

# THE NATURE AND ORIGIN OF REE MINERALIZATION IN THE ASHRAM DEPOSIT, ELDOR CARBONATITE COMPLEX, QUEBEC

Caitlin MJ Béland & AE Williams-Jones



# Outline

- Regional and local geology of the Ashram Deposit
- Typical mineralization textures
- Mineralization paragenesis
- Apatite compositions
- REE mineral compositions
- Likely origin of mineralizing fluids
- Summary of findings

# Regional Geology


- Labrador Trough
  - Rift basin then fold and thrust belt
- Eldor intruded near end of rifting  $\leq 1870 \pm 4$  Ma (Machado et al., 1997)

## Lithotectonic Zones

### Paleoproterozoic

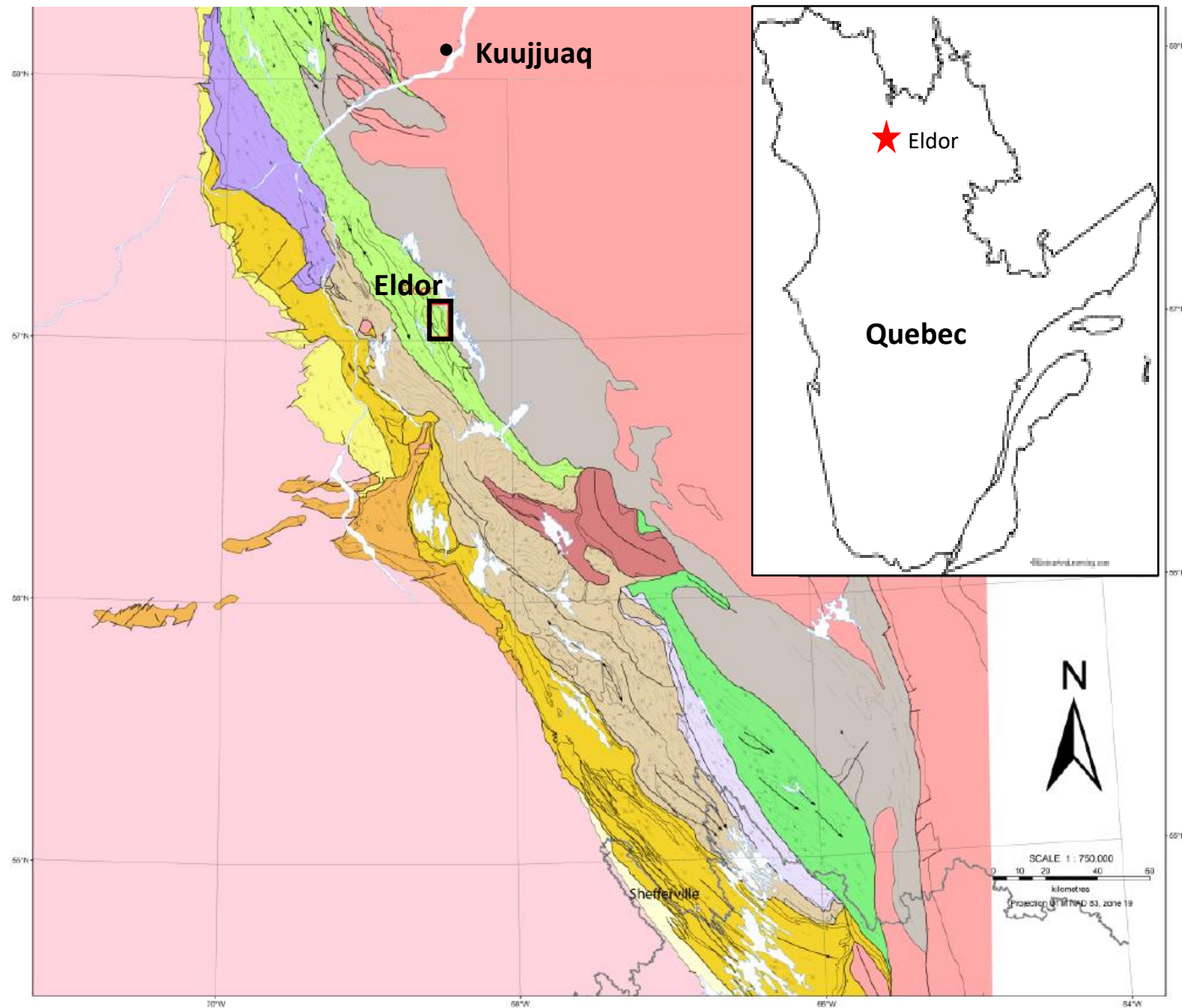
 Tamarack Zone	 Mèlèzes Zone
 Wheeler Zone	 Hurst Zone
 Shefferville Zone	 Parashist, paragneiss, amphibolite
 Berard Zone	 Gerido Zone
 Howse Zone	 Retty Zone
 Cambrien Zone	 Payne Zone

### Proterozoic - Archean

 Superior Province

### Archean

 SE-Churchill Province

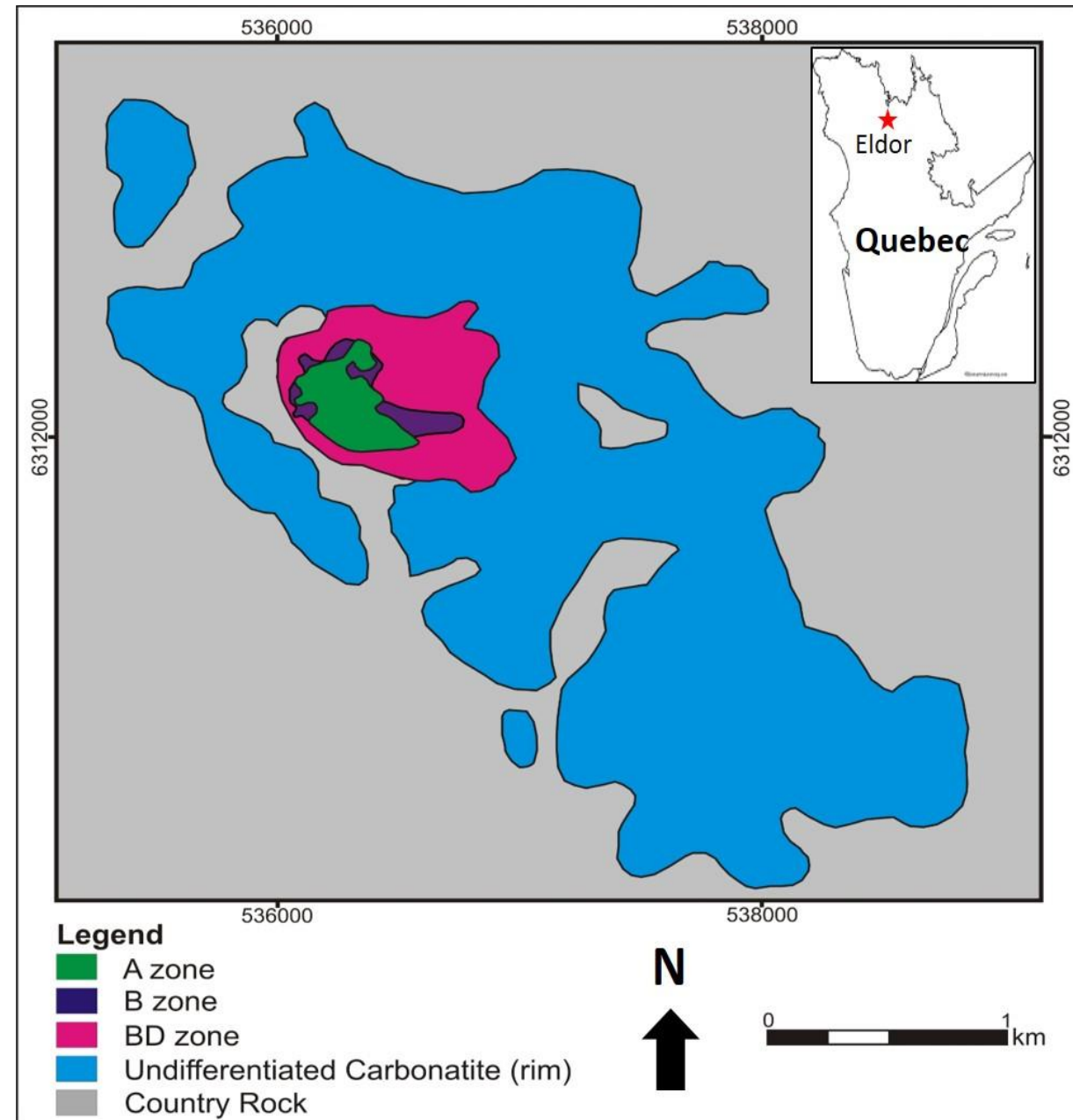


After Clark & Wares (2006)

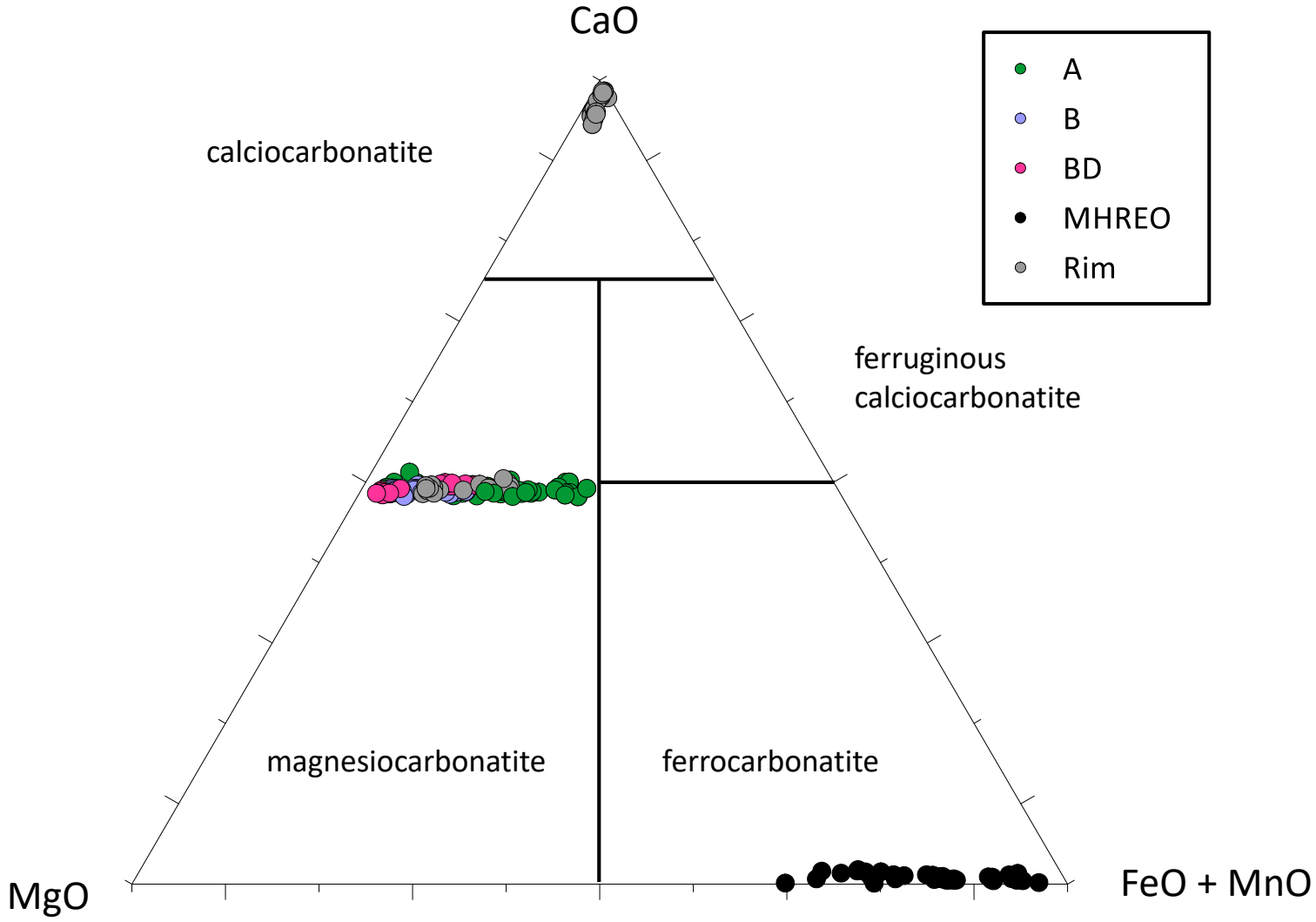
# Eldor Carbonatite General Geology

Ashram

- A zone monazite-dolomite carbonatite
  - MHREO zone monazite-xenotime-aeschnite-ferrocarbonatite
- B zone monazite-dolomite carbonatite
- BD zone REEflc-dolomite-carbonatite
- 'Rim' calcite- and dolomite carbonatites



# Eldor Carbonatite Carbonate Compositions



# 'BD Zone' dolomite carbonatite

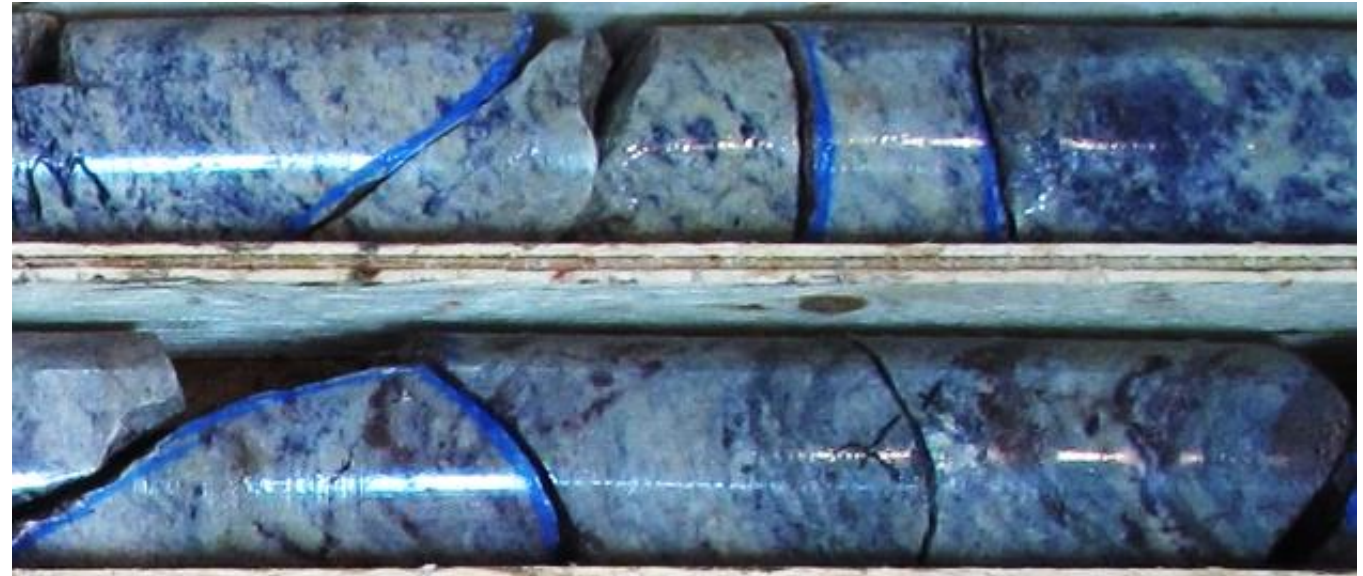
- average apatite 7%
  - Up to 14 wt %  $P_2O_5$
- 0.5 - 1 wt % TREO
  - MHREO/TREO = 7%
- Pink REE fluorocarbonates (REEflc)
  - Bastnasite-(Ce)  
 $CeCO_3F$
  - Parisite-(Ce)  $Ca(Ce,La)_2(CO_3)_3F_2$
  - Synchysite-(Ce)  
 $CaCe(CO_3)_2F$



*Disclaimer: The A, B, BD, and MHREO zones have not been fully defined nor characterized. As such, the values presented herein are a best approximation based on the available data at this time. MHREO/TREO estimated by the author from a preliminary database and is non-43-101-compliant.*

# 'B Zone' dolomite carbonatite

- average fluorite 4%
- 1 – 2 wt % TREO
  - MHREO/TREO = 4%
- monazite-(Ce)  
( $\text{CePO}_4$ )
  - mineralization gives yellow tint



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# 'A Zone' dolomite carbonatite

- average fluorite 8%
- 1 – 3+ wt % TREO
  - MHREO/TREO = 6%
- monazite-(Ce)



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# 'MHREO zone' ferrocarbonatite

- 1.6 wt % TREO
  - MHREO/TREO 11%, ≤ 20%
- Monazite-(Ce)
- Xenotime-(Y)  
HREEPO<sub>4</sub>
- Aeschynite-(Y)  
(Y,Ca,Fe)(Ti,Nb)<sub>2</sub>(O,OH)<sub>6</sub>

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MHREO

A

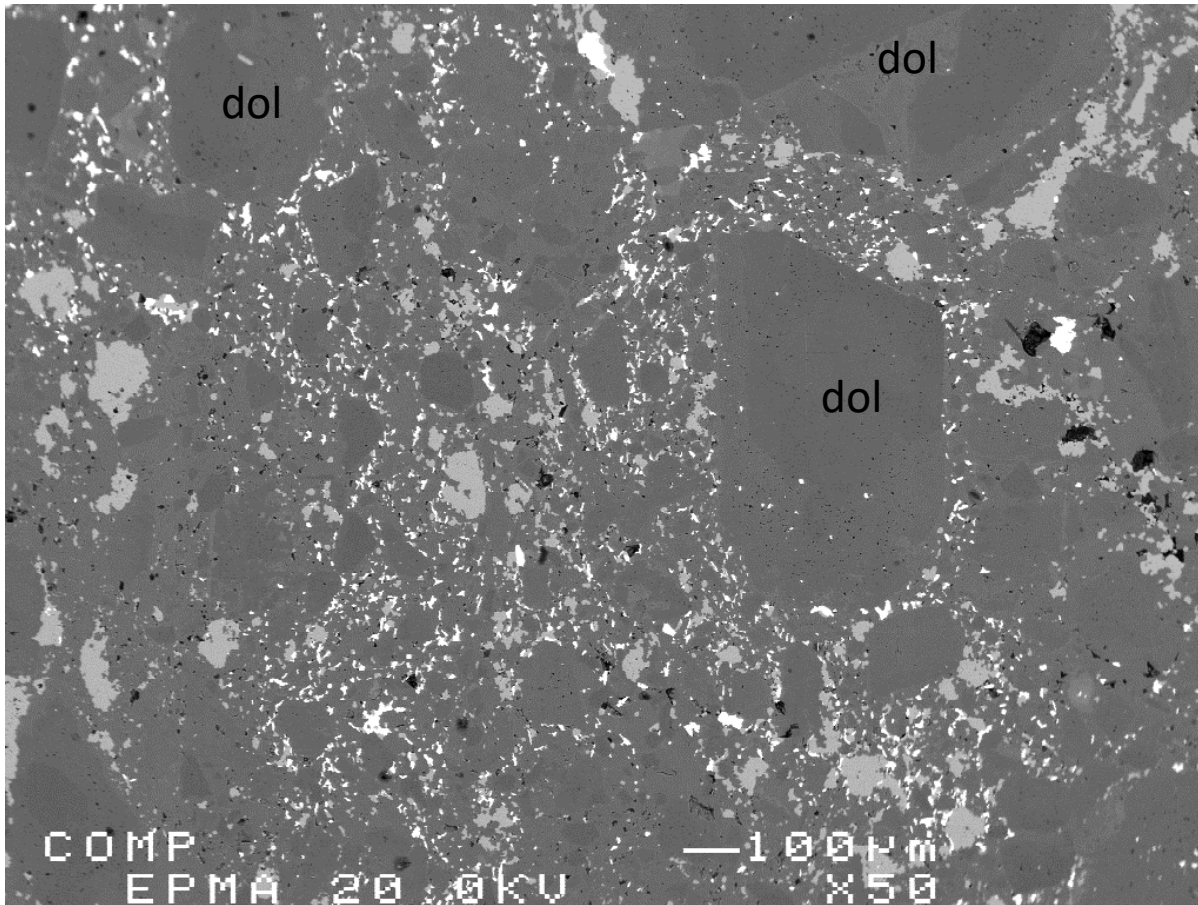


Zone	Grade (wt % TREO)	MHREO/TREO	Principal Ore Mineral (s)	Principal Carbonate	Phosphate Phase	Fluorine Phase
BD	0.6 - 1	~7	REE fluorocarbonates	dolomite	apatite	REE fluorocarbonates
B	1 - 2	~4	monazite-(Ce)	dolomite	monazite-(Ce)	fluorite
A	1 – 3+	~6	monazite-(Ce)	Fe-dolomite	monazite-(Ce)	fluorite
MHREO	1.6	~11	monazite-(Ce), xenotime-(Y), aeschnite-(Y)	siderite	monazite-(Ce) xenotime-(Y)	fluorite

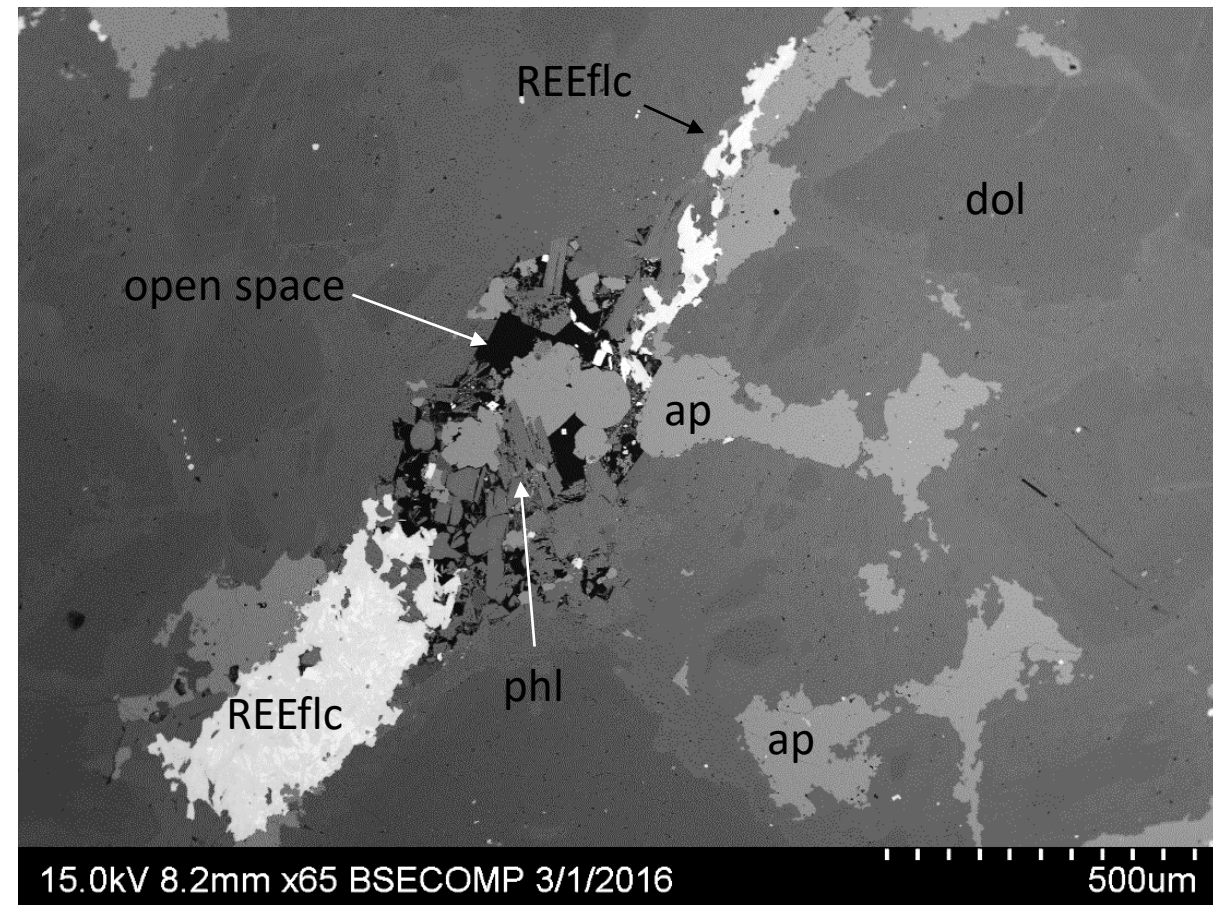
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# 'BD zone' REEflc Textures

Disseminated fluorite, apatite and REEflc in breccia

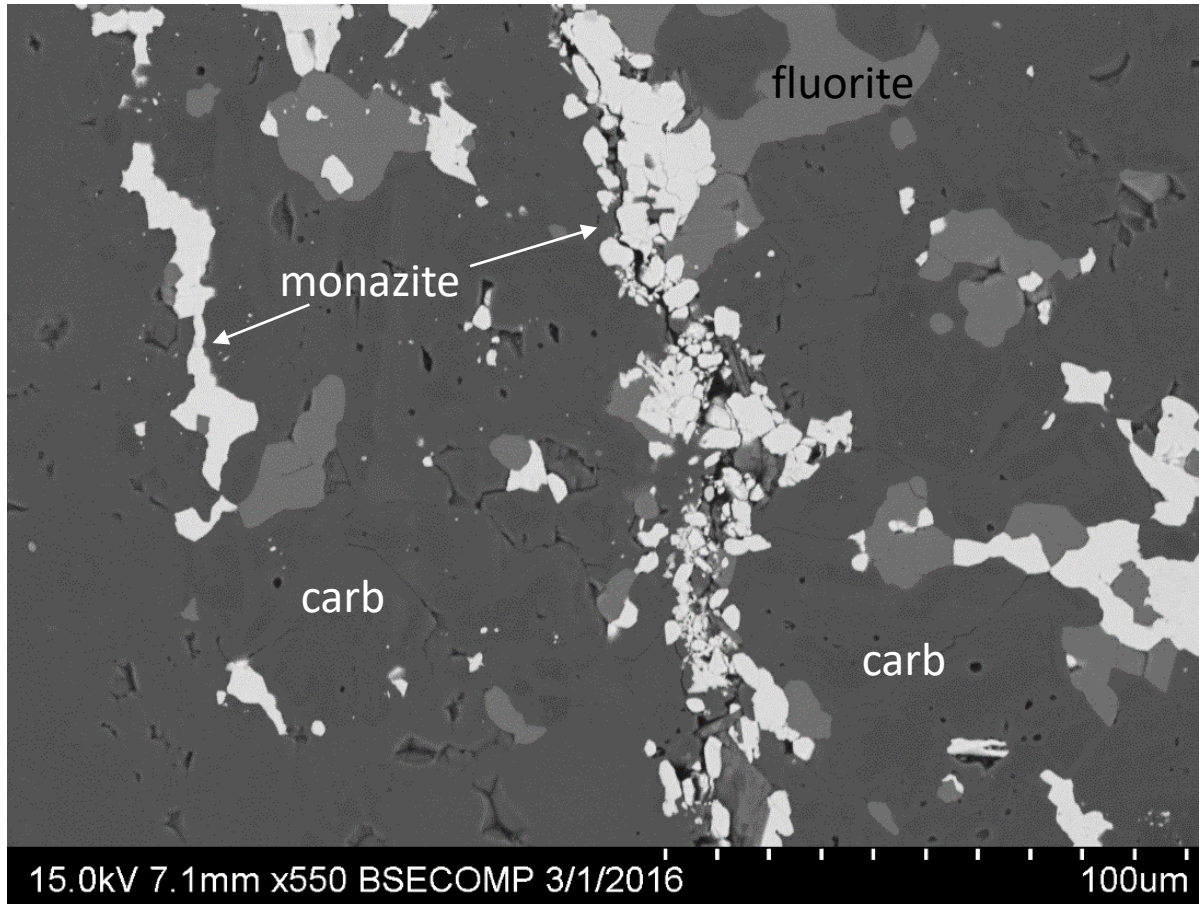


REEflc in veins and vugs



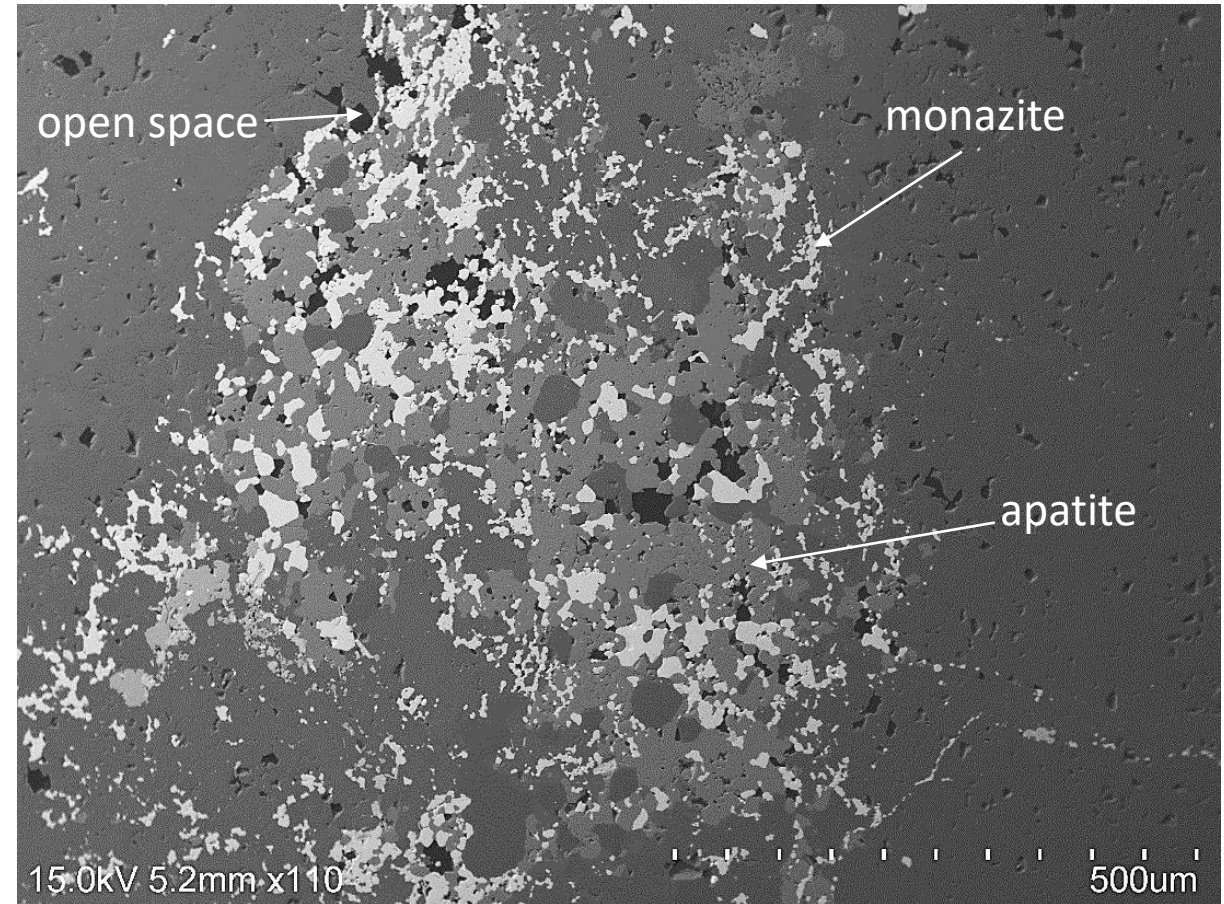
# Monazite Textures

## Fluorite + Monazite-(Ce) in veins



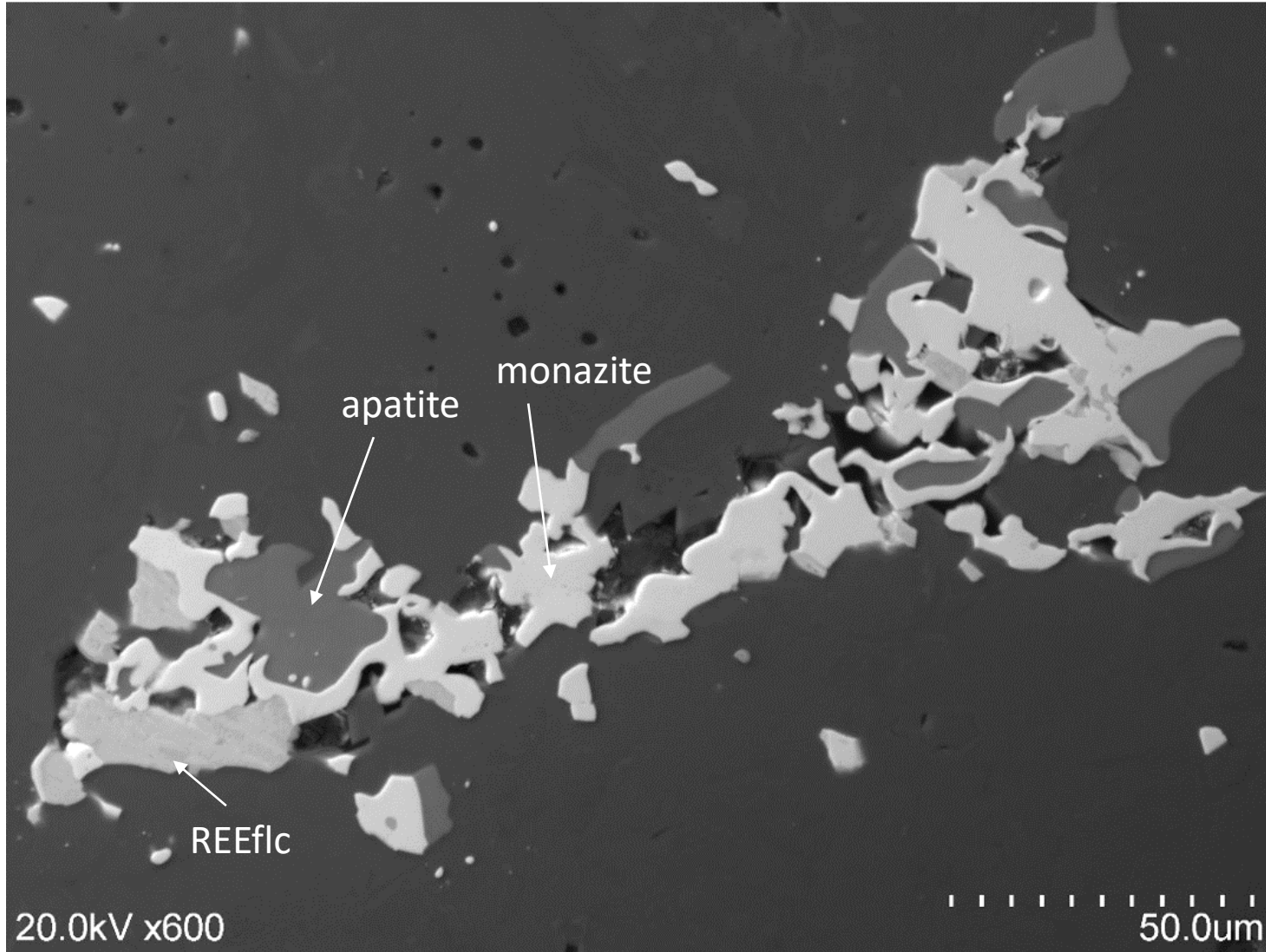
Common

## Apatite + Monazite-(Ce) in veins



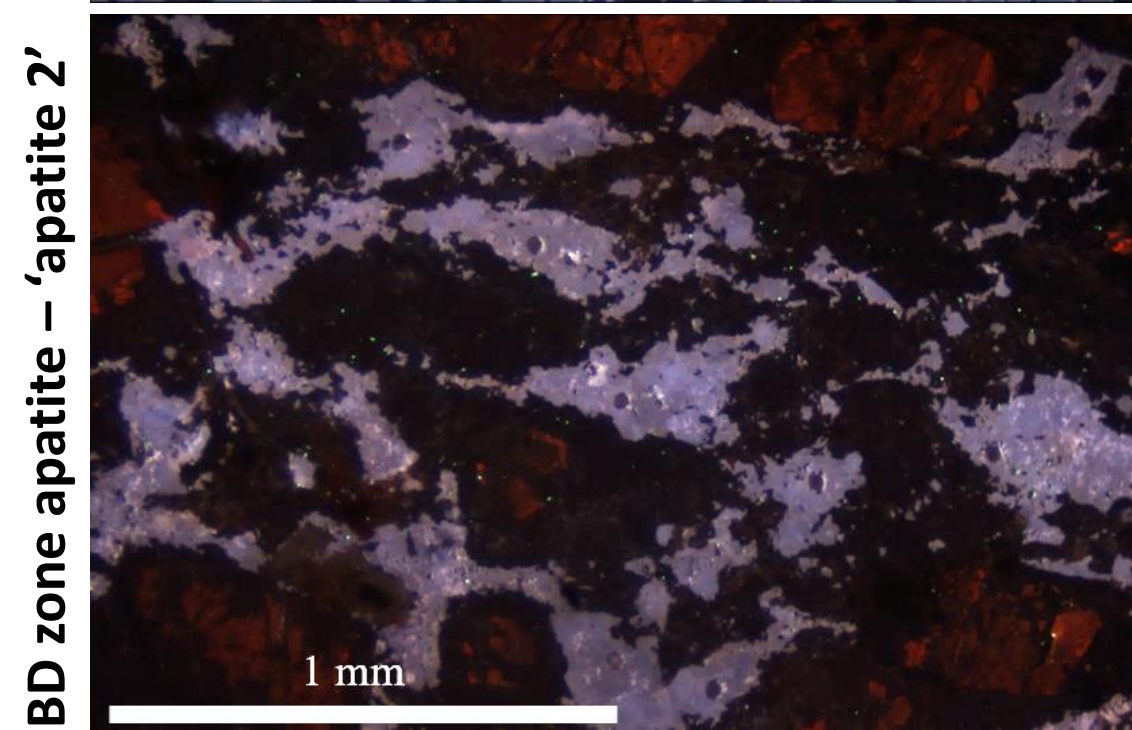
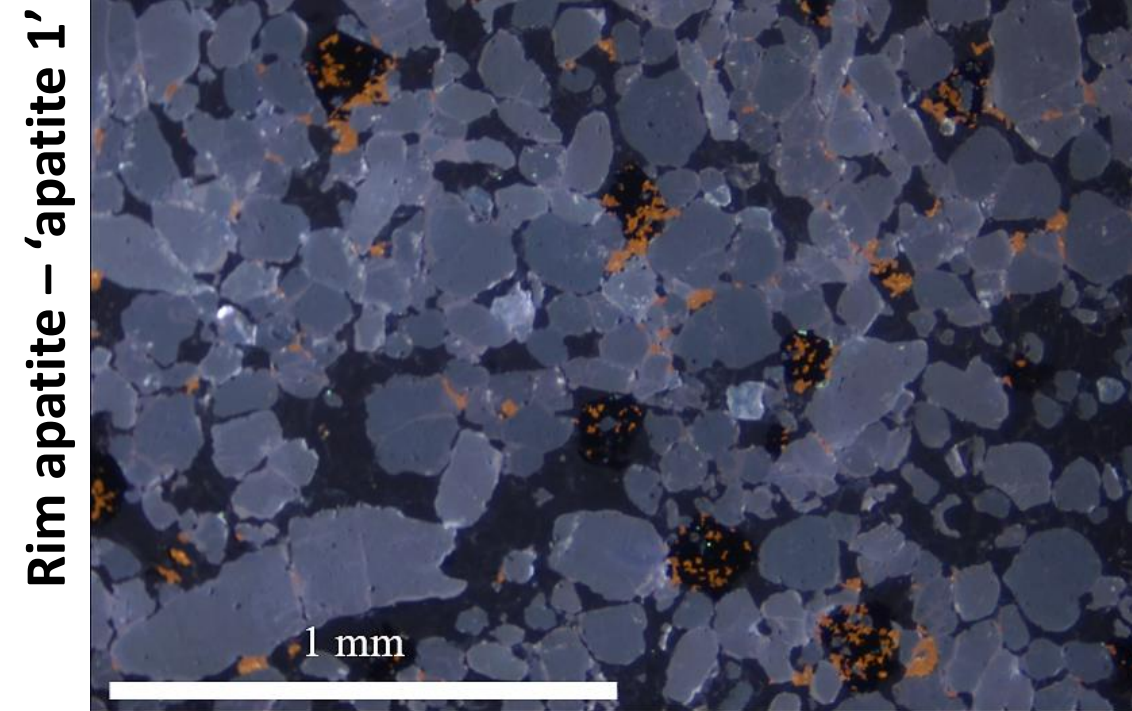
Rare

# Apatite - Monazite – REEflc Relationship

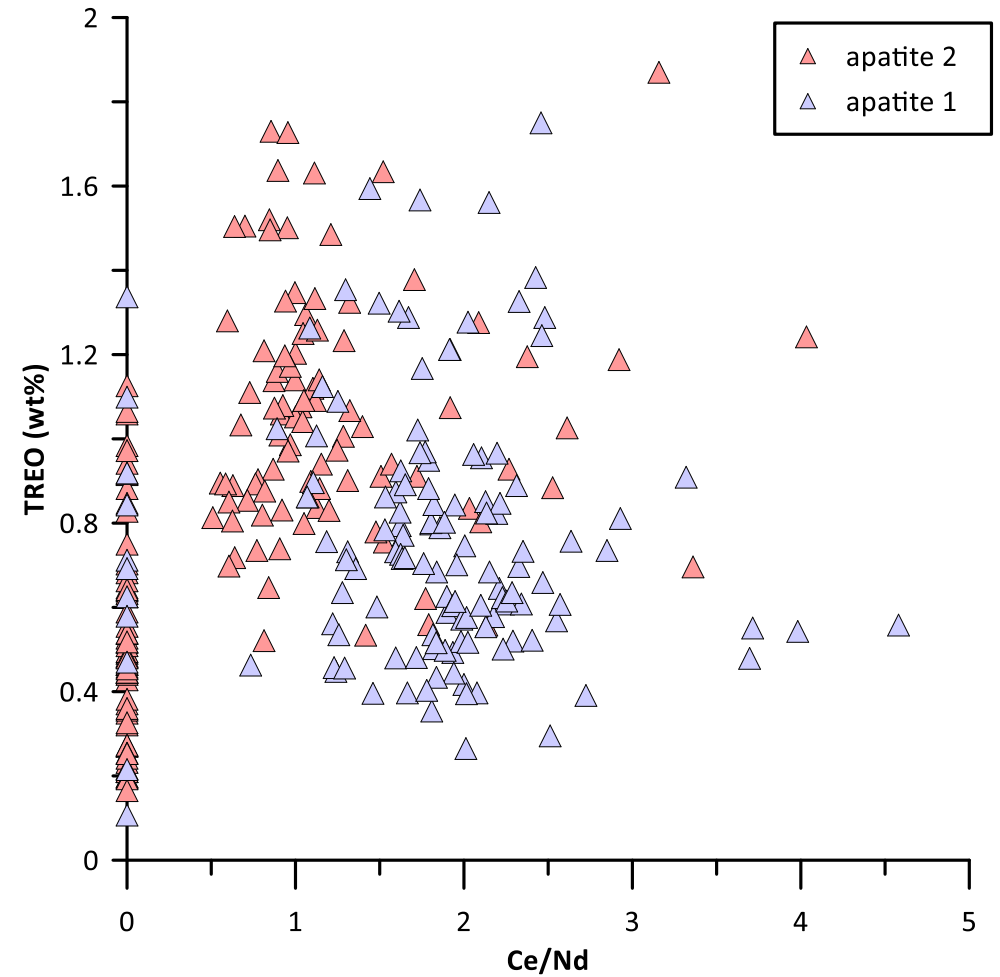


Where observed in contact:

- Monazite-(Ce) occurs within, or mantles apatite
- REEflc mantles monazite

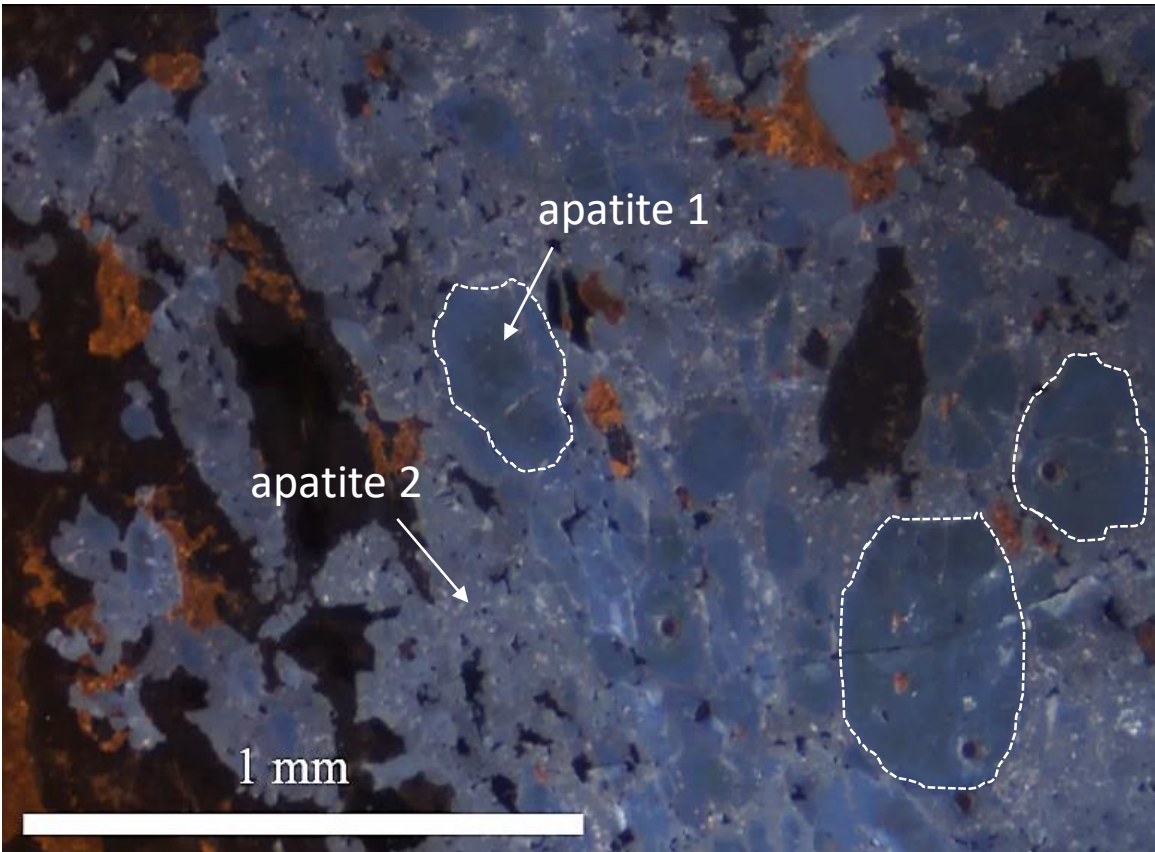


# Eldor-Ashram Apatite

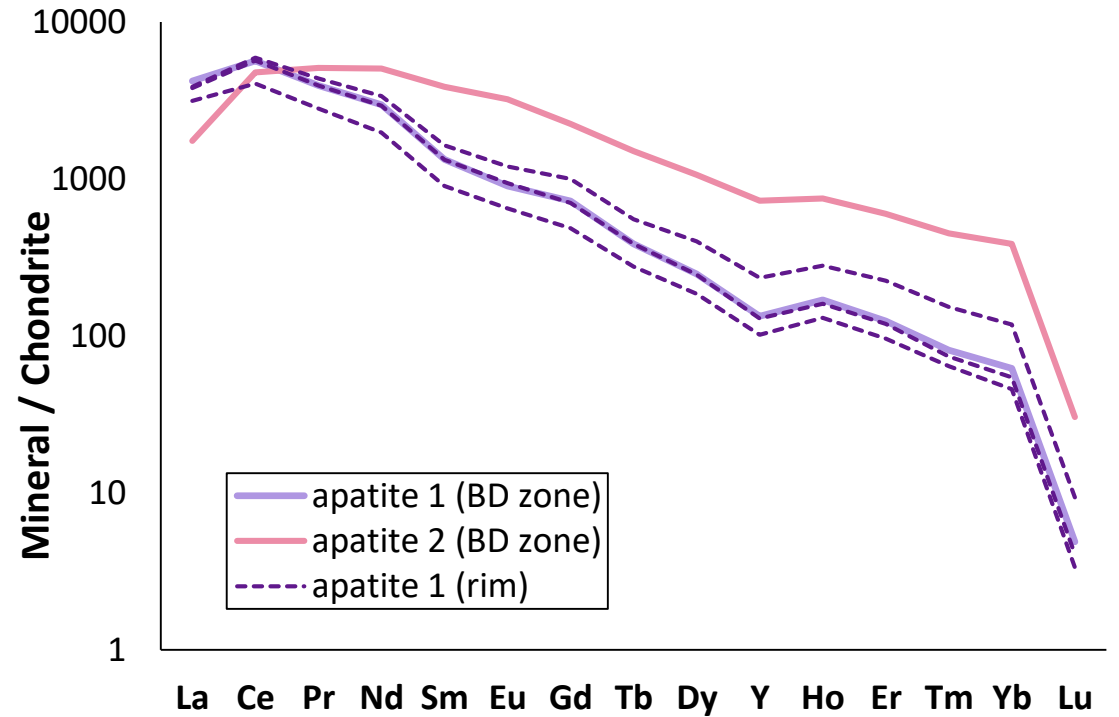


**Apatite 1 and 2 indistinguishable by major element chemistry**

# Apatite Chemistry



**apatite 1 → apatite 2 by dissolution-reprecipitation**



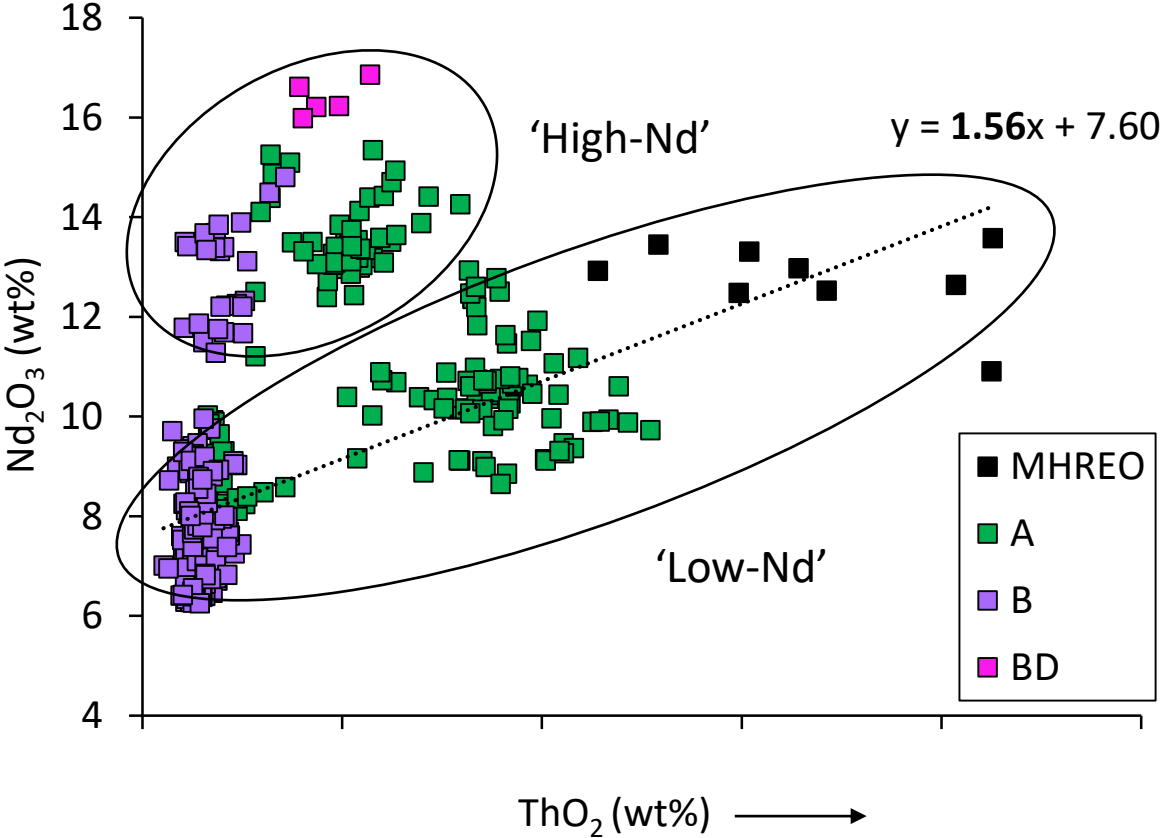
Textural criteria for dissolution-reprecipitation (Putnis, 2009):

- Two generations observed in contact
- Sharp boundary between generations

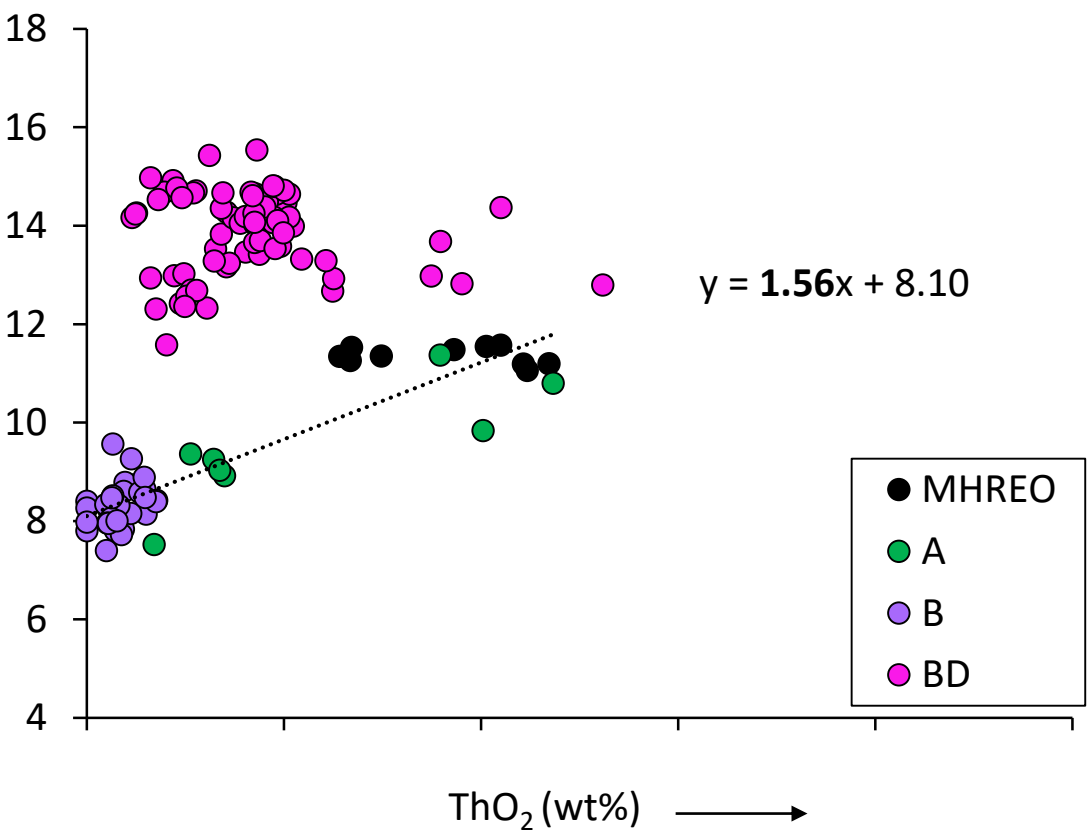
# Ore Mineral Chemistry

Replacement of monazite-(Ce) by bastnäsite-(Ce)

### Monazite-(Ce)

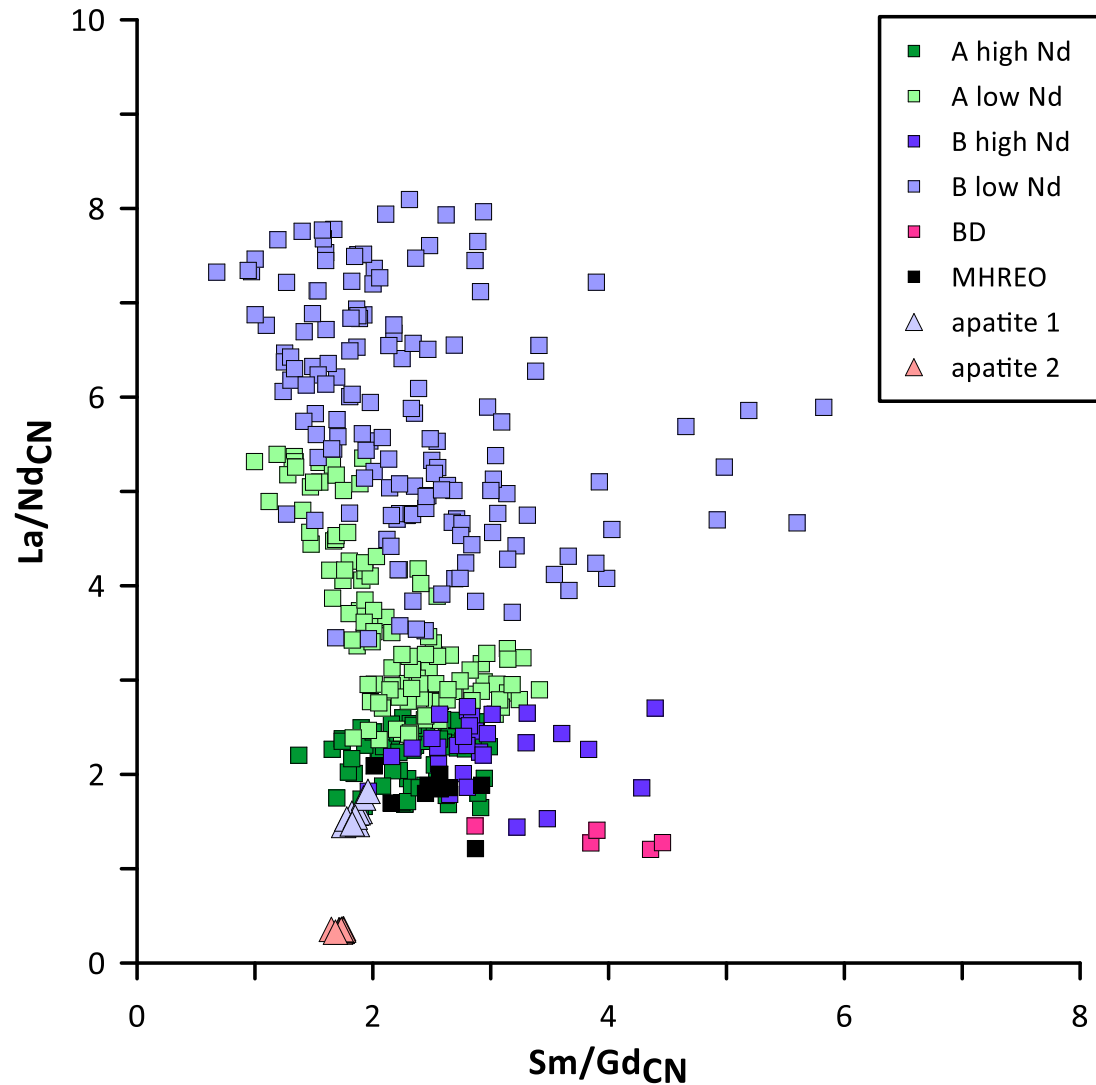
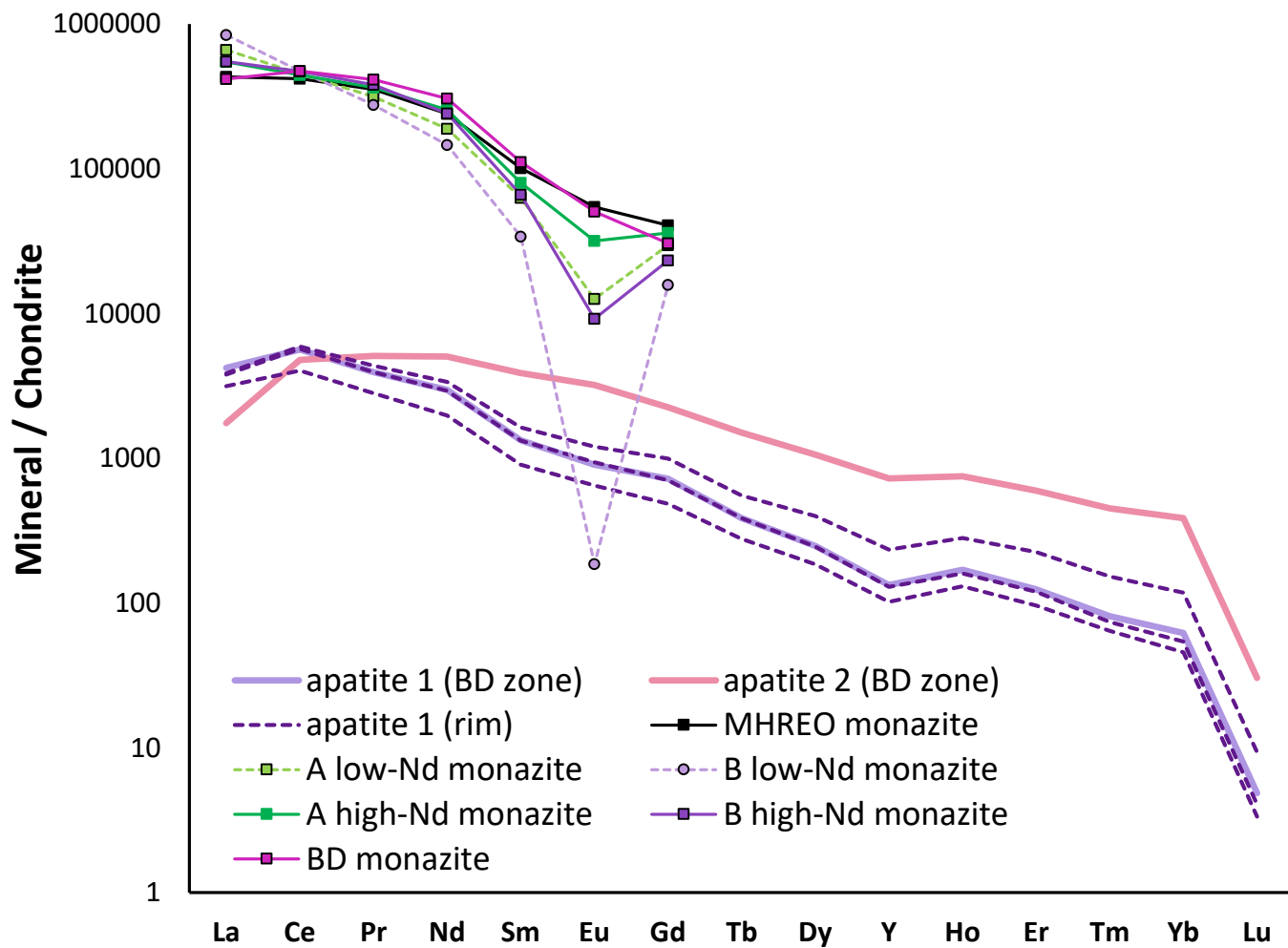


### Bastnäsite-(Ce)



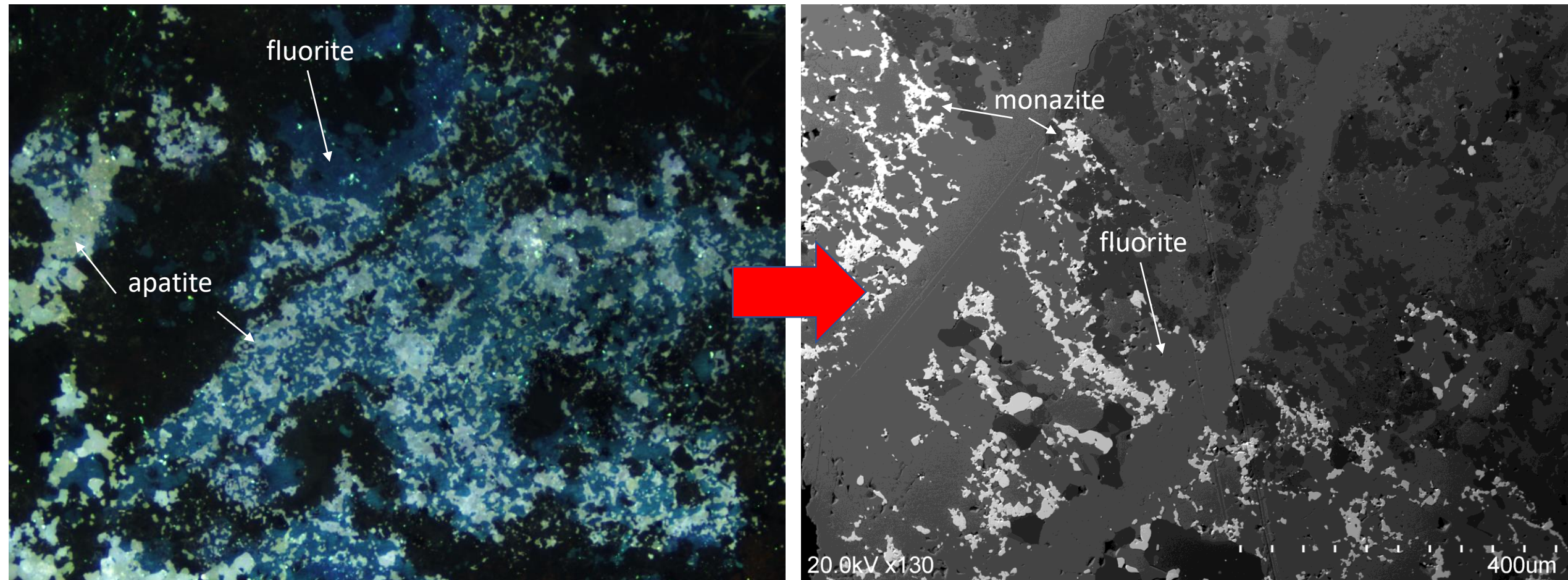


# Apatite-Monazite Relationship

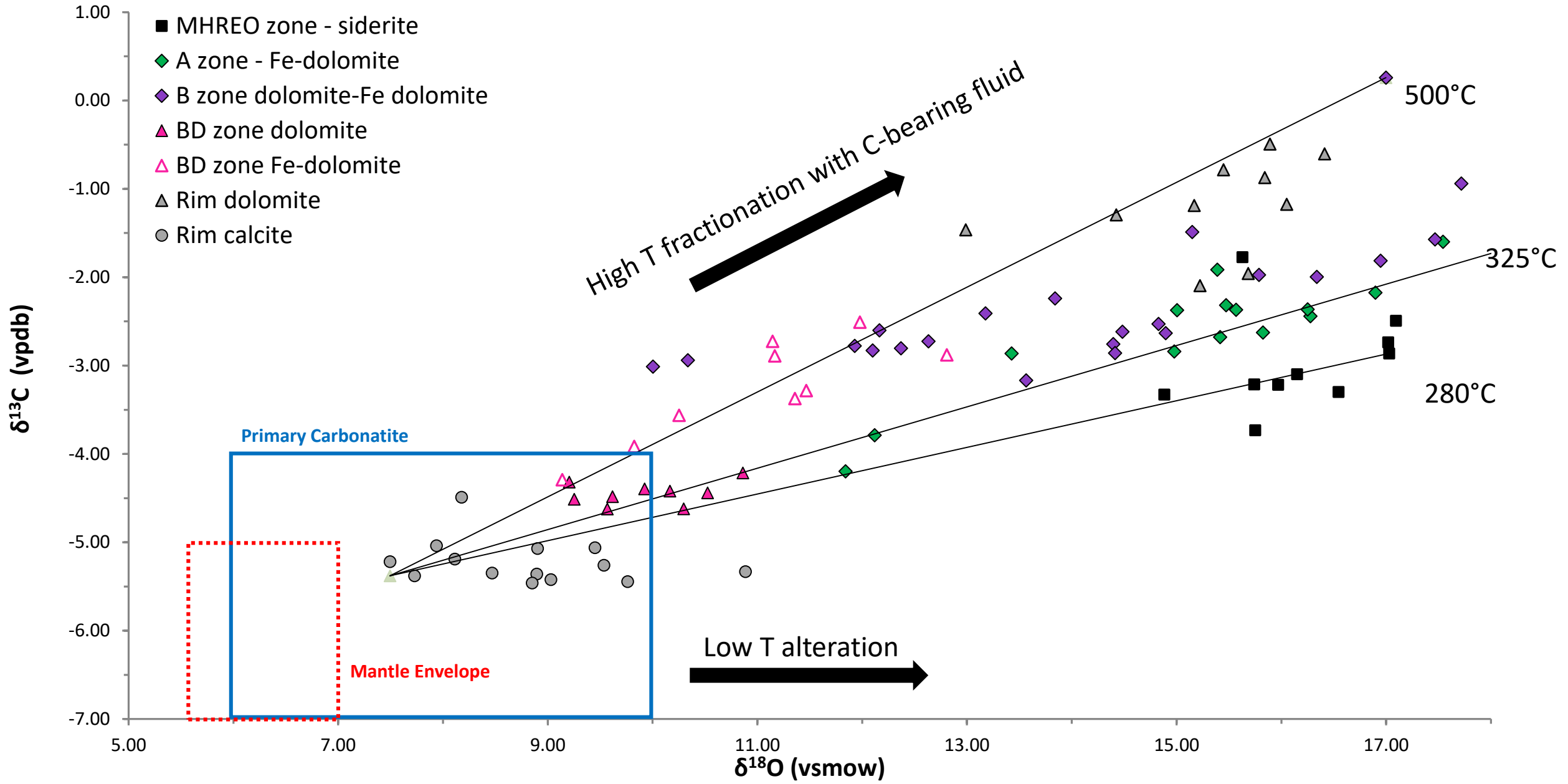


# Apatite-Fluorite Relationship

Apatite  $\rightarrow$  monazite reaction releases Ca and F necessary for fluorite



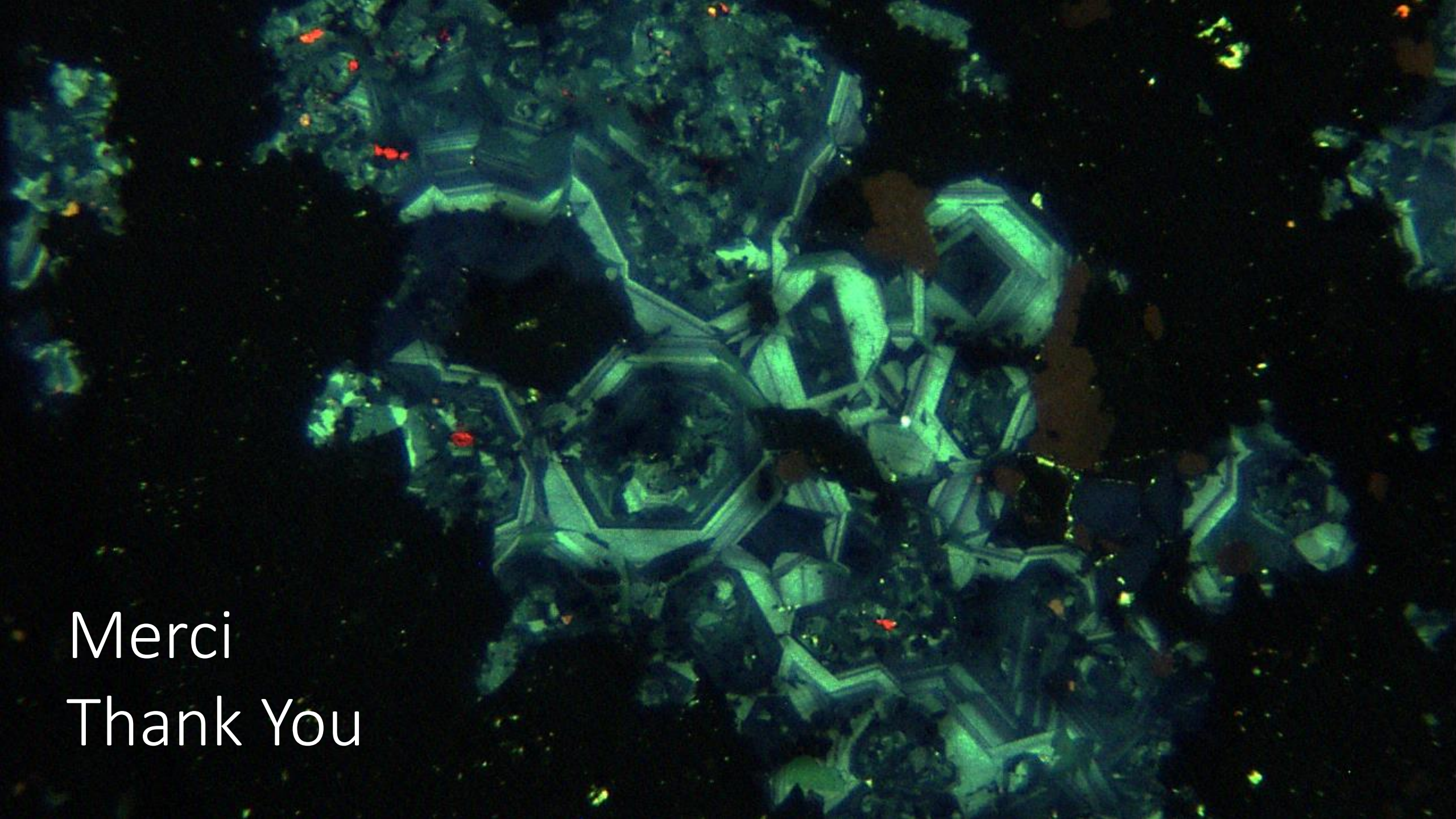
# Likely Source of Fluids?



# Partial Paragenesis

timing uncertain

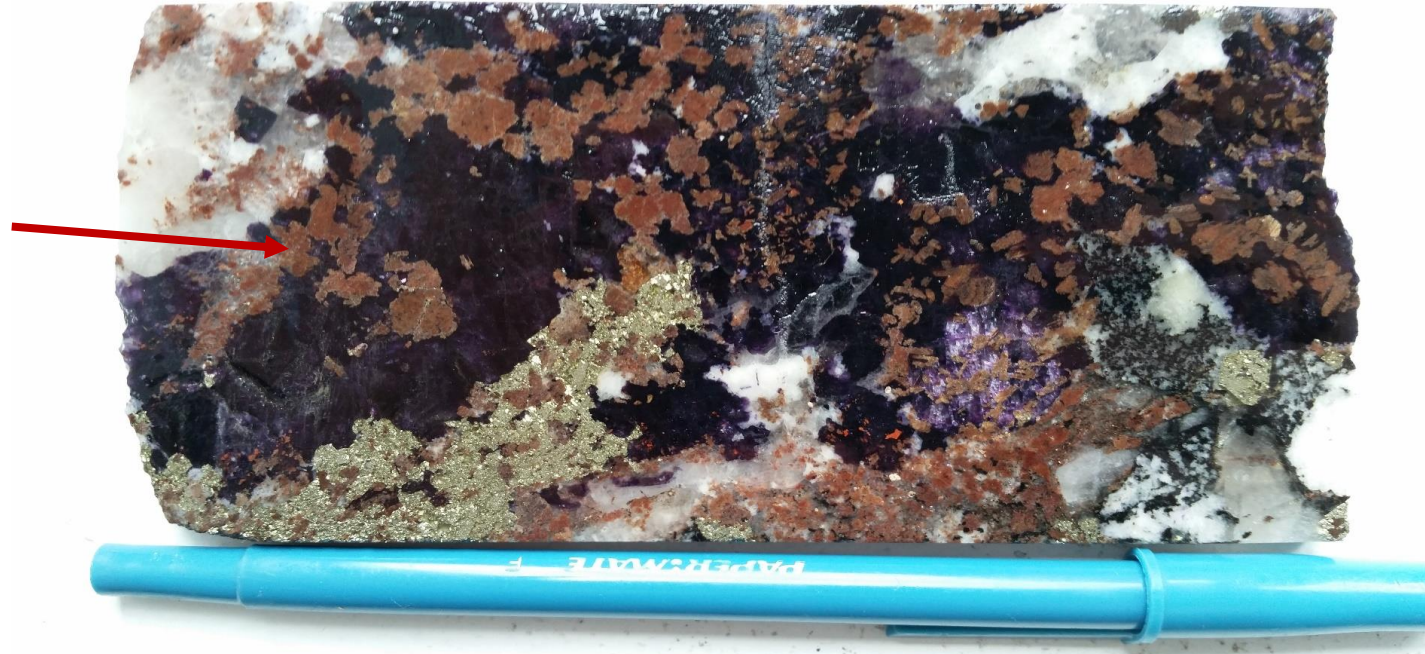
- apatite 1 → apatite 2 by dissolution-reprecipitation
- apatite 1 → high-Nd monazite-(Ce) by dissolution-reprecipitation
  - $\text{Ca}_{4.94}\text{REE}_{0.060}(\text{PO}_4)_3\text{F} = 0.060\text{REEPO}_4 + \text{F}^- + 4.94\text{Ca}^{2+} + 2.94\text{PO}_4^{3-}$
- low-Nd monazite-(Ce) ??
  - From apatite + LREE?
  - From unidentified apatite type?
- monazite-(Ce) → bastnäsite-(Ce)
  - $\text{REEPO}_4 + \text{CO}_3^{2-} + \text{F}^- = \text{REECO}_3\text{F} + \text{PO}_4^{3-}$



Merci  
Thank You

Zone	Grade (wt% TREO)	MHREO/TREO (%)	Principal Ore Mineral(s)
BD	0.6 - 1	~ 7	REE-fluorocarbonates
B	1 - 2	~ 4	monazite-(Ce)
A	1 - 3+	~ 6	monazite-(Ce)
MHREO	1.6	~ 11	monazite-(Ce), xenotime-(Y), aeschynite-(Y),

Coarse-grained REEflc in late vein with fluorite, quartz, pyrite, feldspar



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