Perspectives on cratonic and Phanerozoic deep continental lithosphere from xenoliths:

geochemical, petrological, and microstructural constraints

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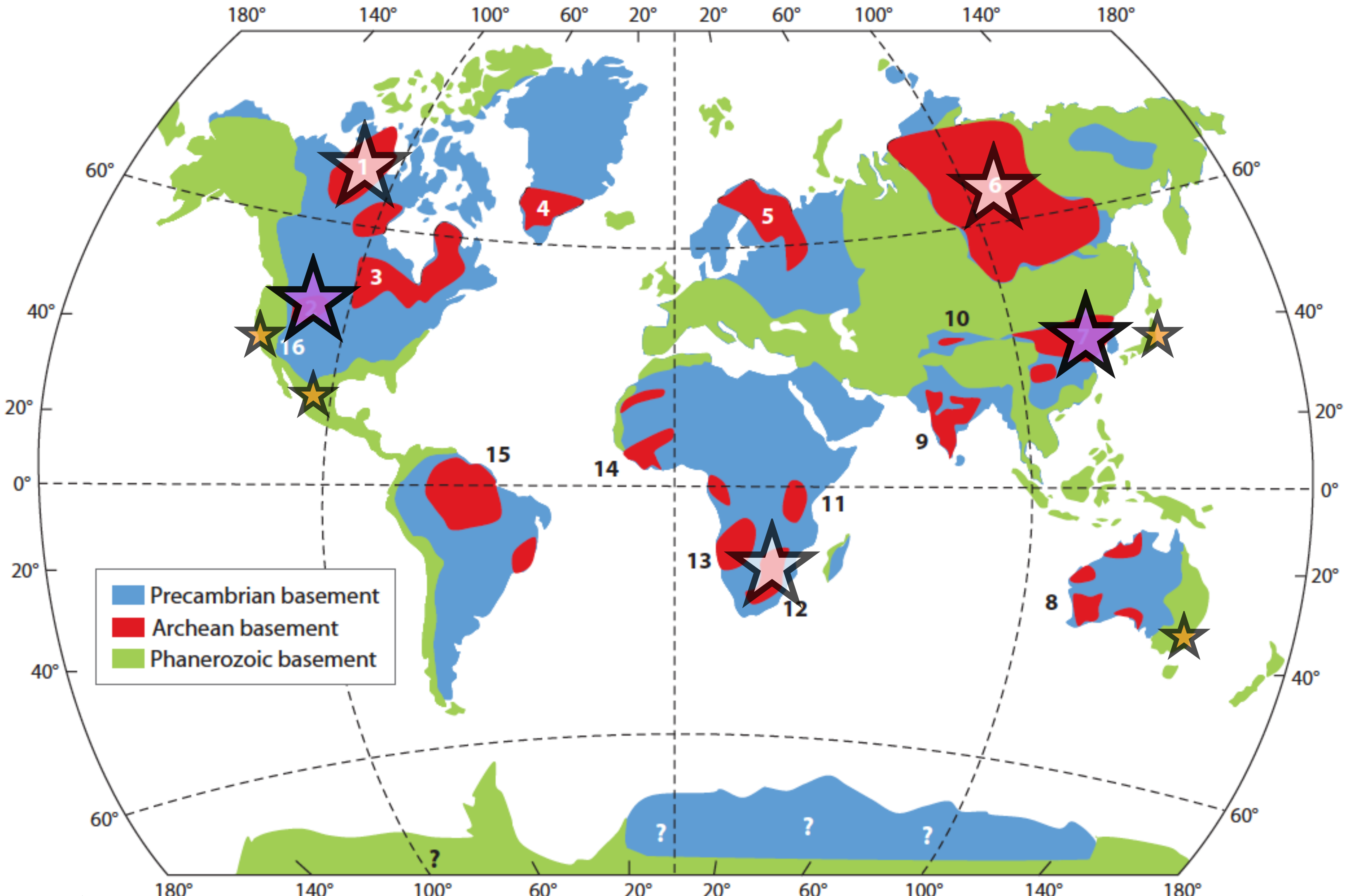


“intact” cratons: **Slave, Siberian, Kaapvaal**

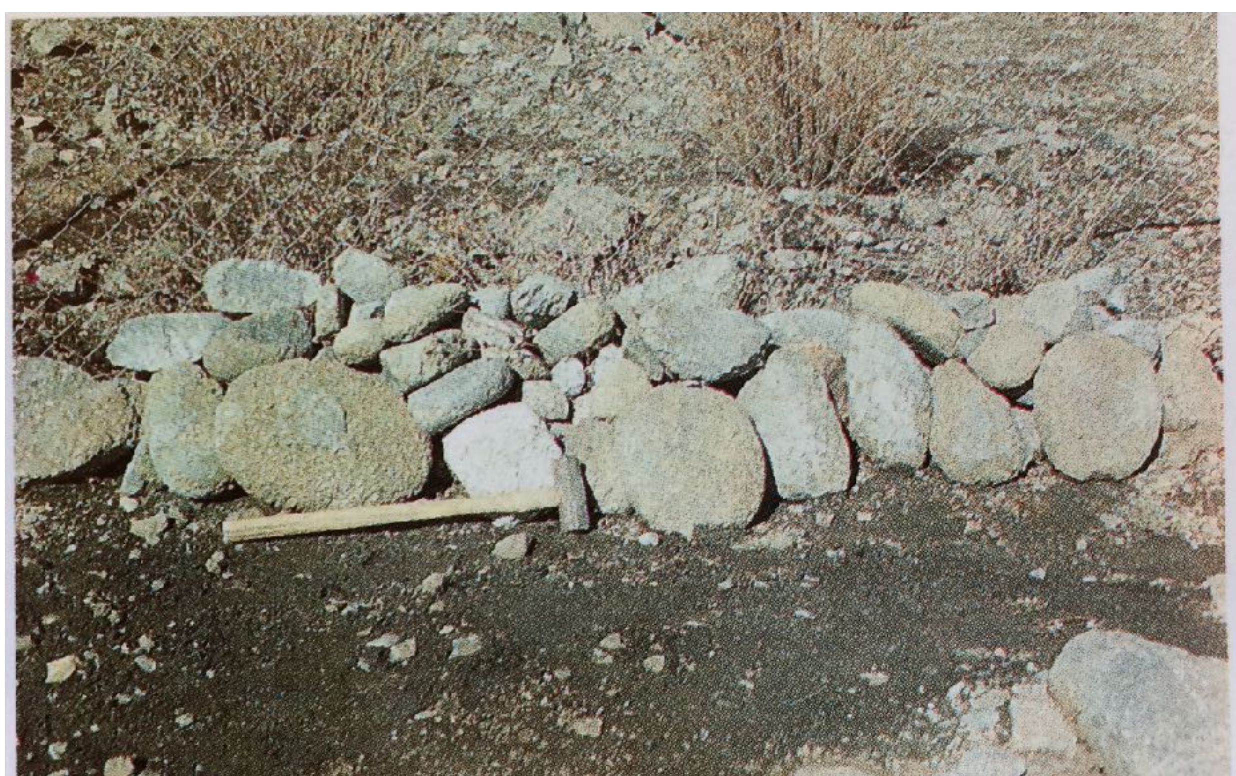
“disturbed” cratons: N. China, **Wyoming**, Colorado Plateau

Phanerozoic mantle lithosphere - **Sierra Nevada, California**

Xenoliths

Dunite

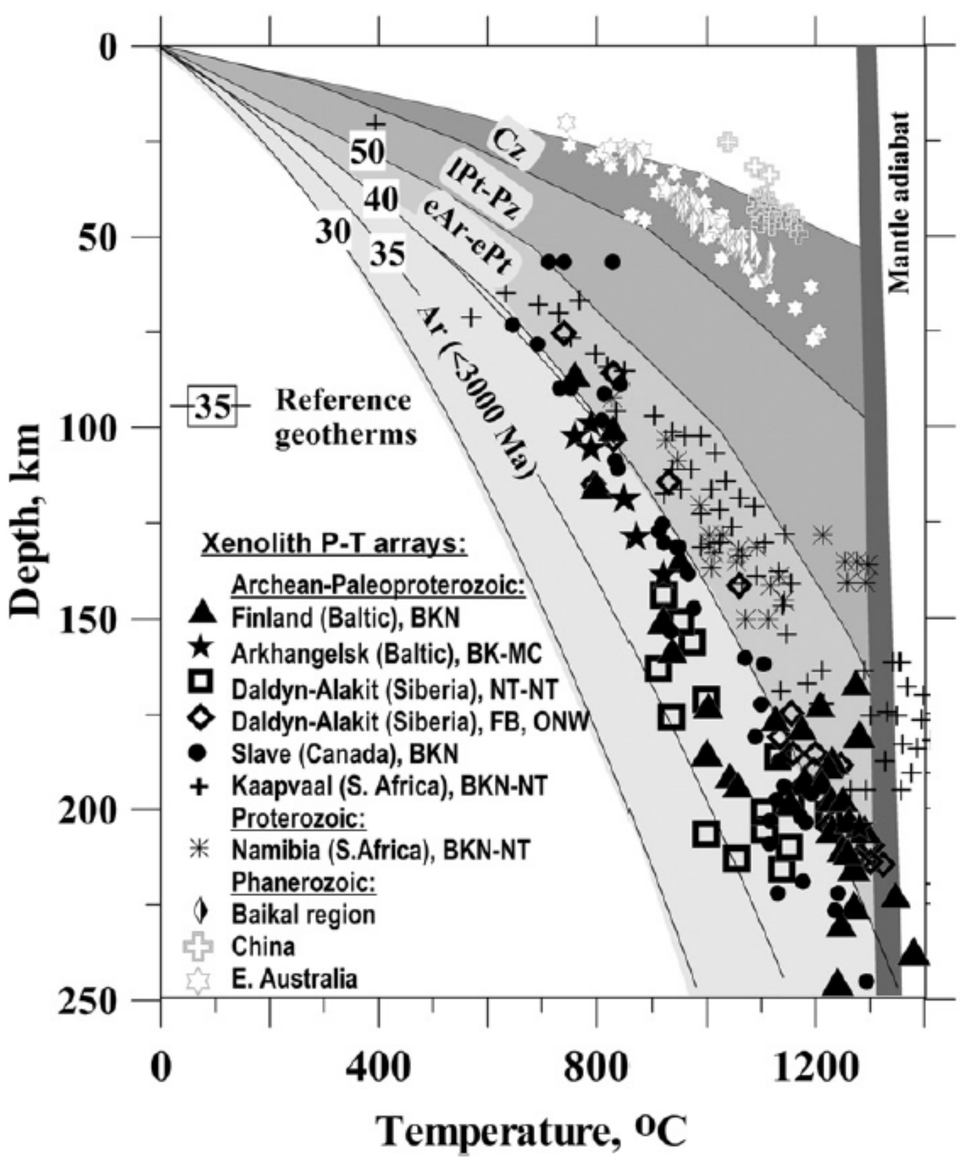
Garnet harzburgite

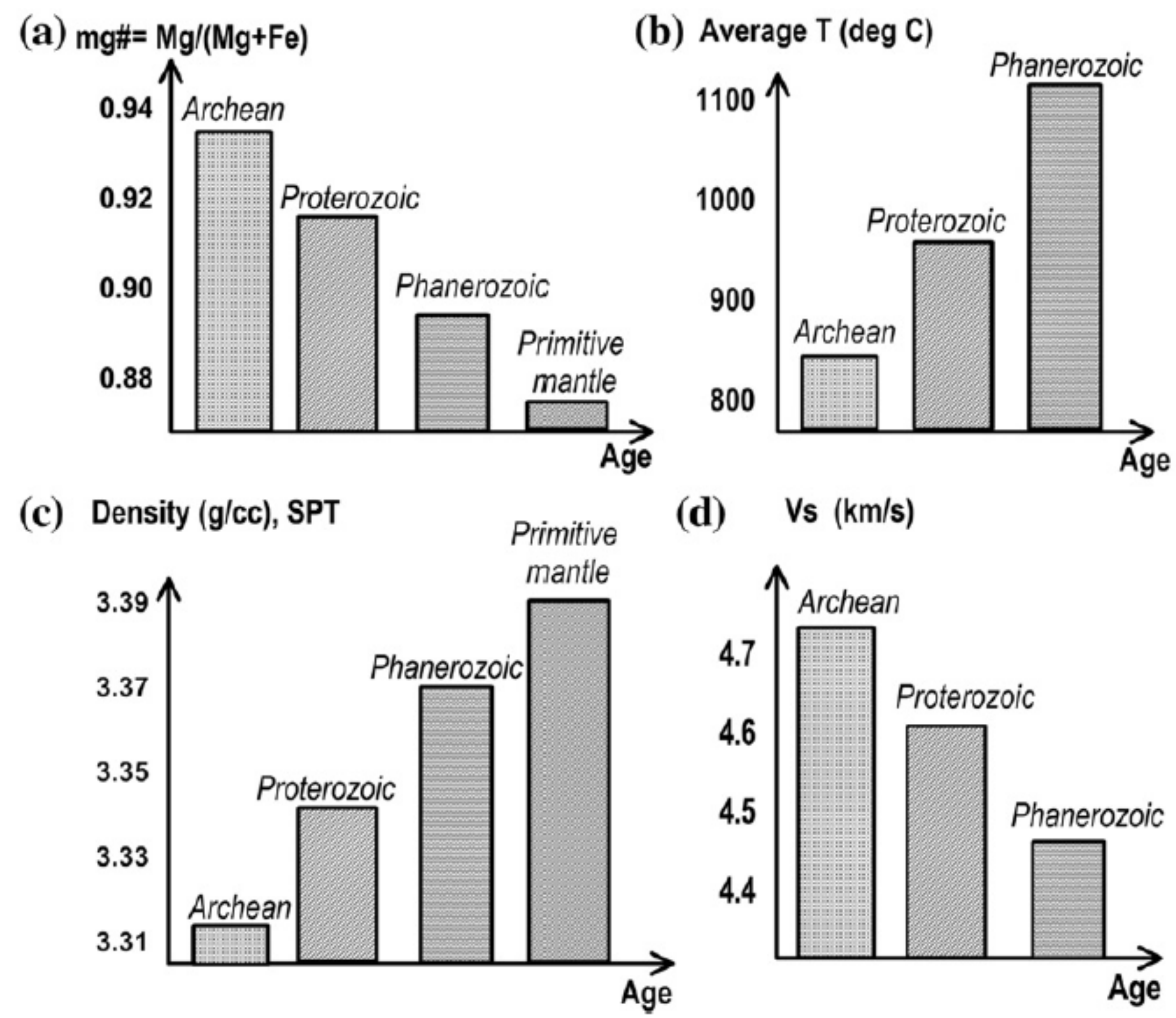


Whole xenoliths from Lesotho kimberlite

Spinel lherzolite

Secular variation in SCLM

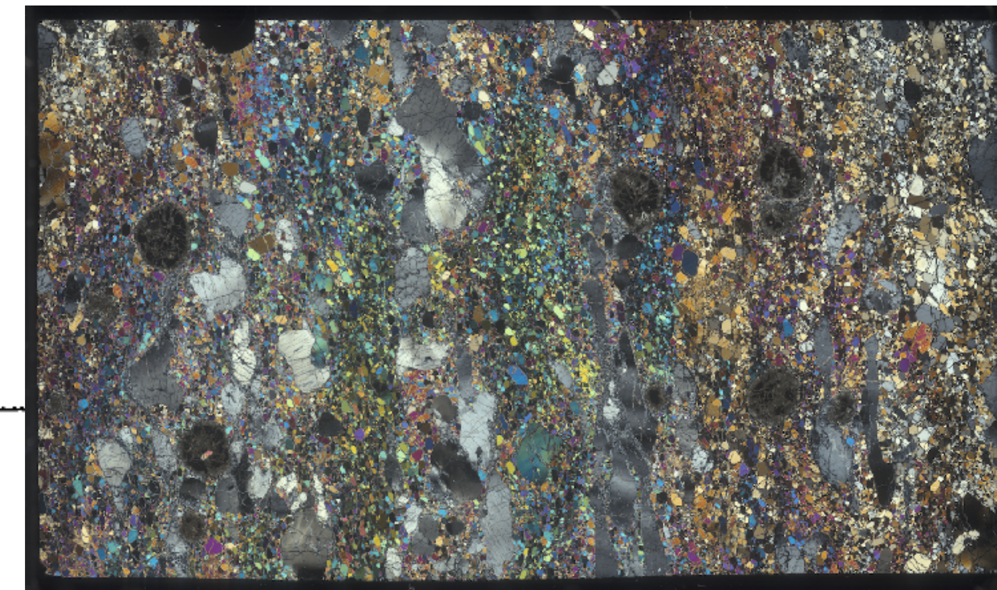




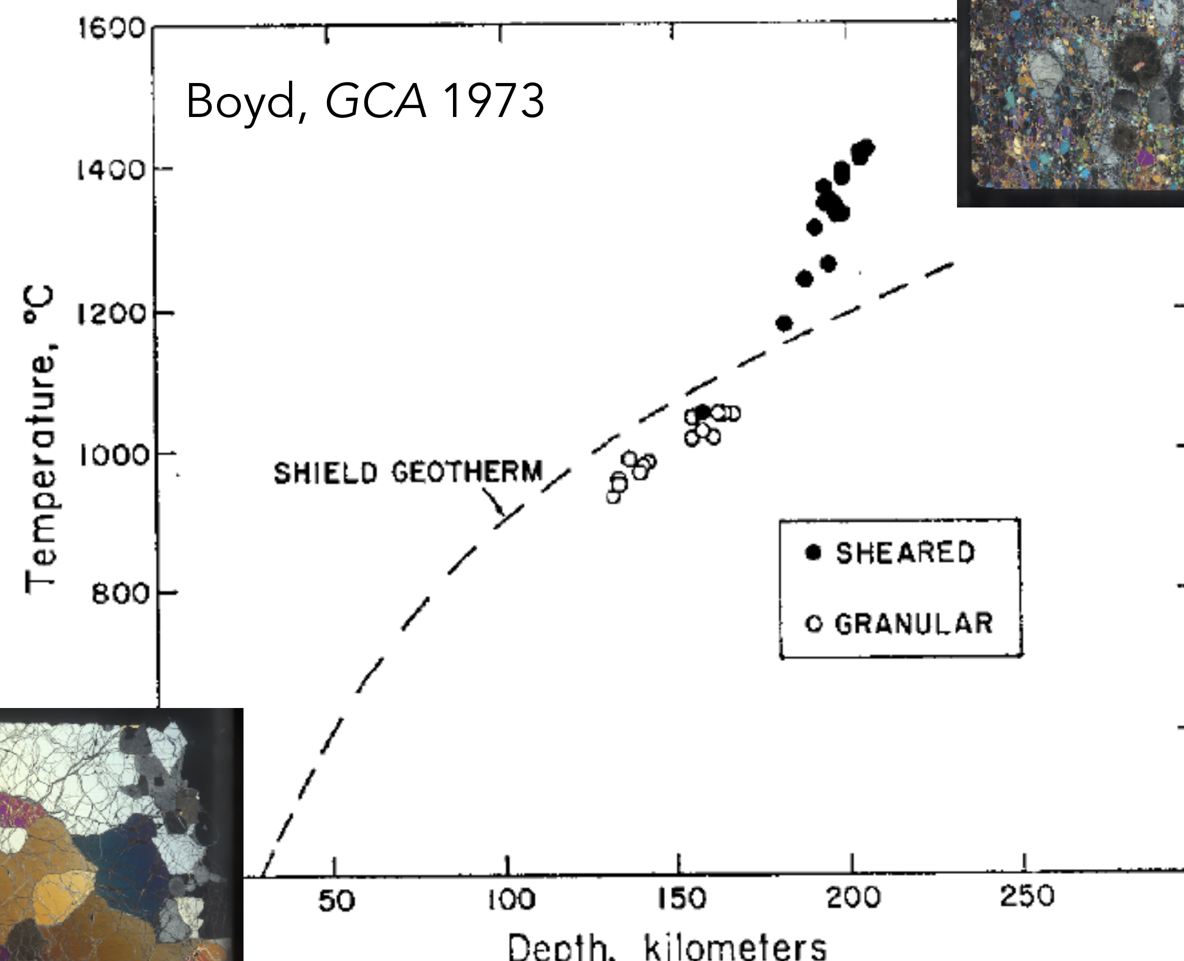
Artemieva, *Lithos* 2009

Textural variation in P-T space

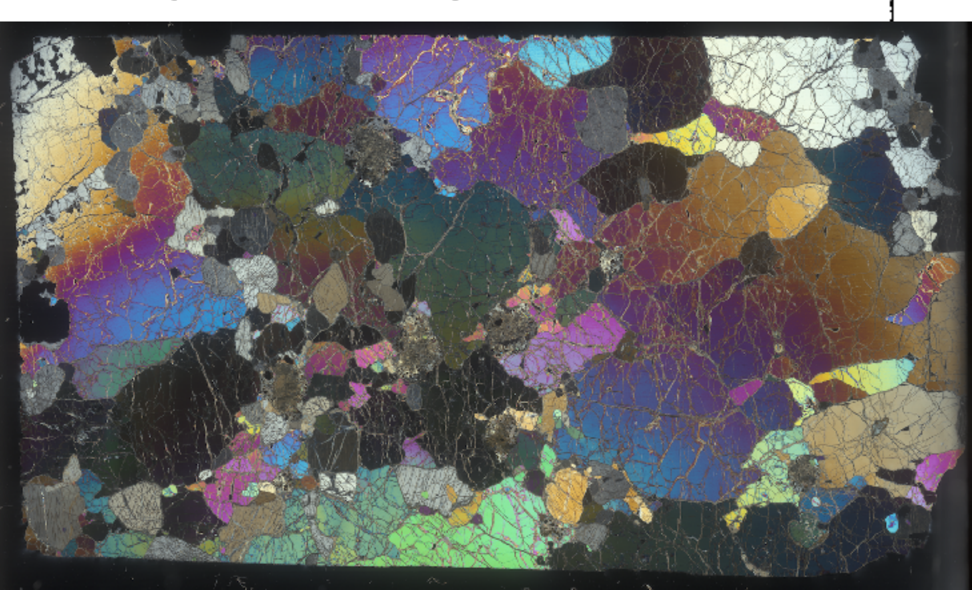
Sheared lherzolite
(Wyoming)



Parks, Chin et al., *in prep*

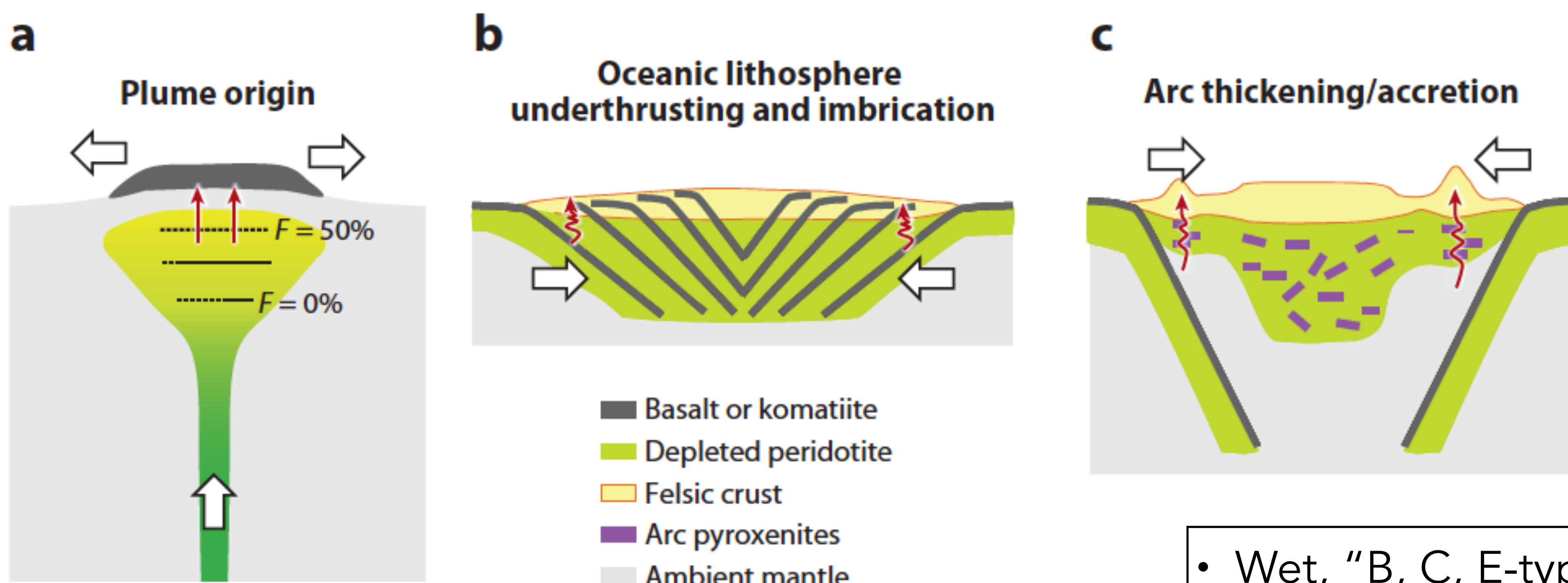


Coarse granular lherzolite
(Wyoming)



Forming cratonic mantle

- Petrology/geochemistry, microstructures, PT path
- Combine with seismology & geophysical observations



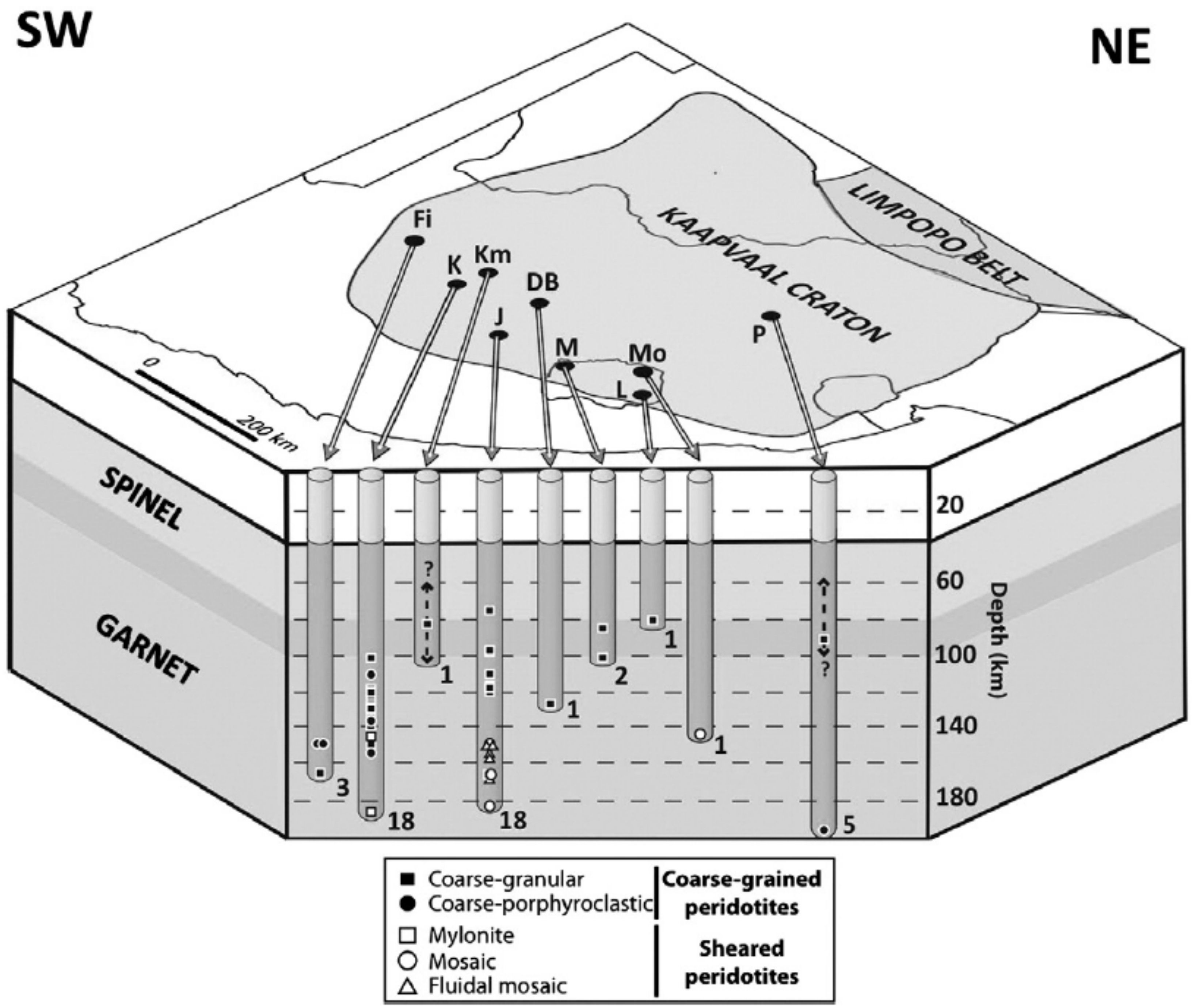
- Dry, "A-type" fabric
- No subduction trace-element
- Isotropic structure?

- Wet, "B, C, E-type" fabric
- Subduction/hydrous trace-element
- Dipping structures

- Wet, "B, C, E-type" fabric
- Subduction trace-element
- Dipping structures, continuity with crustal sutures?

Lee et al., *Annu. Rev.* 2011

Kaapvaal craton



Baptiste et al., *Lithos* 2012

Siberian craton

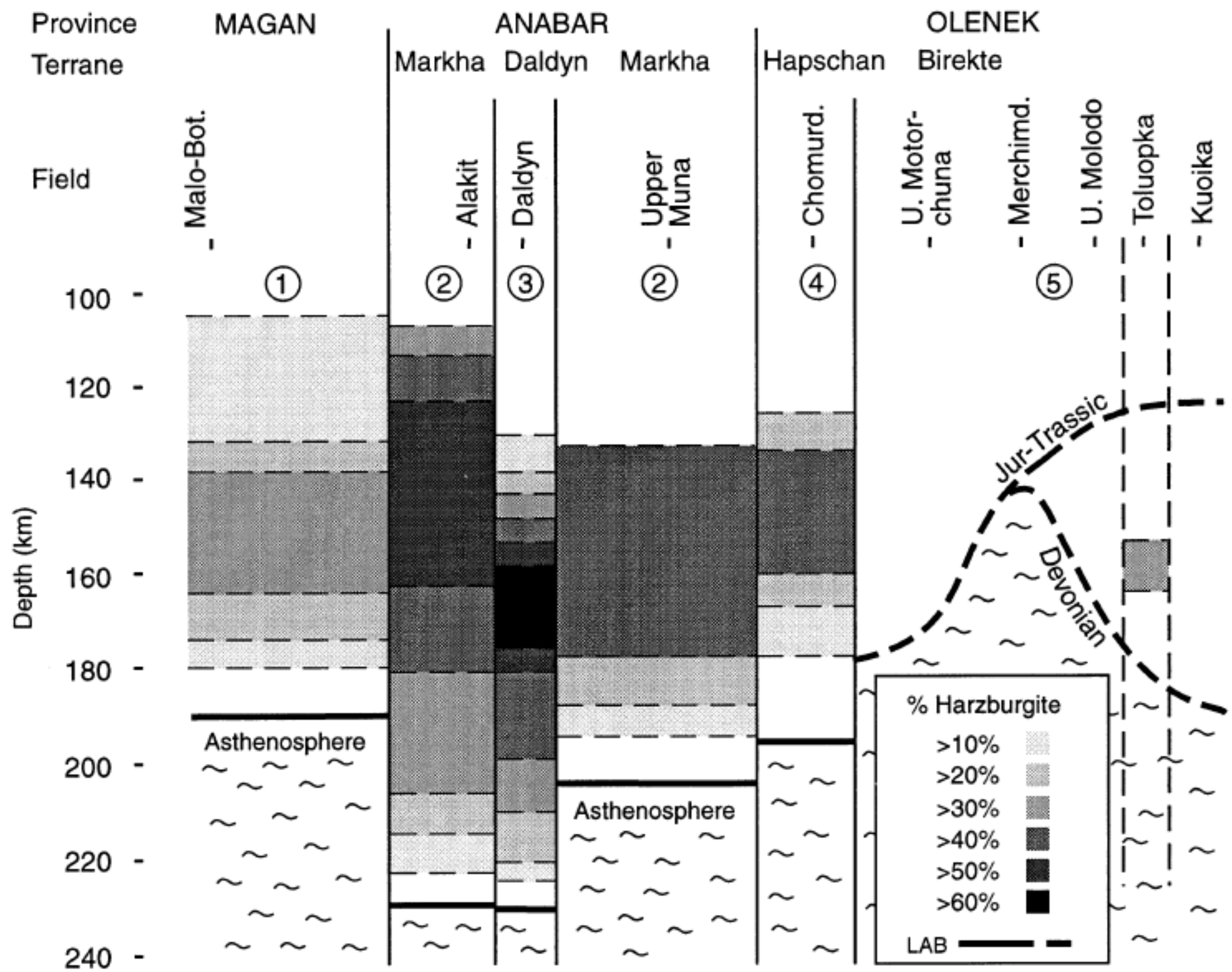
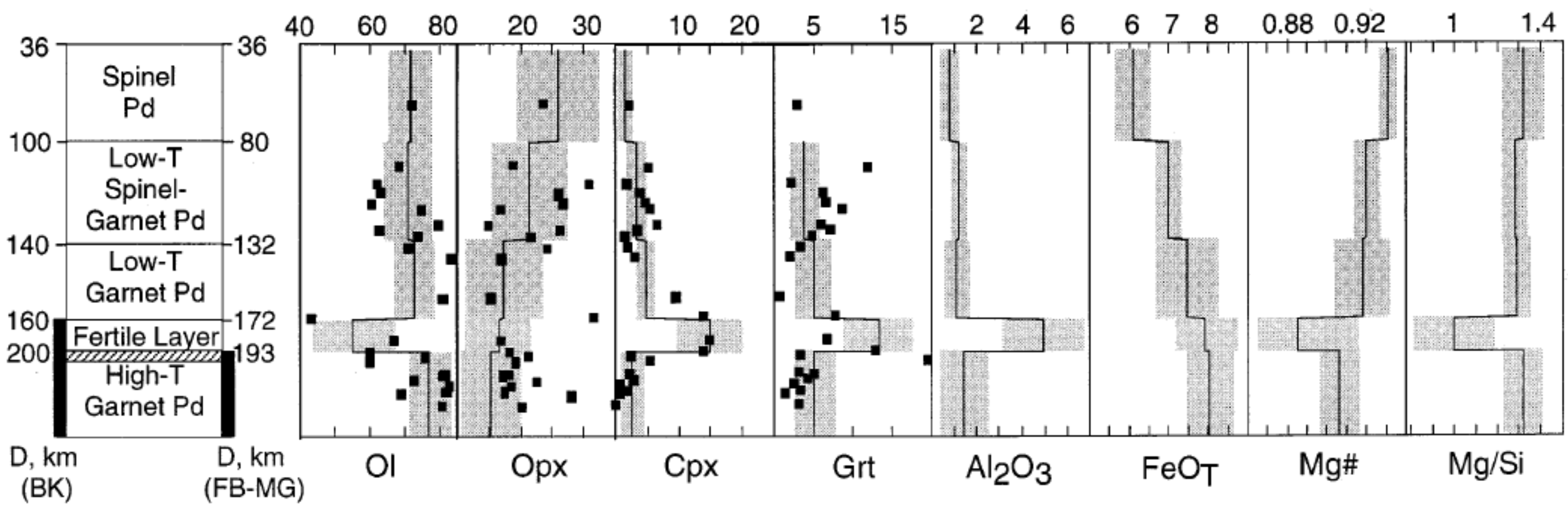


Fig. 9. Detailed distribution of harzburgitic garnets (defined as in Fig. 3a) within each field along the Olenek trend. Lithosphere–asthenosphere boundary (LAB) defined as in Fig. 5. The position of the LAB in two different time slices is shown at the northern end of the traverse.

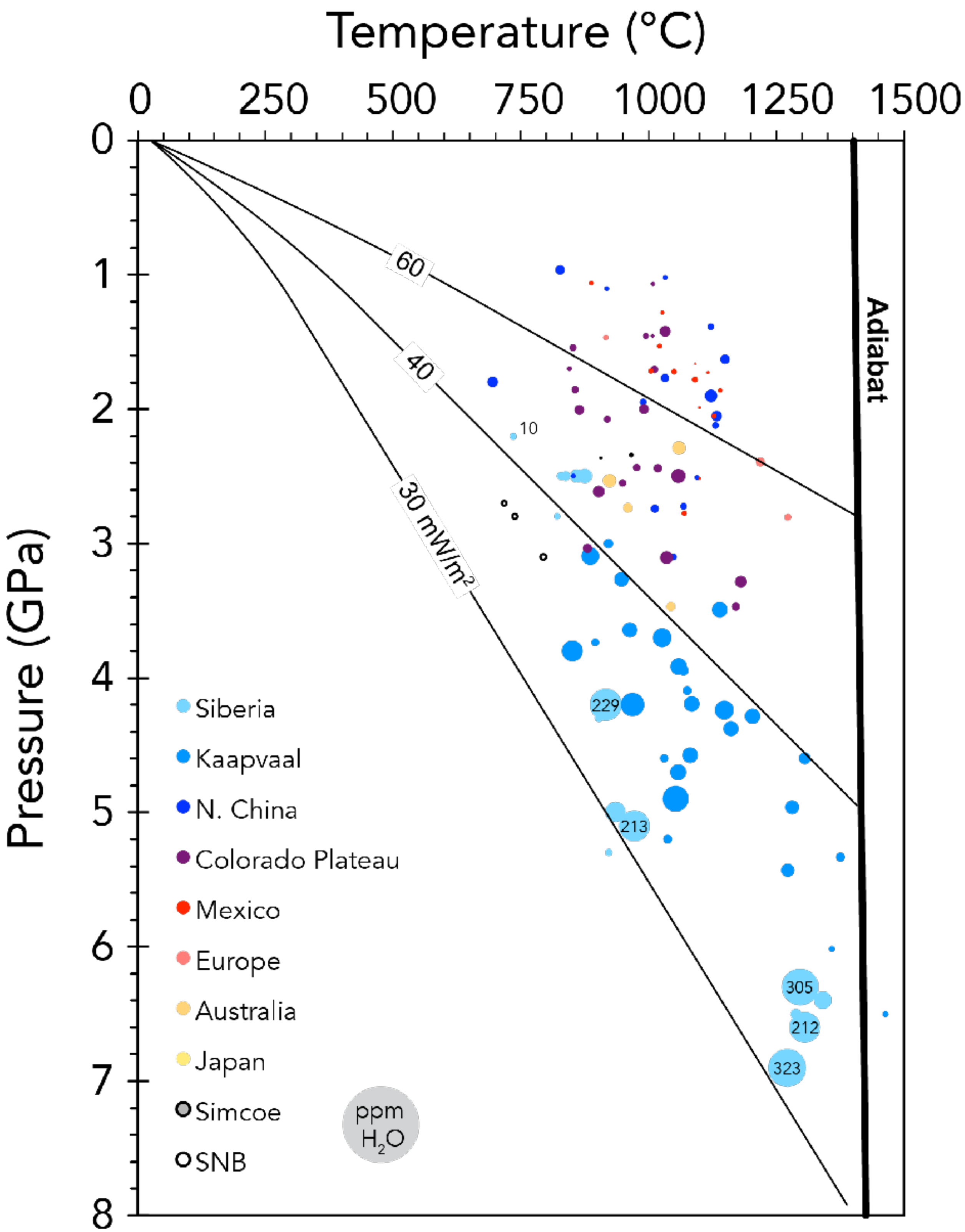
Griffin et al., *Tectonophysics* 1999

Slave craton

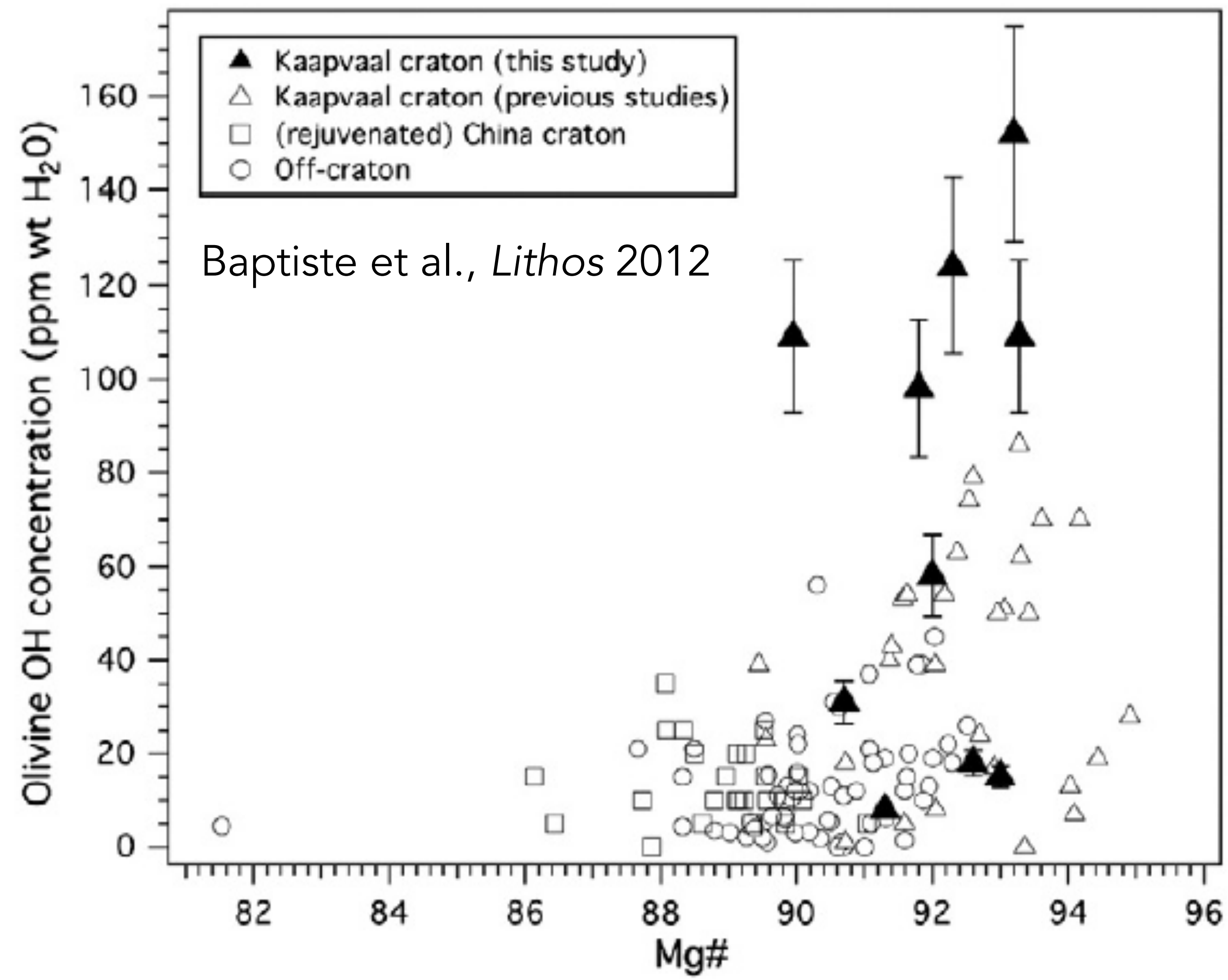


Kopylova & Russell, *EPSL* 2000

Olivine H_2O

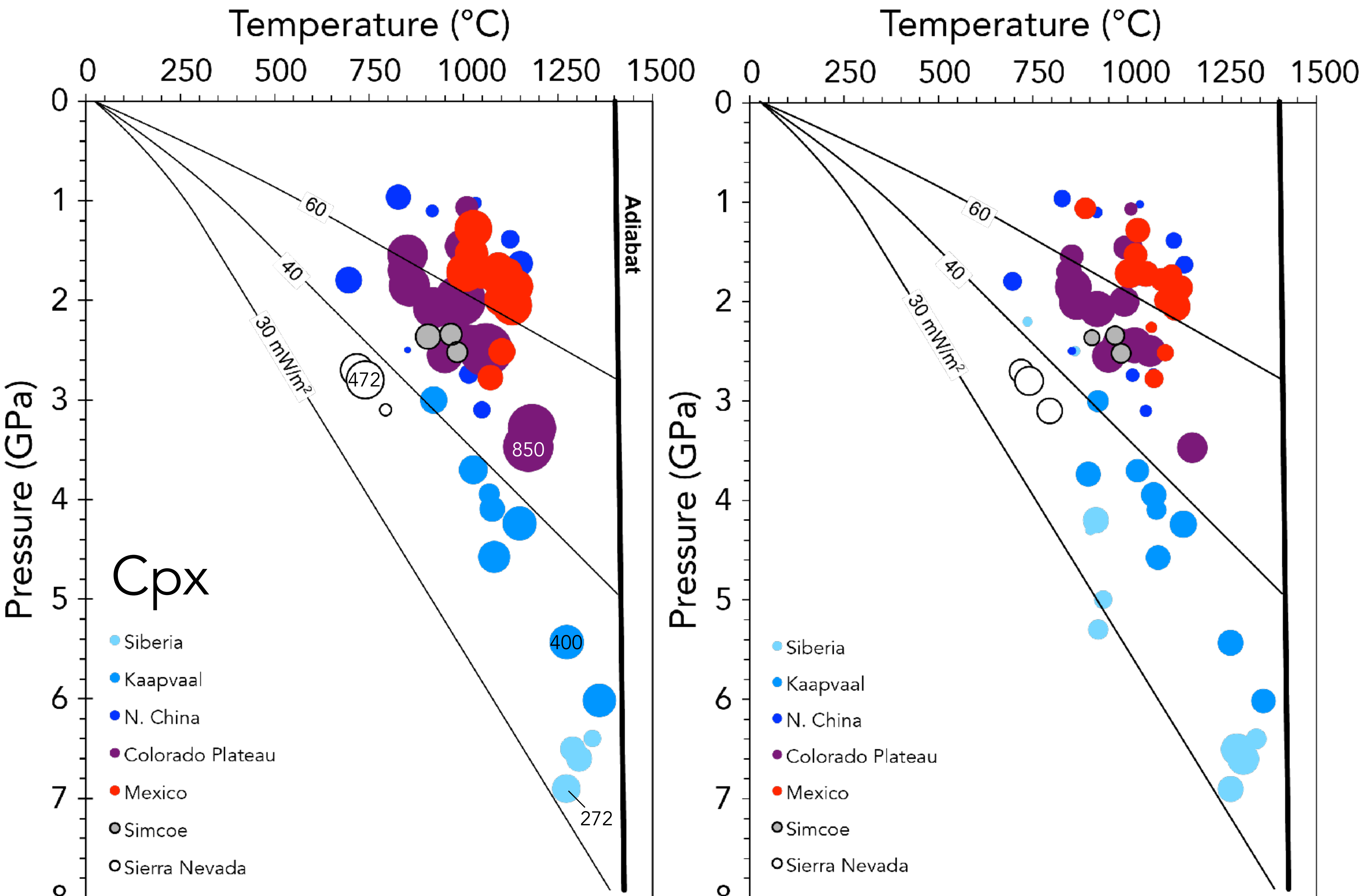


Compiled from various sources



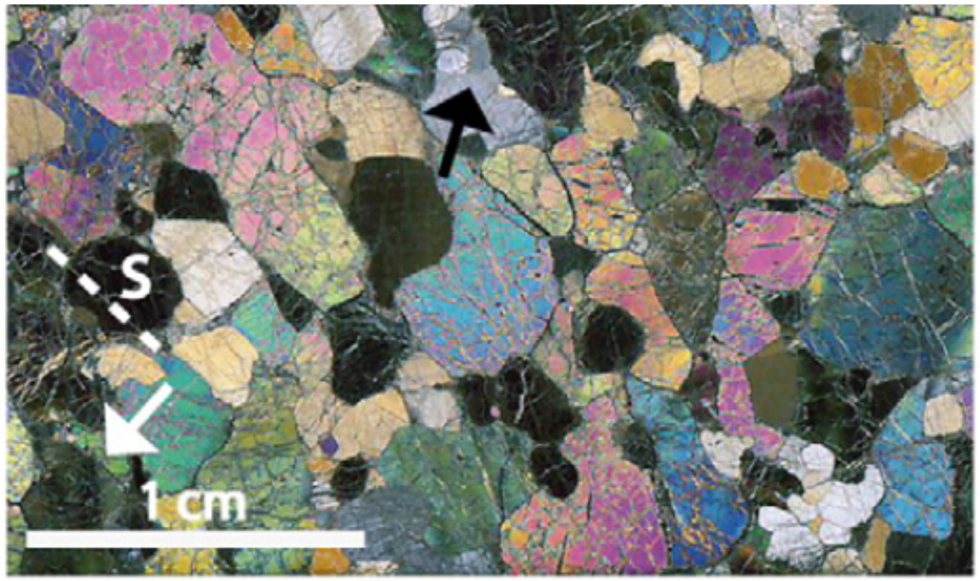
No correlation in H2O and degree of melt depletion

Pyroxene H_2O

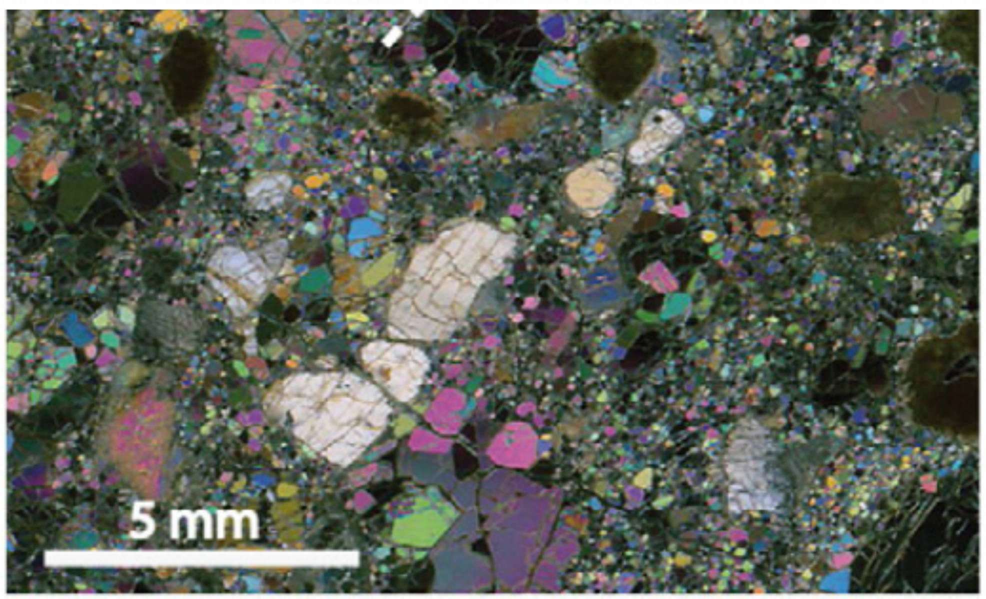


Compiled from various sources

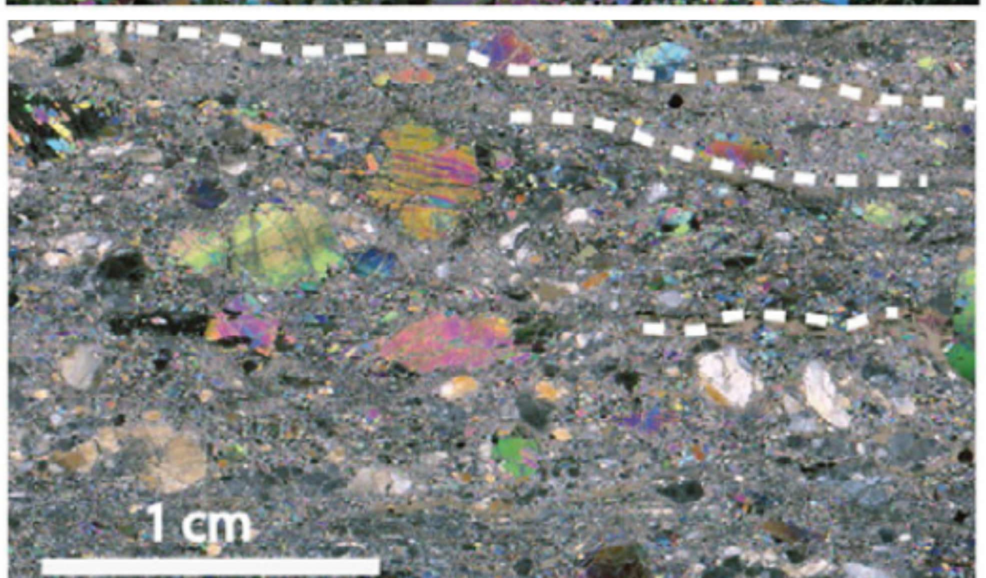
Olivine CPO - Kaapvaal



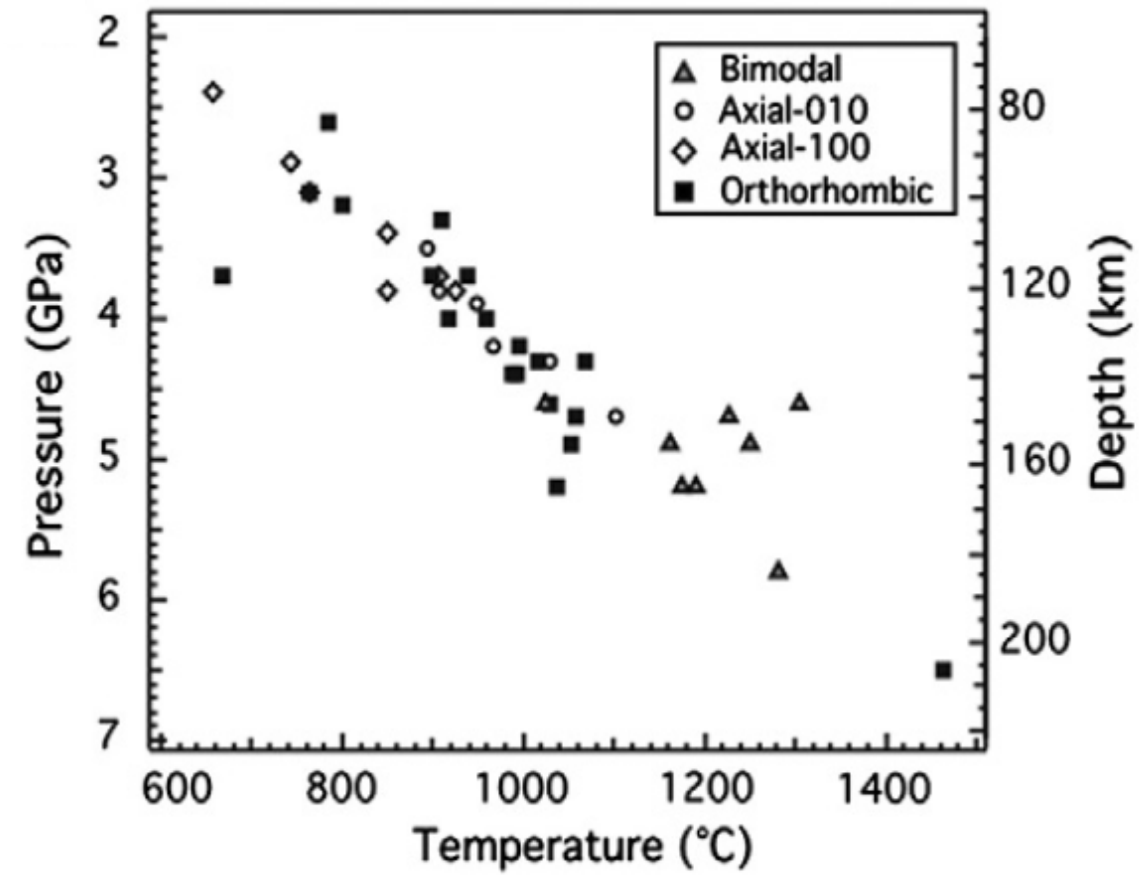
Coarse granular



Fluidal

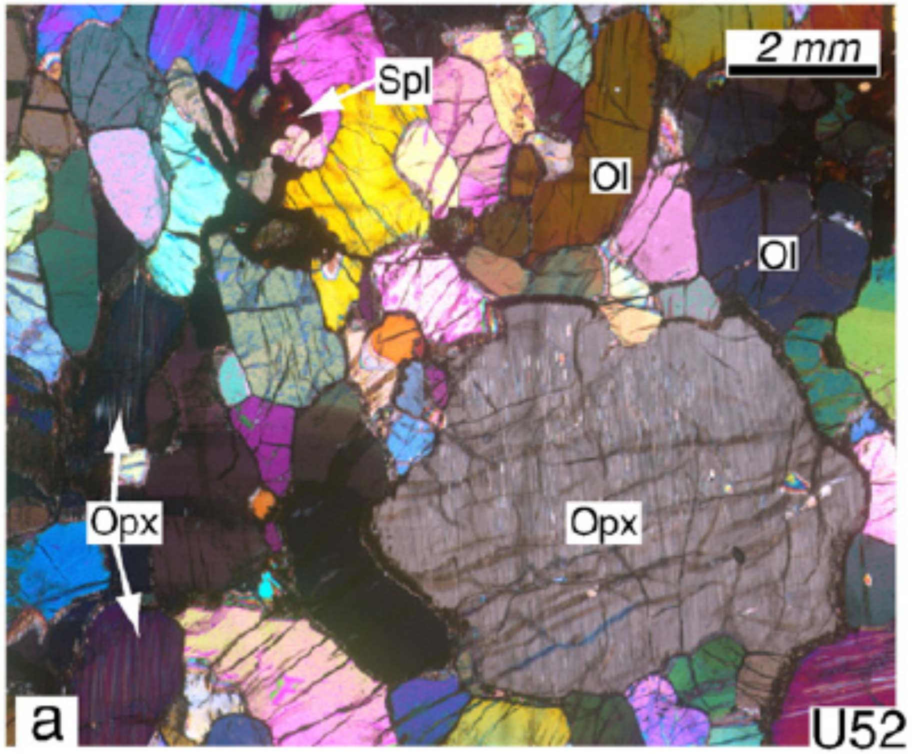


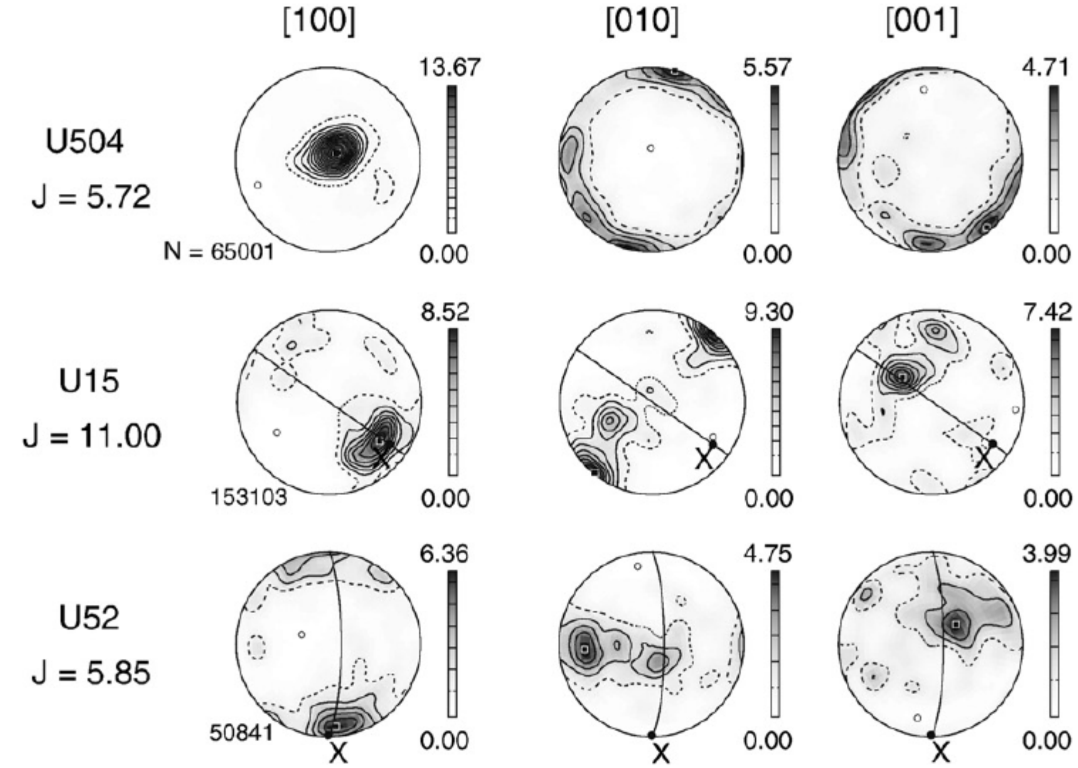
Mylonitic



Baptiste et al., *Lithos* 2012

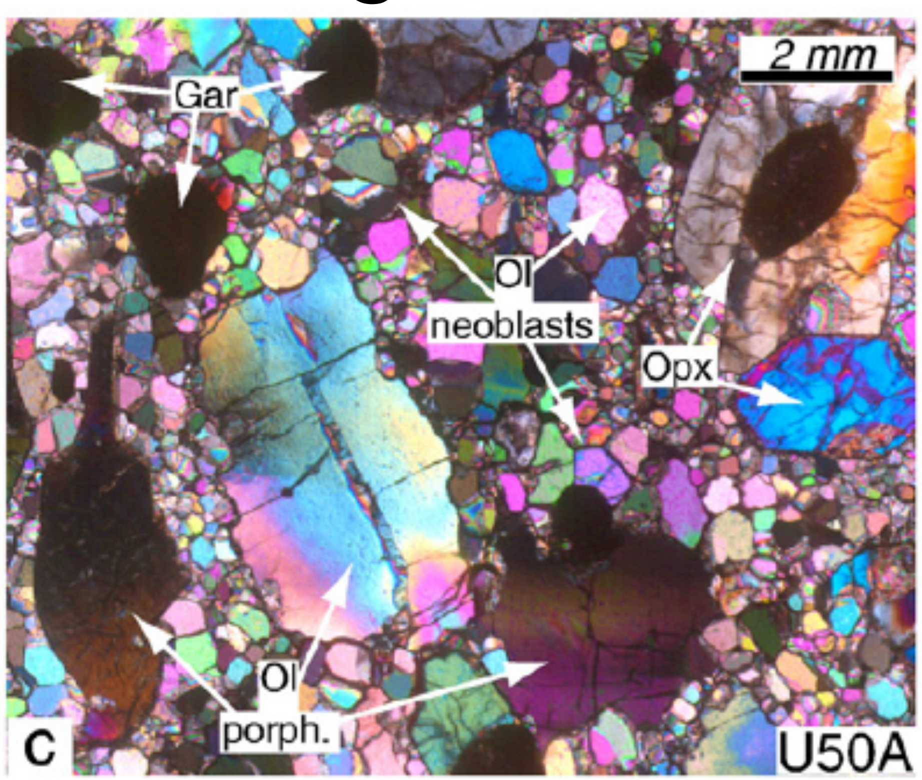
Olivine CPO - Siberia

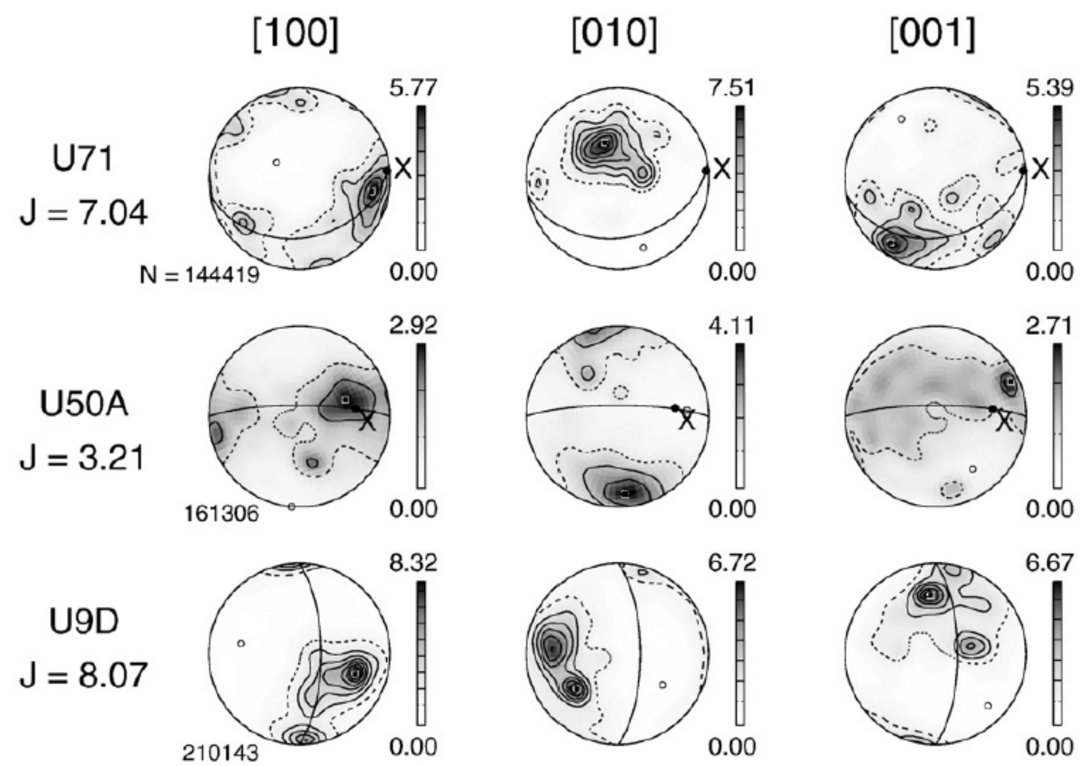




Stronger [100]

Coarse granular



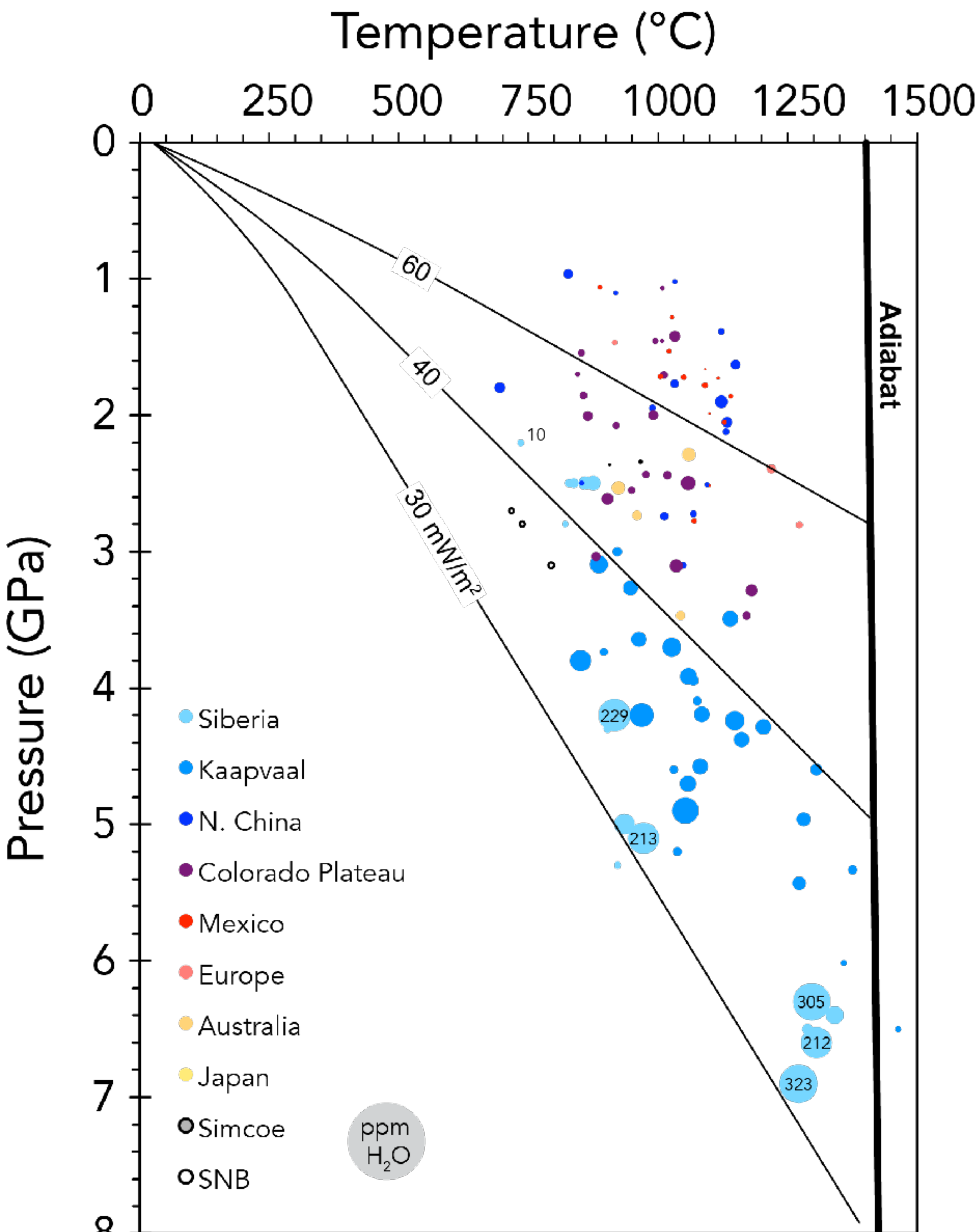


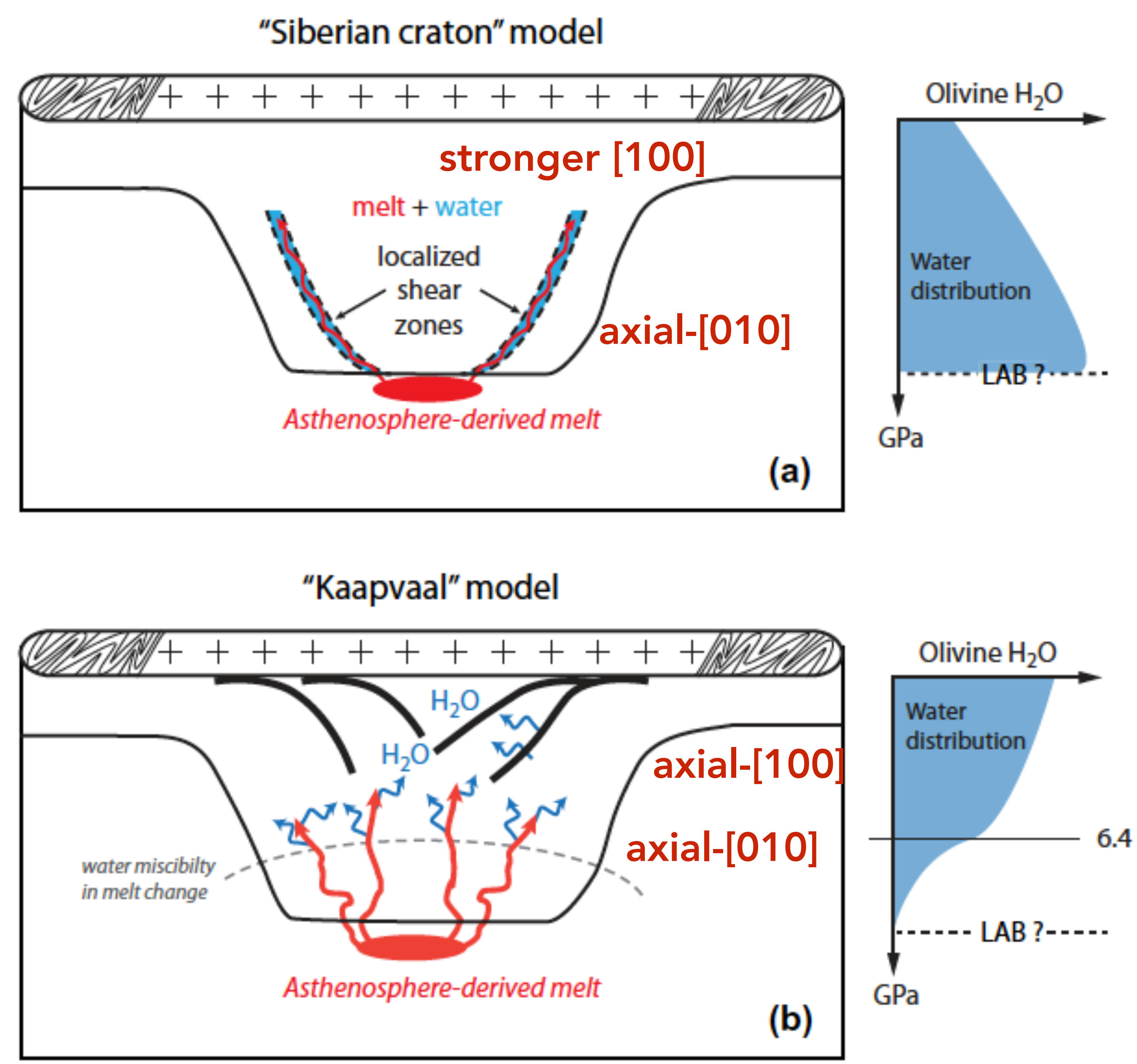
Stronger [010]

Porphyroclastic

Bascou et al., *EPSL* 2011

Different formation mechanisms?





Doucet et al., *GCA* 2014

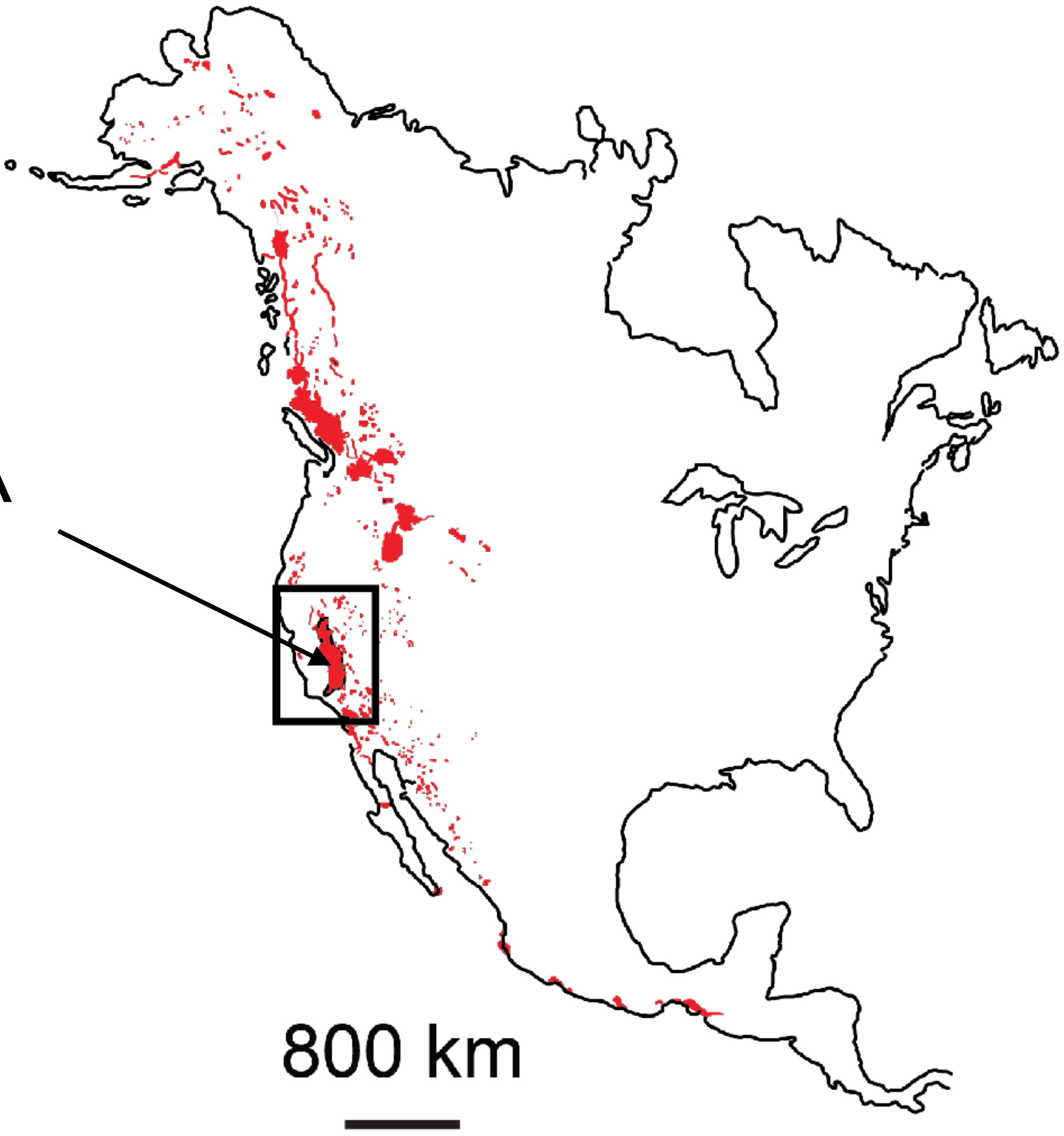
Cratonic peridotites

- **Cratons vary in degree of stratification**
  - Slave strongly layered
  - Kaapvaal & Siberian less layered
- **With increasing depth:**
  - Water content increases
  - Bimodal & axial-[010] olivine CPO increases

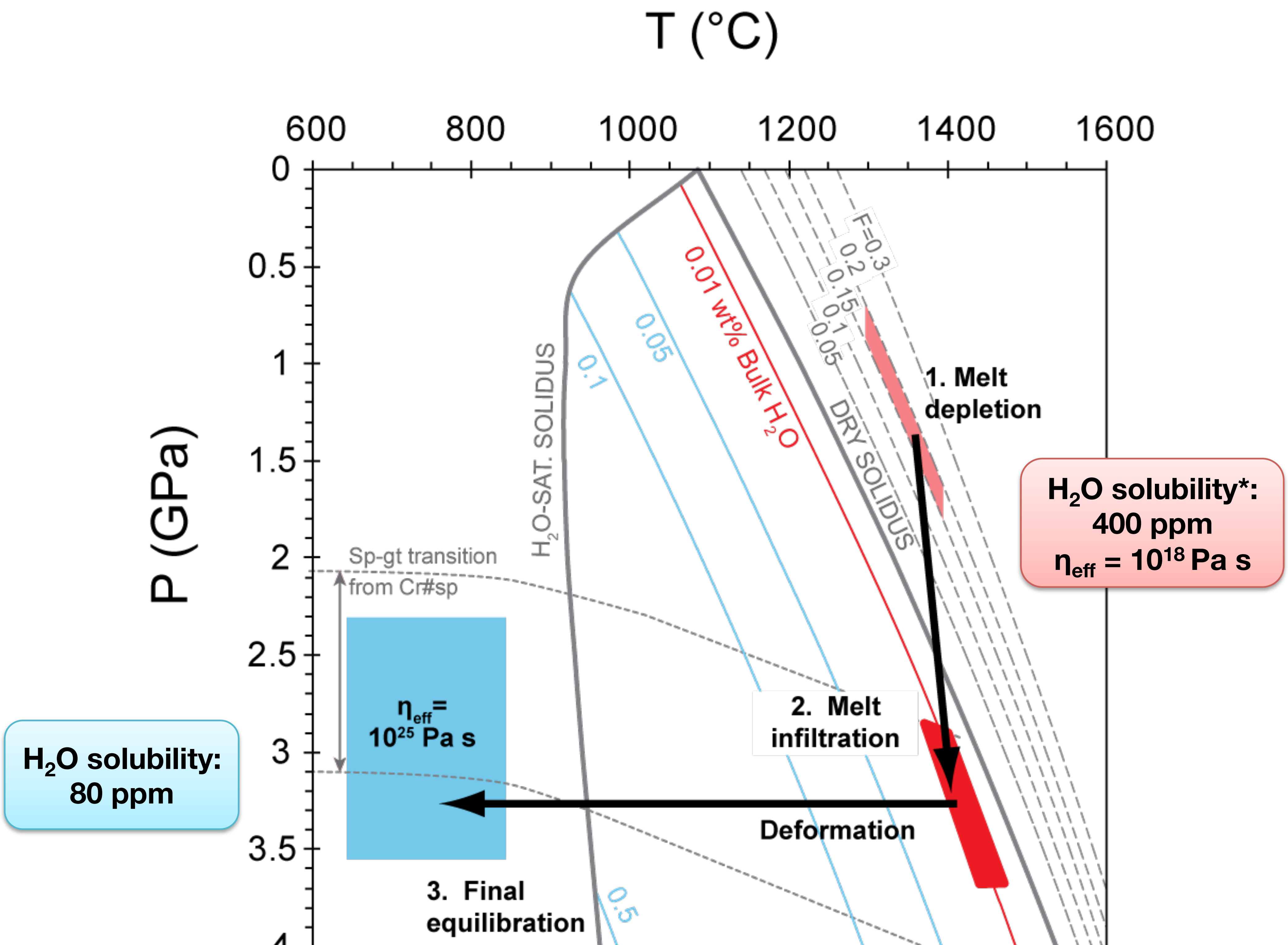
What can we learn from non-cratonic peridotites?

A Mesozoic example
from North America

Sierra Nevada Batholith, CA



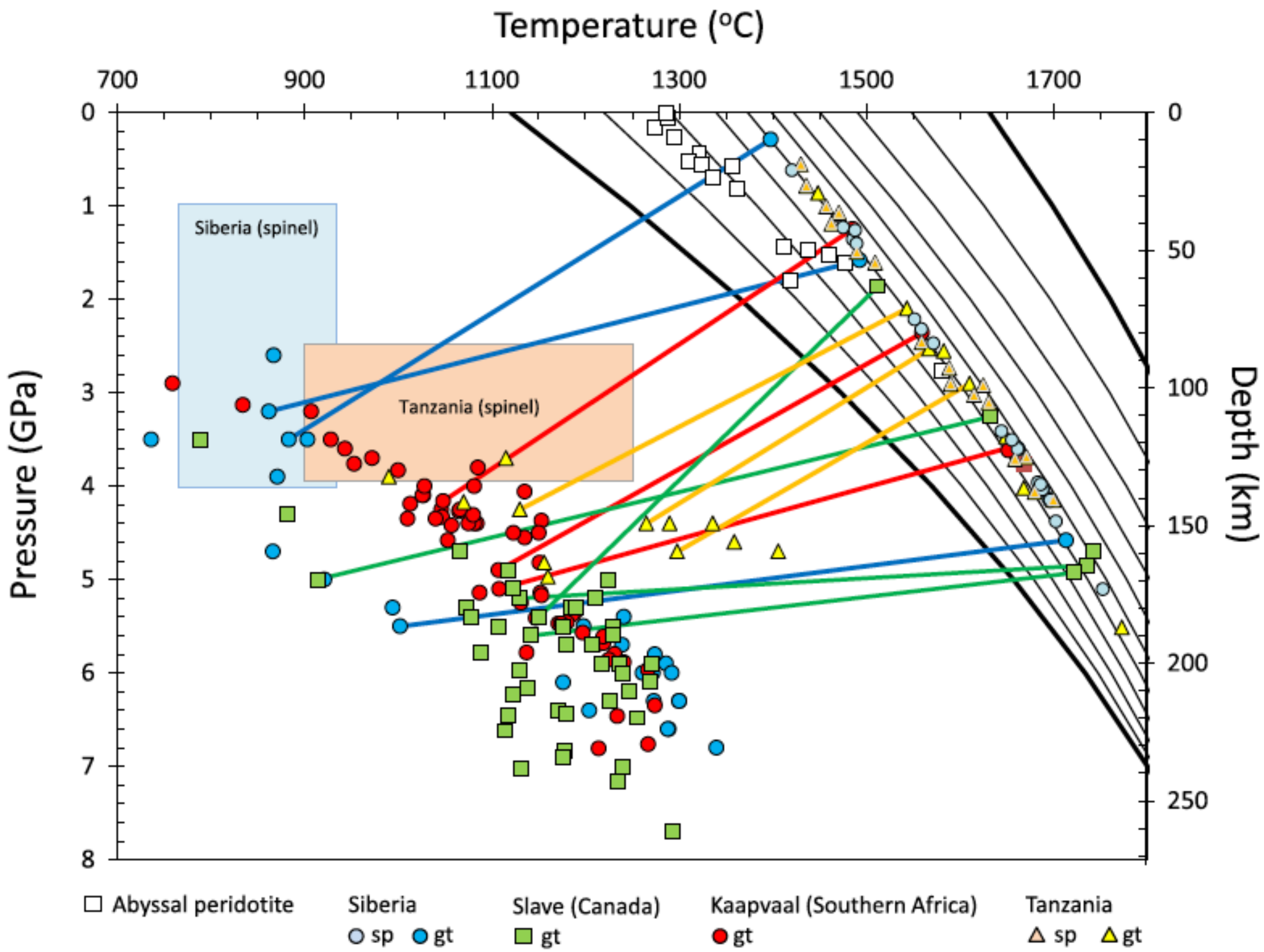
Thicken, cool, stabilize



Chin et al., G^3 2016

Melt depletion PT ≠ final PT

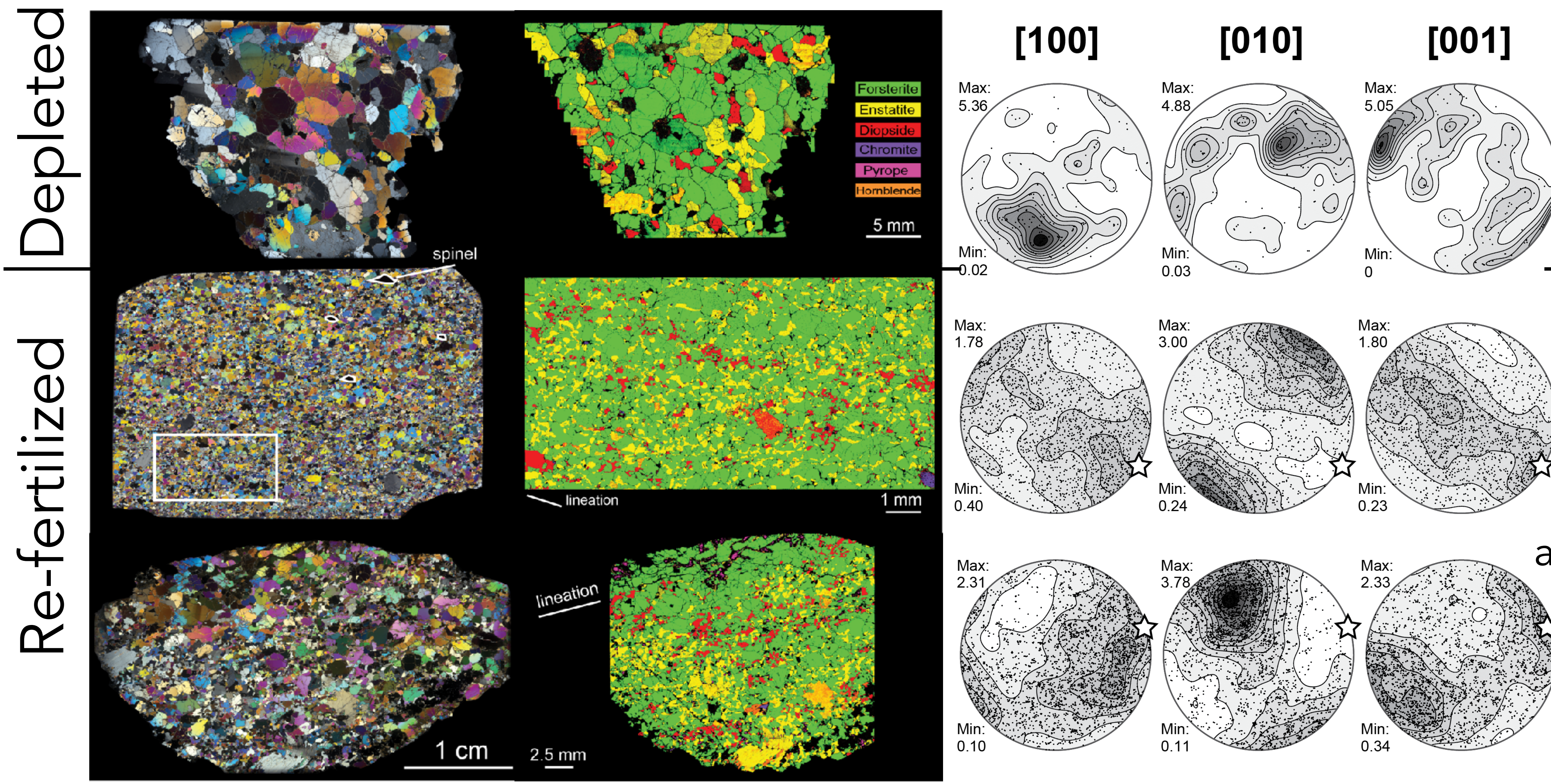
also observed in cratons



Lee & Chin, *EPSL* 2014

Olivine CPO varies with depth,

similar to some cratonic xenoliths

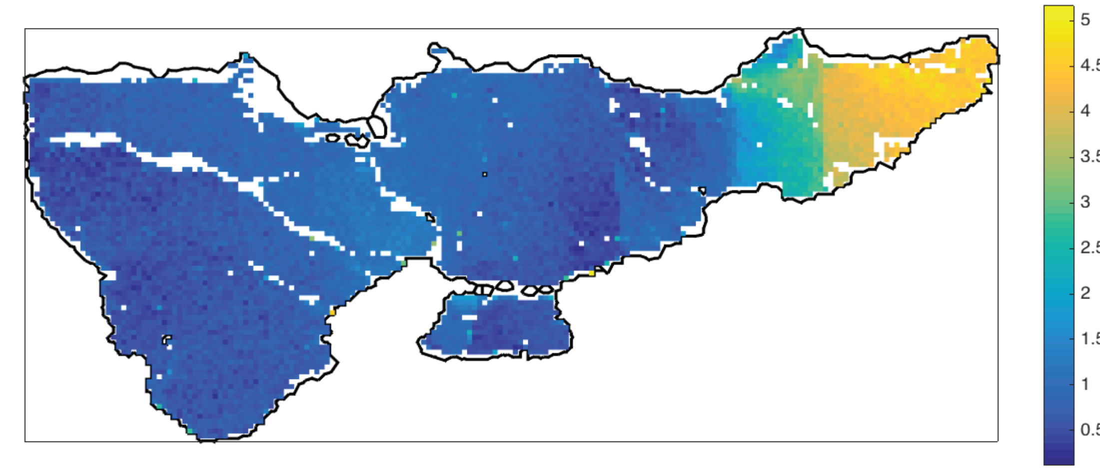


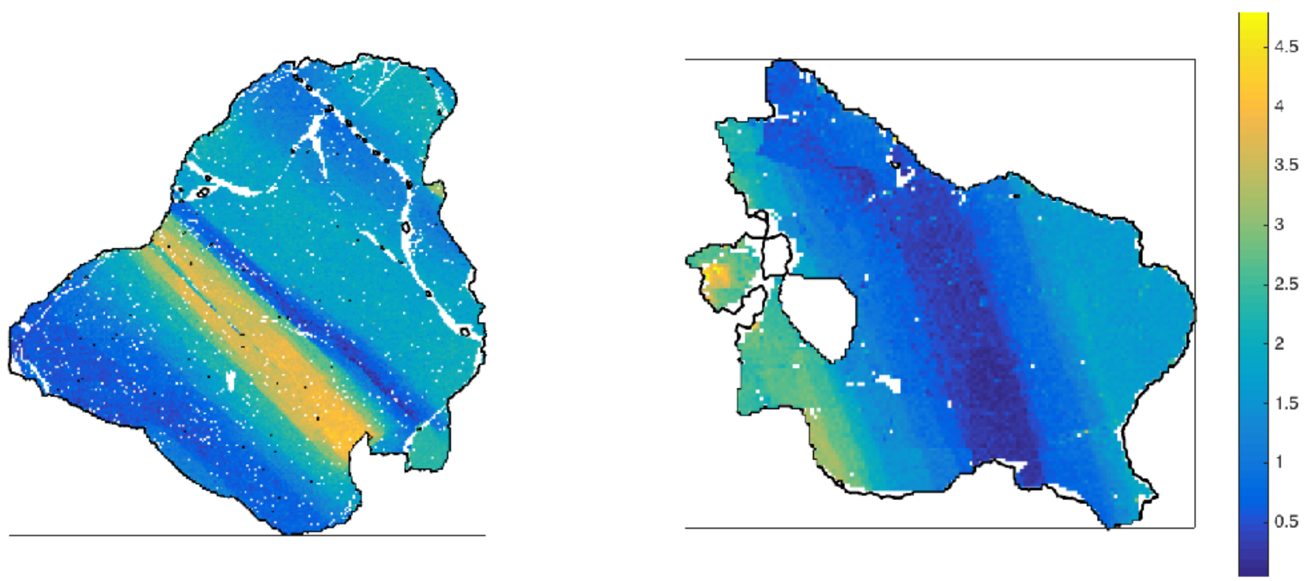
Strong, ortho-rhombic

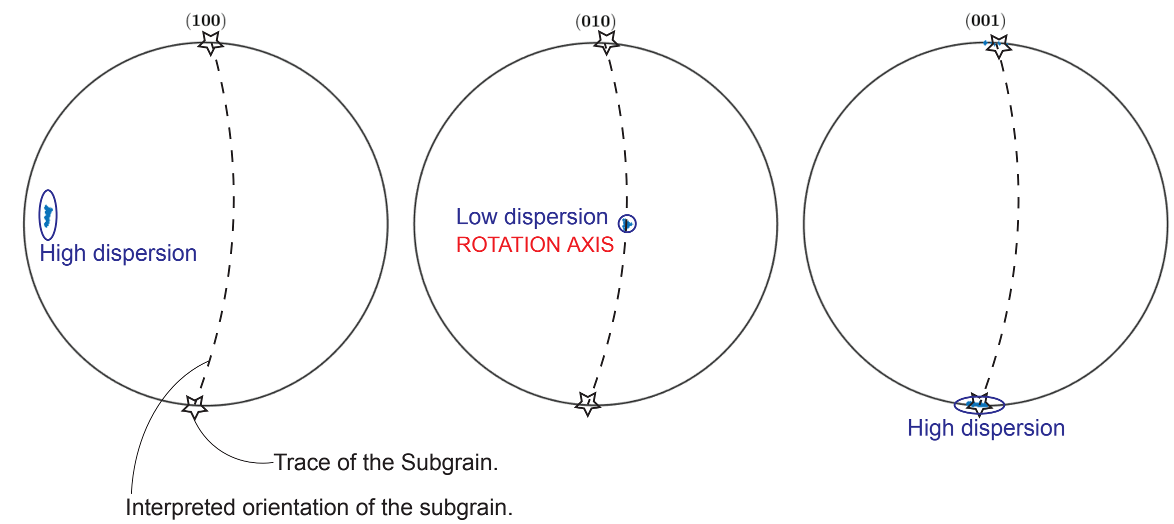
Weak, girdled axial-[010]

Chin et al., *G*^{3} 2016

Bulk CPO vs. intragranular microstructures



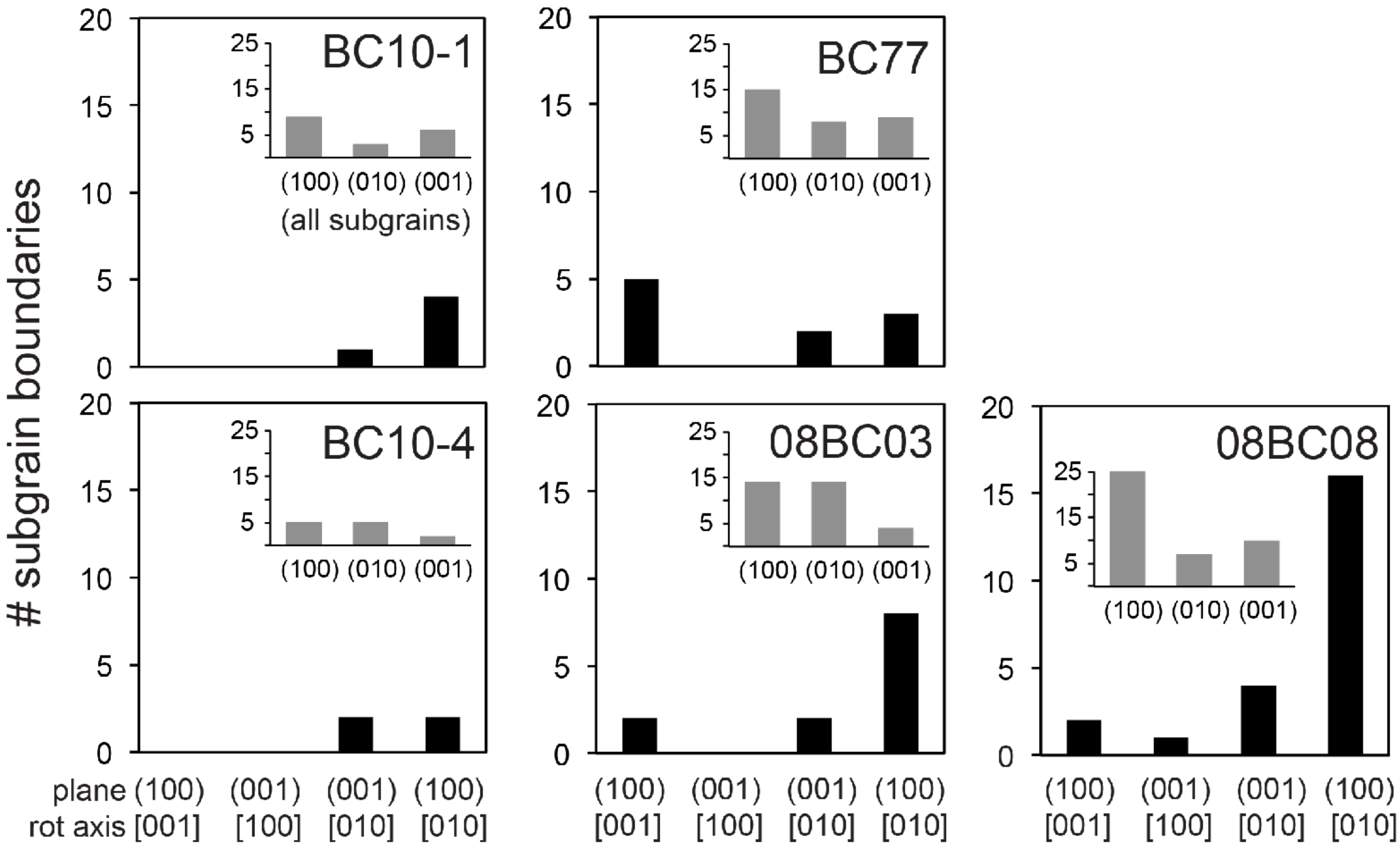




Chin et al., G^3 2016

Slip System & CPO	**Tilt Boundary**	**Twist Boundary**
	Row 1 **plane // to subgrain bndry.** ***Row 2*** **rotation axis**	**plane // to subgrain bndry.** **rotation axis**
(010)[100] A-type	(100) [001]	(010) [010]; requires [001] & [100] screws
(010)[001] B-type	(001) [100]	(010) [010];requires [100] & [001] screws
(100)[001] C-type	(001) [010]	unlikely, since b ≠ [010]
(001)[100] E-type	(100) [010]	unlikely, since b ≠ [010]

"E-type" subgrains dominate



- E-type — high water
- Yet bulk CPO anhydrous (A/B type) and olivine only has 10 ppm H2O

Sierran arc xenoliths

- **Depth gradient from orthorhombic CPO to weak axial-[010]**
  — Reflected in composition

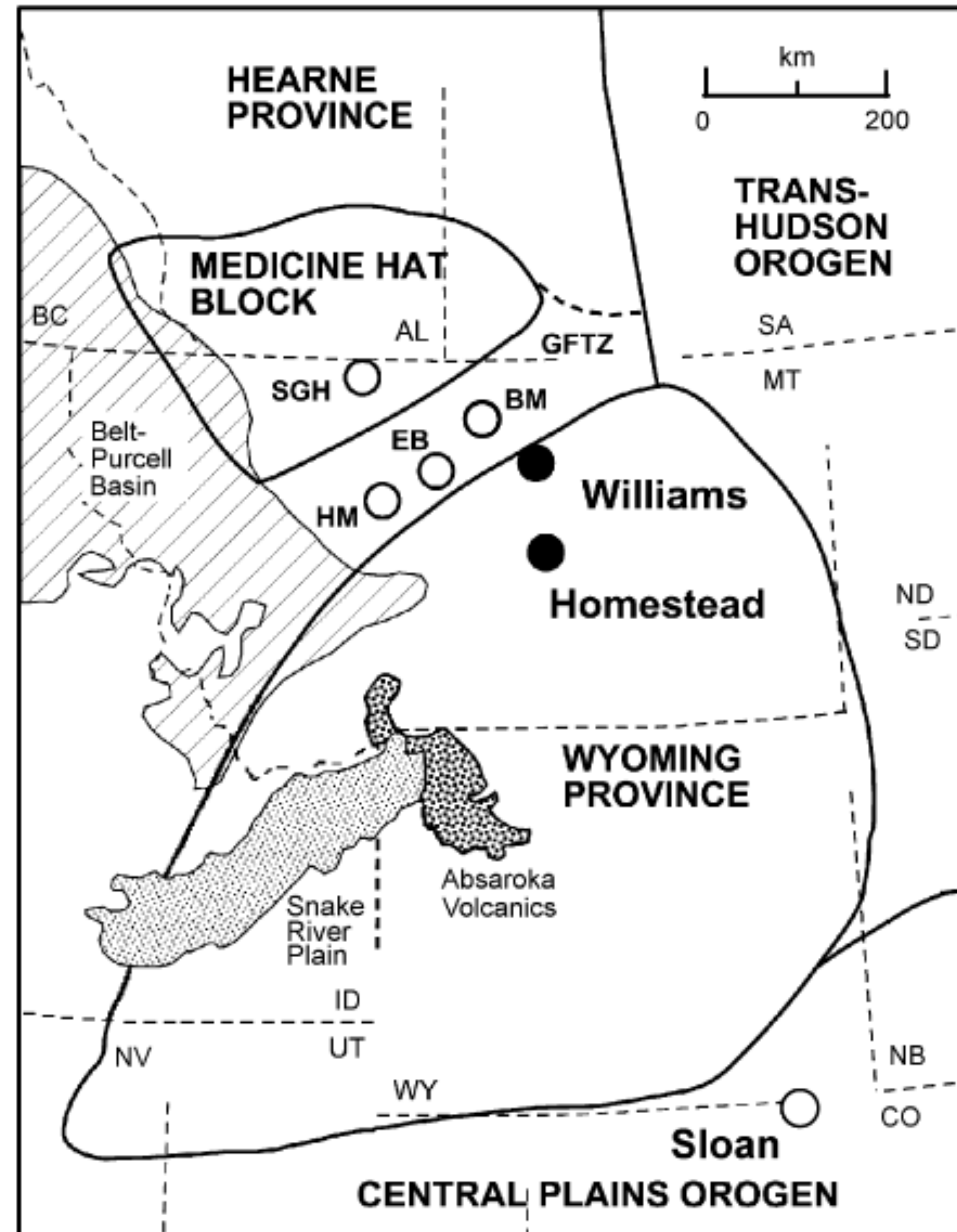
- **Subgrains preserve earlier, hi-T hydrous deformation**
  — Low T_{final}: low H_2O solubility

- Orthorhombic E-type to weak axial-[010] decreases Vp anisotropy *(Michibayashi et al. 2016)*

- **Similar to cratons, with increasing depth:**
  - Water content increases
  - Bimodal & axial-[010] olivine CPO increases

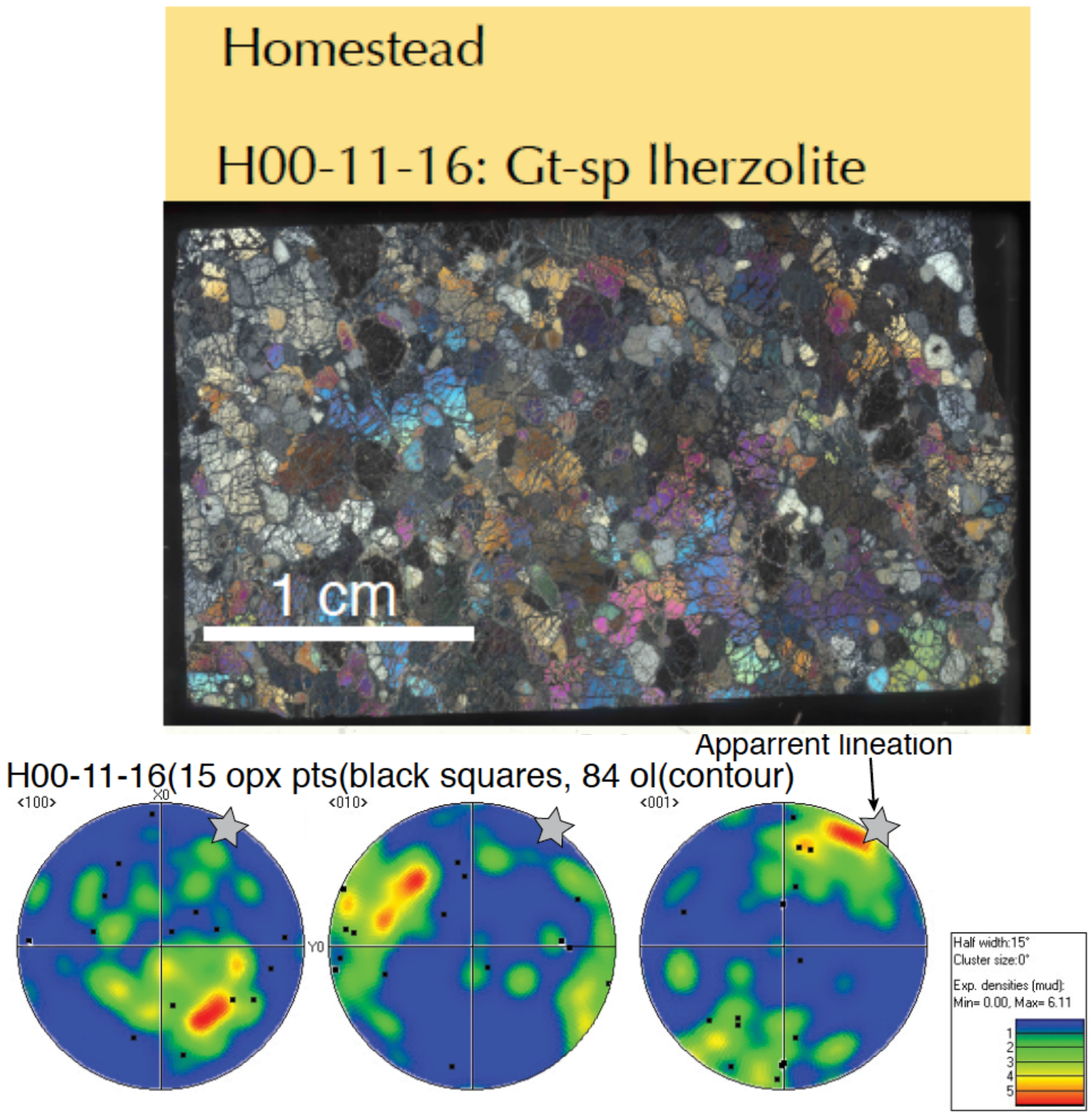
Are cratons forever?

Petrofabric & geochemistry of Wyoming peridotites

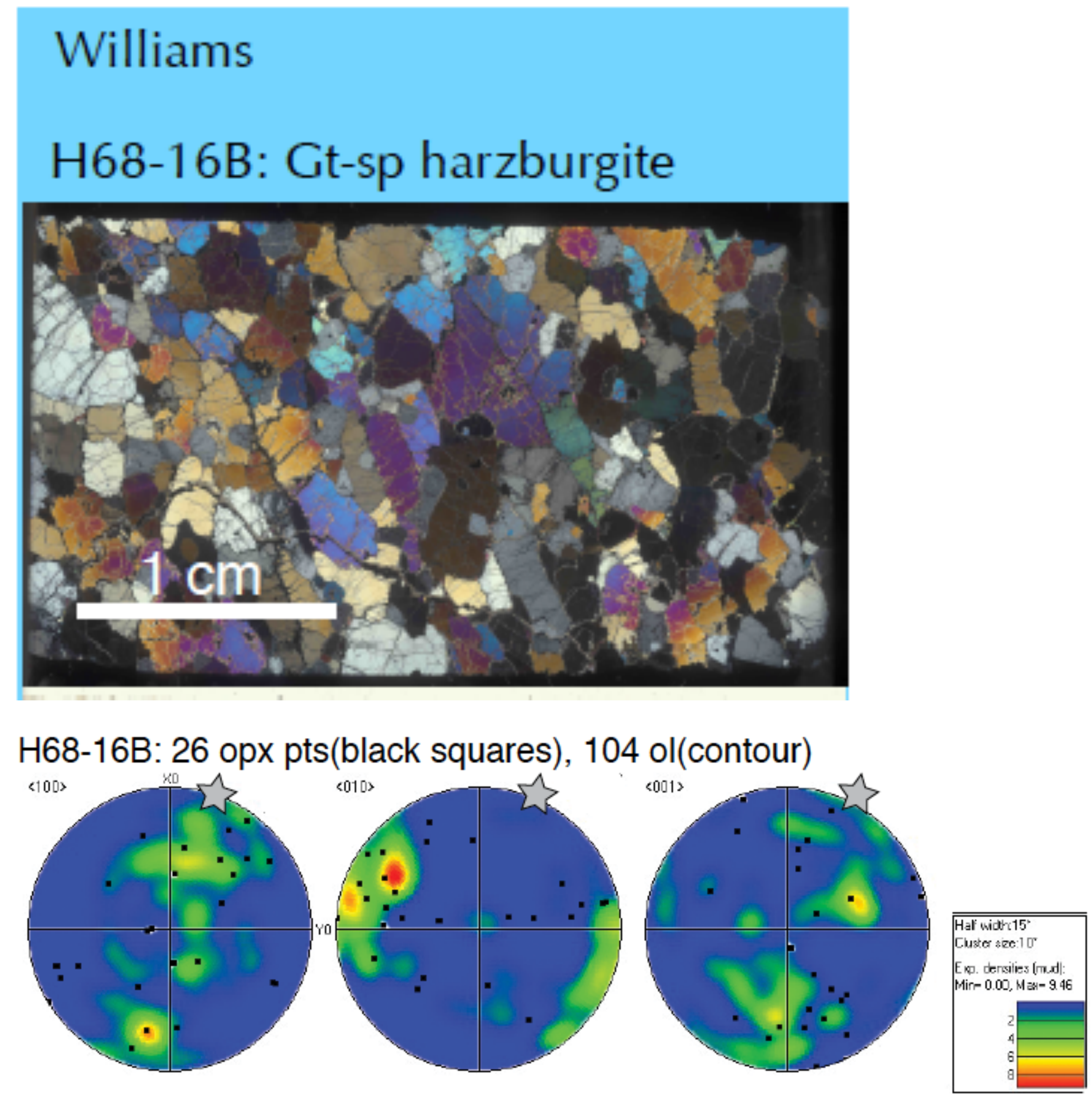


From Carlson et al. (2004)

Olivine CPO of Wyoming Craton xenoliths



B-type

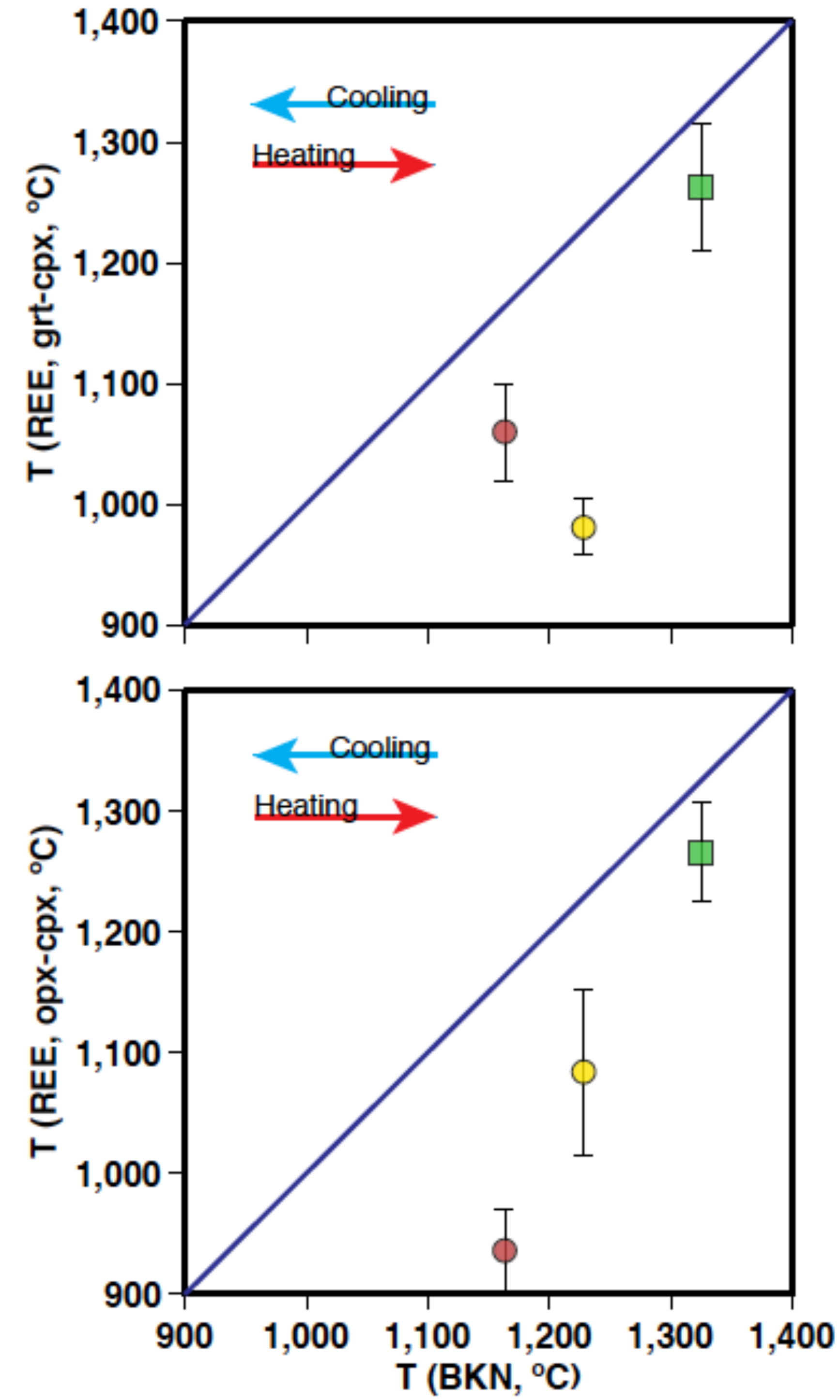


axial-[010]

Parks, Chin et al., *in prep*

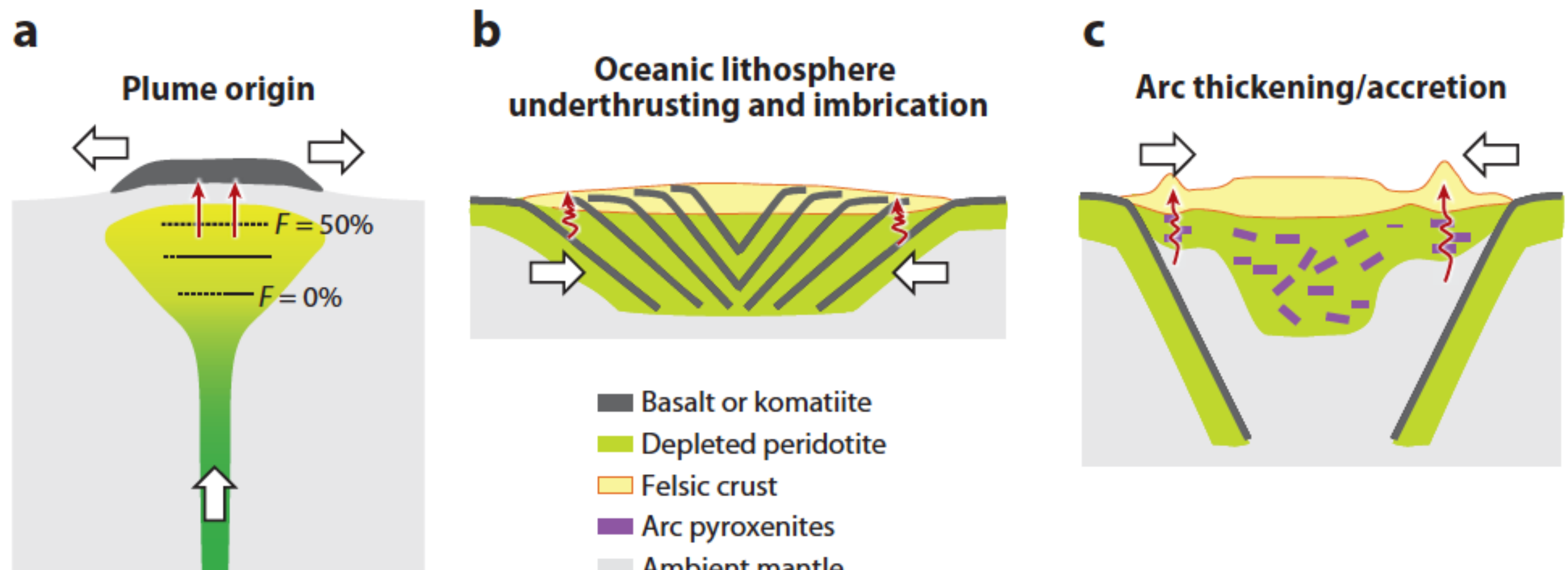
Effects of Laramide Orogeny on Wyoming Craton

- Hydration & metasomatism disturbs SCLM
- B-type, axial-[010] olivine CPOs
- High T_{REE} - transient heating



Parks, Chin et al., *in prep*

Similarities between Archean & Phanerozoic mantle



Lee et al., *Annu. Rev.* 2011