Metamorphic Processes: Metasomatism and geochemical cycling in subduction zone mélanges

Sarah Penniston-Dorland

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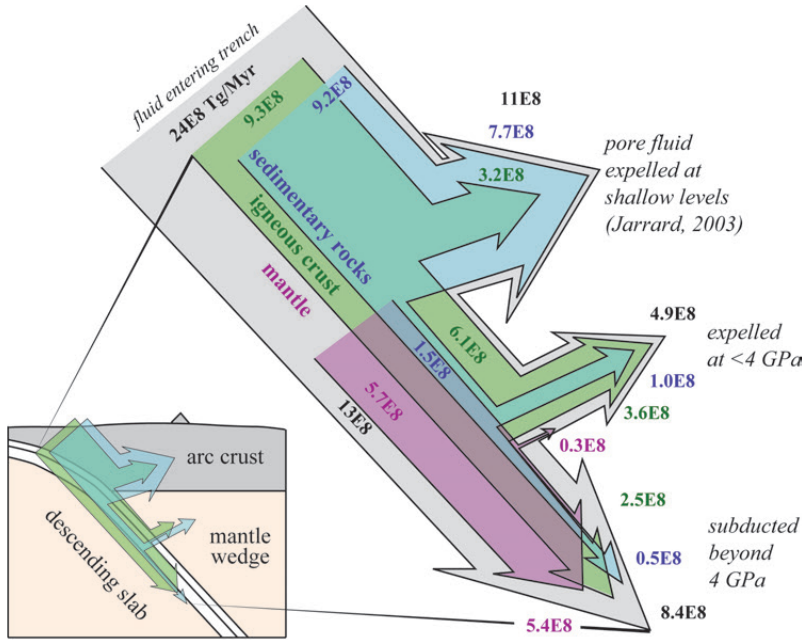
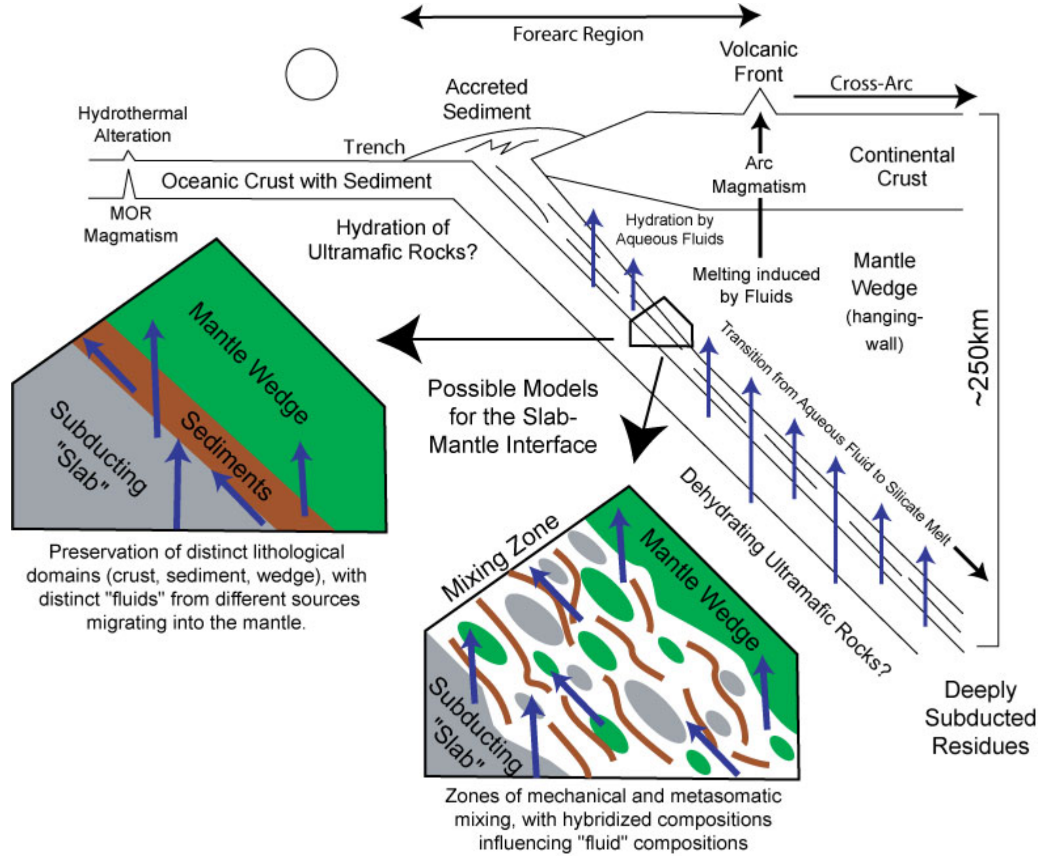
Metamorphic Processes: The inner workings of GeoPRISMS



Hacker, 2008

Bebout, 2007



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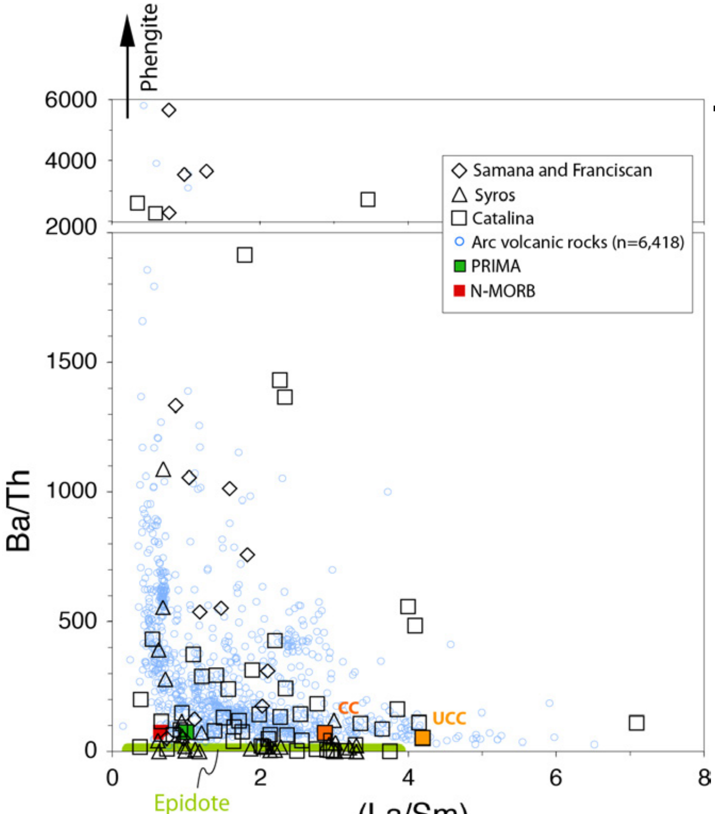
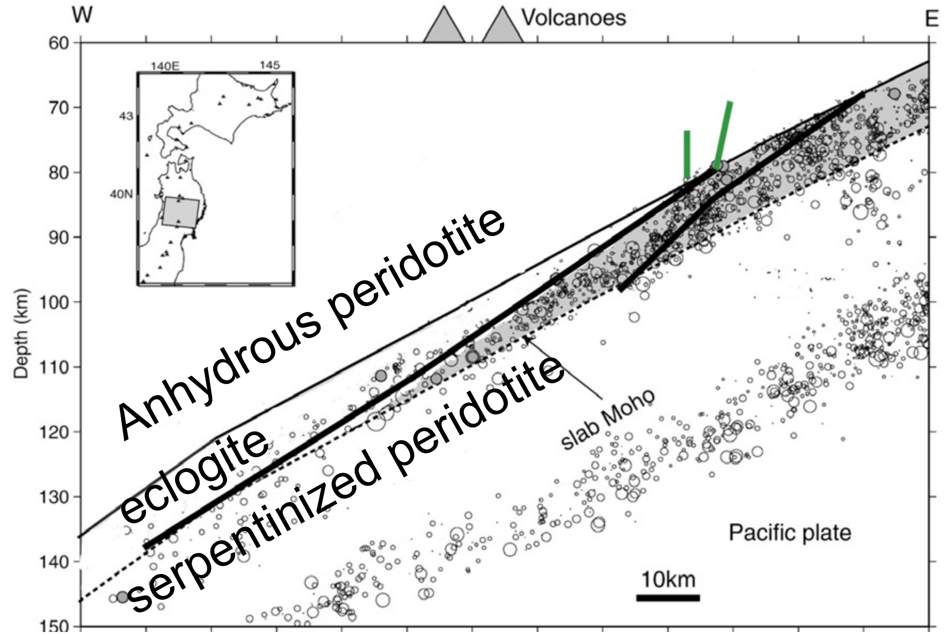
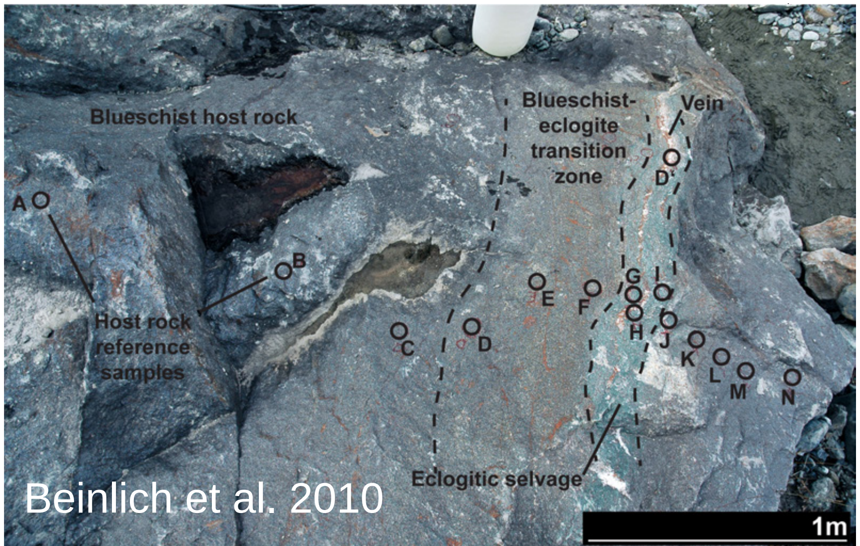


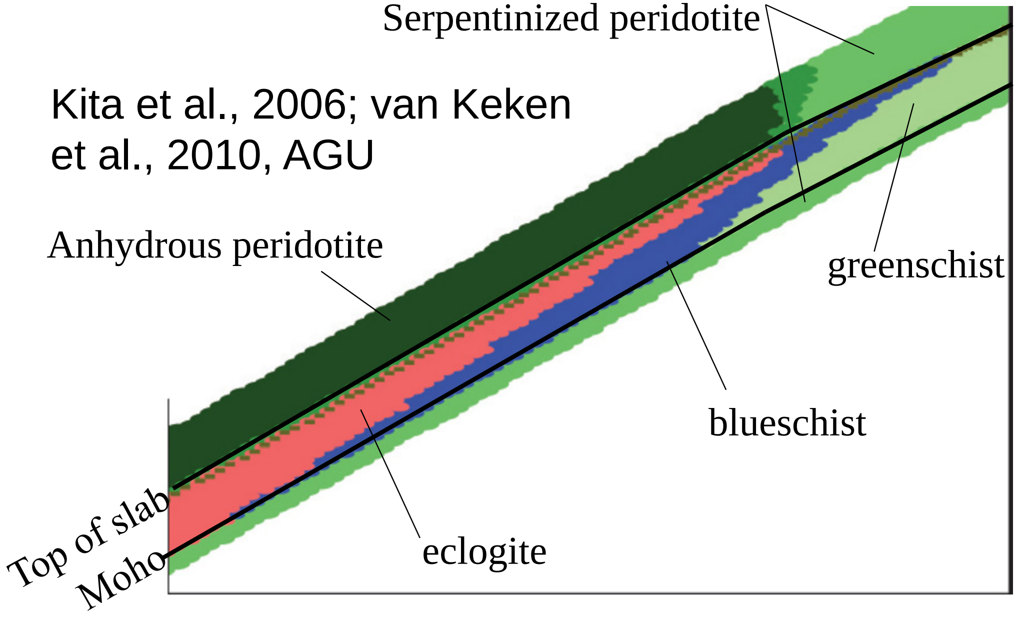
Schumacher et al., 2010, AGU



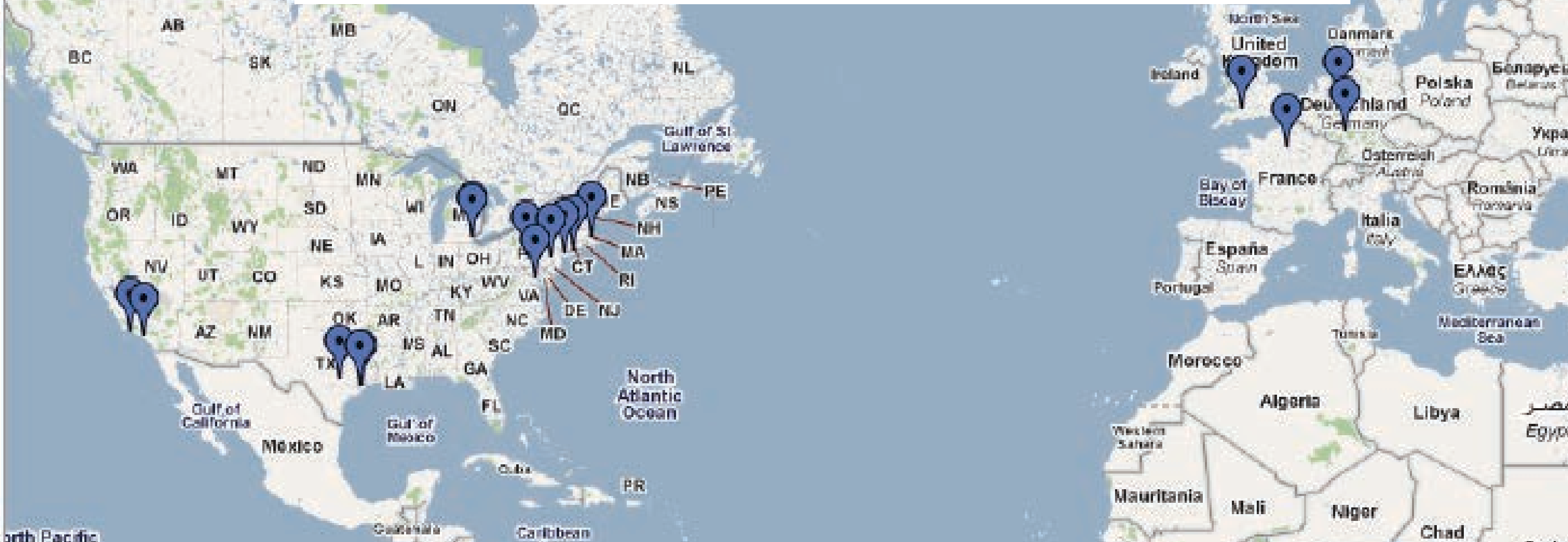


Beinlich et al. 2010

Kita et al., 2006; van Keken et al., 2010, AGU



Metamorphic Processes Participants



Sarah Penniston-Dorland (U. Maryland), Gray Bebout (Lehigh U.)

Brad Hacker (U.C. Santa Barbara), Horst Marschall (U. Bristol)

Maureen Feineman (Penn State), Timm John (U. Münster)

Philippe Agard (UPMC Paris VI), Peter van Keken (U. Michigan)

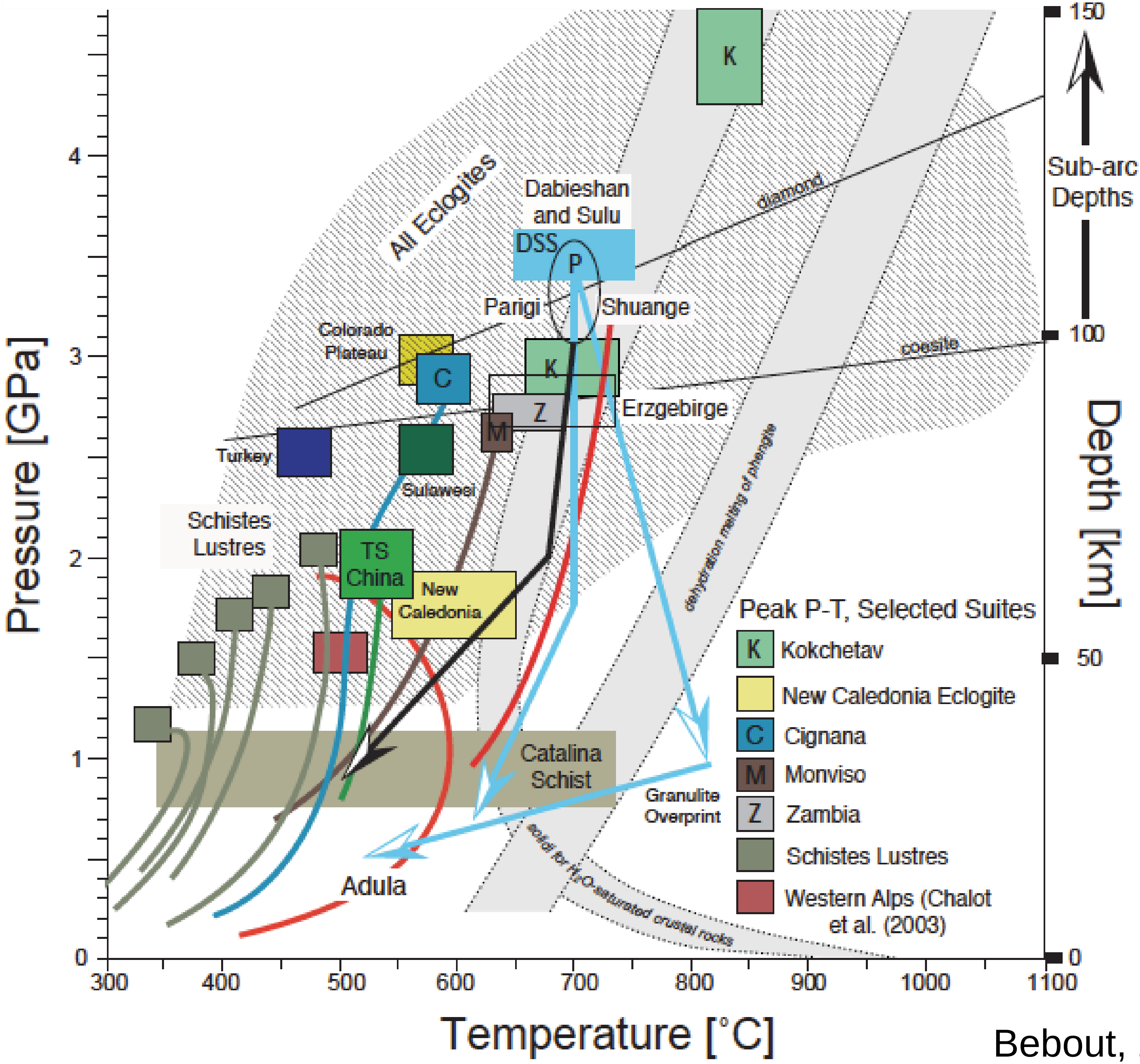
Geoff Abers (Lamont), Craig Manning (UCLA)

Justin Filiberto (Rice U.),Thomas Zack (U. Mainz)

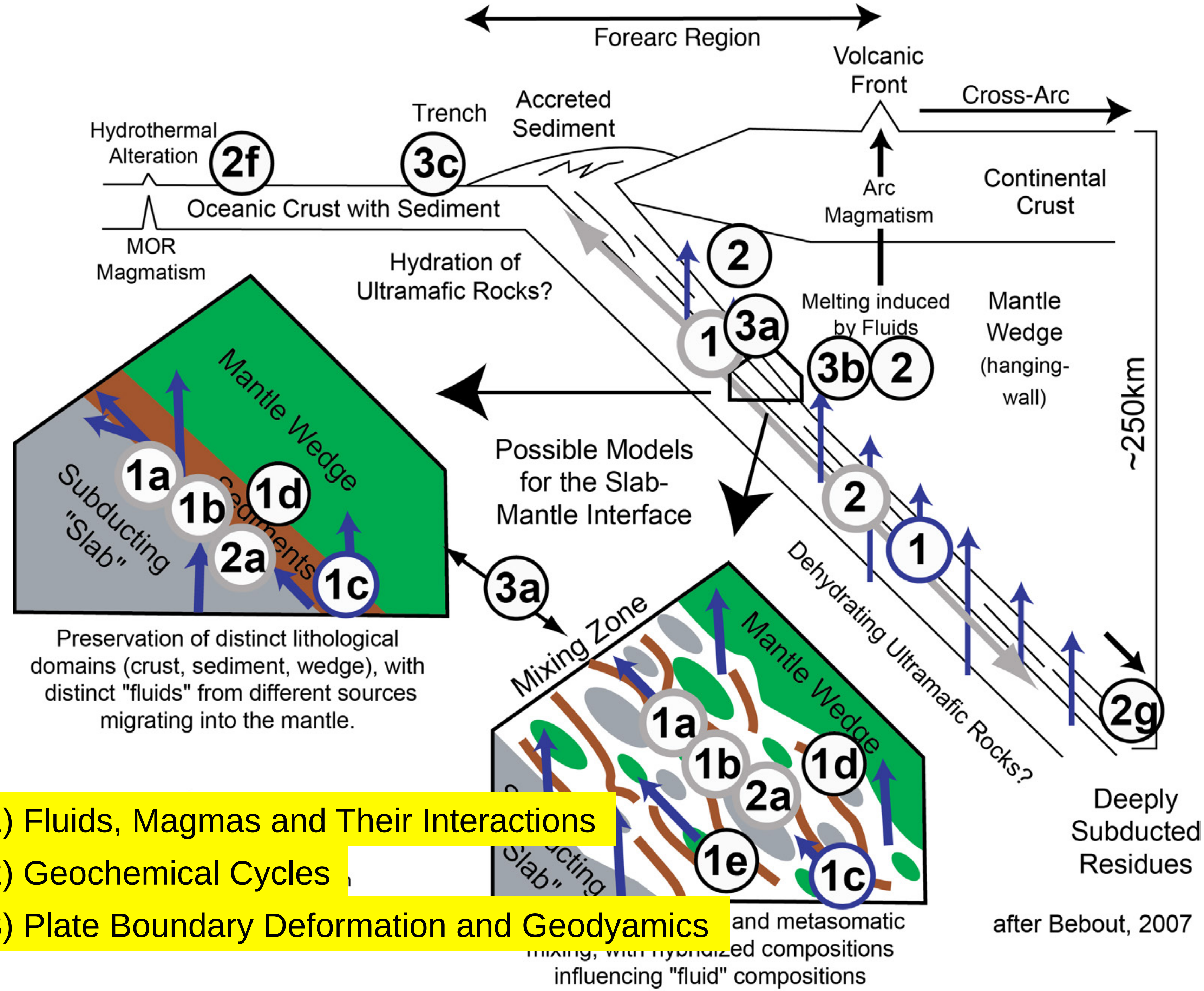
Juliane Gross (LPI), Jay Ague (Yale), Ethan Baxter (Boston U.)

Jeff Alt (U. Michigan), M. Cloos (U. Texas)

Metamorphic Sample Repository



Bebout, 2007



1) Fluids, Magmas and Their Interactions

2) Geochemical Cycles

3) Plate Boundary Deformation and Geodyamics

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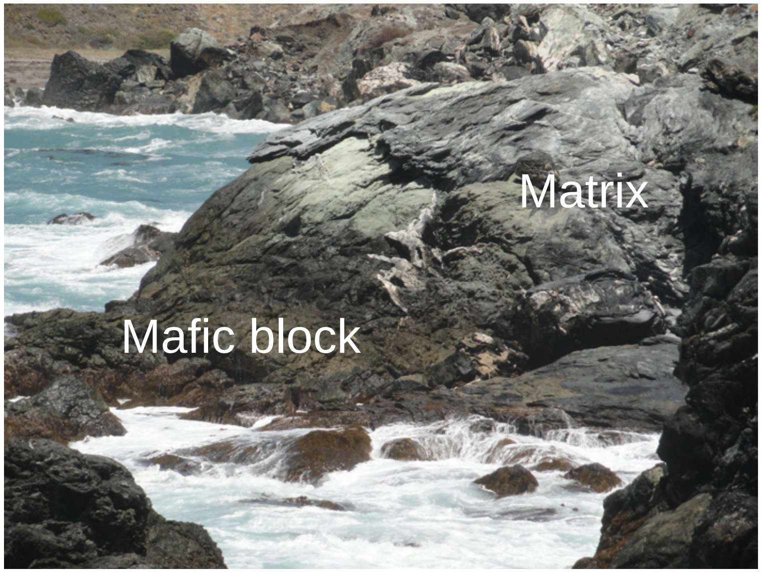

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Philip Pogge von Strandmann
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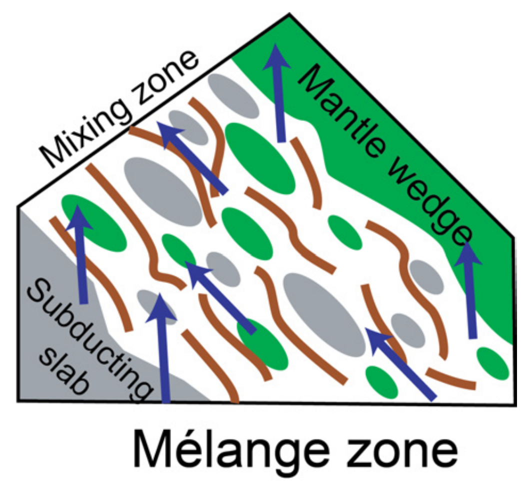


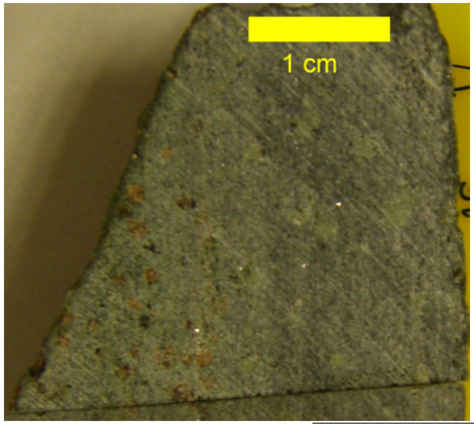
Why use Lithium?

^{7}Li ^{6}Li

- Li is a fluid mobile element
- Li partitions into fluid phase at high temperature ($K_{d\ \mathit{min\text{-}fluid}}$<1)
- For many minerals the heavier isotope fractionates into fluid phase ($\delta^{7}Li_{fluid} > \delta^{7}Li_{min}$)
- Lithium diffuses rapidly and can fractionate during diffusion

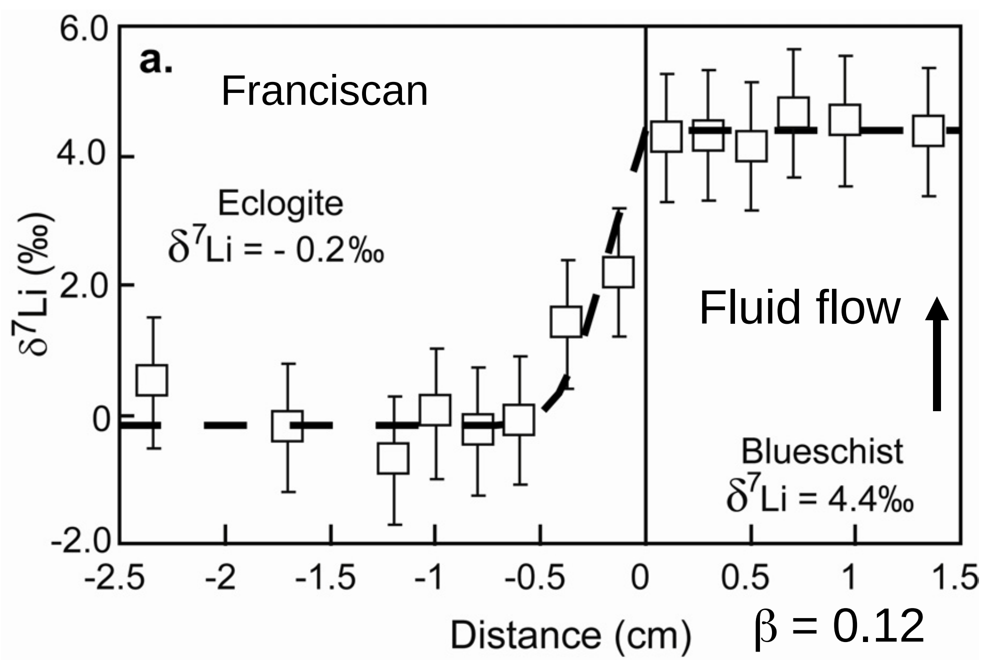
$$\delta^{7}Li = \left(\frac{{}^{7}Li/{}^{6}Li_{sample} - {}^{7}Li/{}^{6}Li_{L-SVEC}}{{}^{7}Li/{}^{6}Li_{L-SVEC}} \right) \times 1000$$

Diffusivity of Li

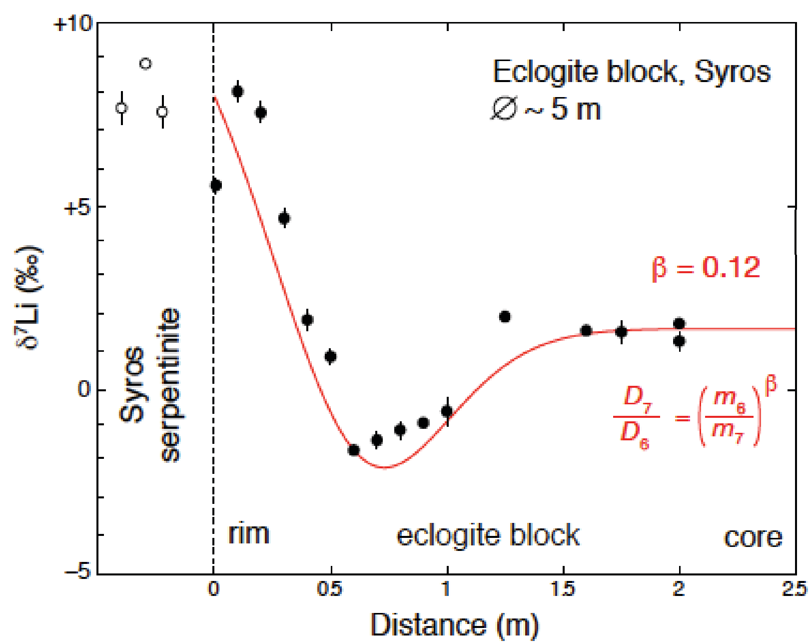


Eclogite

Blueschist

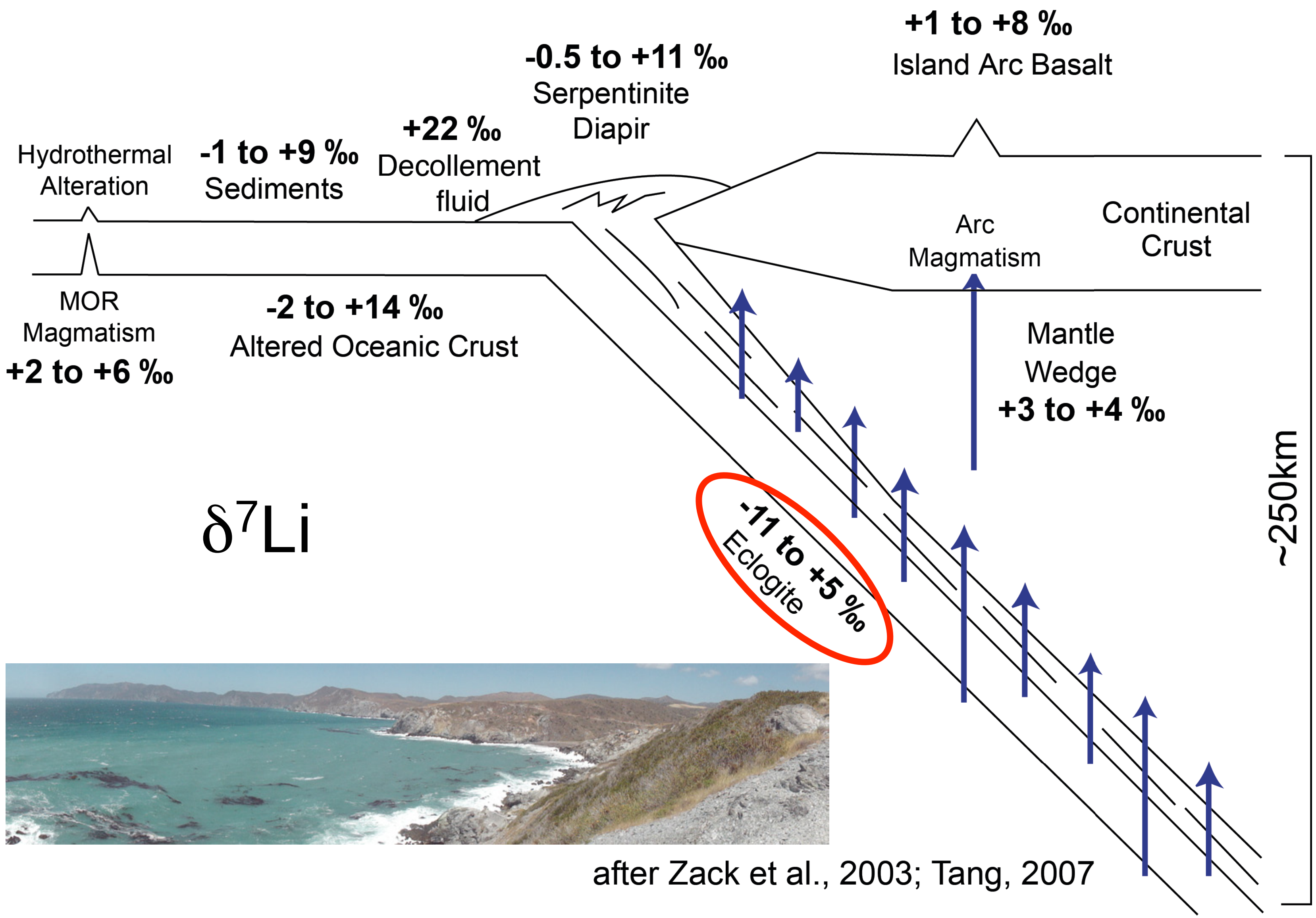


Penniston-Dorland et al., 2010



Marschall, unpub. data

Geochemical cycling of Li



after Zack et al., 2003; Tang, 2007

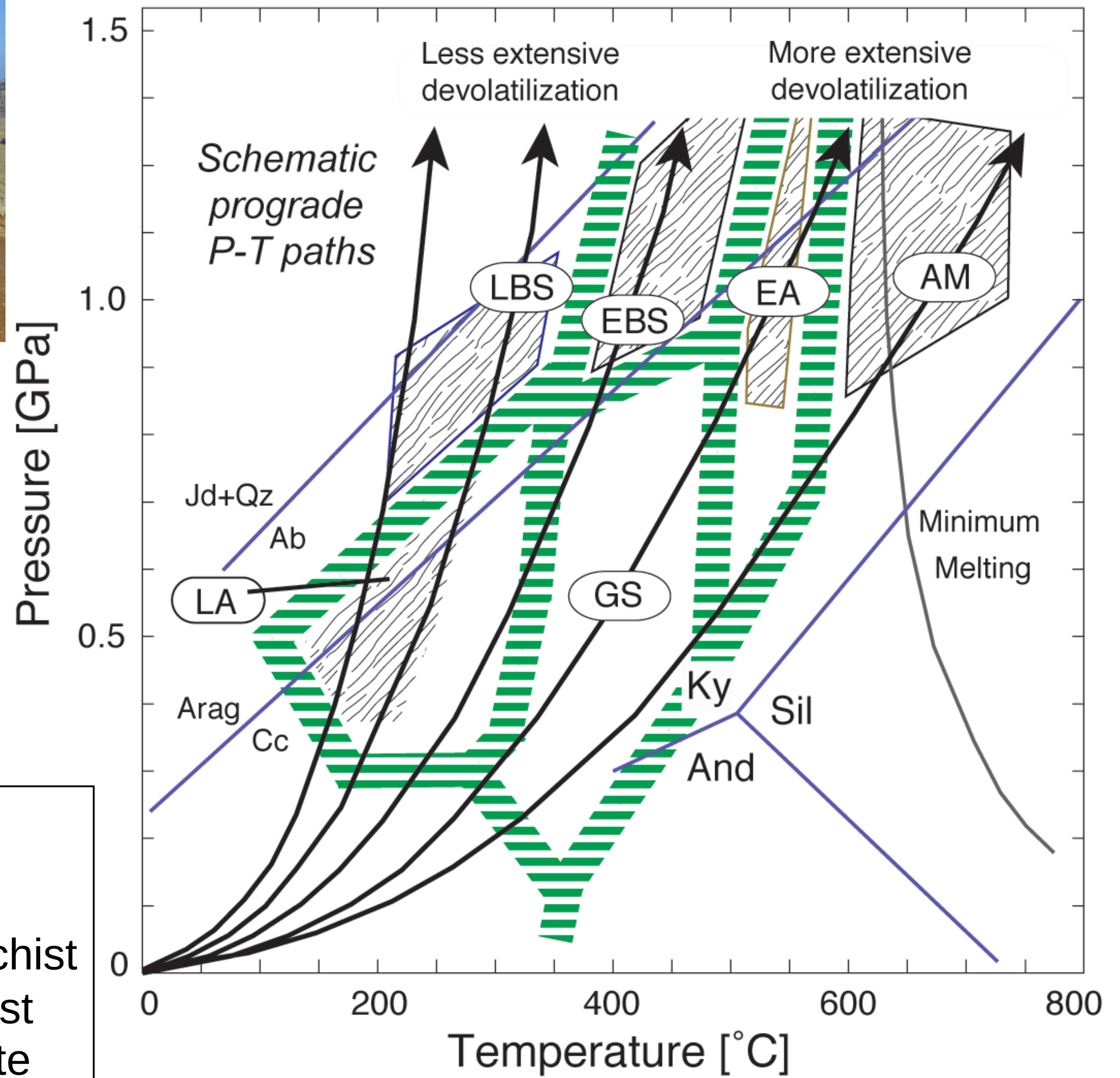
P-T conditions

Catalina Schist

Metamorphic facies

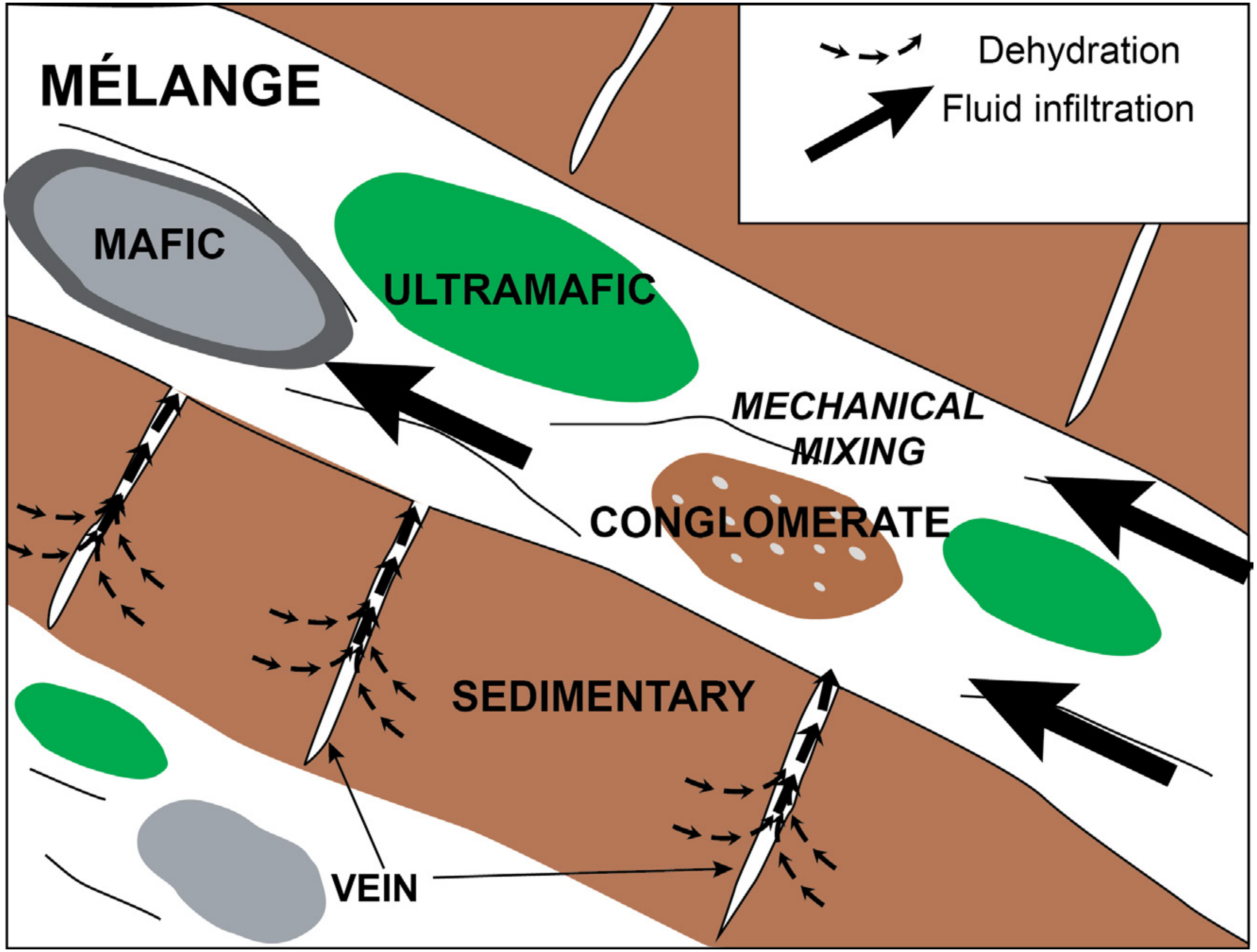
LOW ↓ HIGH

- LA = Lawsonite-albite
- LBS = Lawsonite blueschist
- EBS = Epidote blueschist
- EA = Epidote amphibolite
- AM = Amphibolite



Bebout, 2007

Conceptual model for metasomatism and fluid flow in Catalina Schist



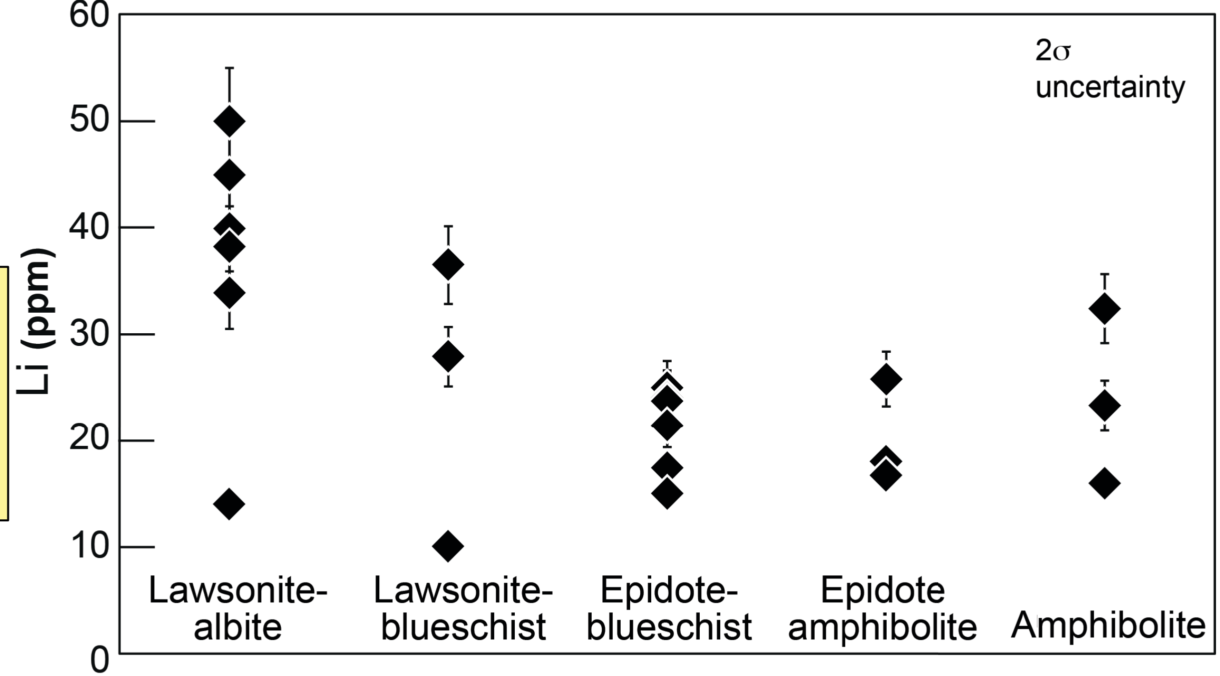
after Bebout et al., 1997

Metasedimentary rocks

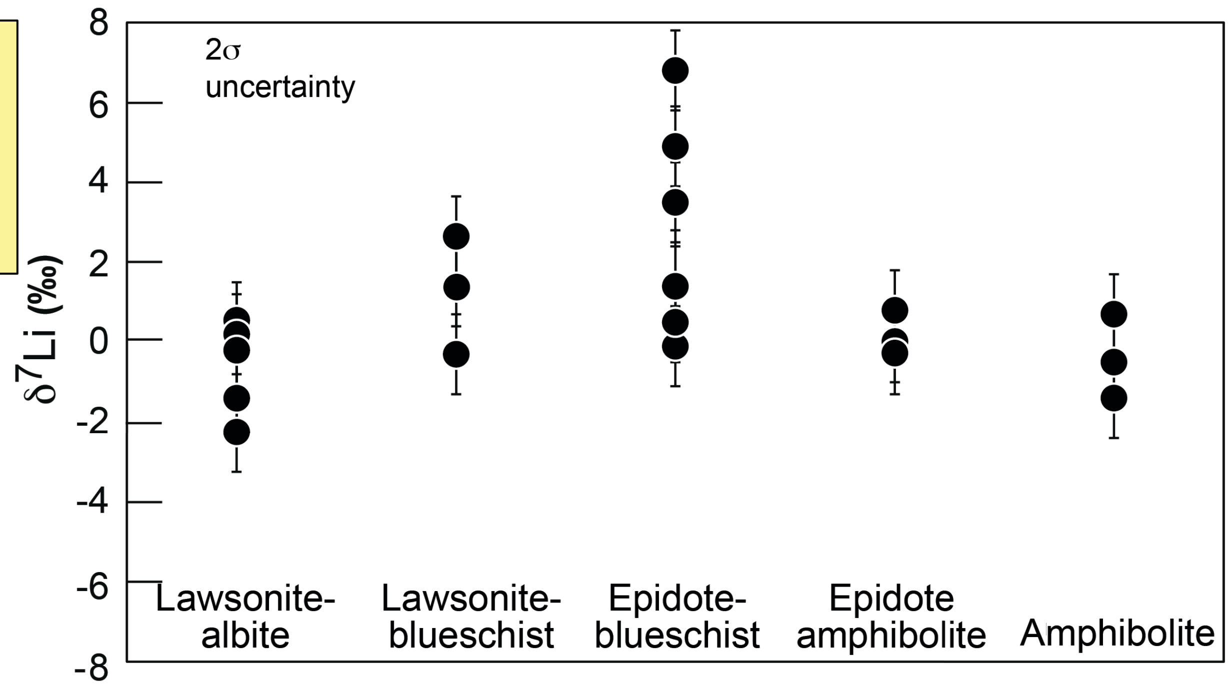
No systematic change in Li concentration and δ^7Li with grade

Contrasts with B, Cs, N all of which show dramatic losses with metamorphic grade

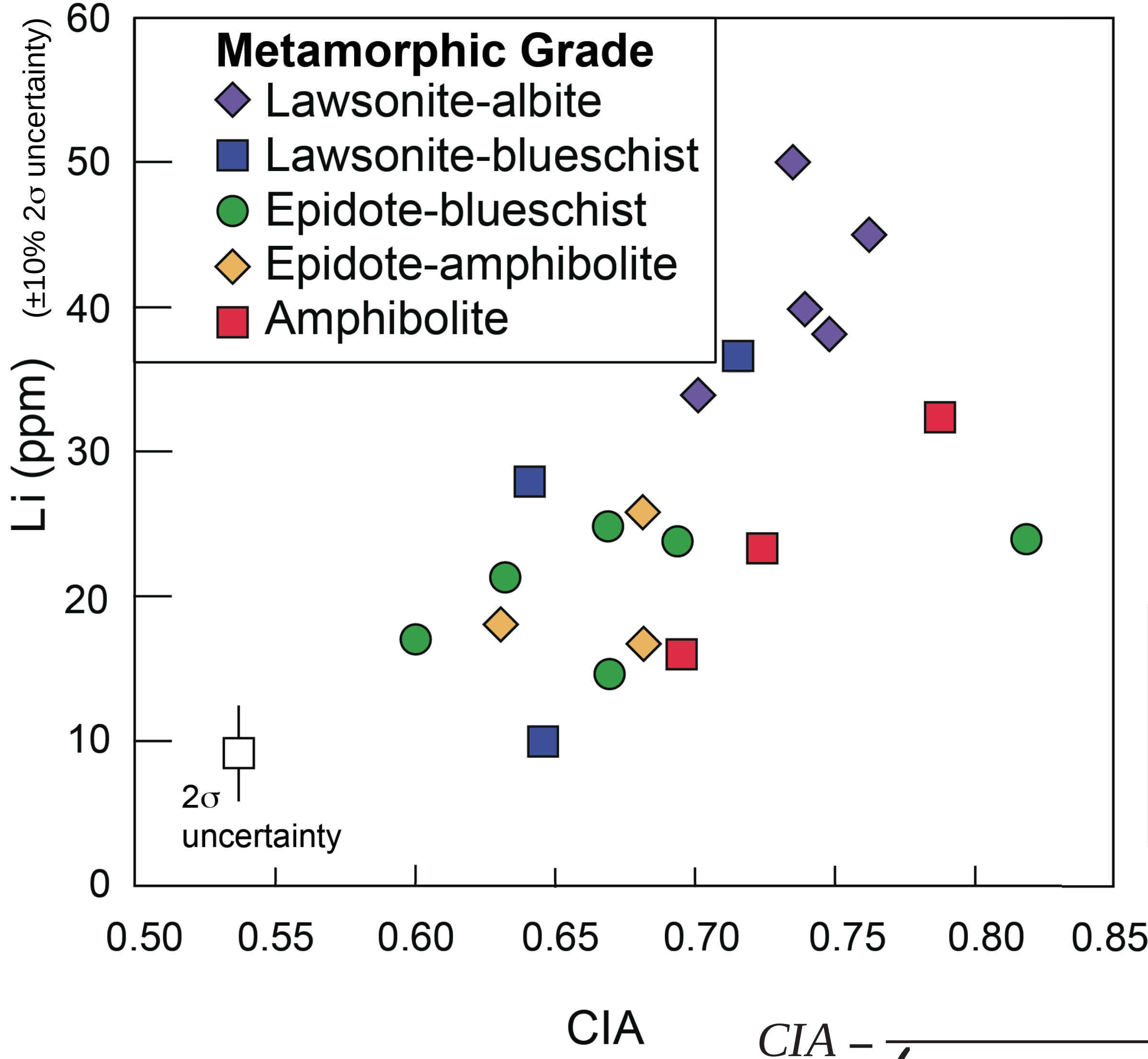
Dehydration reactions do not drastically affect Li



LOW GRADE → HIGH GRADE



Metasedimentary rocks



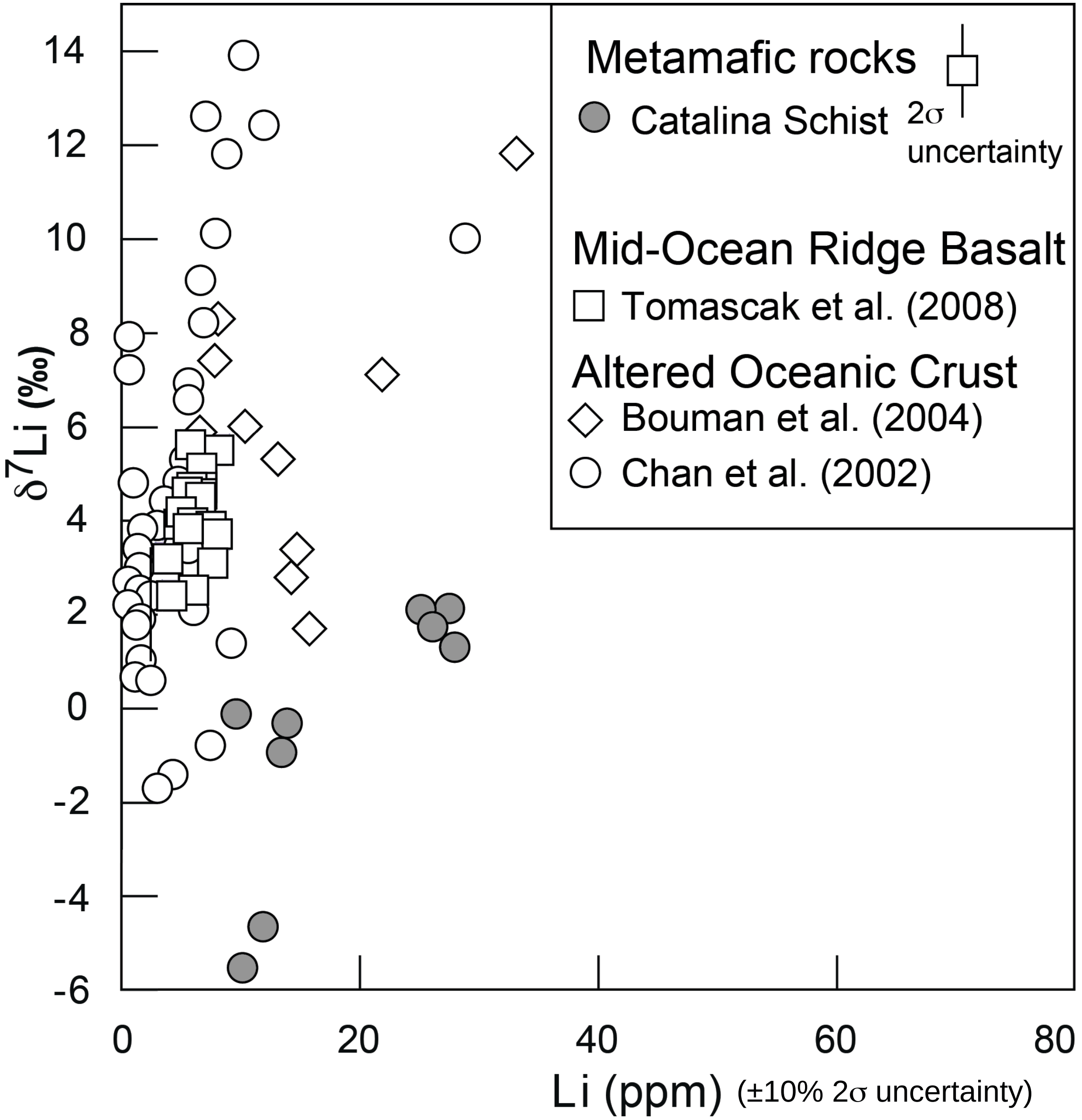
Li concentration correlates with Chemical Index of Alteration (CIA)

Li reflects degree of weathering of source of protolith

$$CIA - \frac{wt\%Al_2O_3}{\left(wt\%Al_2O_3 + wt\%Na_2O + wt\%K_2O + wt\%CaO^*\right)}$$

Metamafic rocks

Mafic rocks have
more Li than protolith

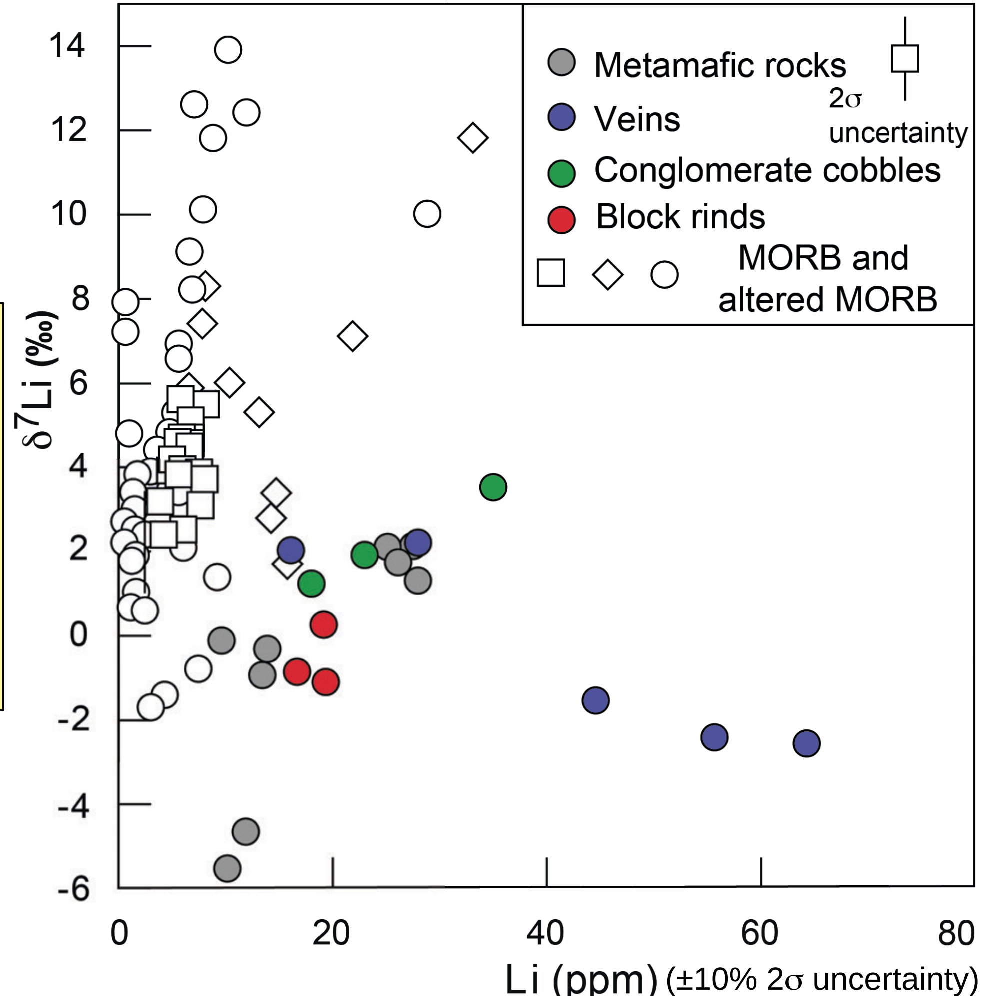


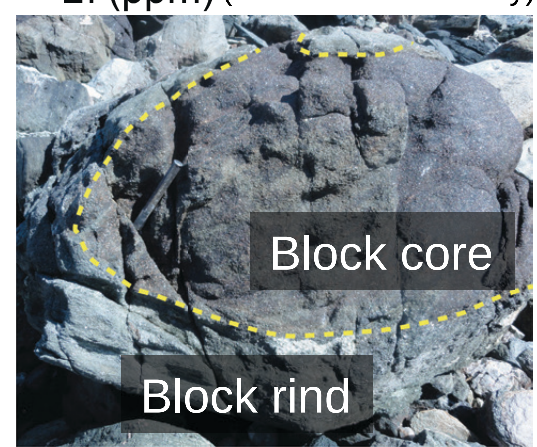
Suggests external source of Li

infiltration of Li-bearing fluid into block or diffusion of Li into block through grain boundary fluid.

Metasomatic features

Veins, conglomerate cobbles, and reaction rinds, all features indicative of fluid-rock interactions – wide range of Li compositions

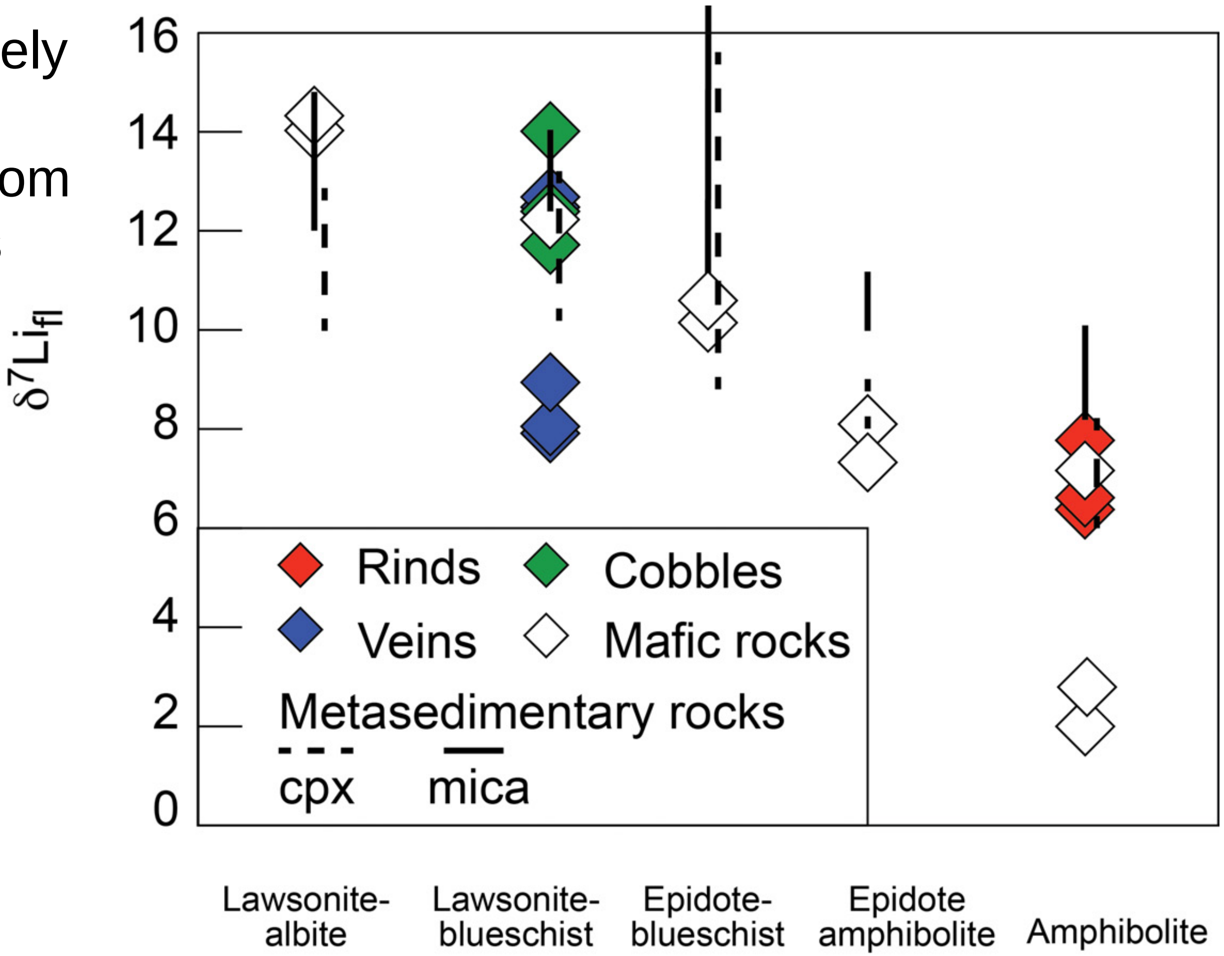




Fluid compositions of metamafic rocks and metasomatic features largely overlap with fluid compositions calculated from metasedimentary rocks

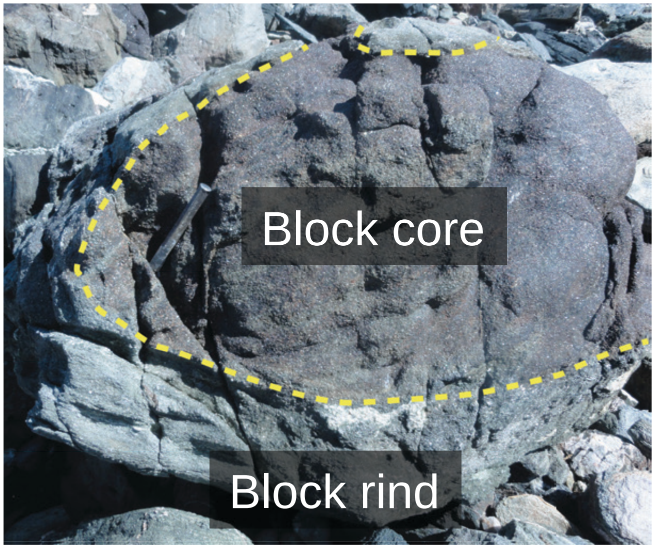
Local metasedimentary rocks as source of Li?

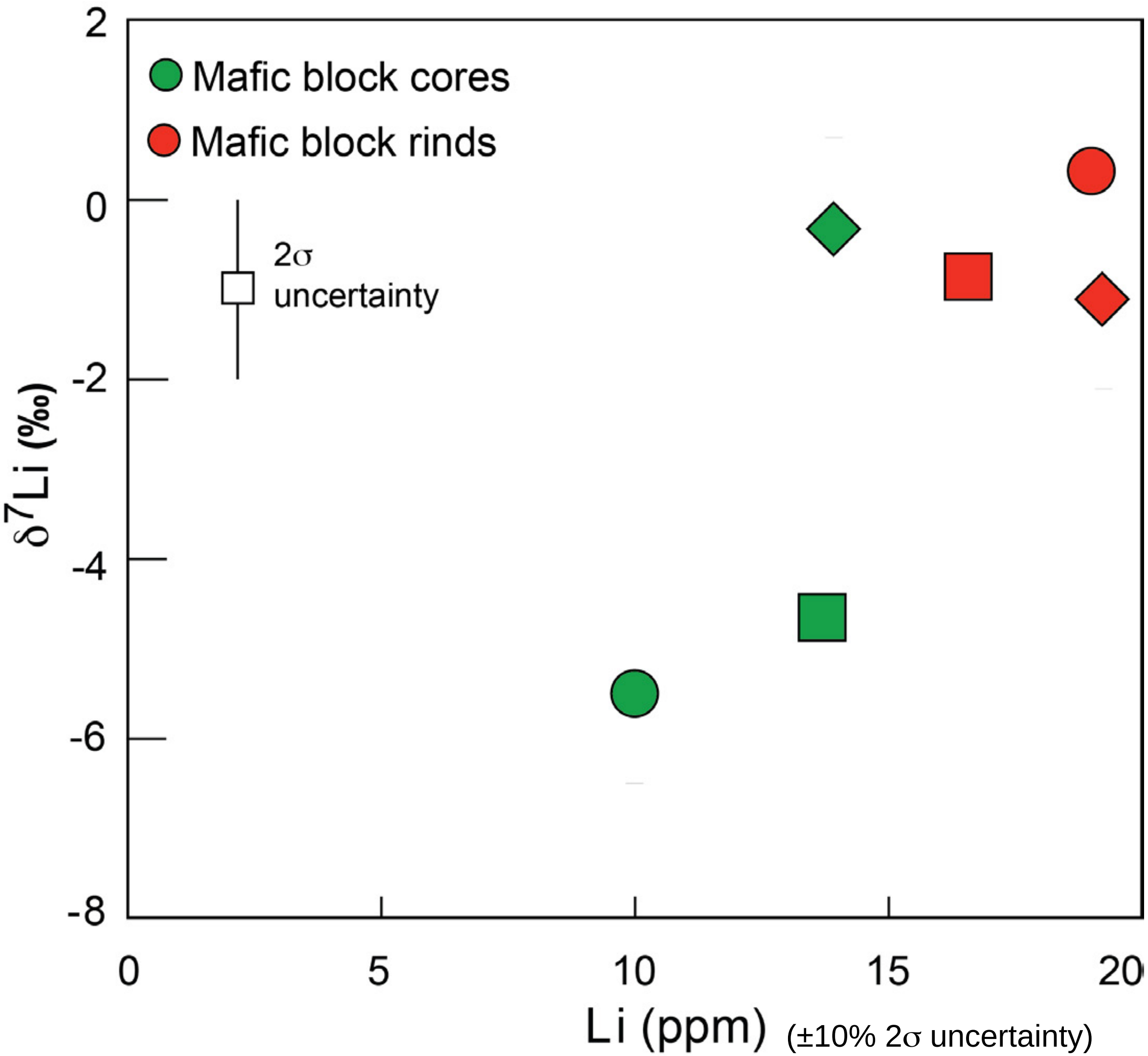
Calculated fluid δ^7Li

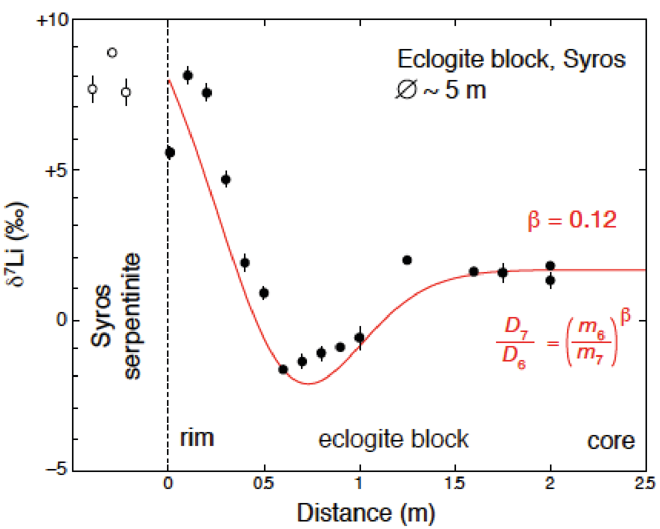


Calculated using cpx-fluid fractionation of Wunder et al. (2006) [and mica-fluid fractionation of Wunder et al. (2007)]

Diffusive Fractionation?







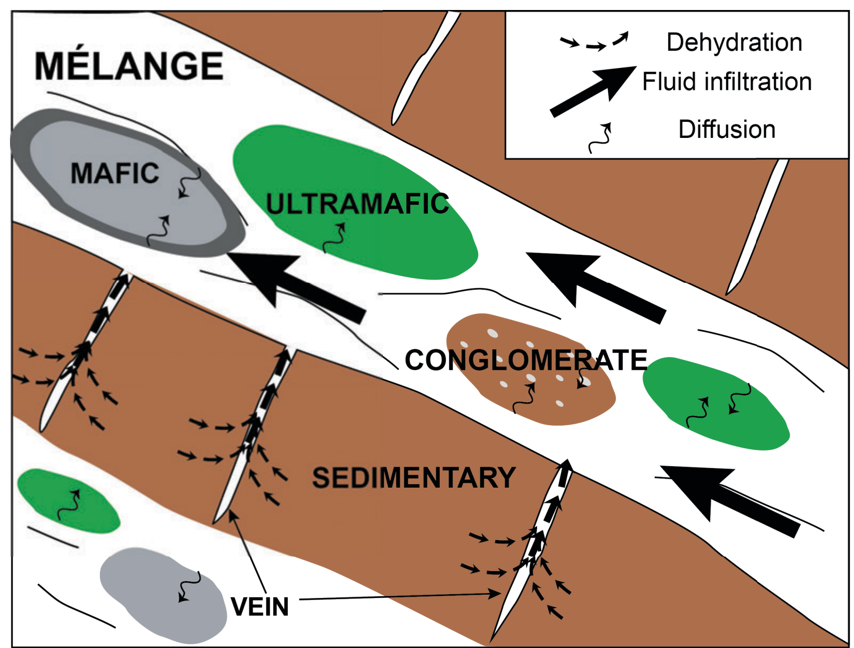
Most block cores are have significantly lower δ^7Li than rinds suggesting diffusive fractionation

Observations

- No systematic change in Li of metasedimentary rocks with grade
- Li of metasedimentary rocks correlates with CIA

Interpretations

- No significant effect of dehydration on Li – however some loss of Li during dehydration likely
- Li reflects weathering of source of protolith

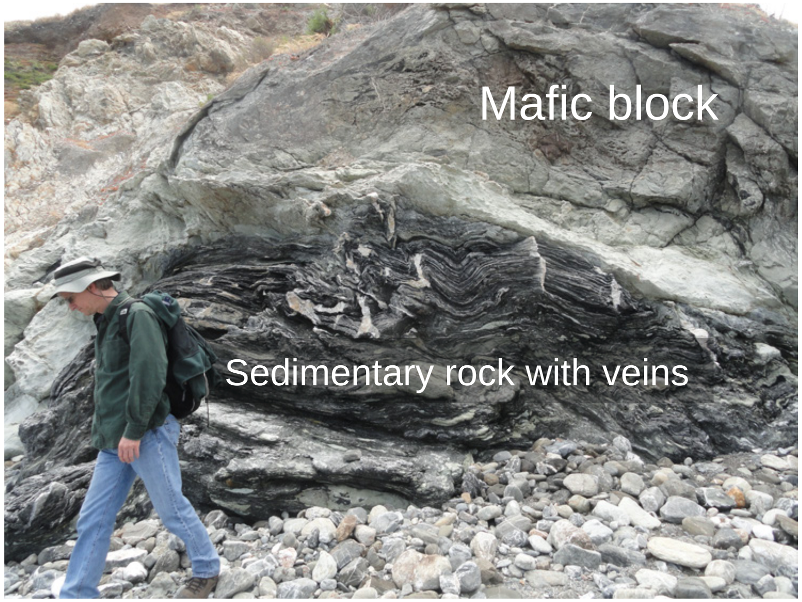


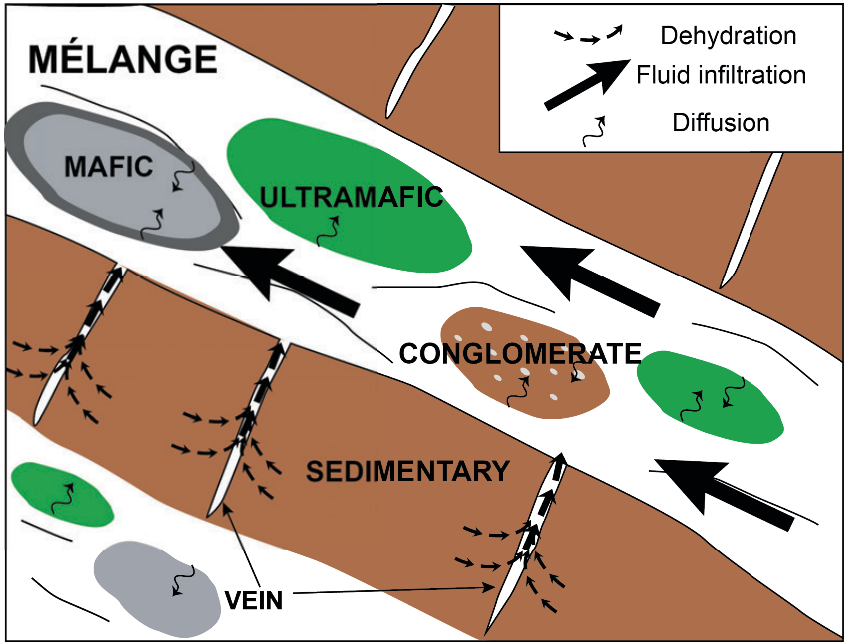
Observations

- Mafic rocks have high Li compared to protolith
- Calculated fluid δ^7Li for mafic rocks & most metasomatic features overlaps metasedimentary rocks of the same metamorphic grade
- Large difference in Li between block cores and rinds

Interpretations

- Mafic rocks interacted with fluids likely derived from metasedimentary rock
- Fluids are derived from local metasedimentary rocks
- Li may have diffused into blocks





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