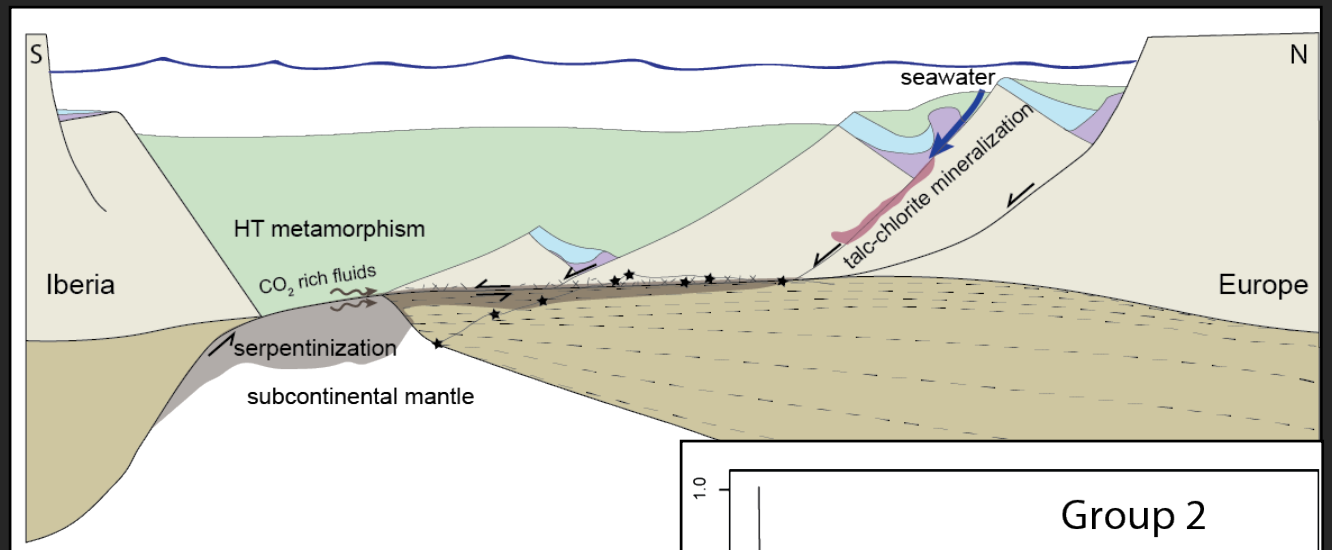
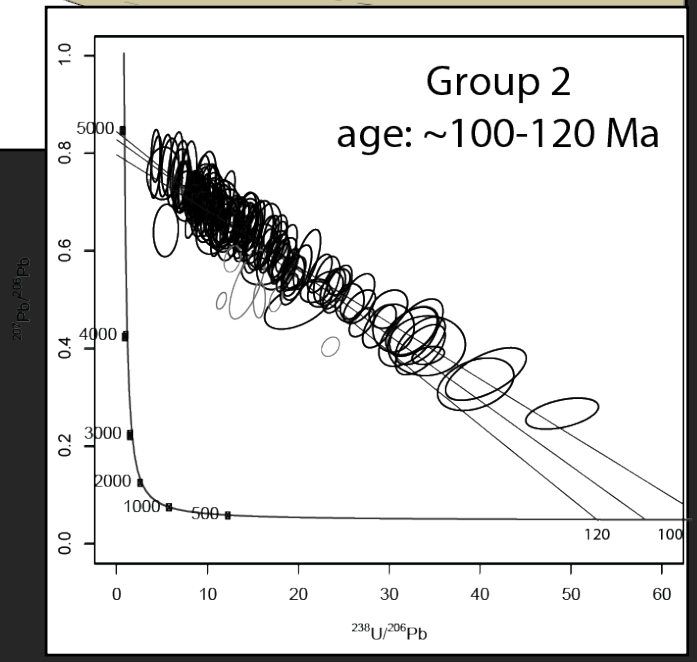
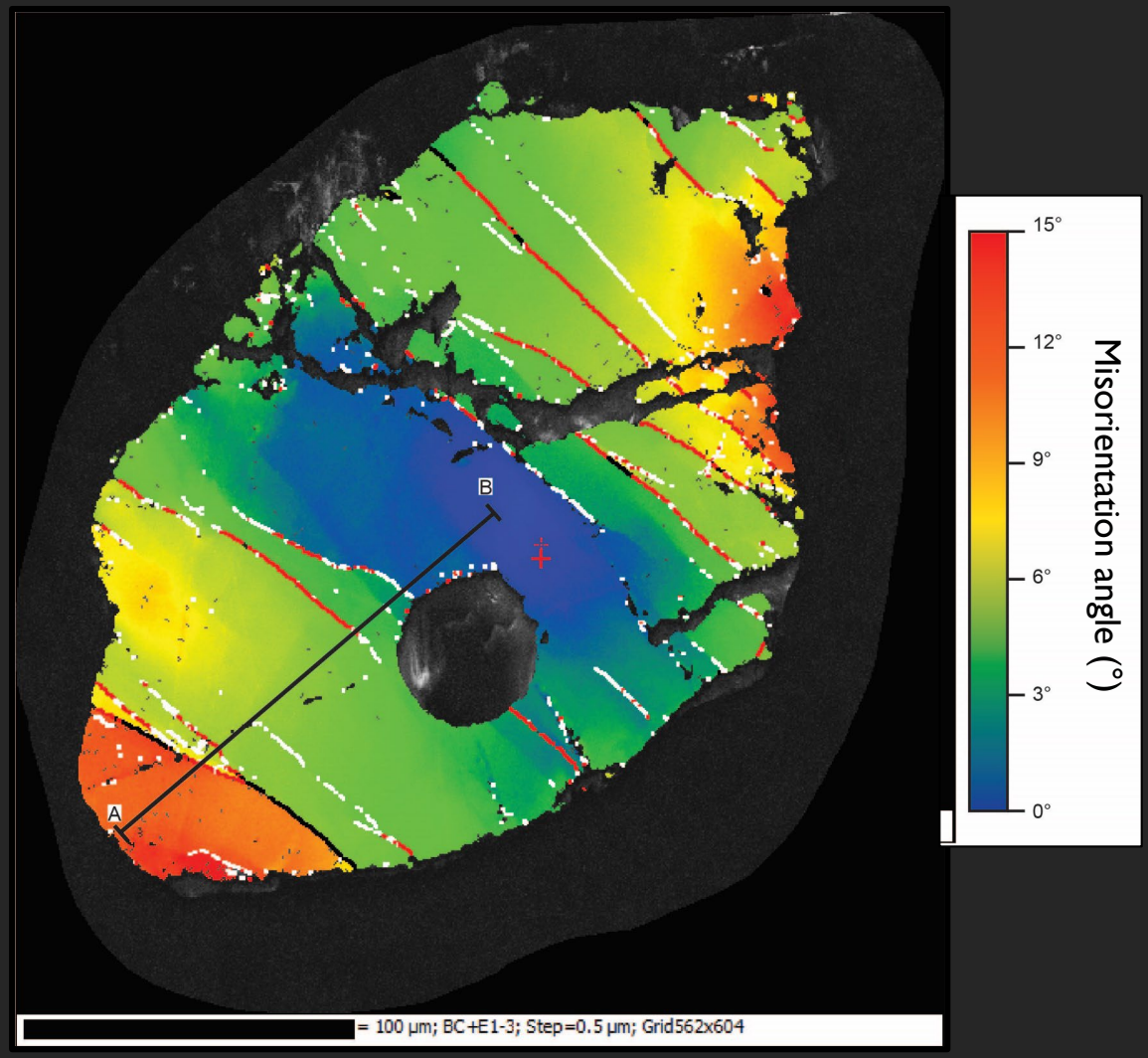
Deformed Apatite Dates Deformation:
Investigating the effect of crystal plastic deformation on U-Pb systematics

Drew Levy (UNR), Margo Odlum (USU), and Joel DesOrmeau (UNR)



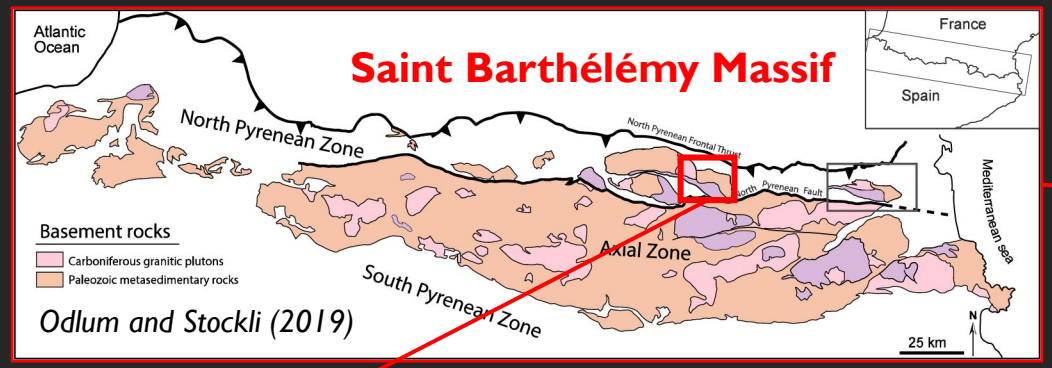
Odlum and Stockli (2020)



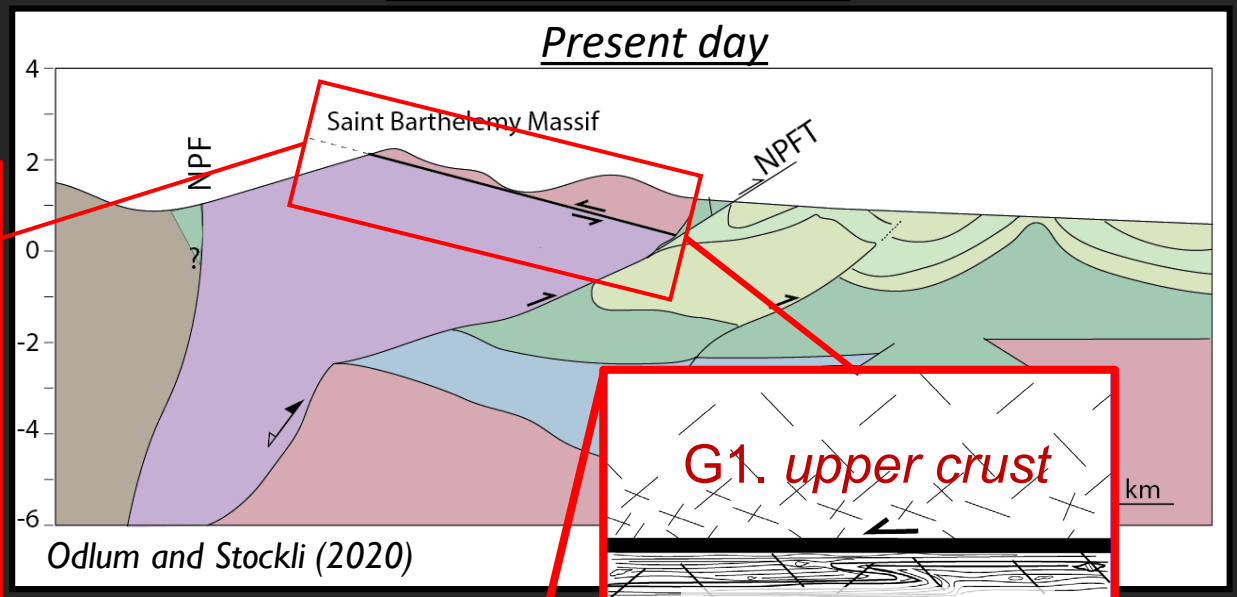


Early Cretaceous Hyper-Extension of the Variscan Hinterland

- High-grade metamorphic core of the Variscan Orogeny
- Pervasive mylonitic deformation during Cretaceous extension
- Paleocene-present convergence and uplift



Odlum and Stockli (2019)



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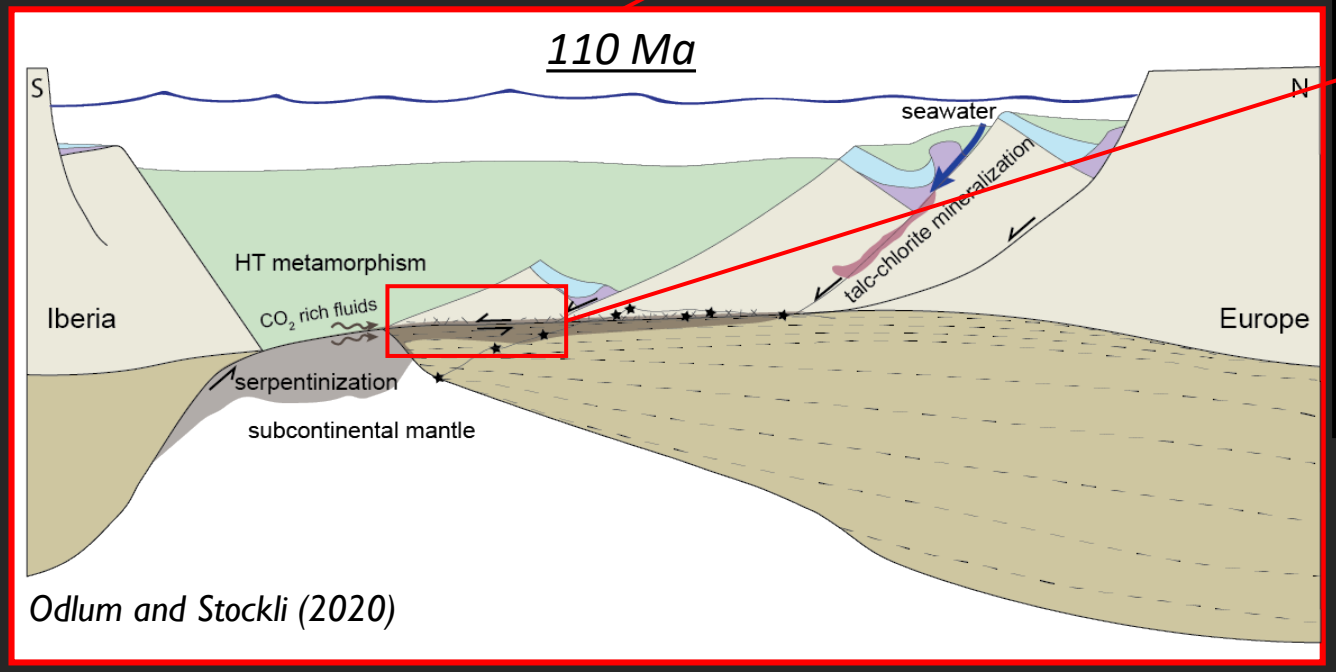
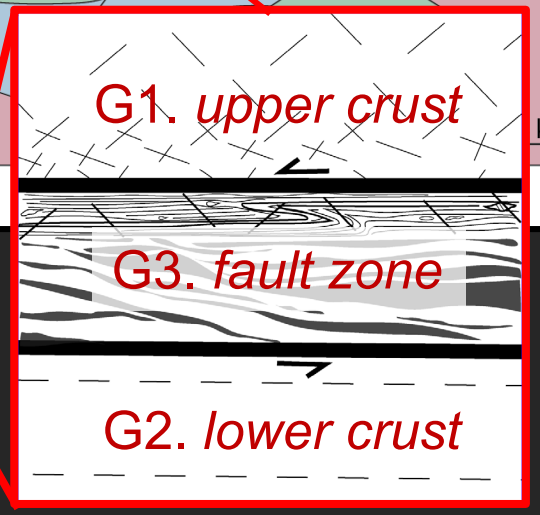


Odlum and Stockli (2020)

3 Strain Domains



3 Strain Domains = 3 Apatite Microtextural Groups

Odlum and Stockli (2020)

Group 1 *(upper crust)*

- Oscillatory zoning
- Post-Variscan cooling

Group 2 *(lower crust)*

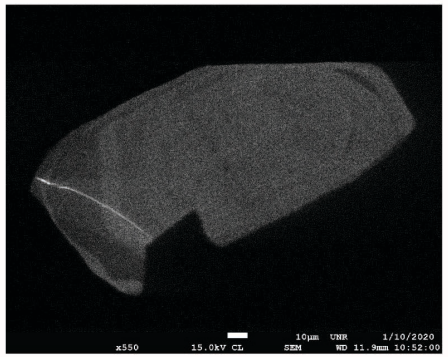
- "tiger-stripe" zoning
- Cretaceous Pb-loss

Group 3 *(fault zone)*

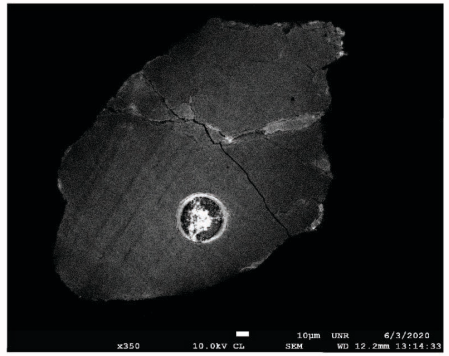
- Patchy zoning
- Variably reset ages

Cathodoluminescence

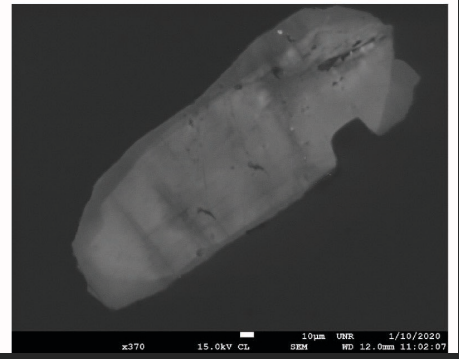
Group 1



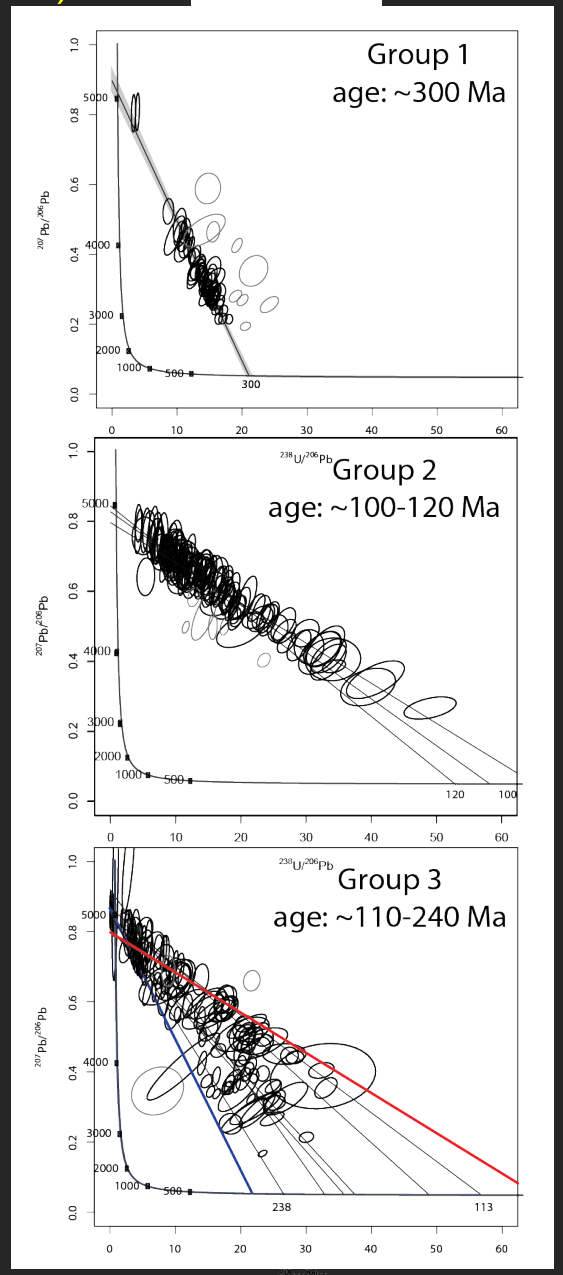
Group 2

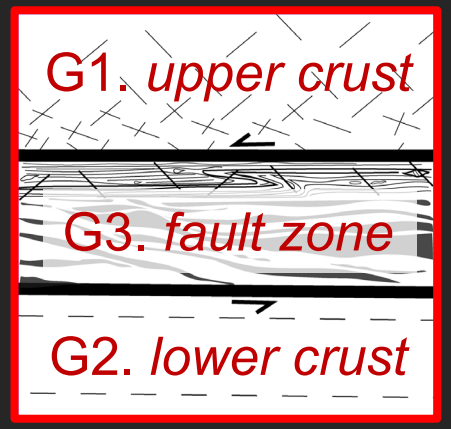


Group 3

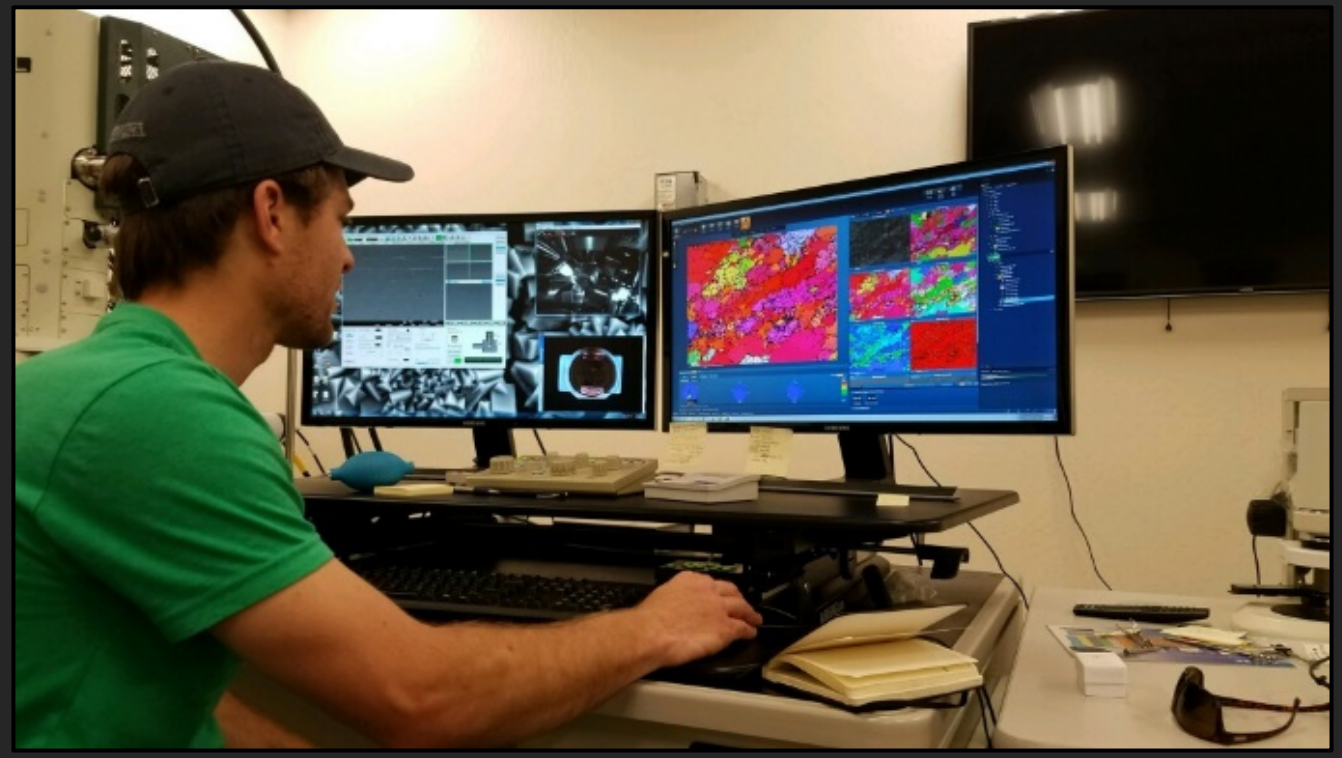


U-Pb ages



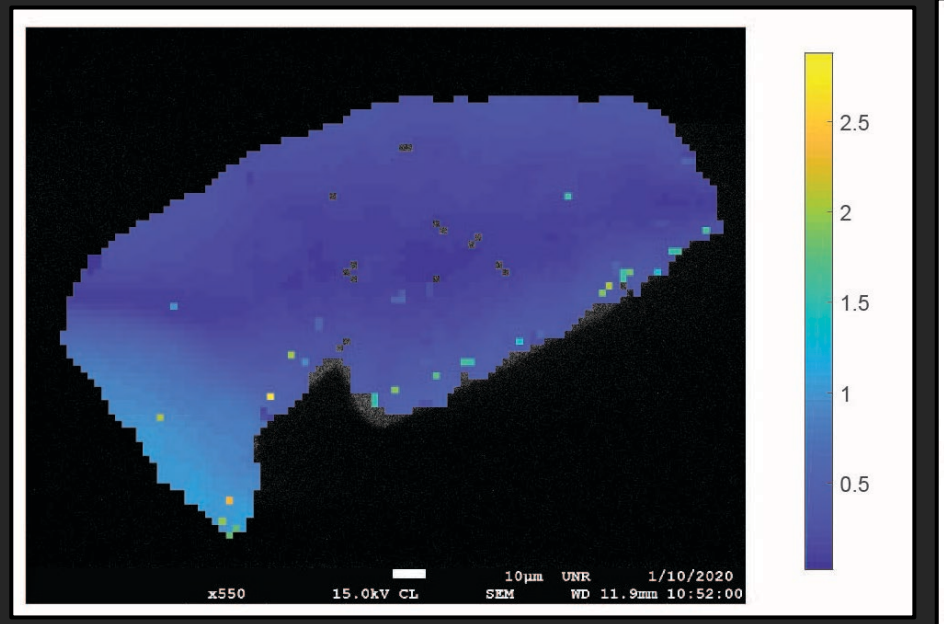


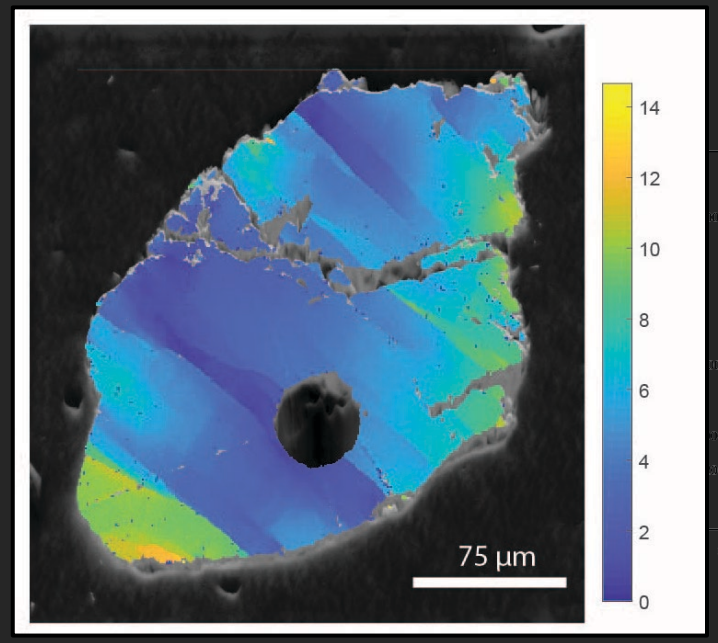
EBSD analysis conducted at UNR Microbeam Laboratory

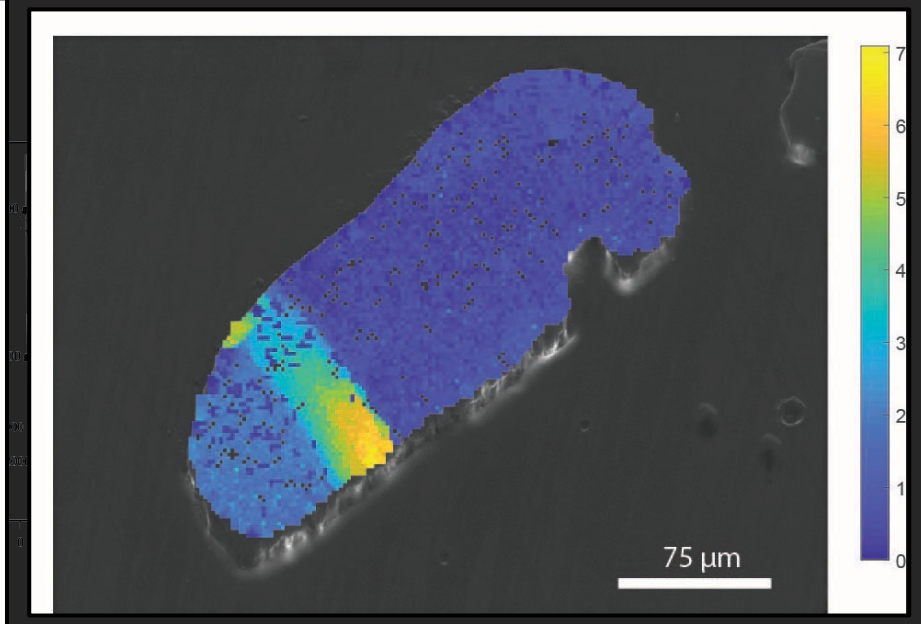


EBSD Data Presentation

Misorientation to the Mean







3 Strain Domains = 3 Apatite Microtextural Groups

Group 1 *(upper crust)*

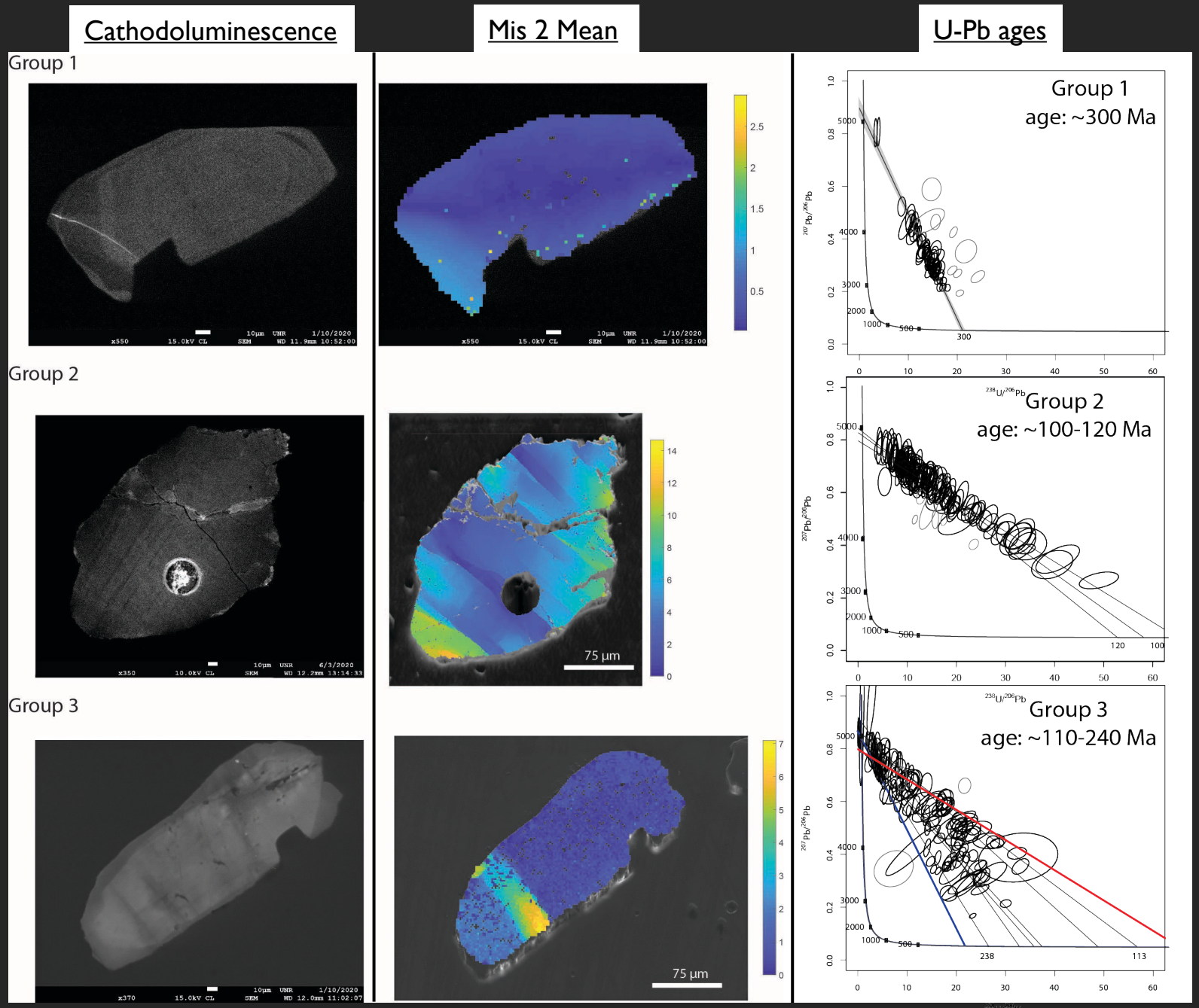
- Oscillatory zoning
- Post-Variscan cooling
- Undeformed

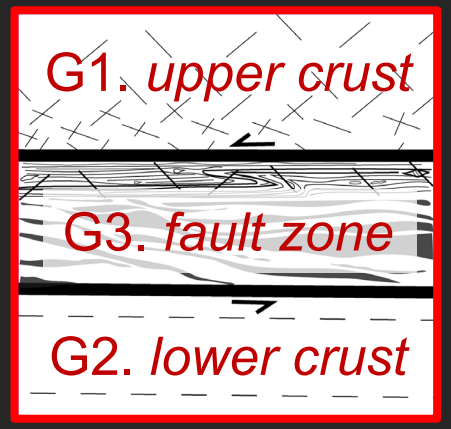
Group 2 *(lower crust)*

- "tiger-stripe" zoning
- Cretaceous Pb-loss
- Strongly deformed

Group 3 *(fault zone)*

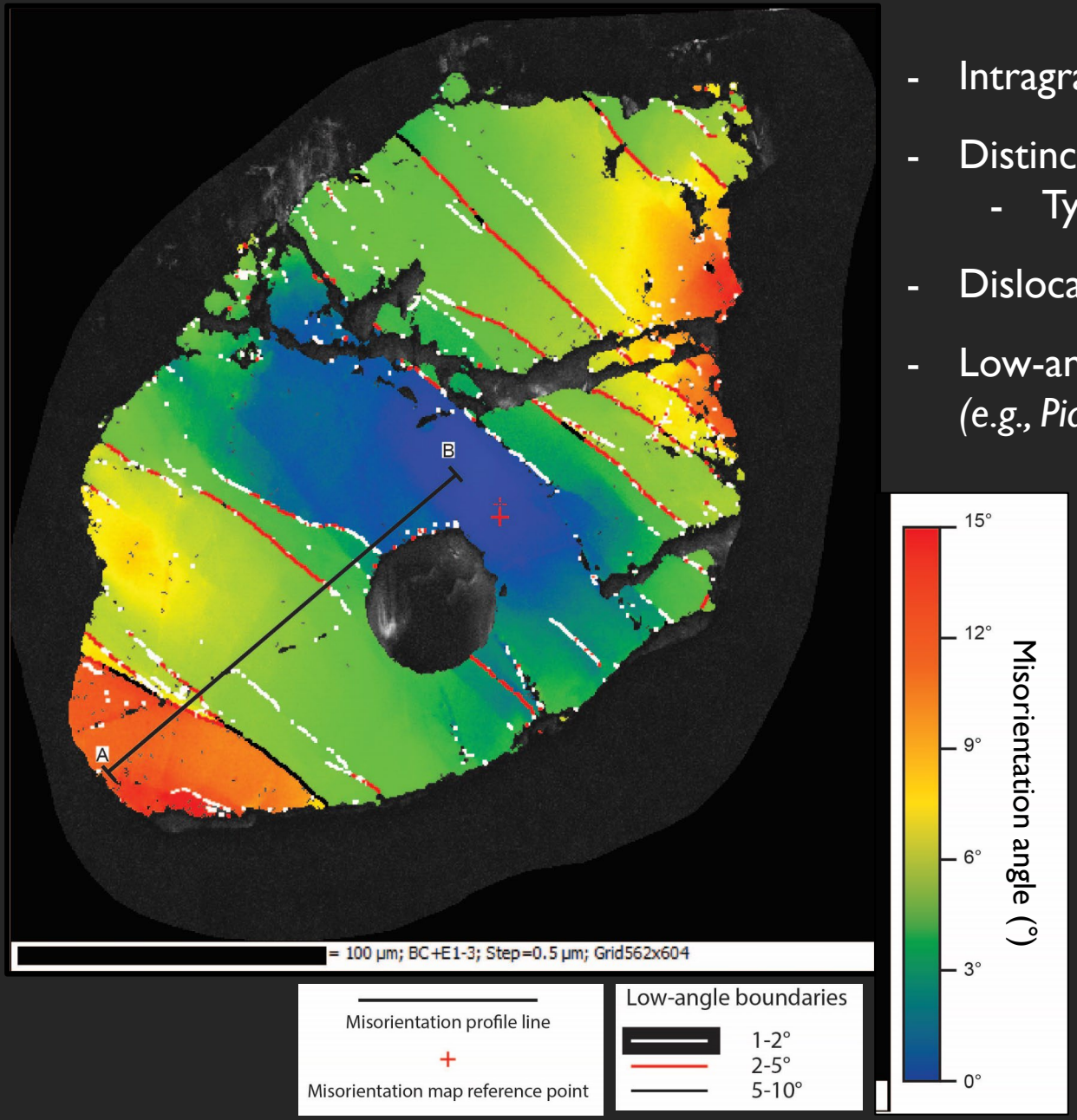
- Patchy zoning
- Variably reset ages
- Variably deformed



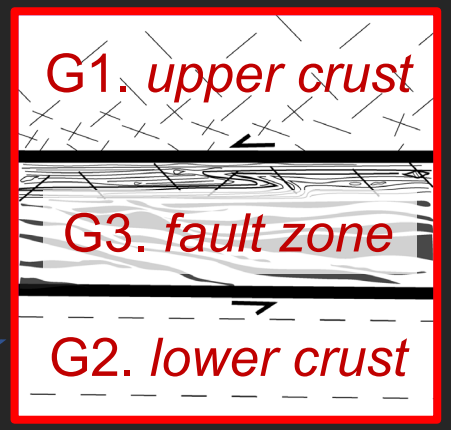


Group 2: Crystal Plastically Deformed Apatite

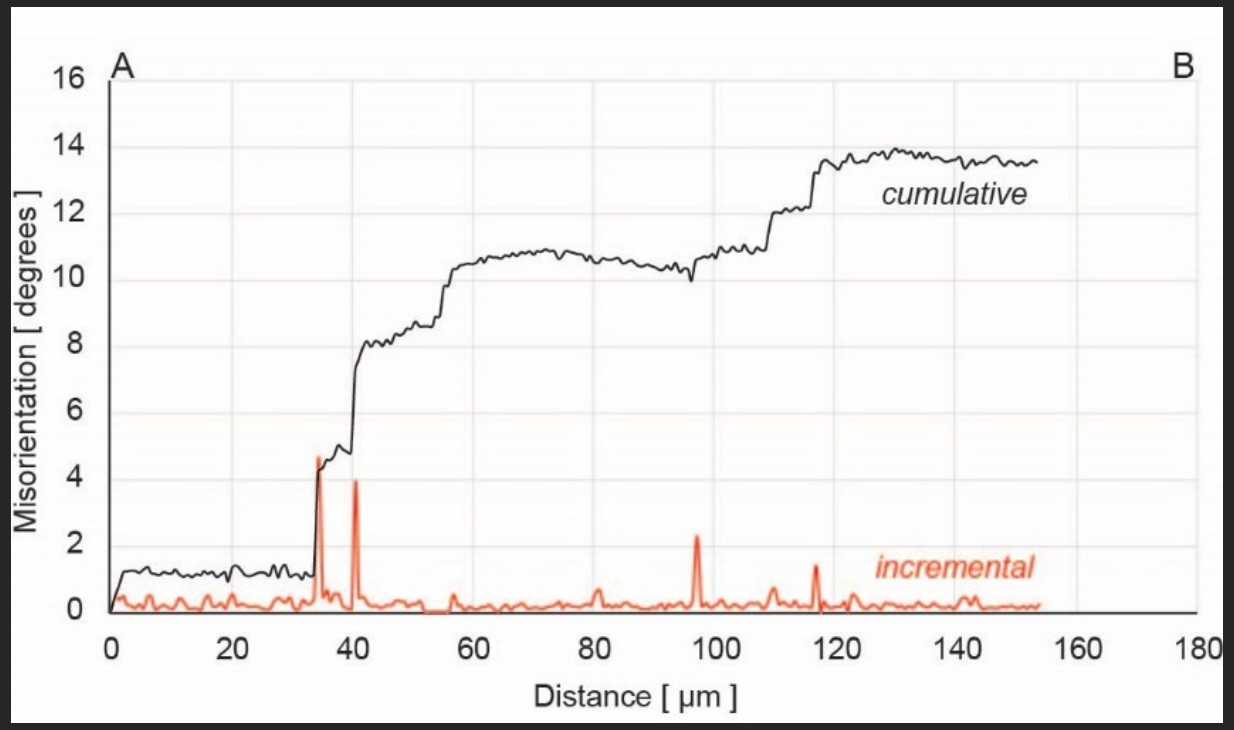
Mis 2 Point



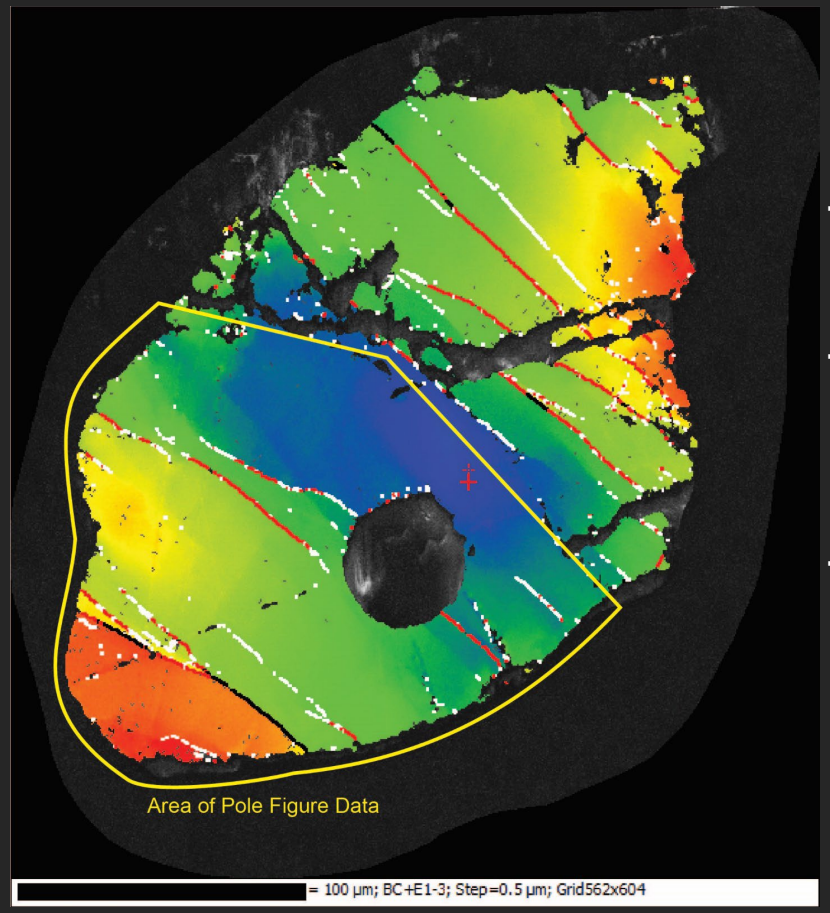
- Intragrain misorientations up to 14°
- Distinct misorientation boundaries
  - Typically low angle (1-5°)
- Dislocation creep deformation mechanism
- Low-angle boundaries capable of diffusion *(e.g., Piazolo et al., 2016)*



Misorientation Profile

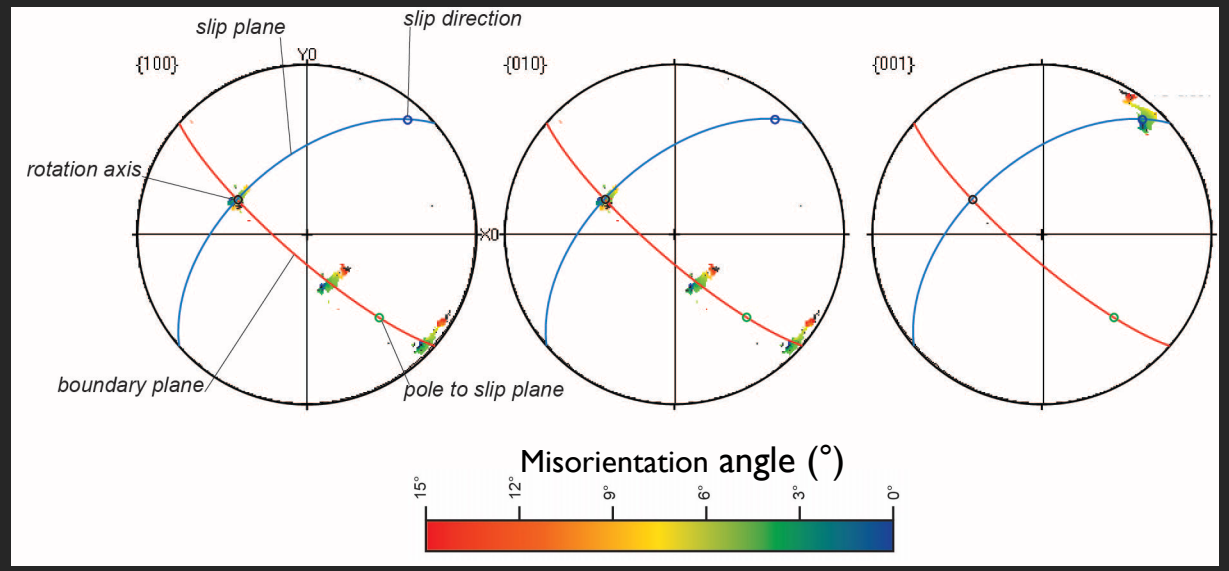


Crystallographic Orientation Data

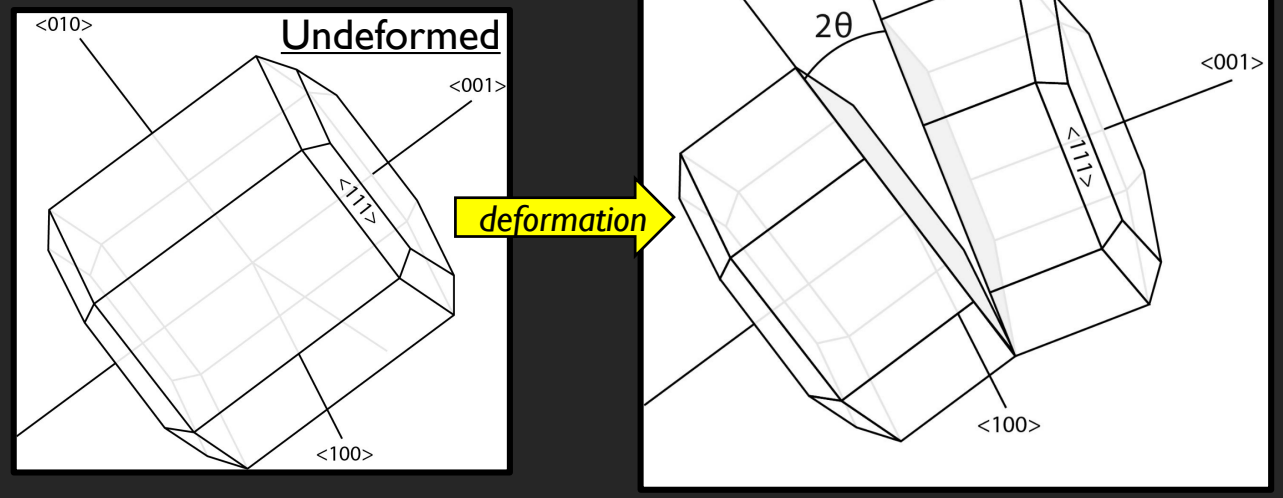


- Points dispersed around rotation axis
- Orthogonal slip and boundary planes
  - Tilt boundary
- Slip system
  [100]<001>

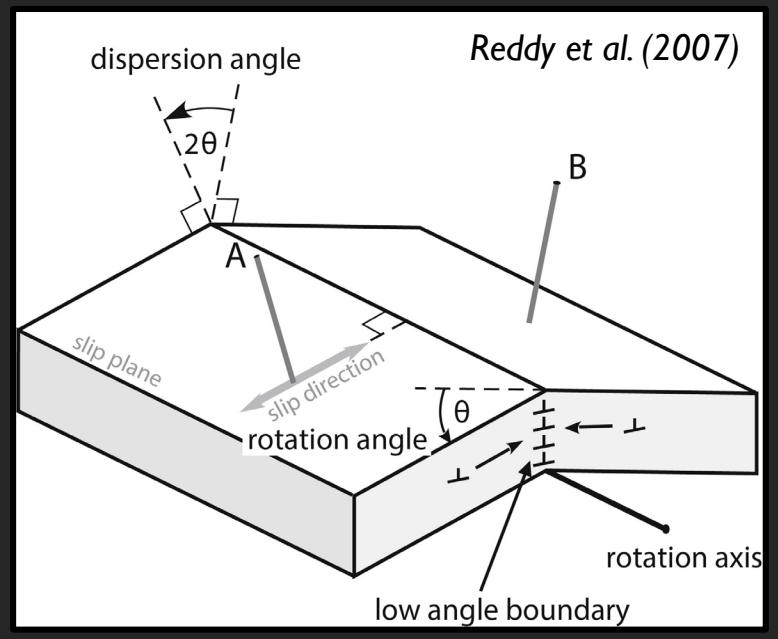
Pole Figures



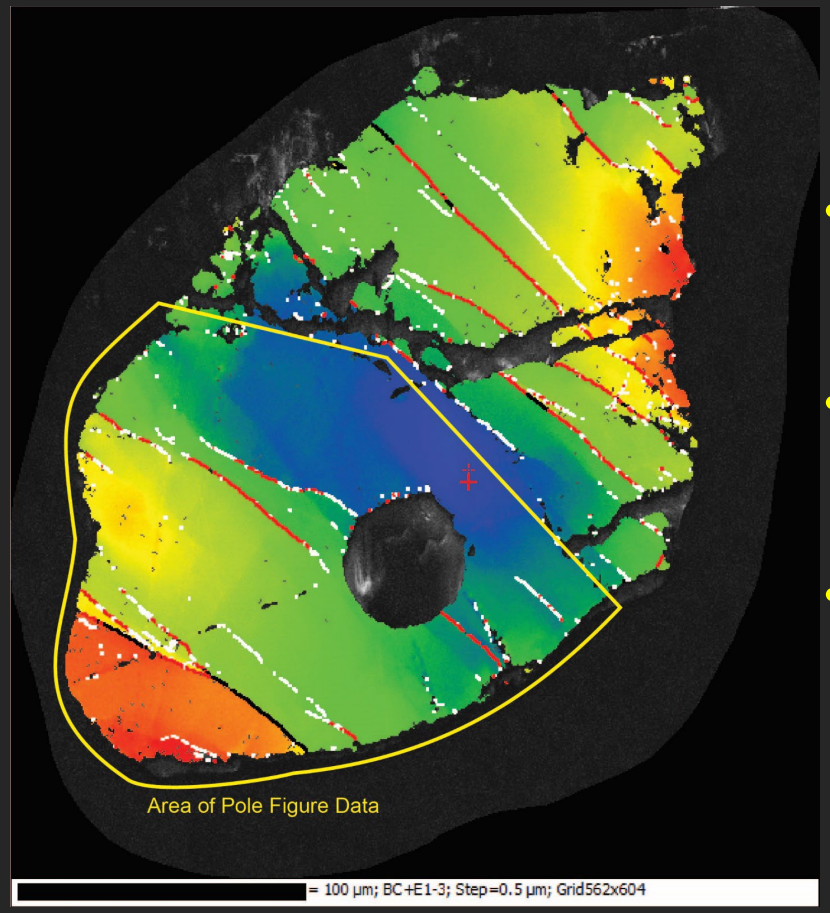
Apatite Crystal



Dislocations and Tilt Boundaries



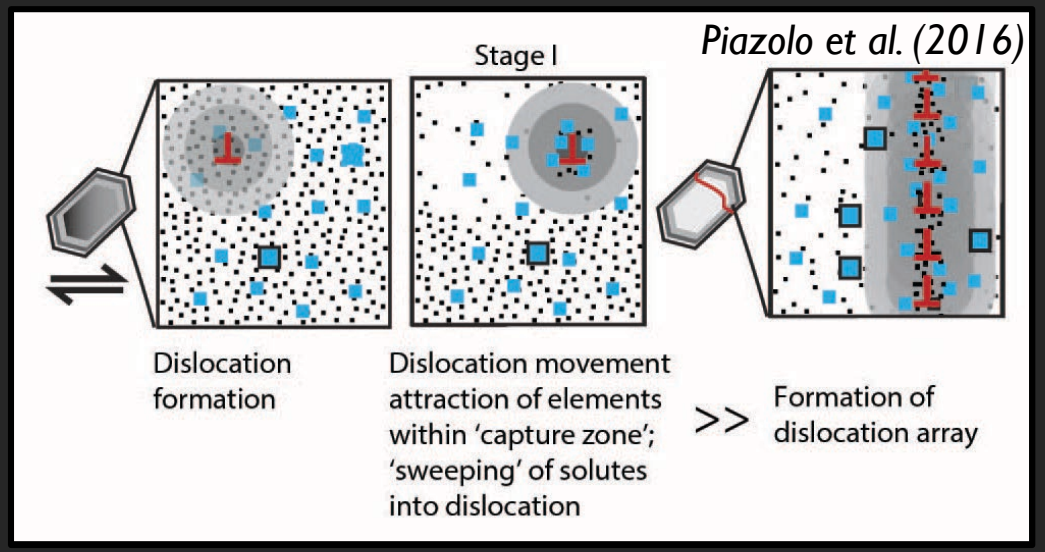
Dislocation Arrays Create Pb-diffusion Pathways?



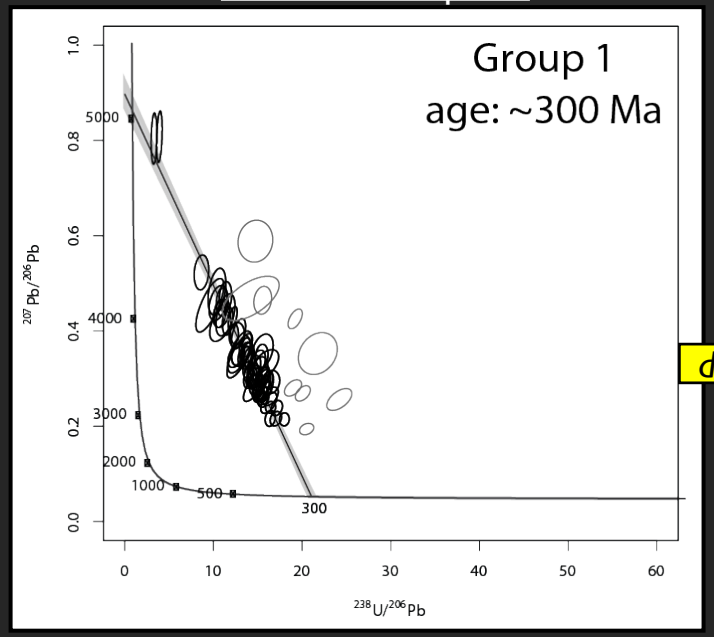
Conclusion

- Grain-scale dislocation arrays accommodate Pb-diffusion?
- Crystal plastic deformation possibly resets the U-Pb system
- Deformed grains record the timing of deformation

Zircon

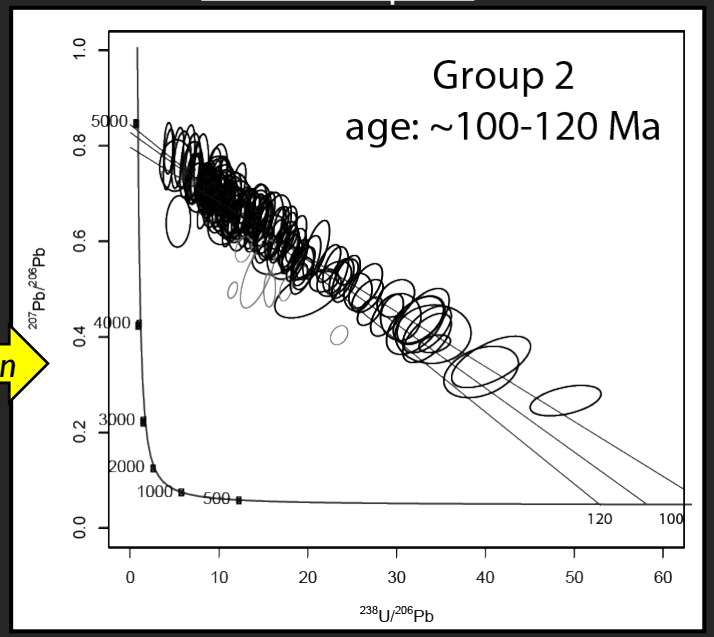


Undeformed Apatite

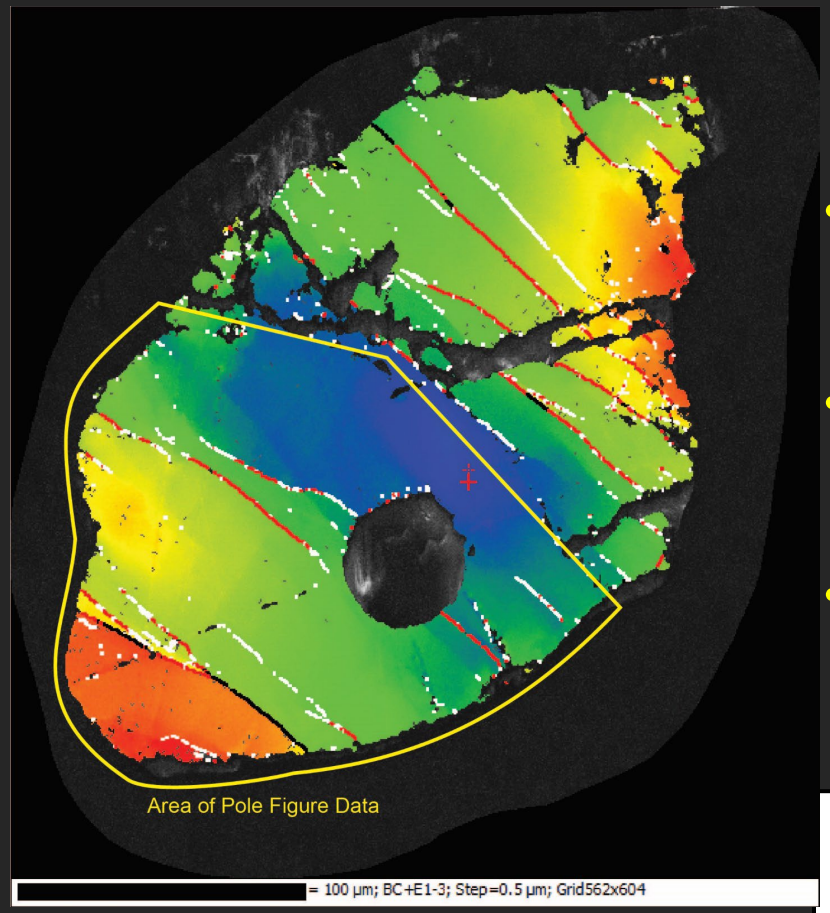


deformation

Deformed Apatite



Dislocation Arrays Create Pb-diffusion Pathways?



Conclusion

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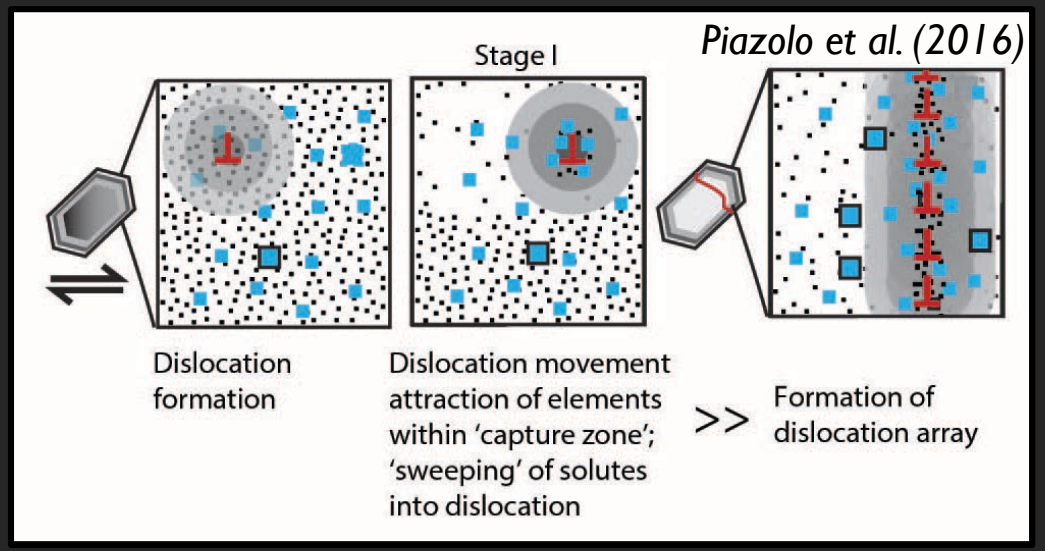
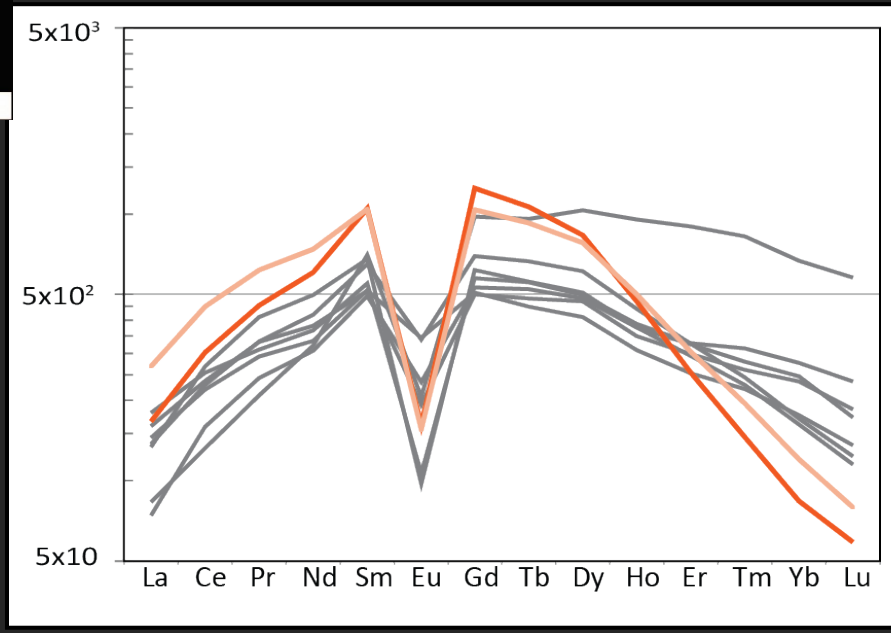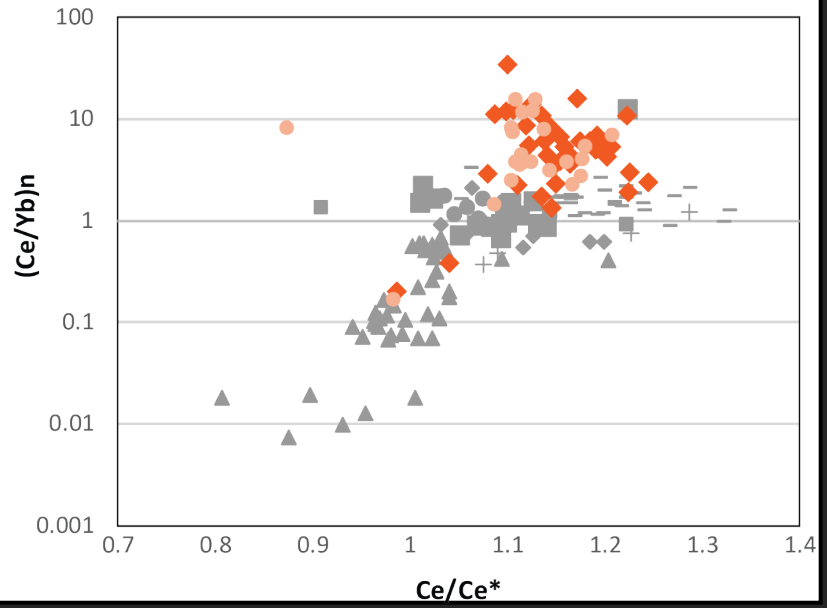
Deformation also affects REE Systematics