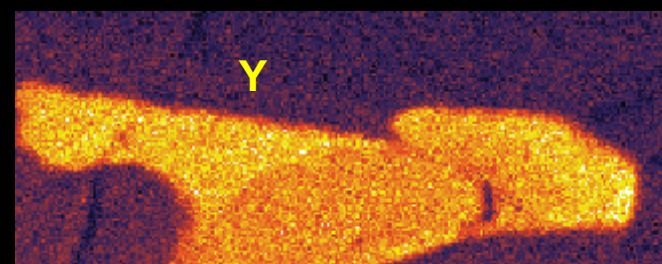
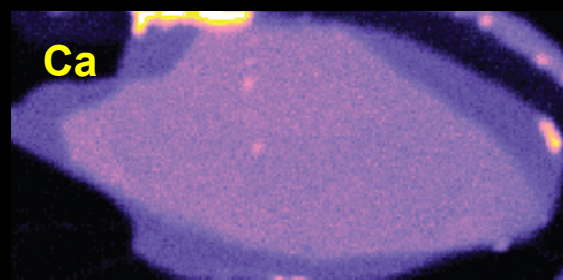
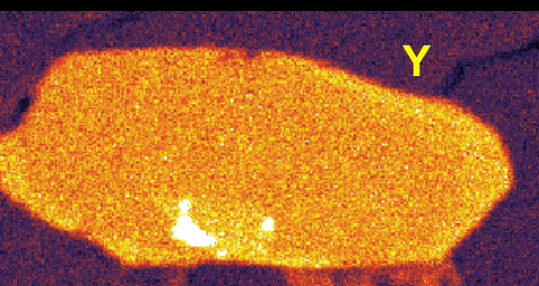
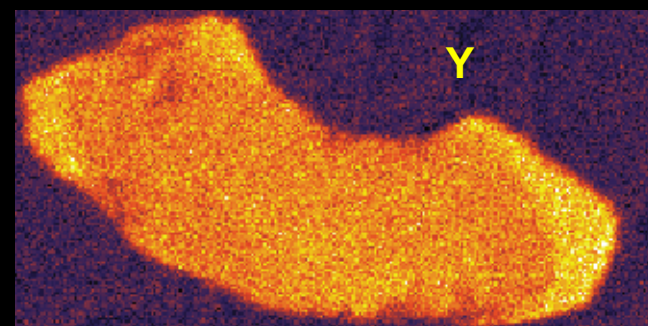
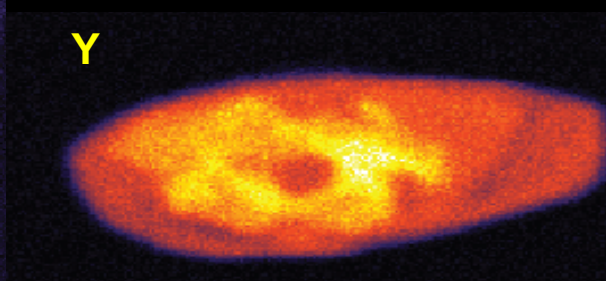
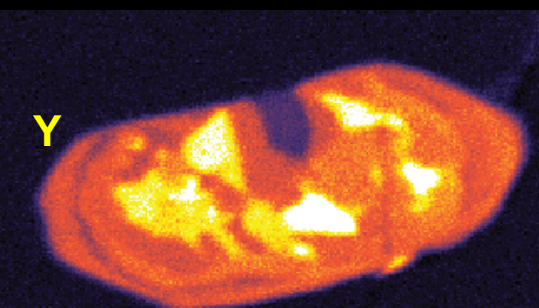
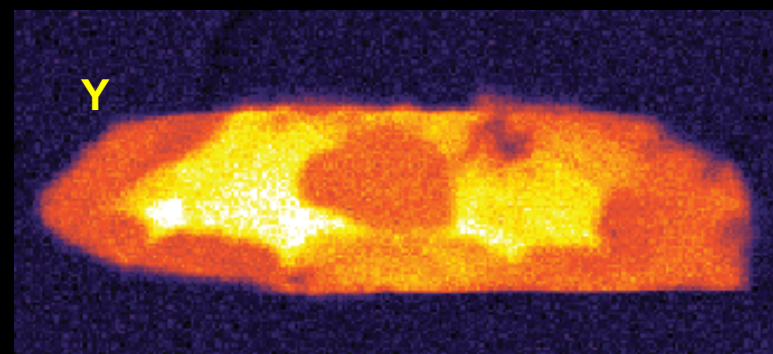
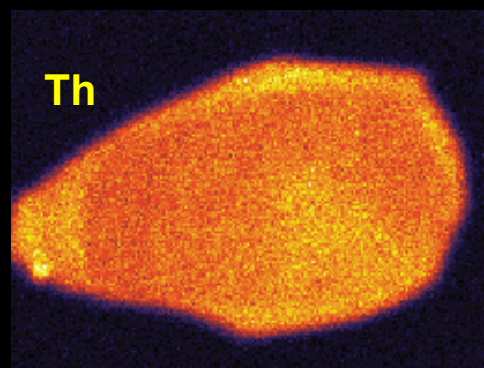
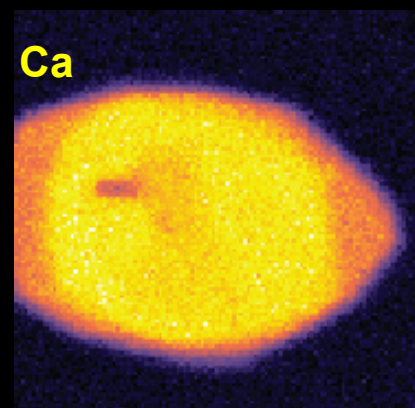


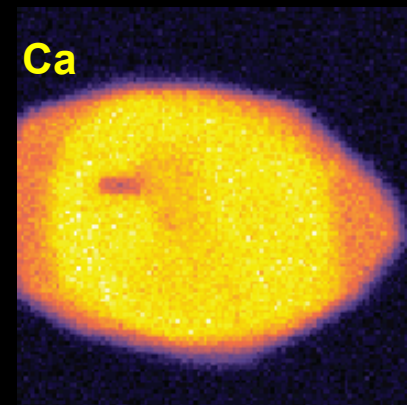
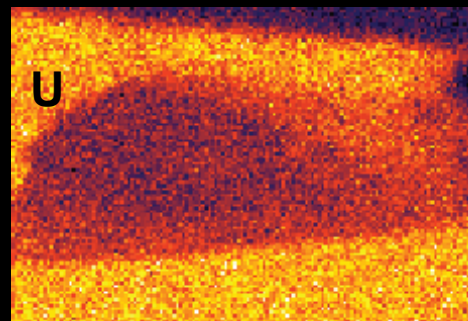
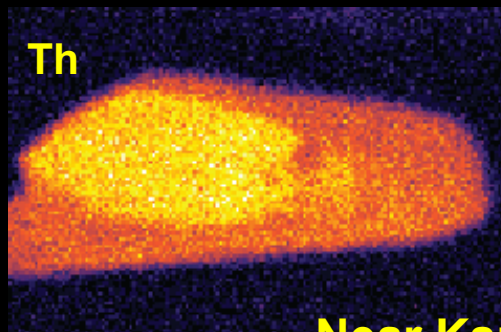


Sample JM-MLW-07-01
Full Section_rectangular thin section

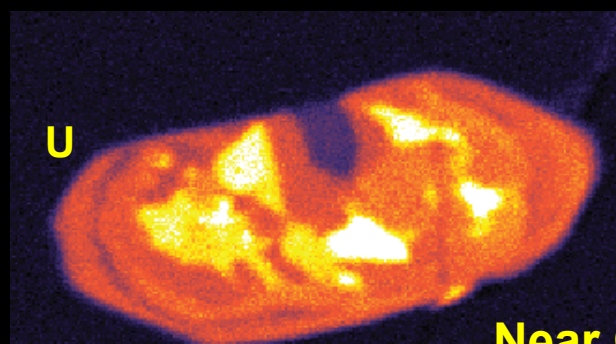
Ca-Map



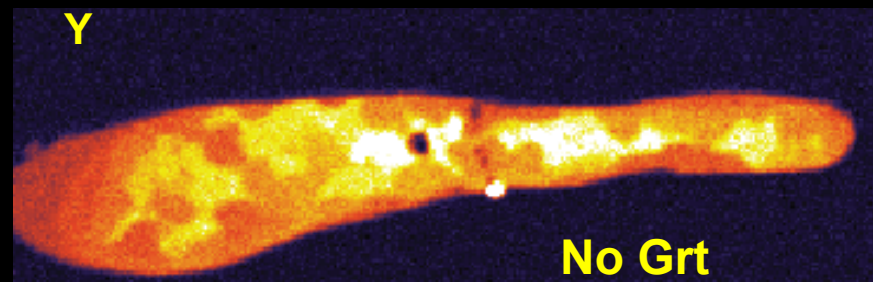




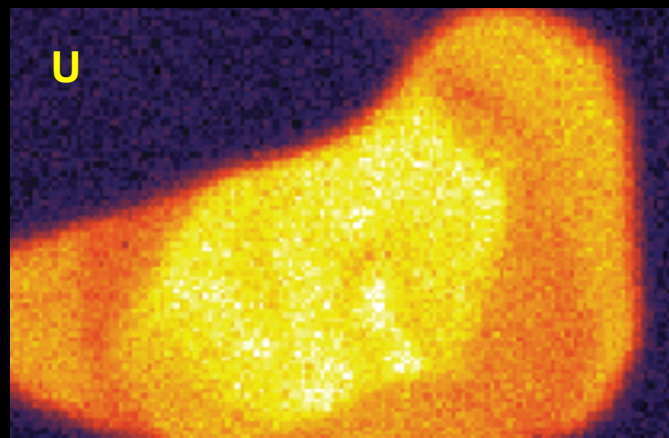
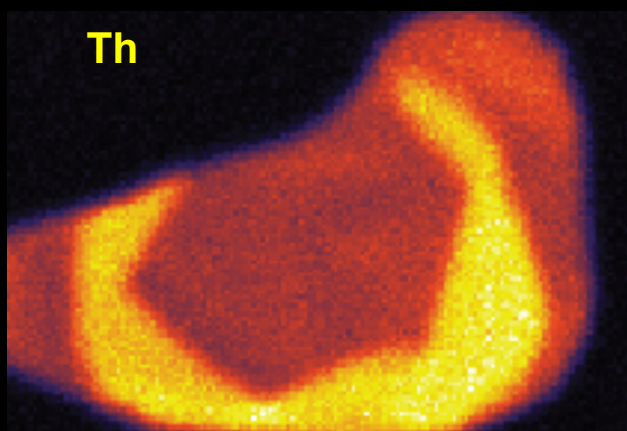
Near Ksp

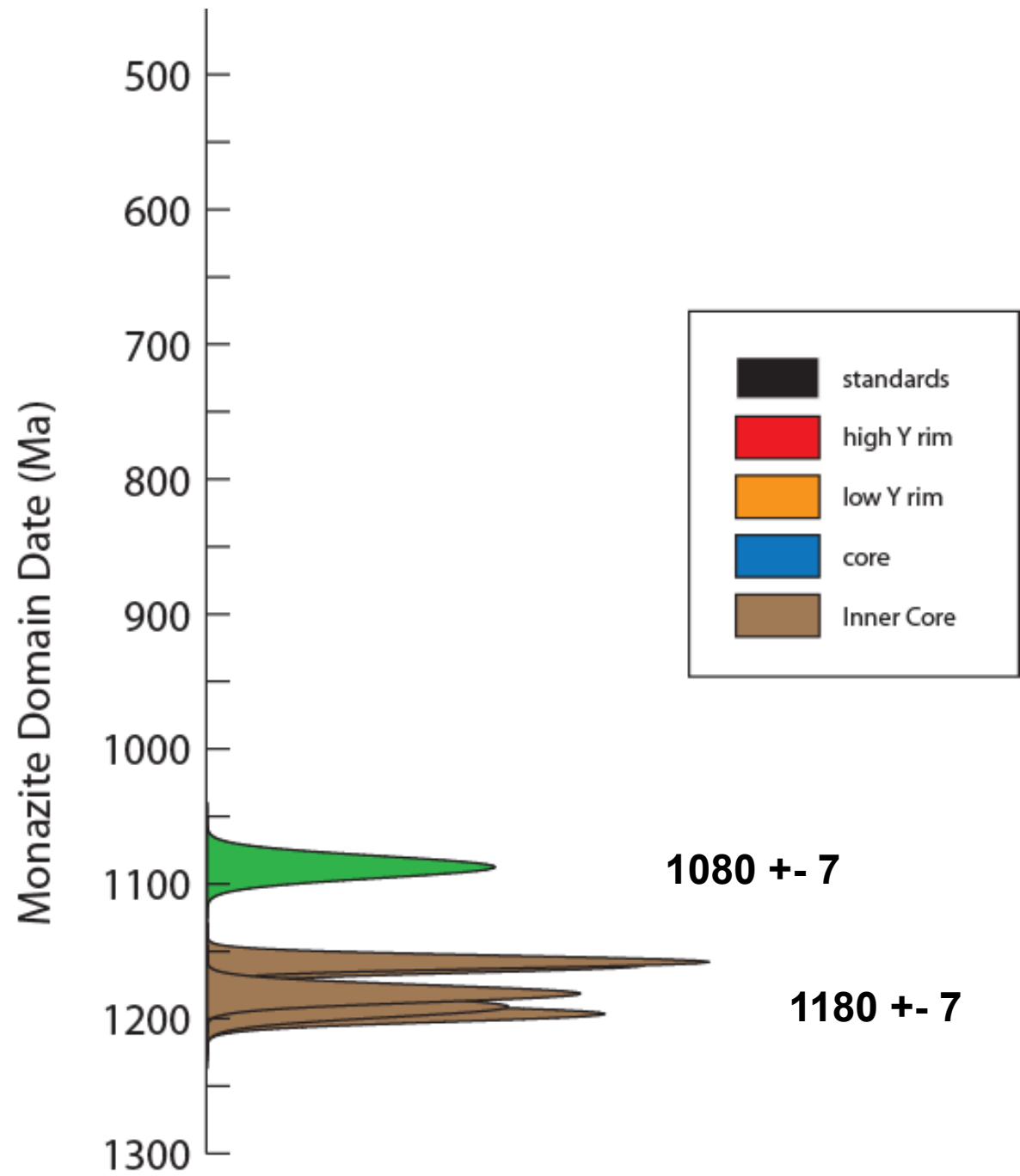


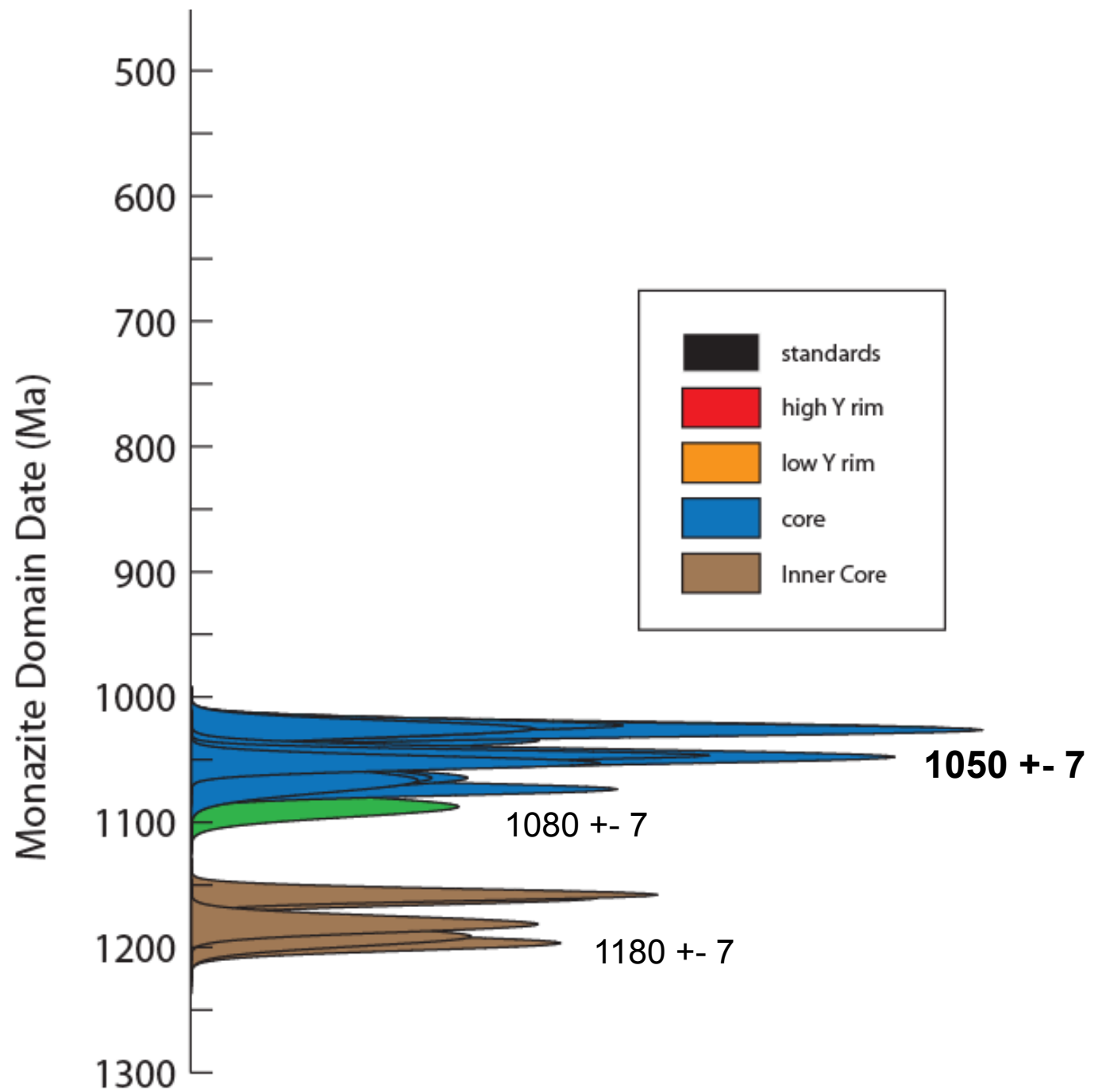
Near Grt

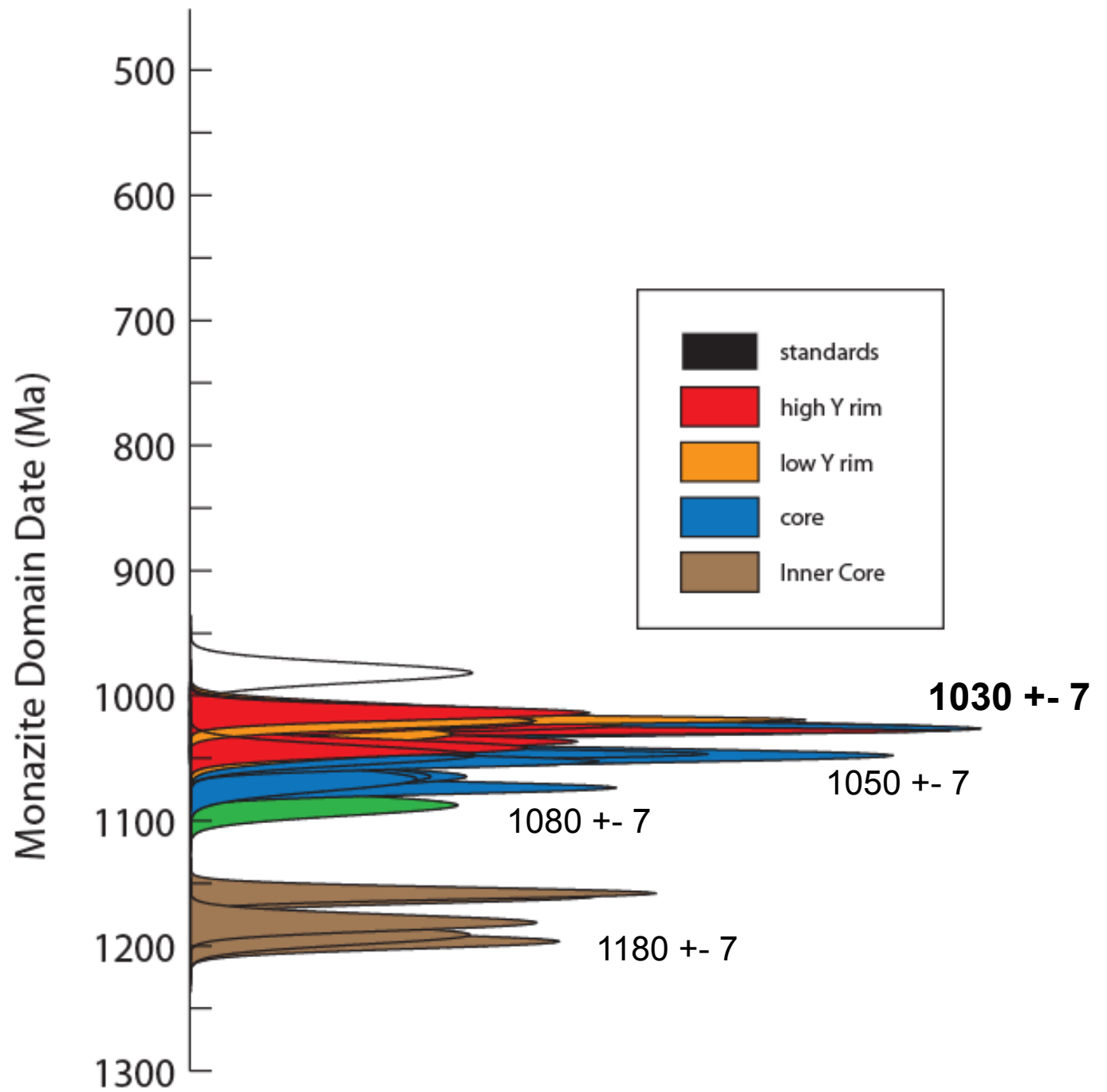


No Grt







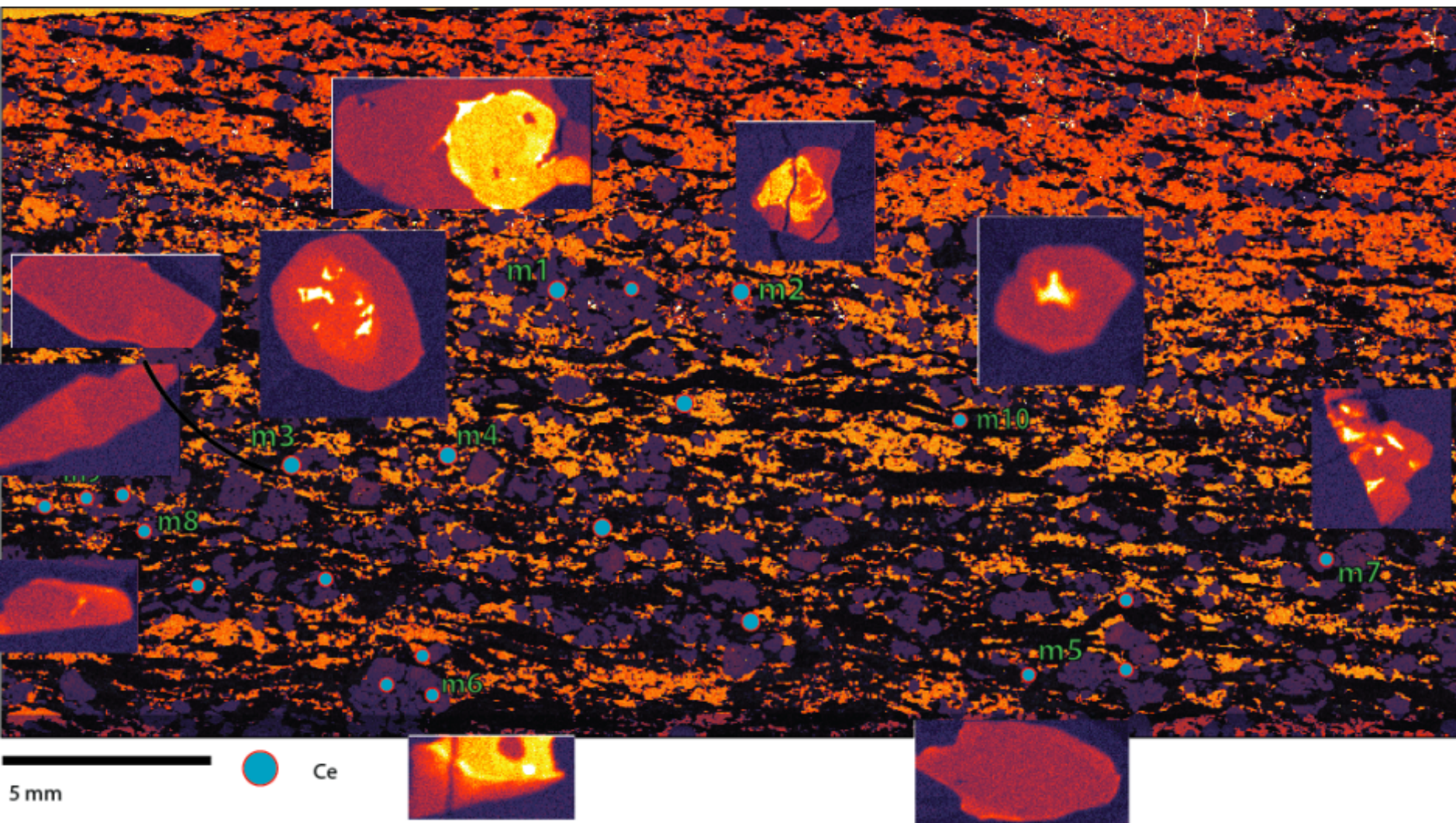


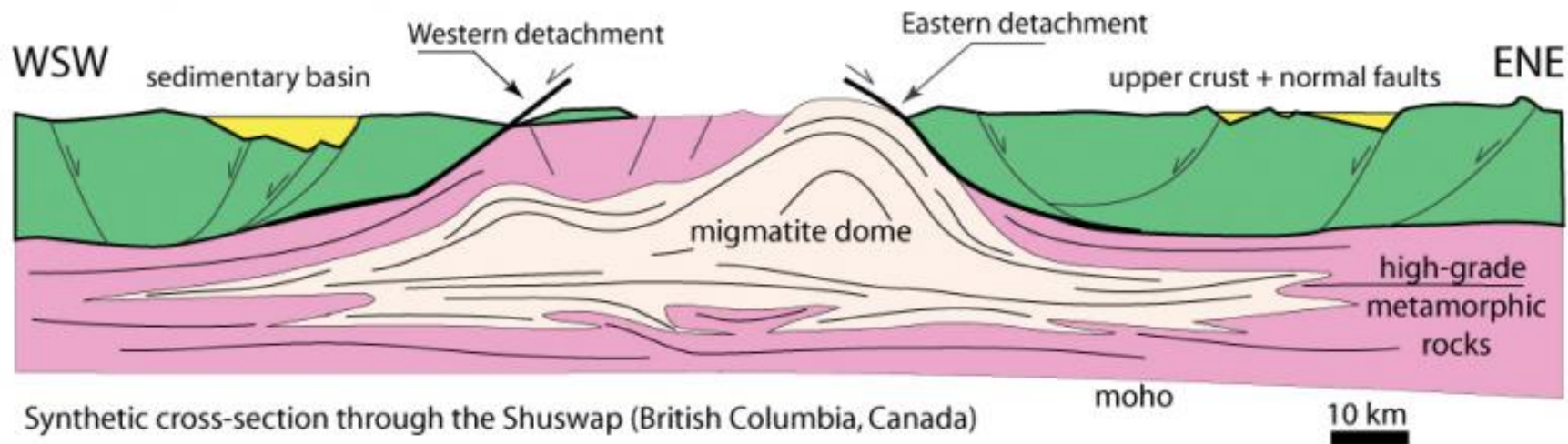
Grt => Bt + Pl + Qtz + Y-monazite + HREE monazite

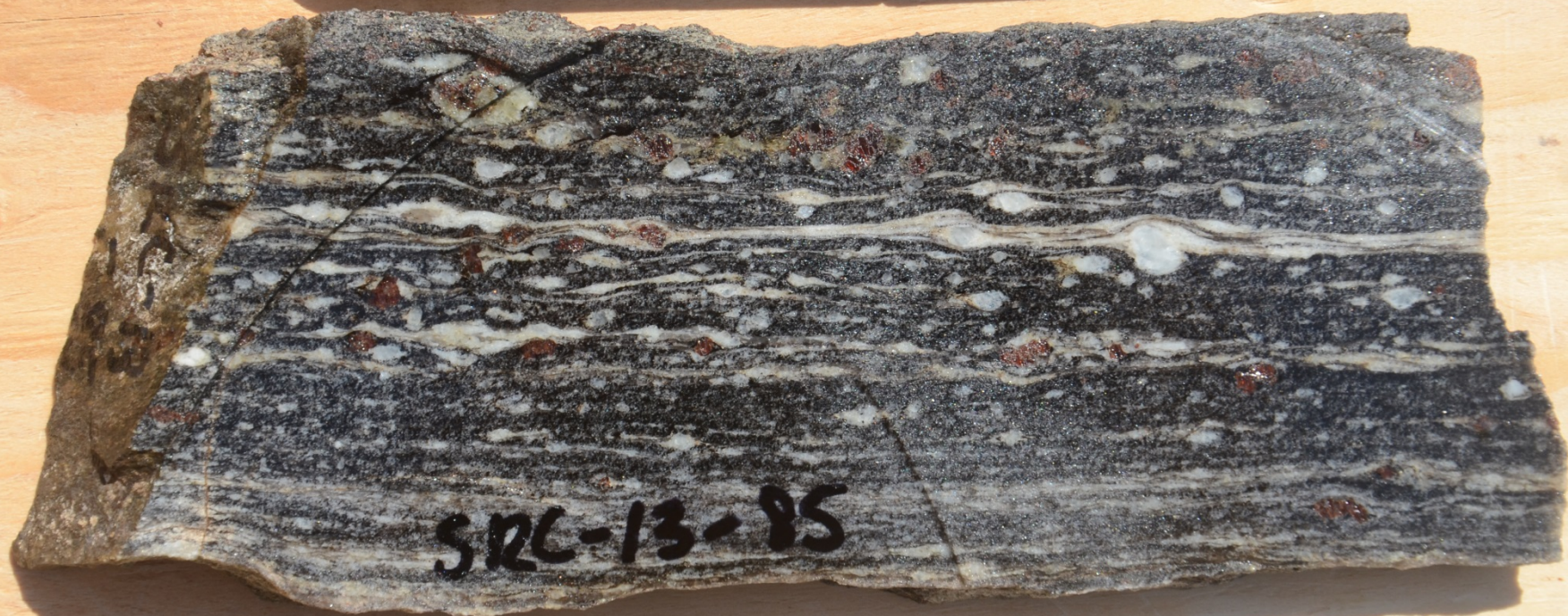
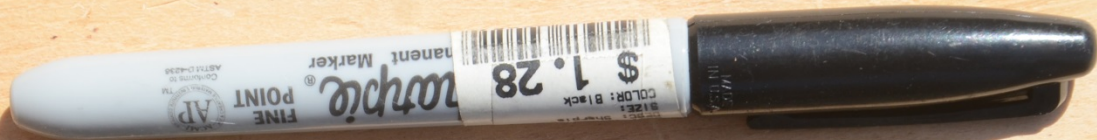
Kspar => Recrystallized Kspar + U-monazite + apatite

Monazite => Apatite + Ca-poor monazite

Decompression, Cooling, Dynamic recrystallization

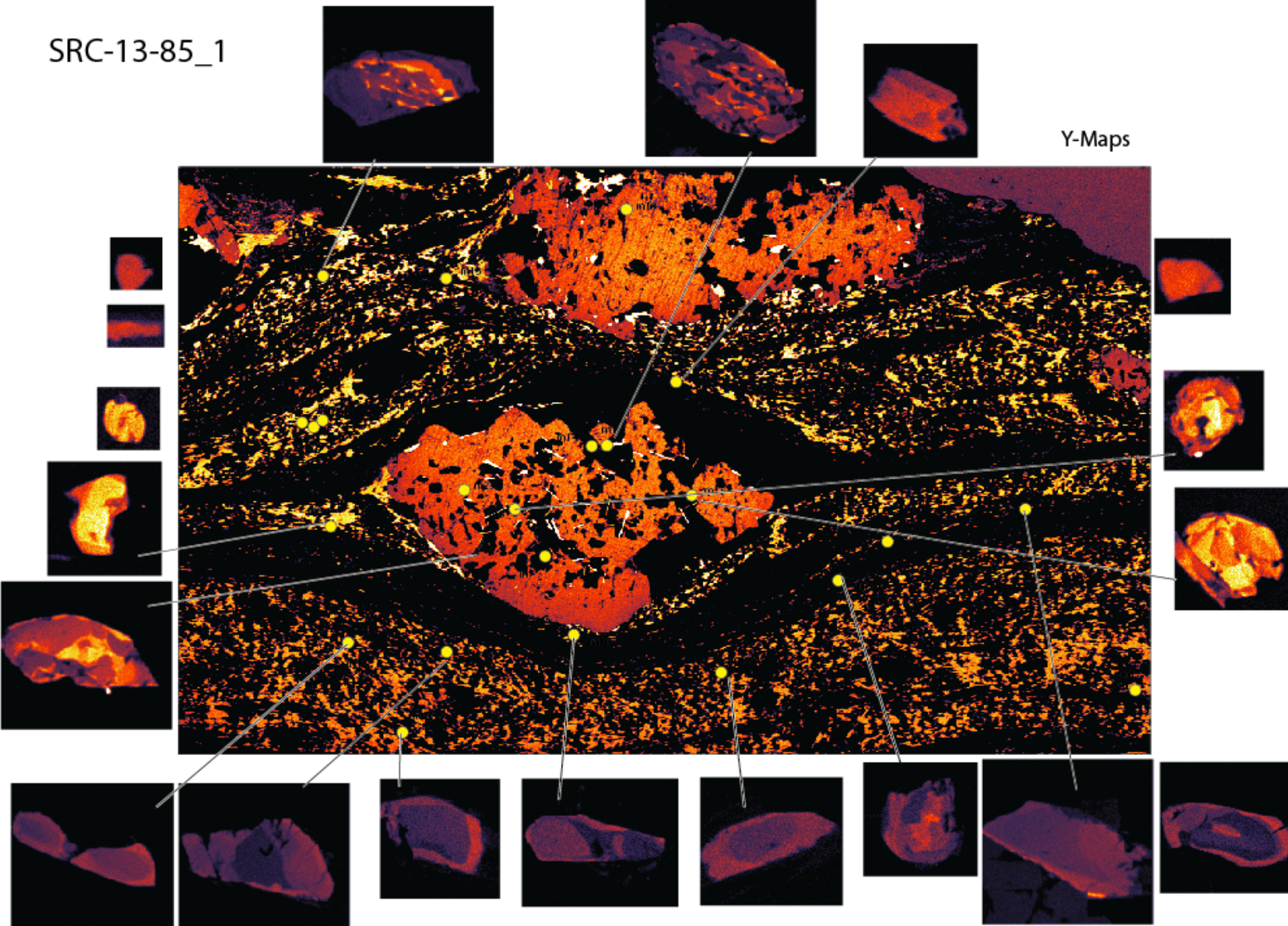




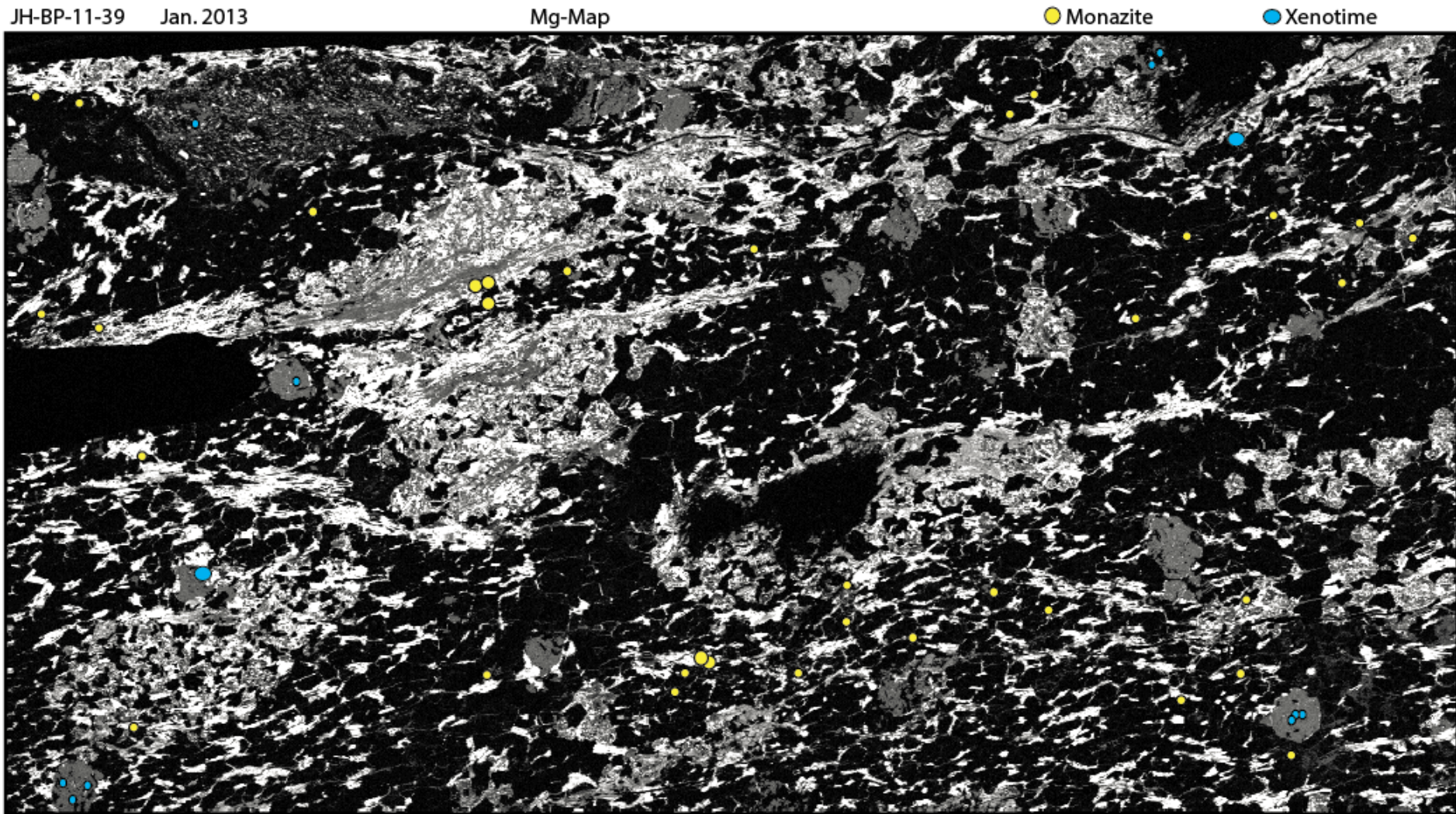


SRC-13-85_1

Y-Maps

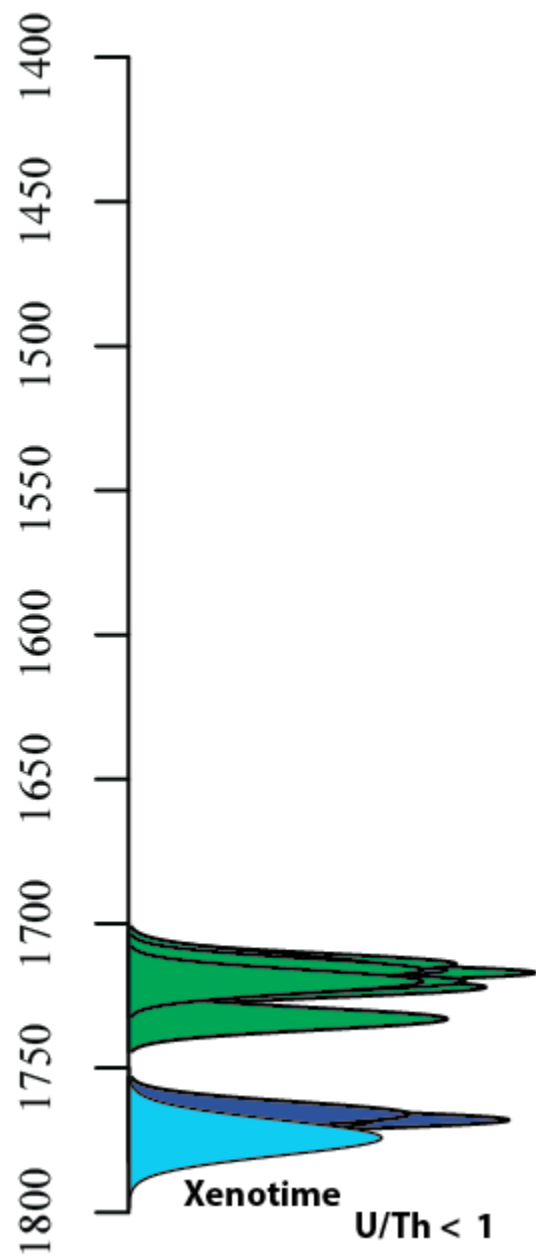


Xenotime-dating



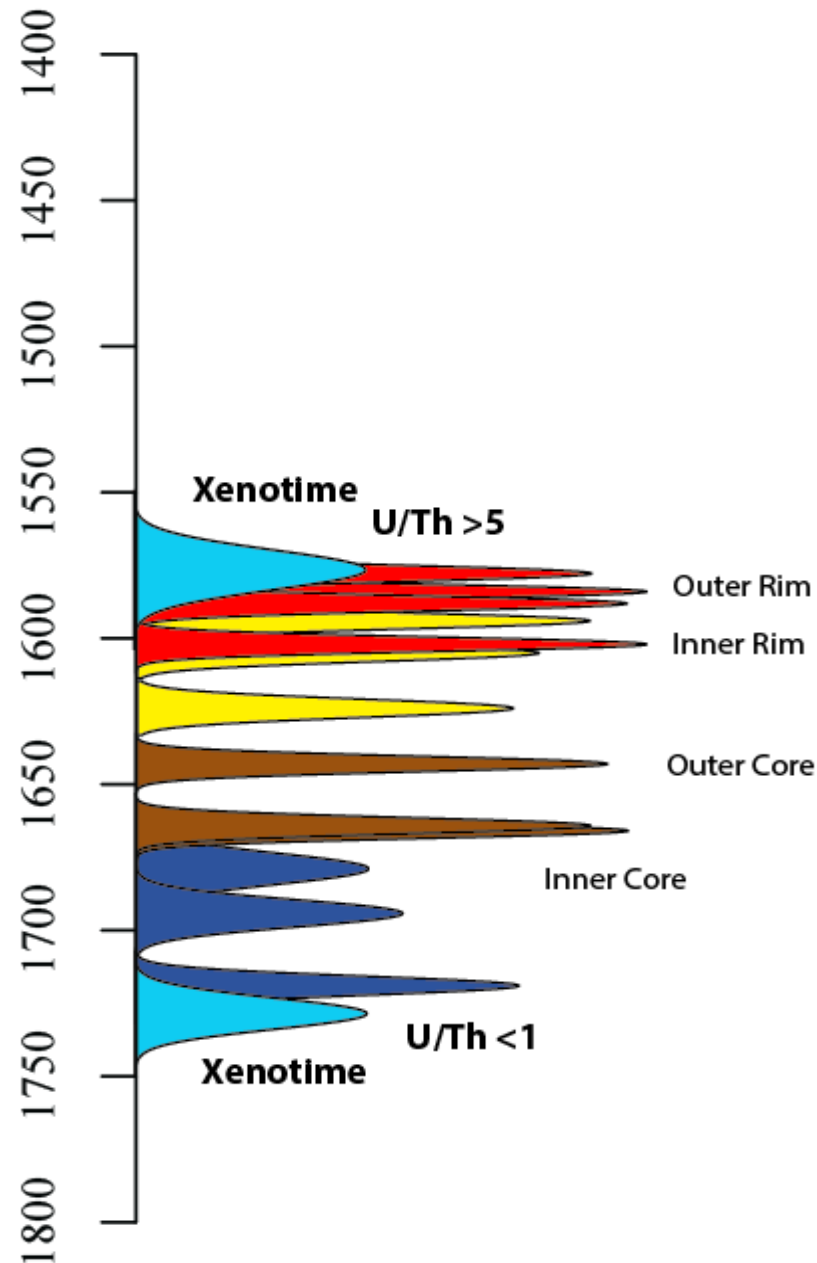
BP-11-39

Age (Ma)



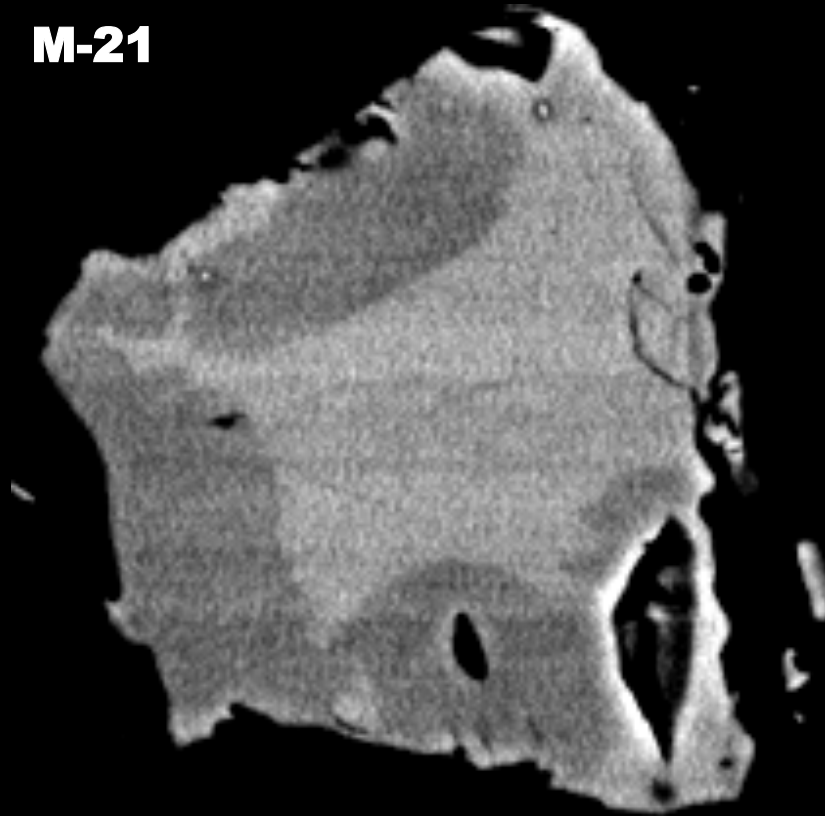
BP-12-19

Age (Ma)



Dissolution-Precipitation

M-21



5μ

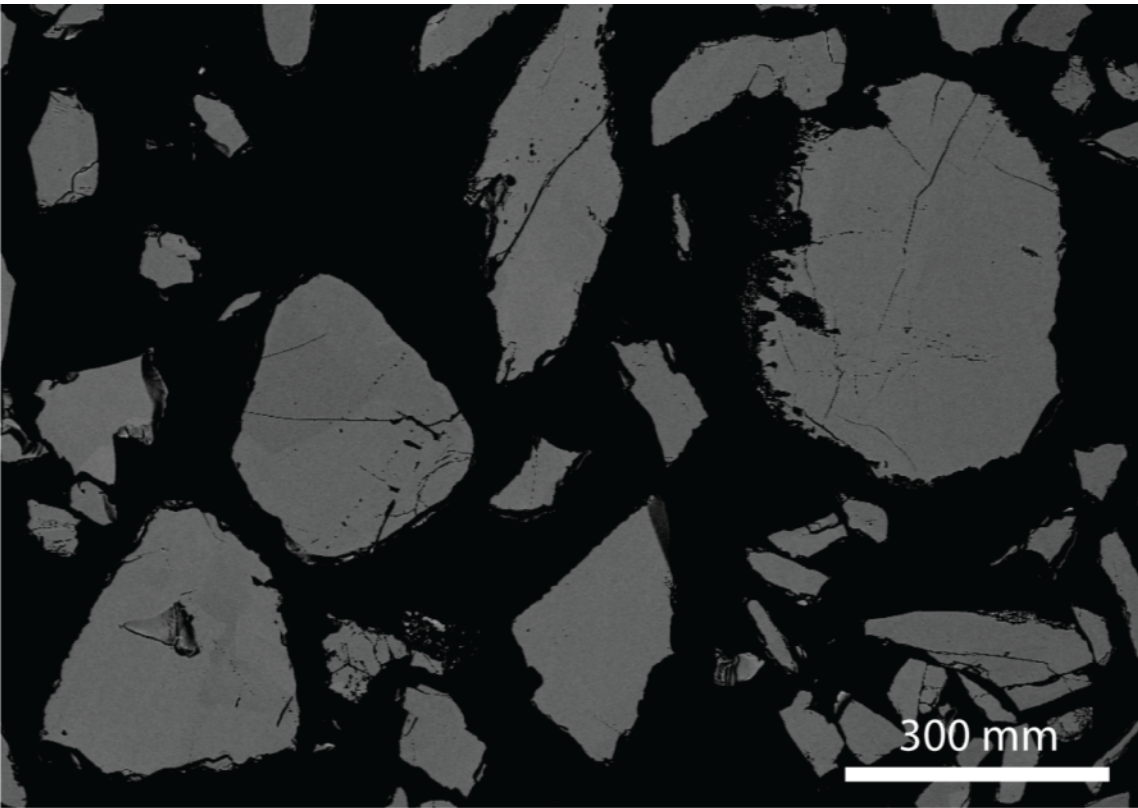


Starting monazite

The monazite chosen for the experiment was taken from a heavy-mineral sand deposit at Cumuruxatiba, Bahia State, Brazil D.

Moderately rounded, semi-euhedral, relatively transparent, inclusion-free, 100 – 500 μm , amber-colored grains.

The monazite grains were hand-picked out of the heavy mineral sand, crushed to 50 – 150 μm size fragments and then washed in ethanol in an ultrasonic bath.



ThO_2 : 7-8 wt %,

UO_2 : 0.5-0.75 wt%

Assemblage:

monazite,
muscovite,
albite,
amorphous SiO_2

Reagents:

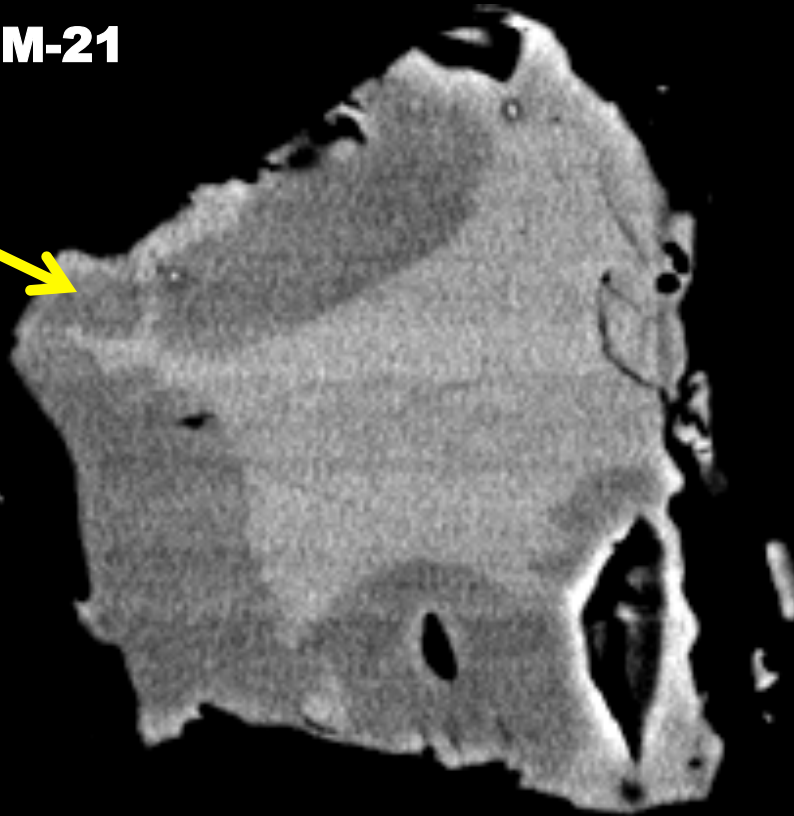
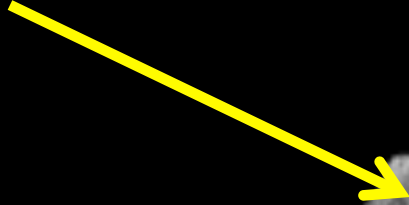
CaF_2
 $\text{Na}_2\text{Si}_2\text{O}_5$

Experimental conditions

4.5 kbar, 450°C for a
Duration: 16 days.

See: Budzyn (2009)

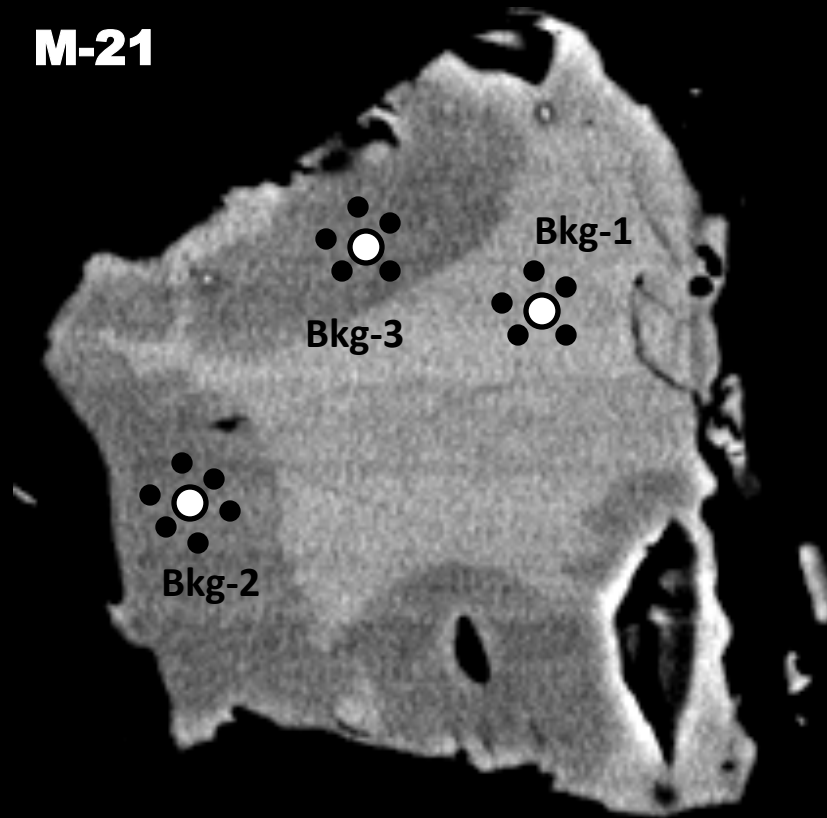
M-21



5μ



M-21

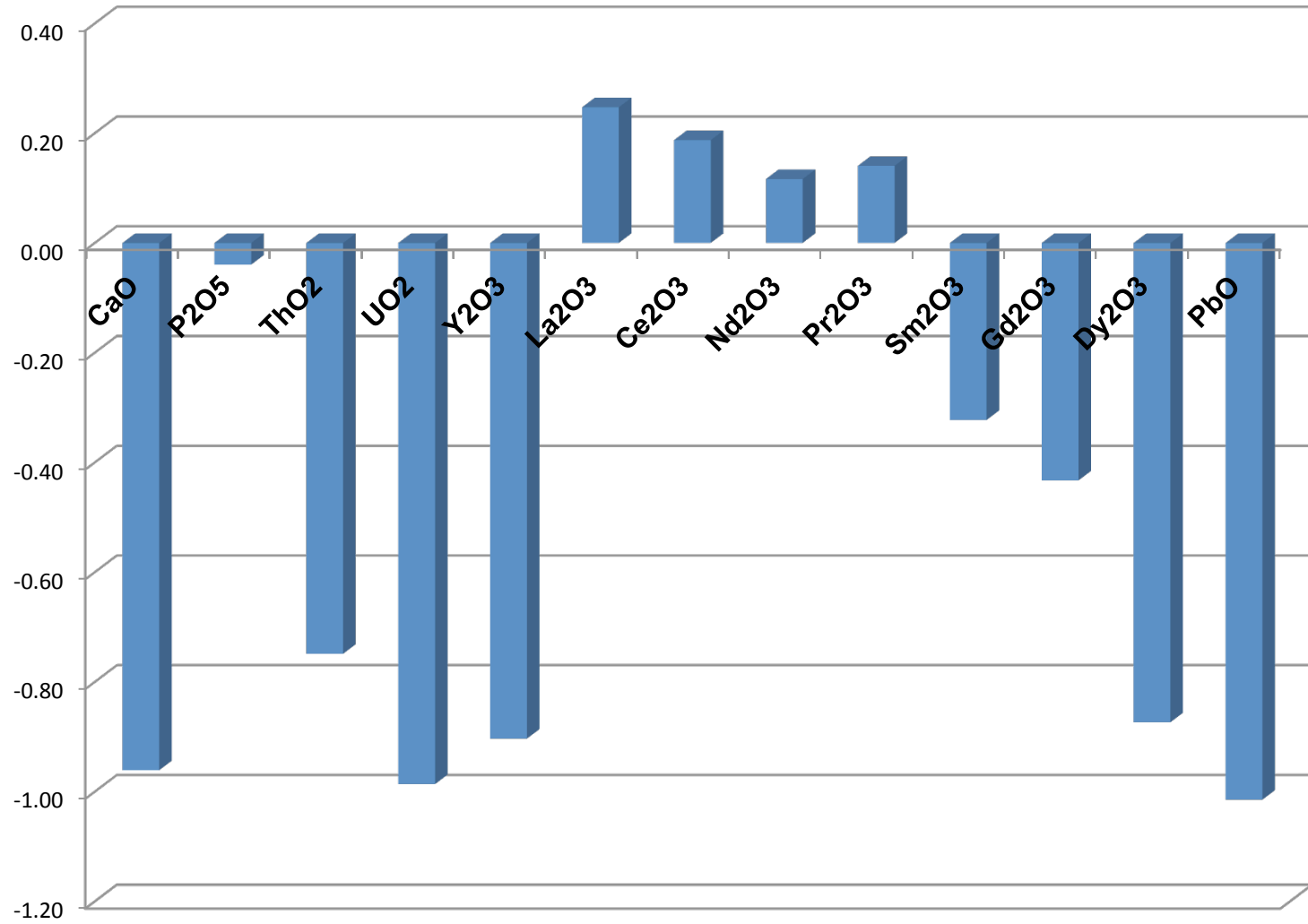


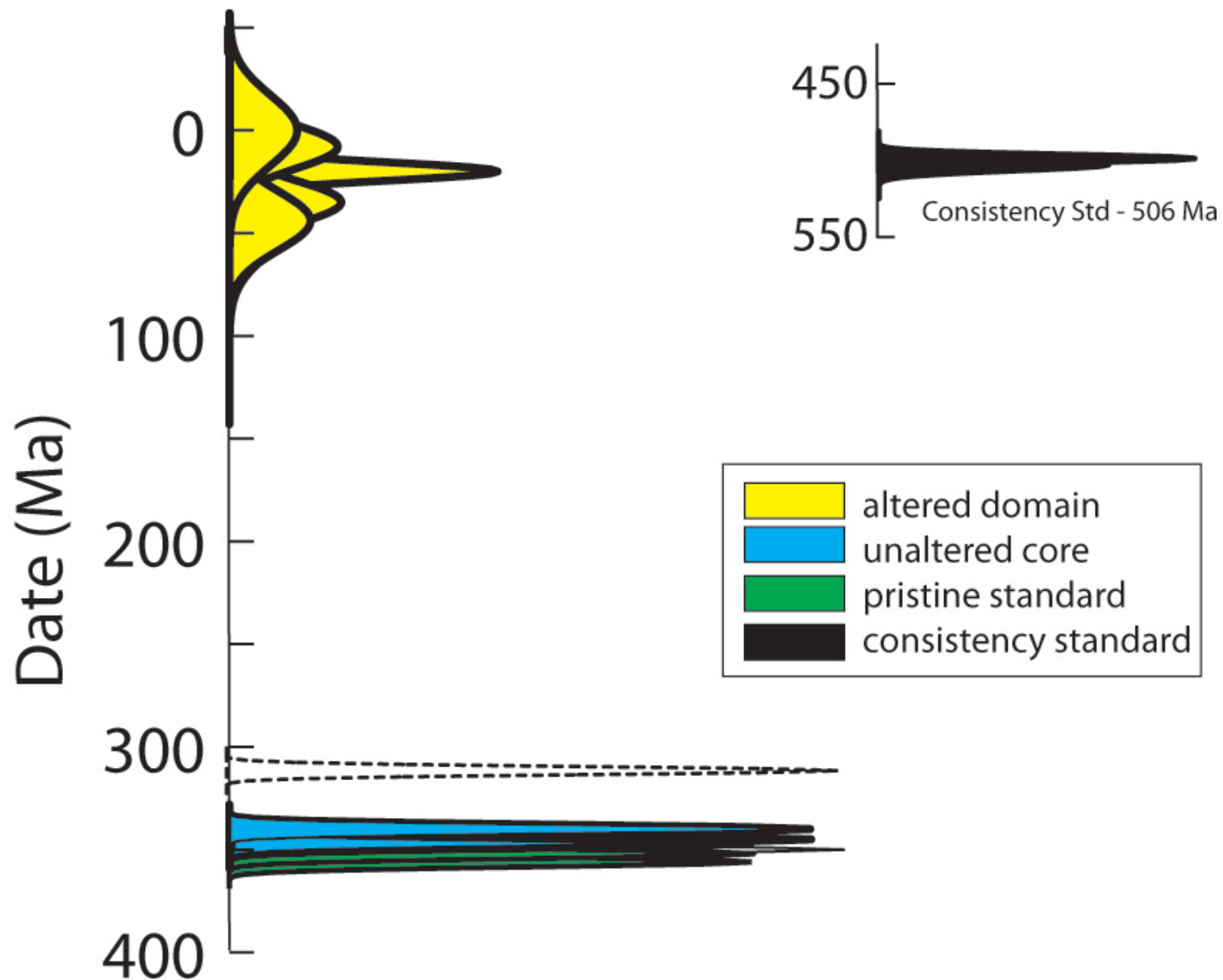
Bkg-3

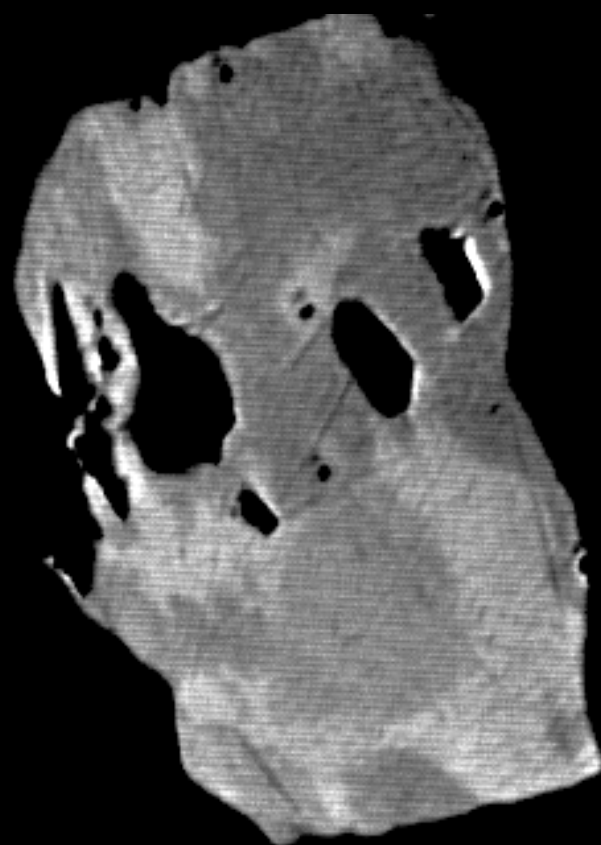
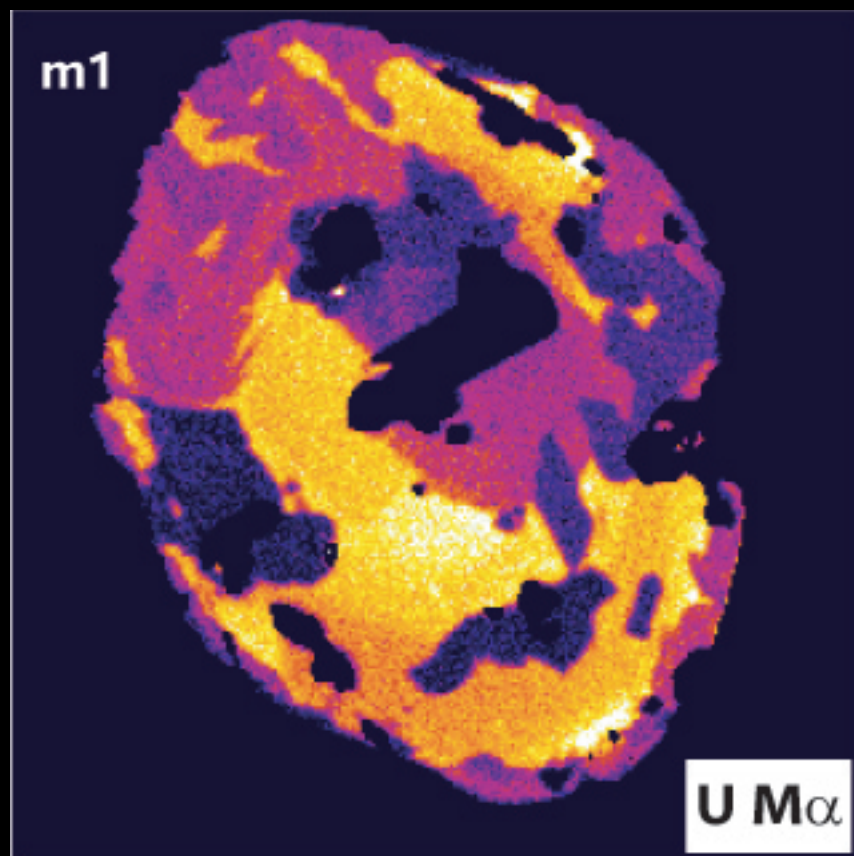
Bkg-1

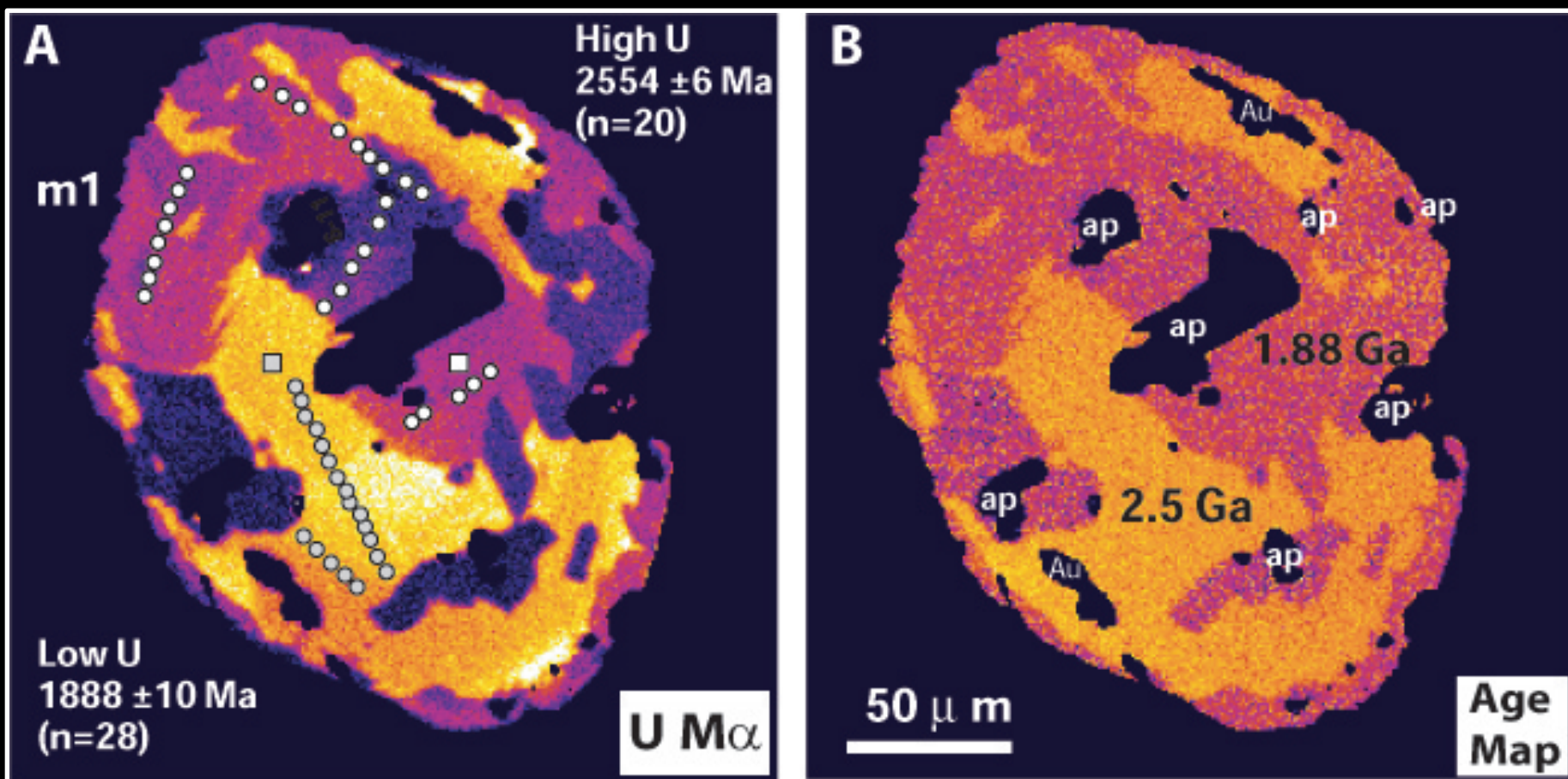
Bkg-2

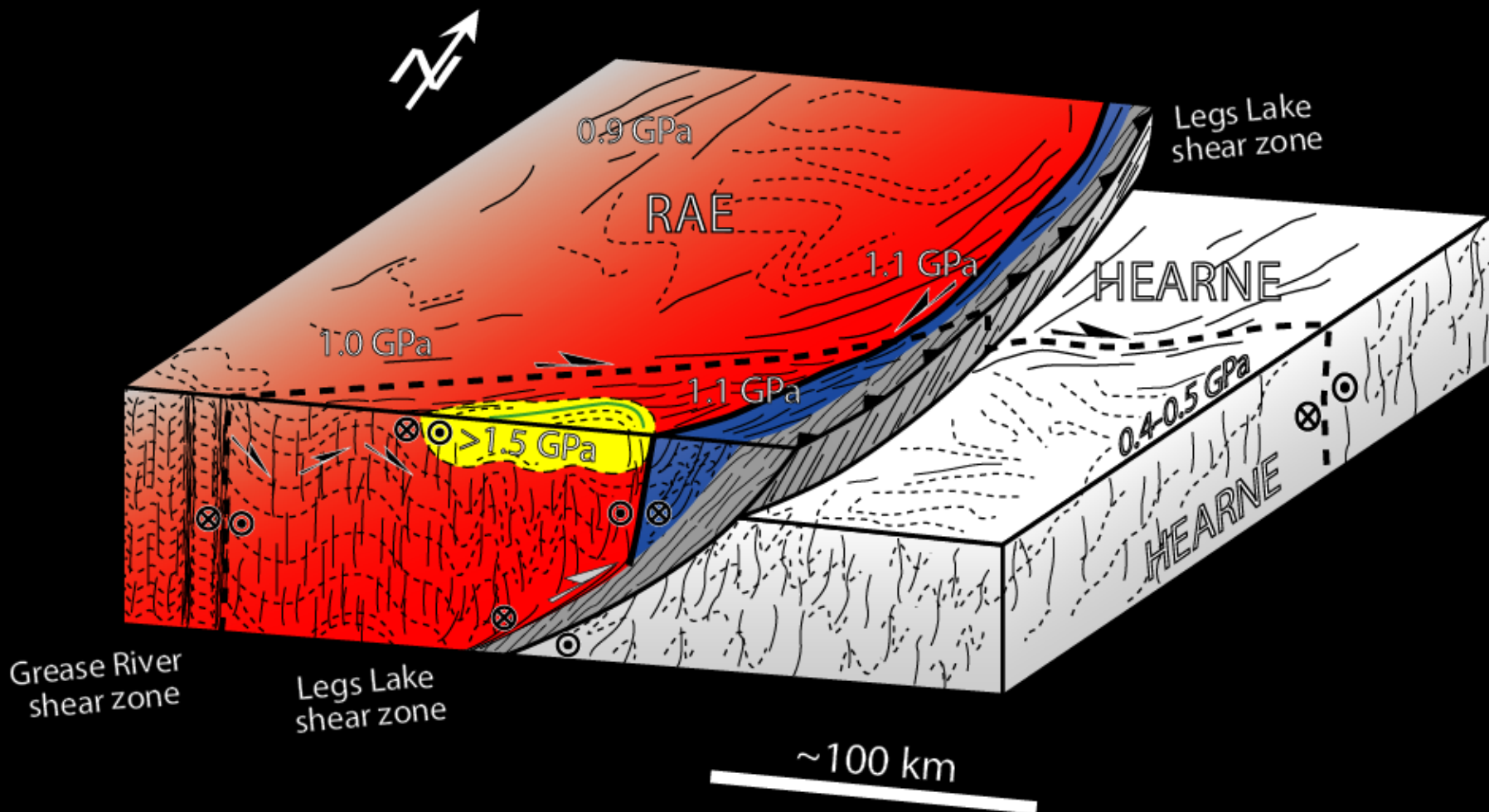
5μ











SRC-13-85_1

