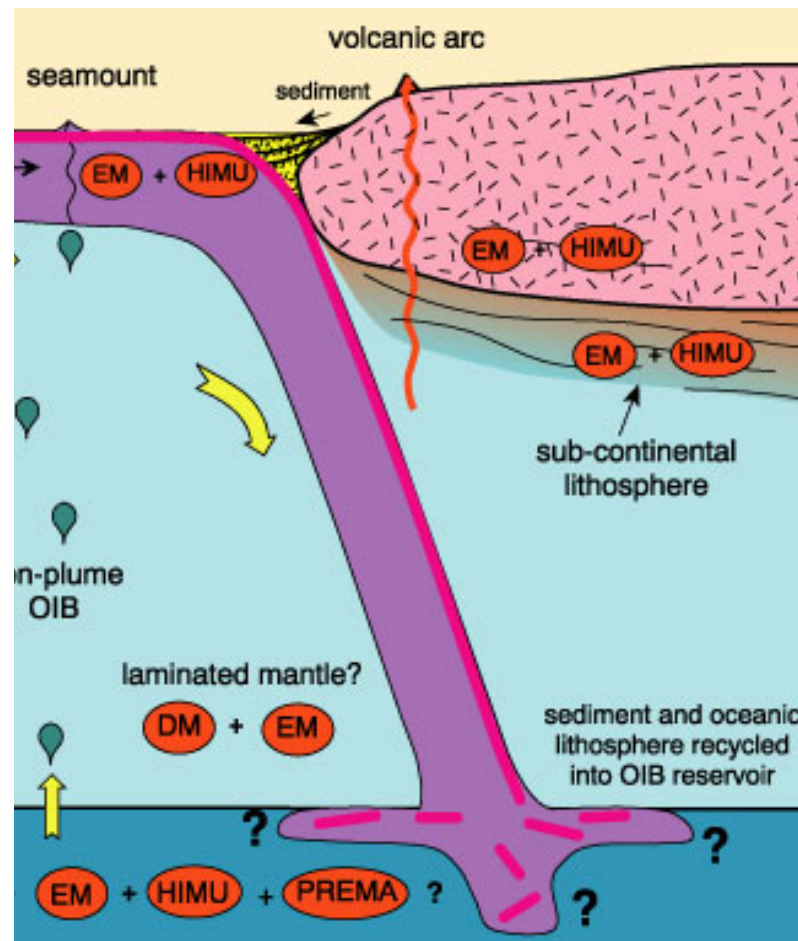


Geochemical Products of Subduction



Maureen Feineman

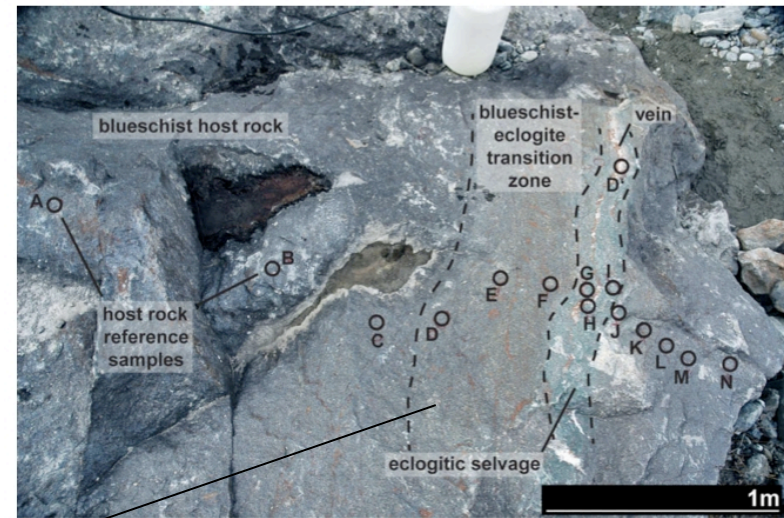
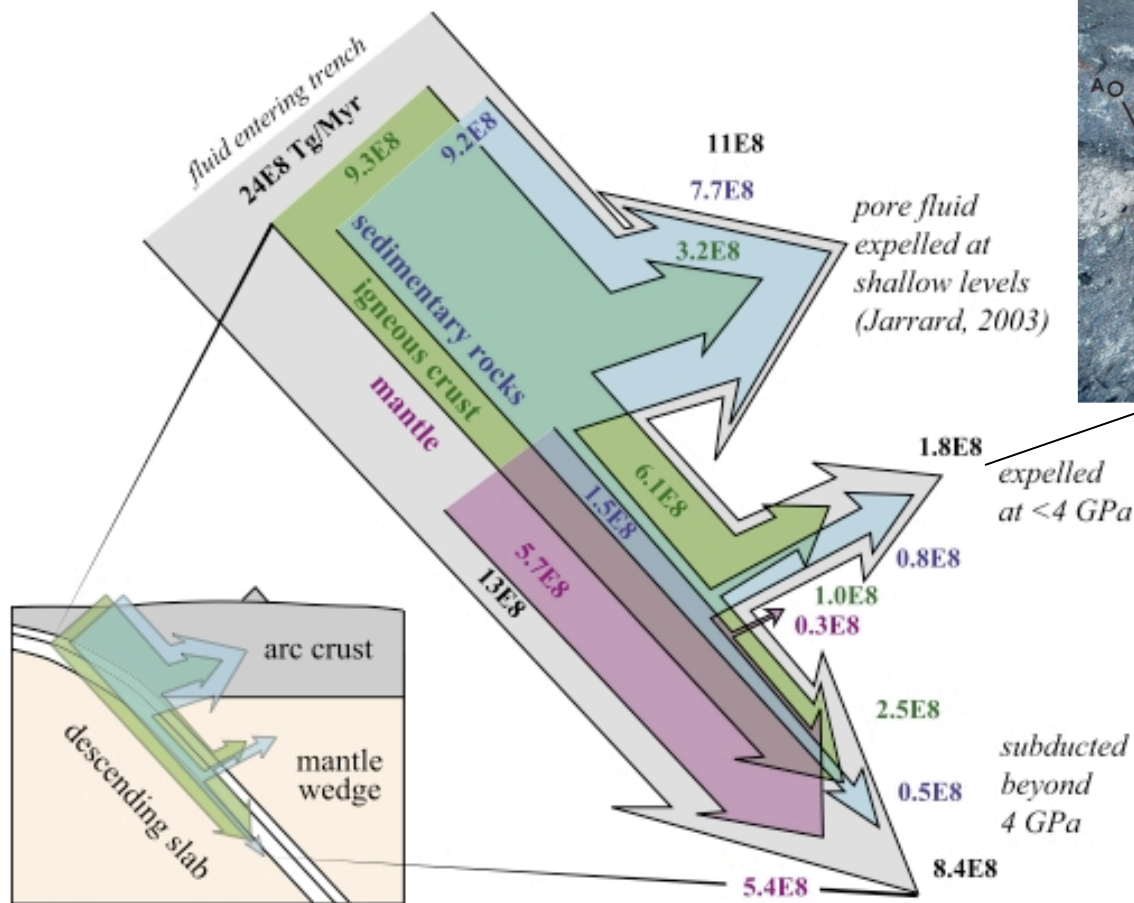
GeoPRISMS SCD Implementation Workshop

January 2011, Austin, TX

What are the geochemical products of subduction?

- Fluids
 - aqueous, supercritical, brines, volcanic gases
- Melts
 - Slab melts, mantle melts, crustal melts

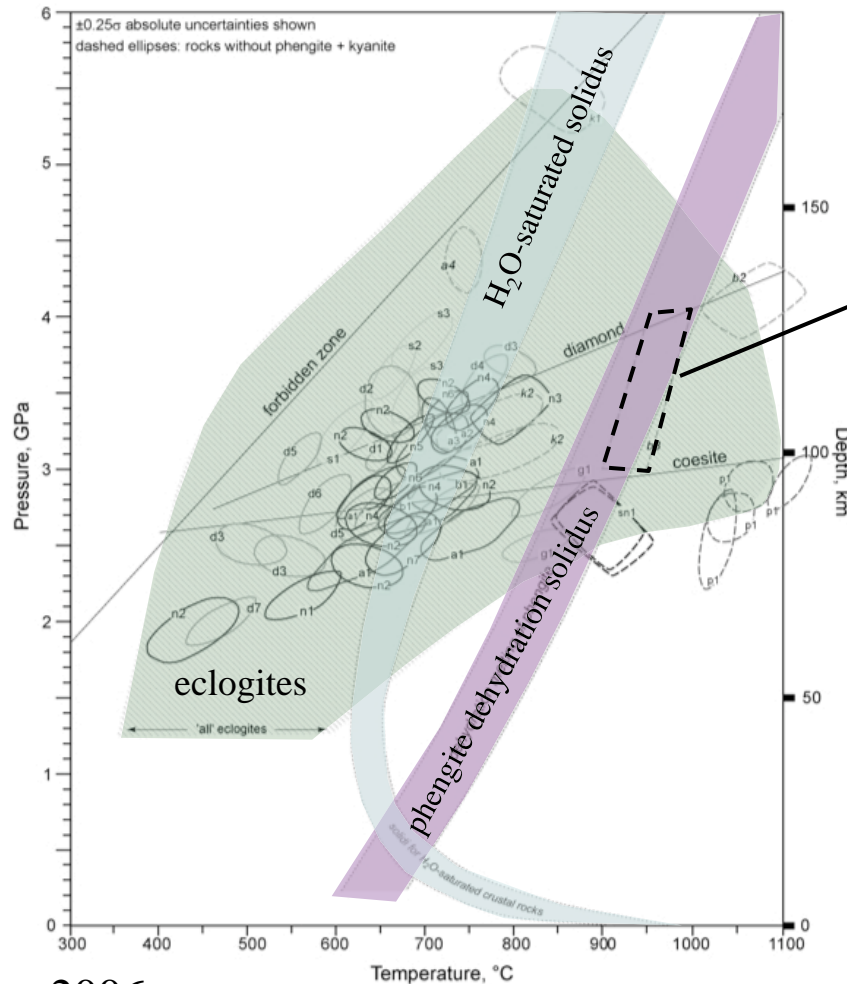
Fluid production in the slab



Tianshan blueschist
Beinlich et al. 2010

Partial melting of eclogite

Migmatized eclogite
Erzgebirge, Germany

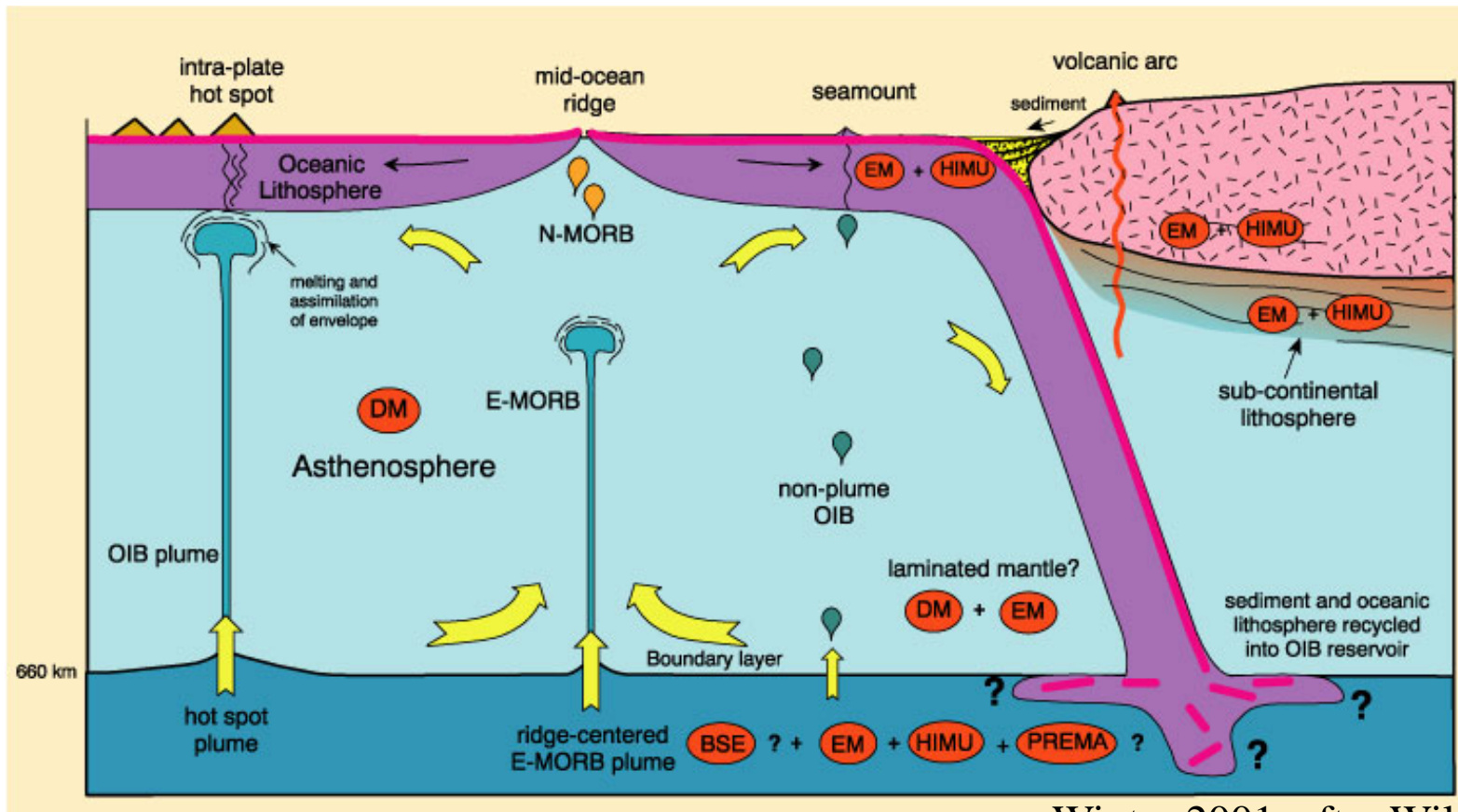


LeVay et al. submitted

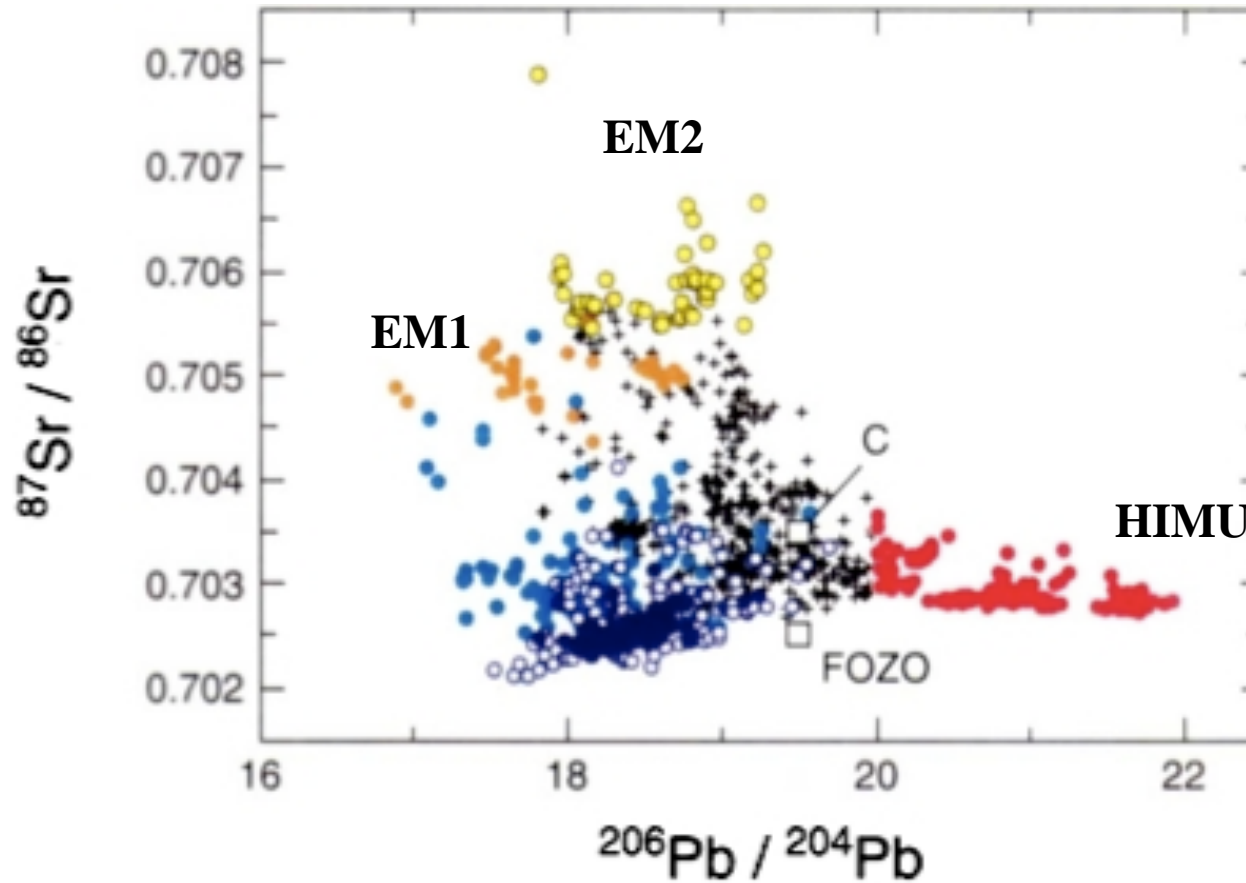
Products of Subduction

- Forearc fluids
- Arc lithosphere
- Ash, weathering products, and sediments
- Atmospheric volatiles
- Mantle domains

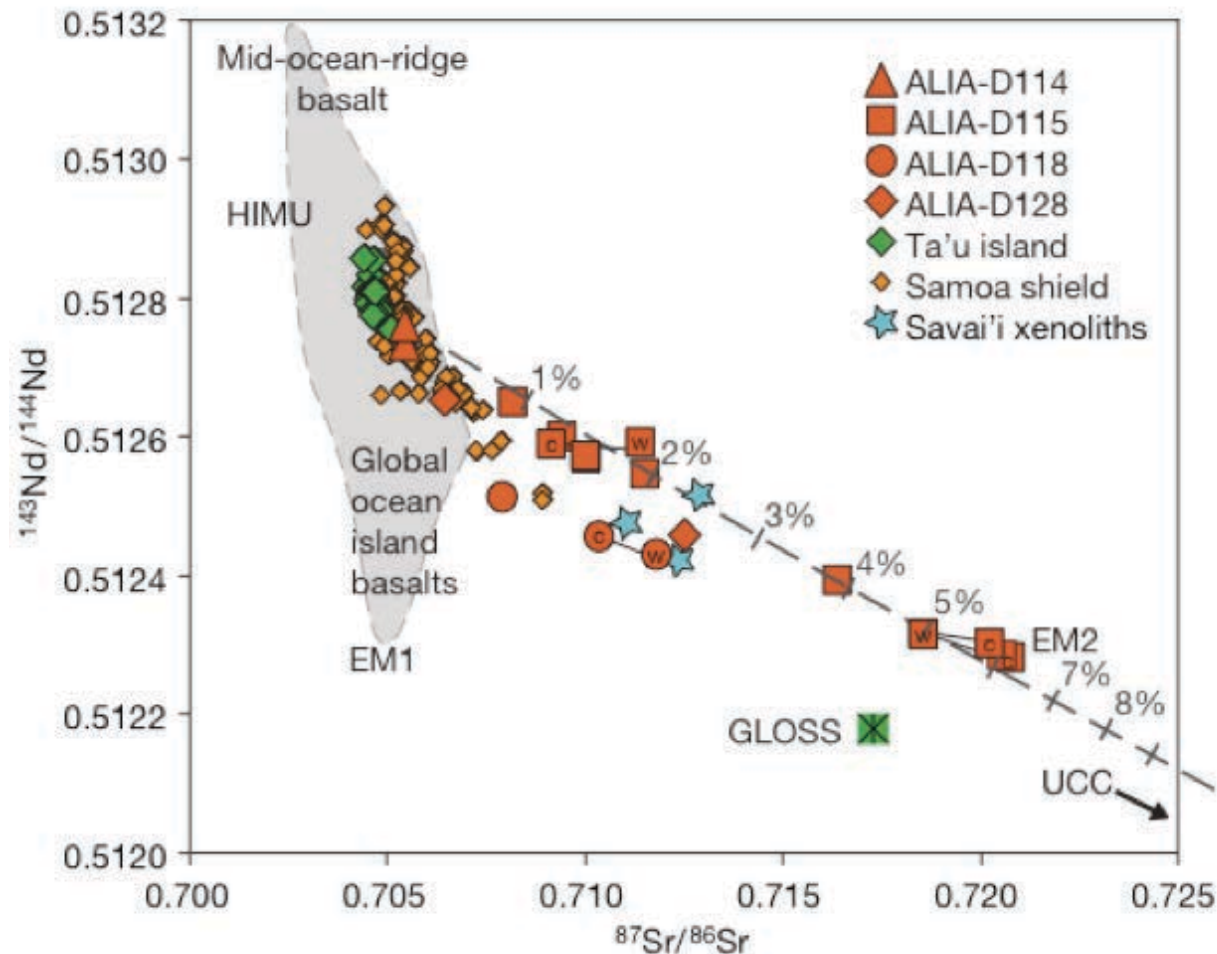
- What are the geochemical characteristics of the materials that subduction returns to the Earth's mantle, and how are these related to the development of long-term mantle heterogeneity?



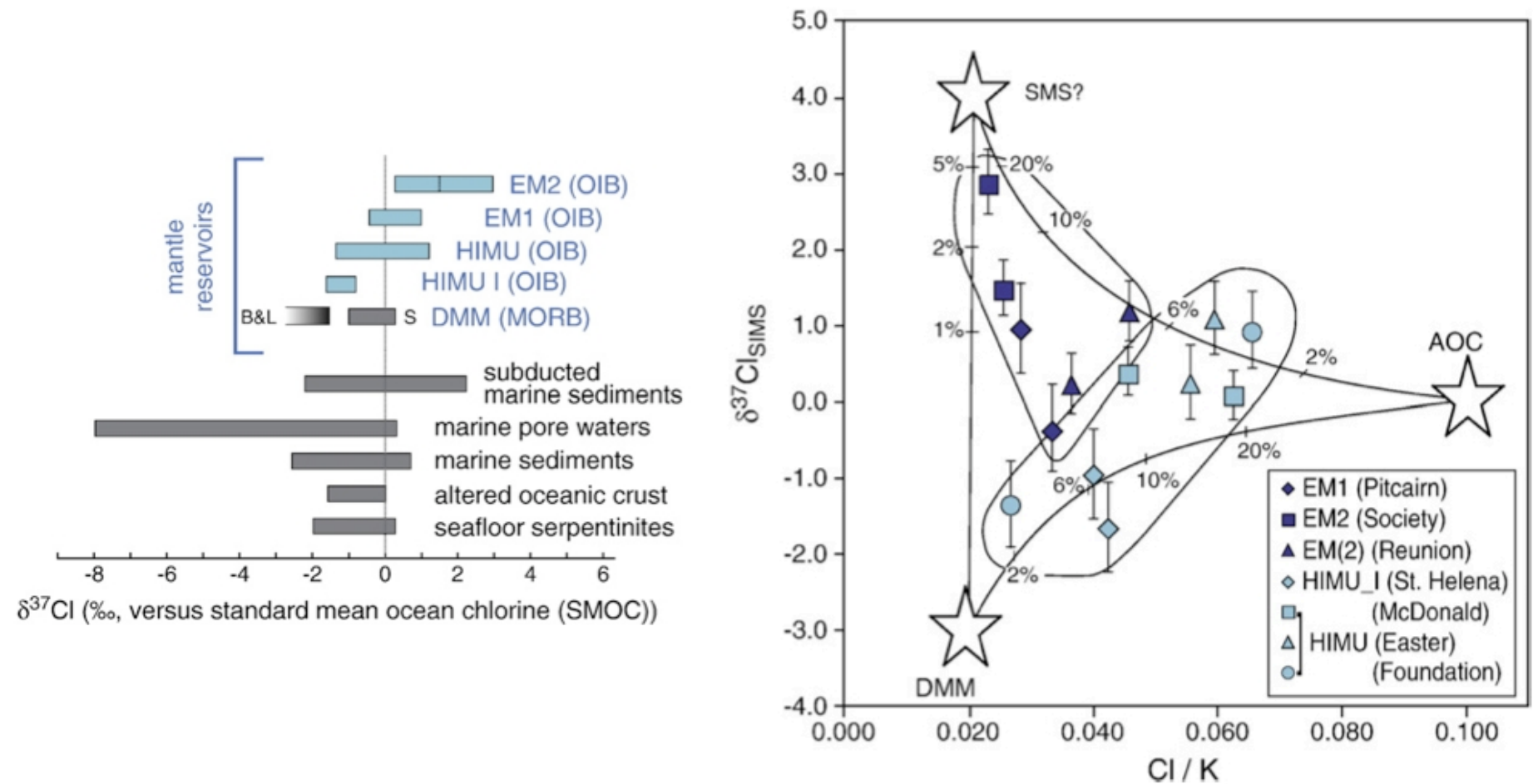
Mantle reservoirs



Evidence for sediment recycling

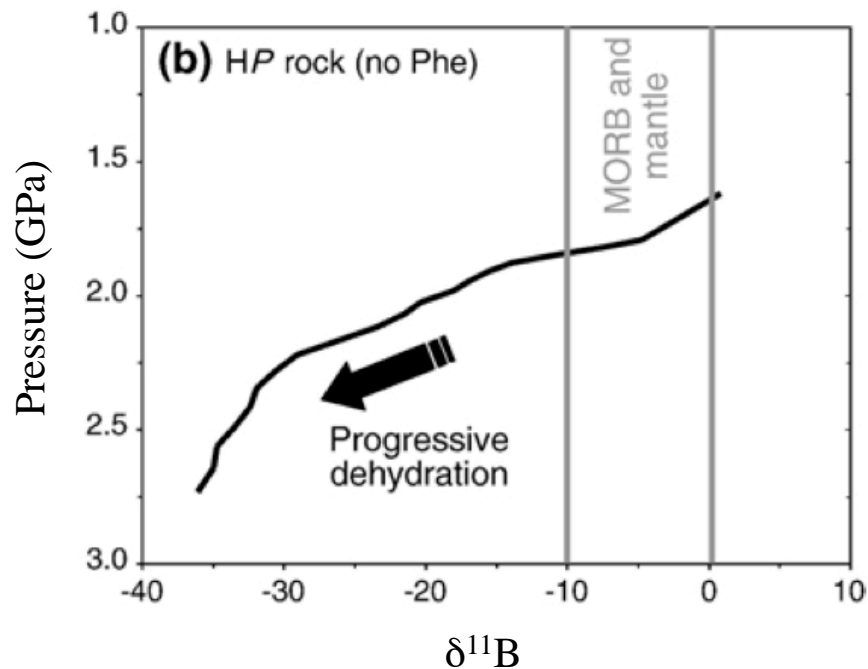


Cl isotope evidence for subducted material in the mantle



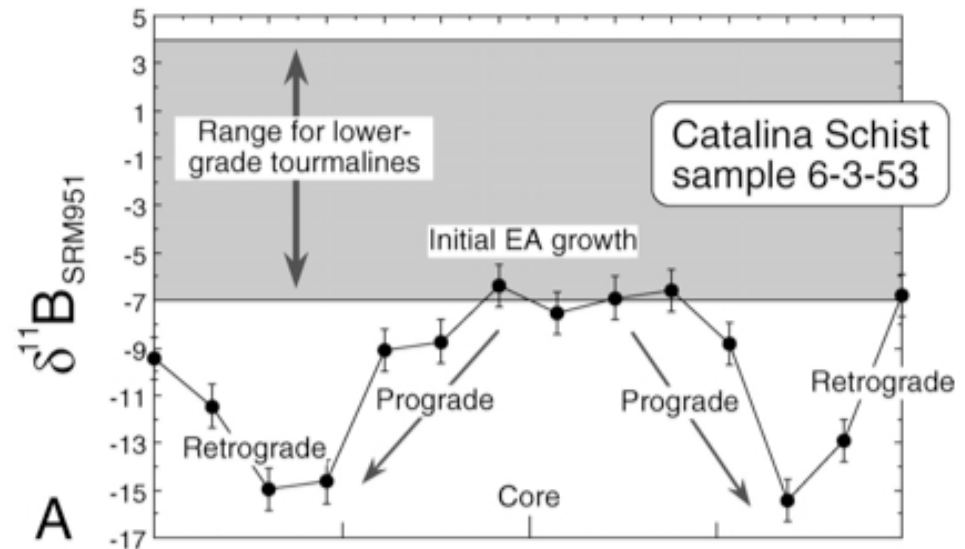
Boron isotope fractionation and recycling

Dehydration modeling



Marschall et al. 2007

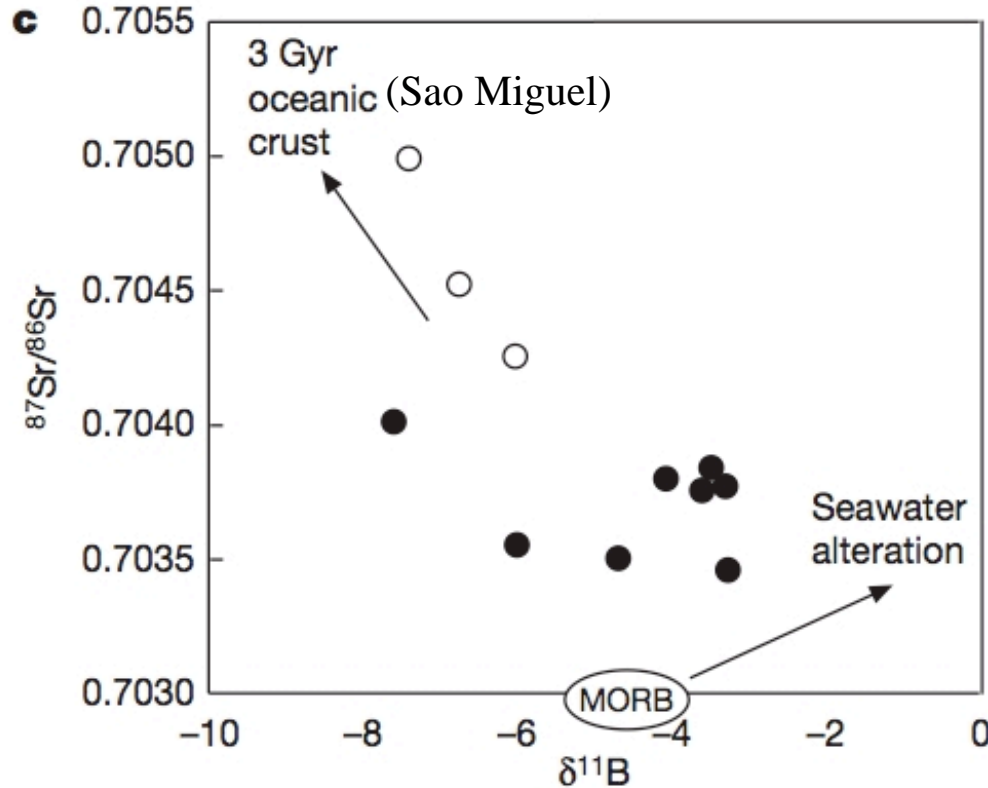
Tourmaline zoning



Bebout and Nakamura 2003

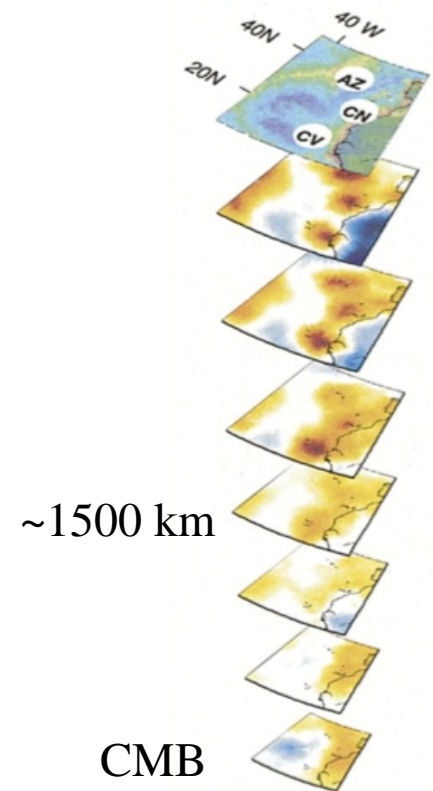
Boron isotope fractionation and recycling

Azores OIB



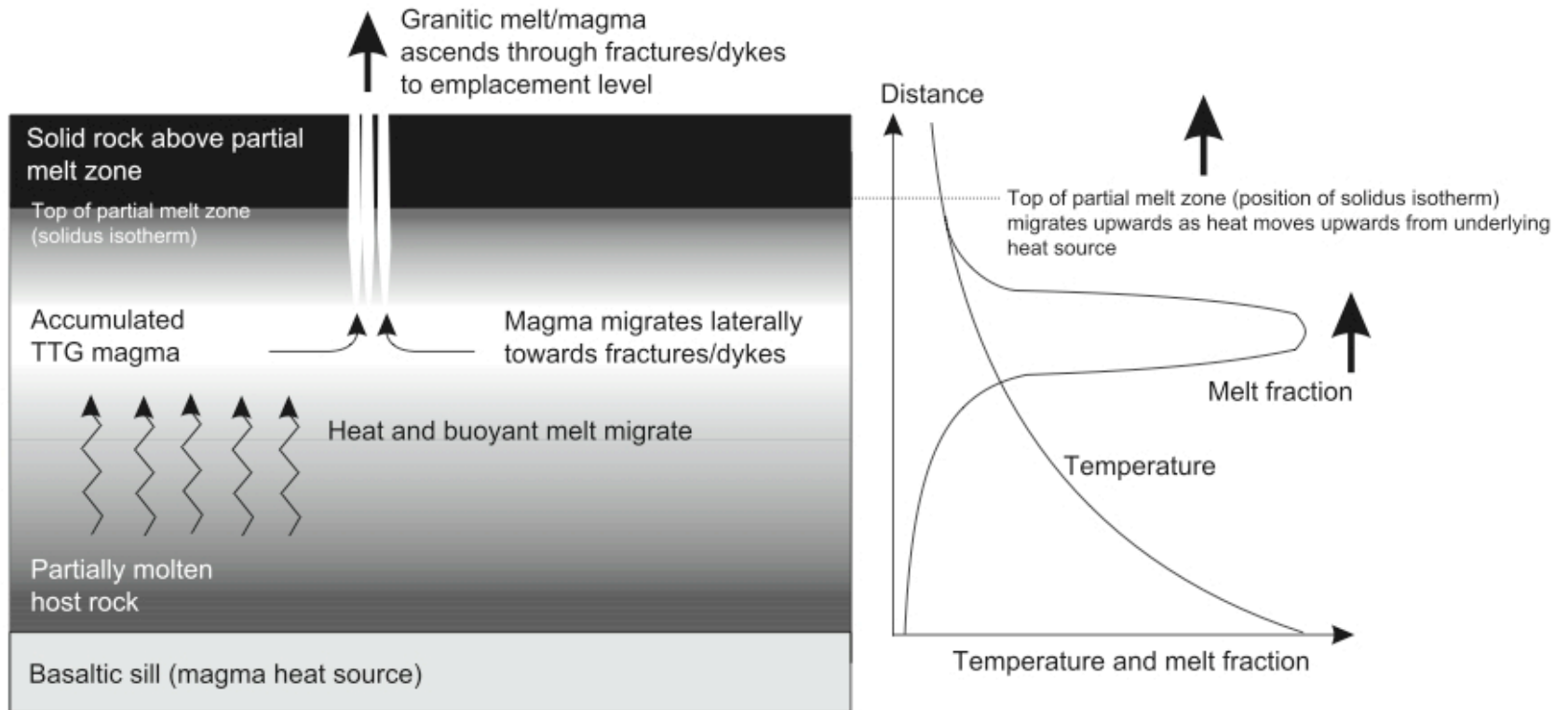
Turner et al. 2007

Azores Plume

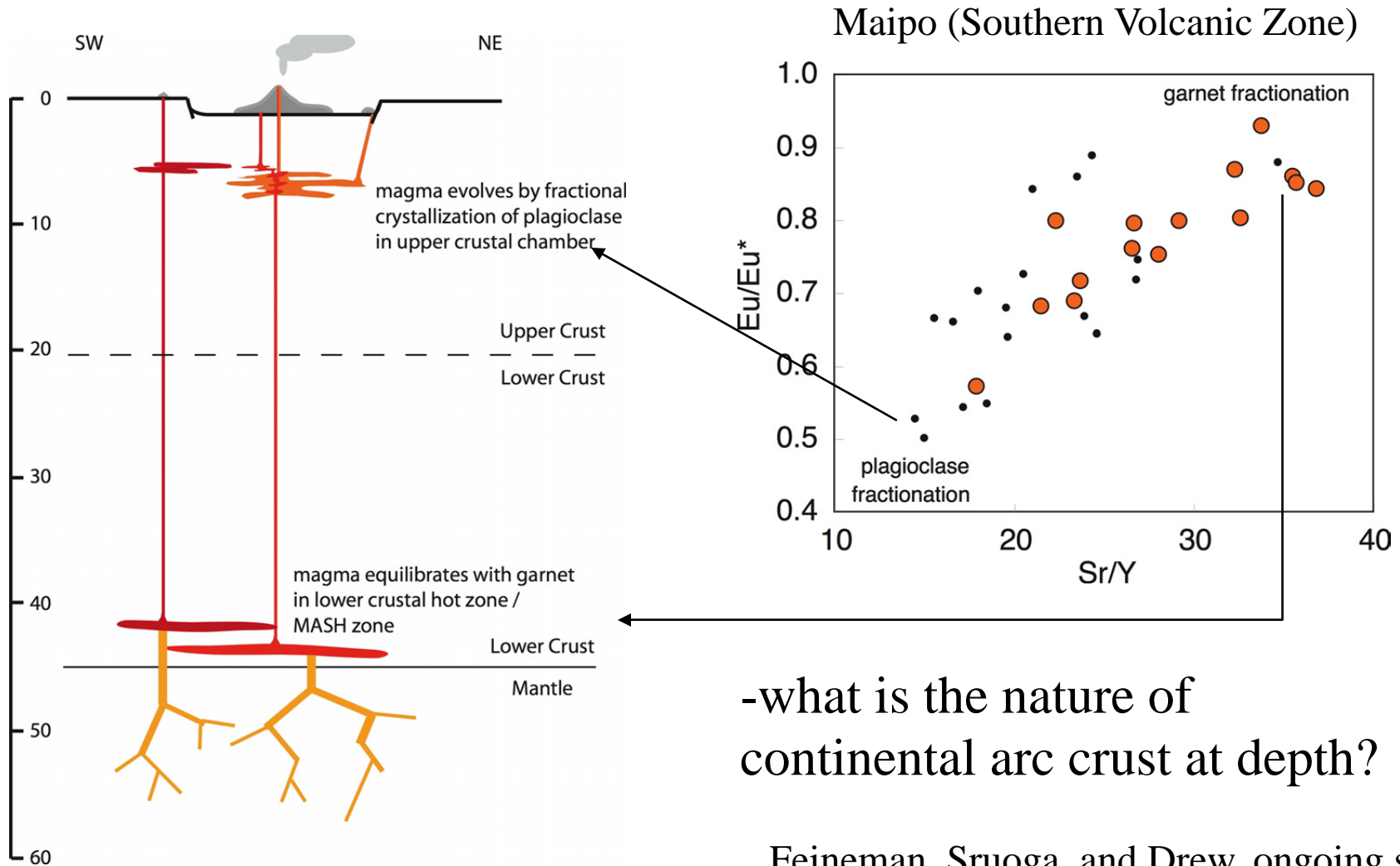


Montelli et al. 2004

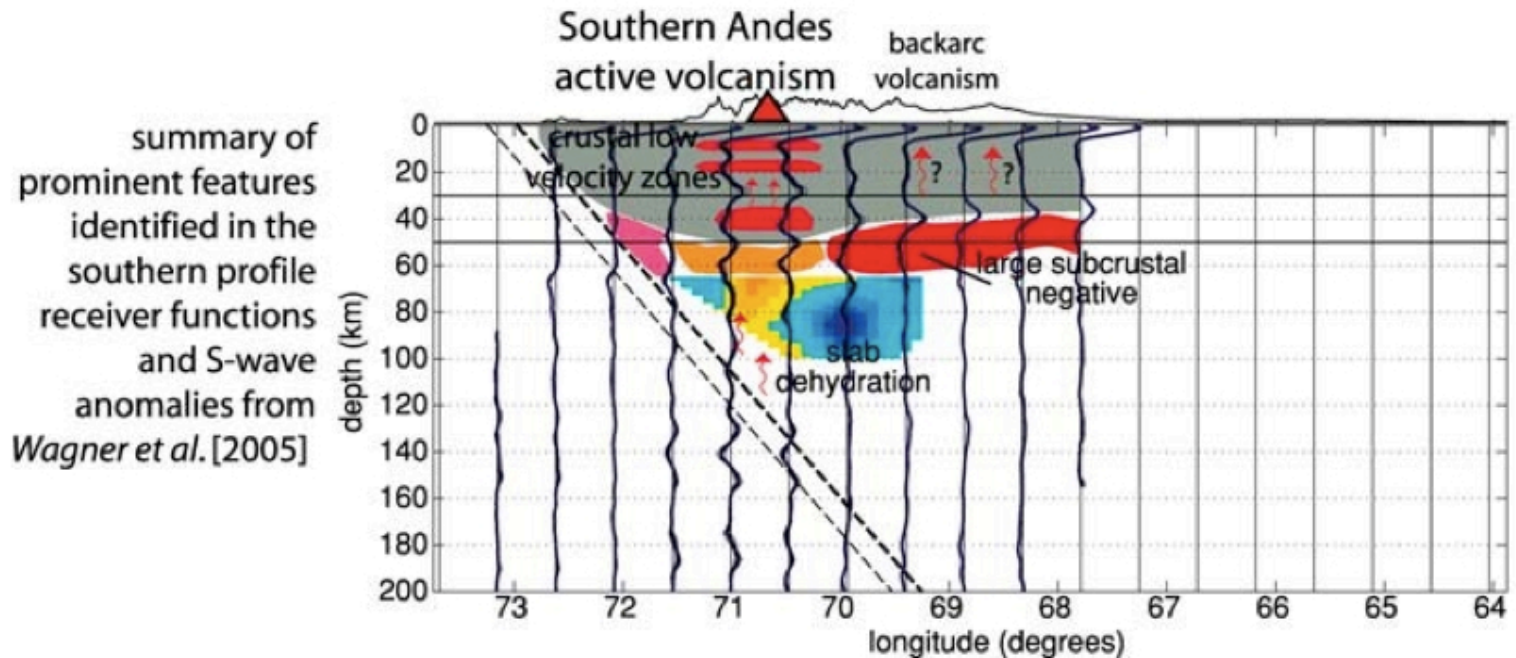
- What are the rates and processes of arc crust growth and differentiation and how is arc crust transformed to continental crust?



Continental Arc Magmas - upper and lower crust contributions



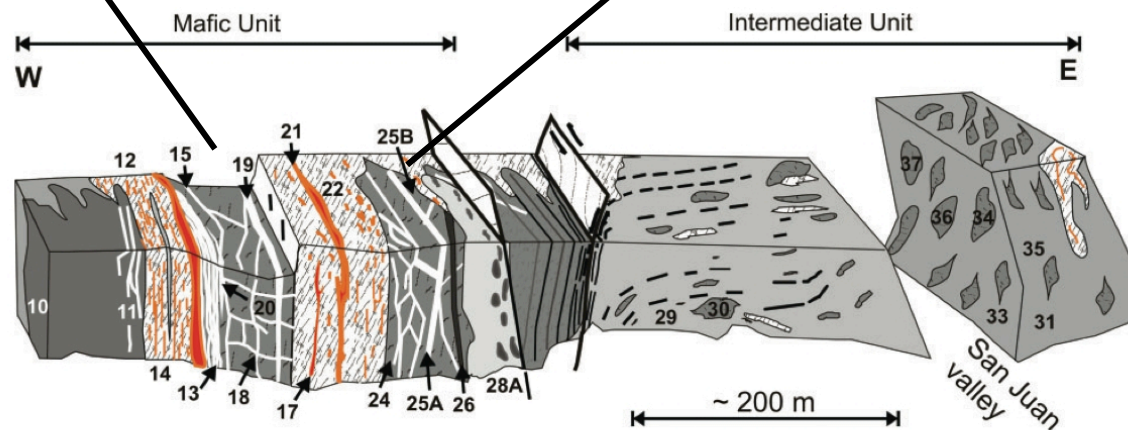
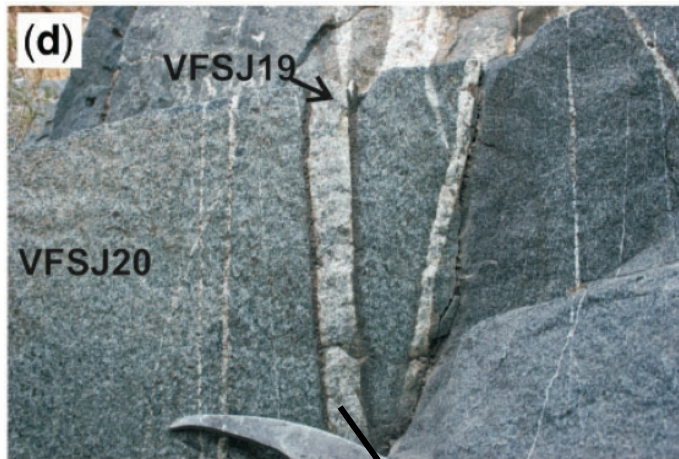
Low velocity zones in the lower crust



GILBERT ET AL 2006

Continental arc crust

Valle Fertil, Argentina (Famatinian Arc)



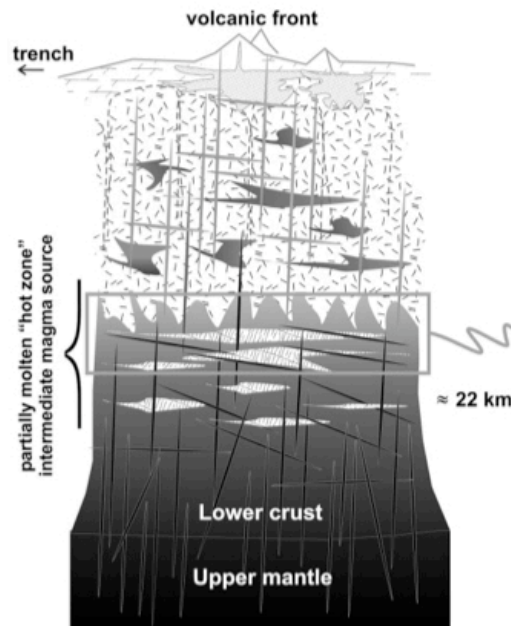
EXPLANATION

- Gabbroic rock
- Mafic migmatite
- Leucotonalitic vein

- Metasedimentary migmatite
- Leucogranite (leucosome / dike)
- Tonalitic rock
- Dioritic rock

Formation of intermediate arc magmas in the mid/lower crust

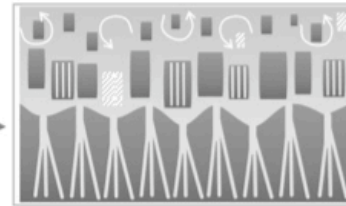
Architecture of a subduction-related magmatic arc crust at a mature stage



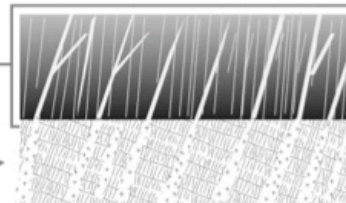
Reference

- volcano-sedimentary rocks
- sub-volcanic plumbing systems
- dyke & sill network
- metasedimentary "screen" rocks
- intermediate & silicic plutonic rocks
- gabbroic & dioritic rocks cumulate or recrystallized
- ultramafic "cumulate & residual" rocks

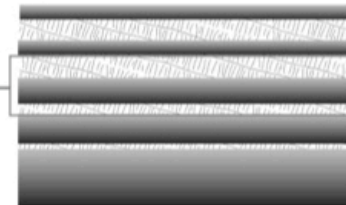
Sequence of main evolutionary stages forming intermediate magmas



Coalescence of leucotonalitic veins to form magma bodies. Leucotonalitic magmas react, commingle and mix with mafic and metasedimentary solid fragments entrained in them

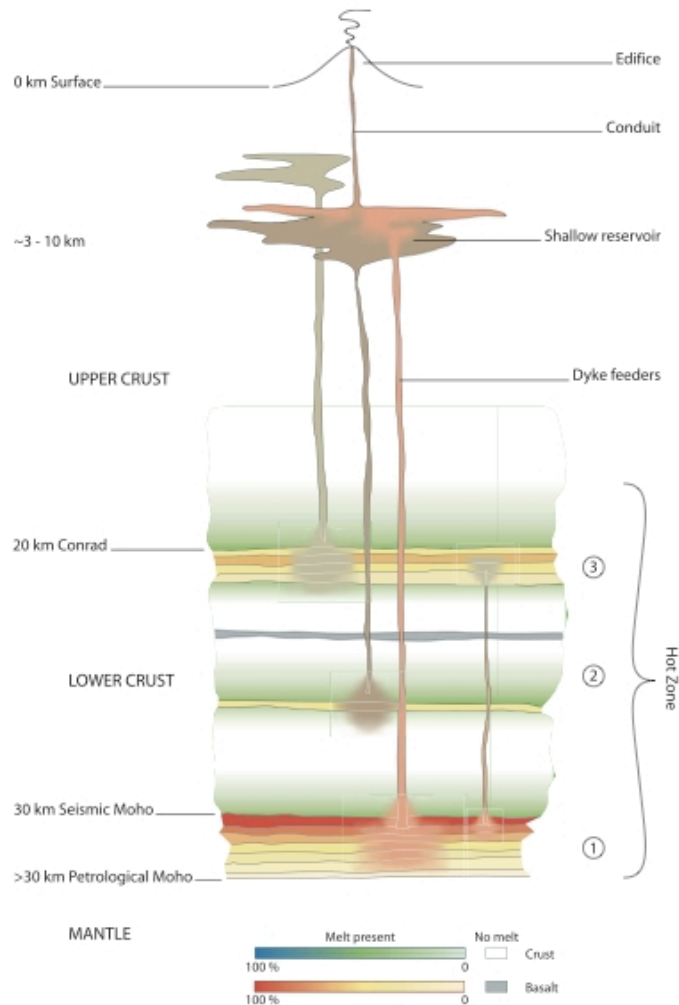


Physically & chemically coupled partial melting of gabbroic and metasedimentary rocks, forming leucotonalitic veins and dykes within the mafic migmatites

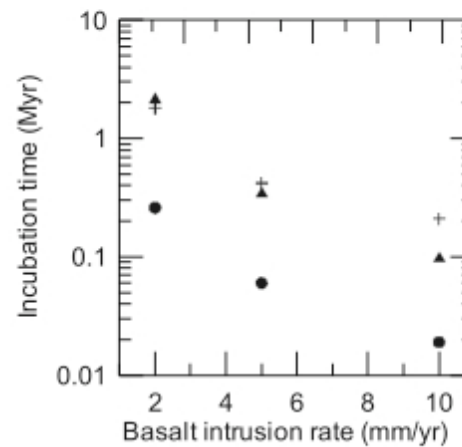


Under- & intraplating emplacement of hydrous mafic magmas into a crustal sequence of metasedimentary rocks

Timescales of differentiation and deep crustal melting

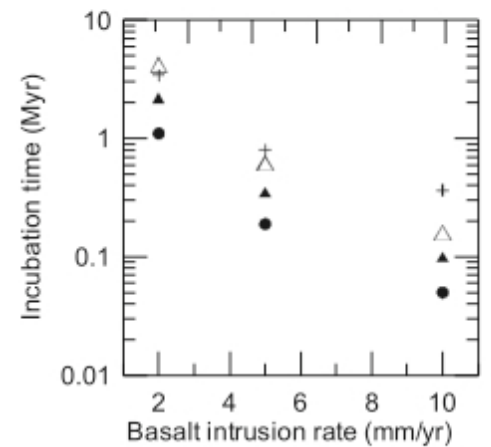


(a) Residual melt (basalt crystallization)



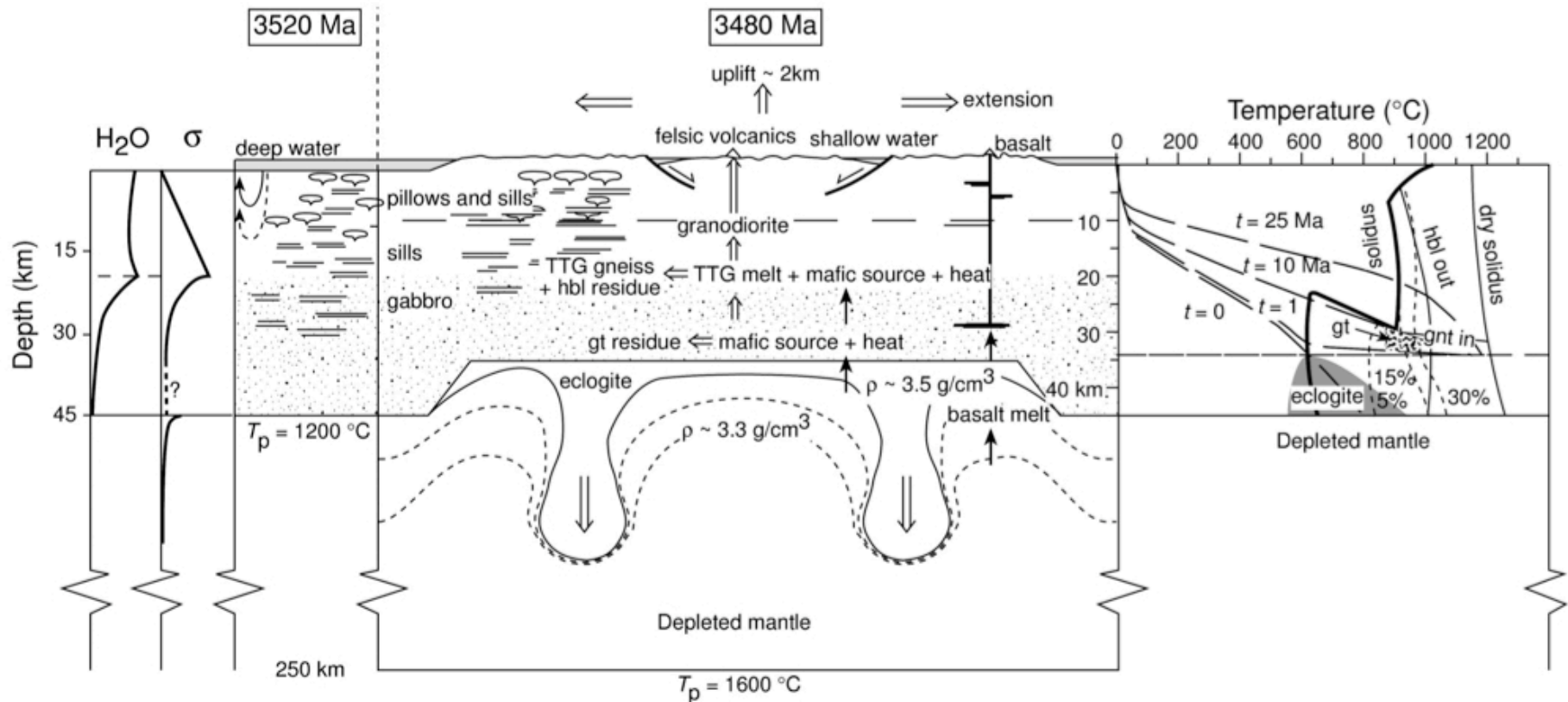
Intrusion depth
 ● 30 km
 + random
 ▲ 20 km

(b) Partial melt (crustal melt)

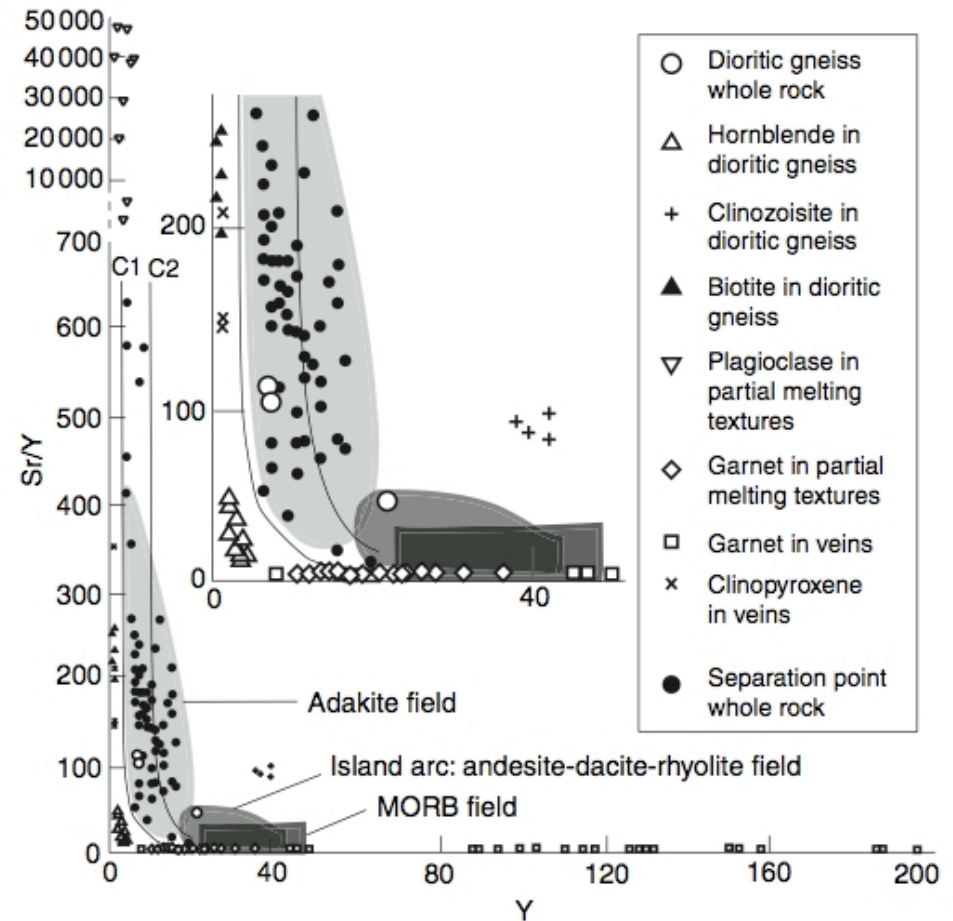
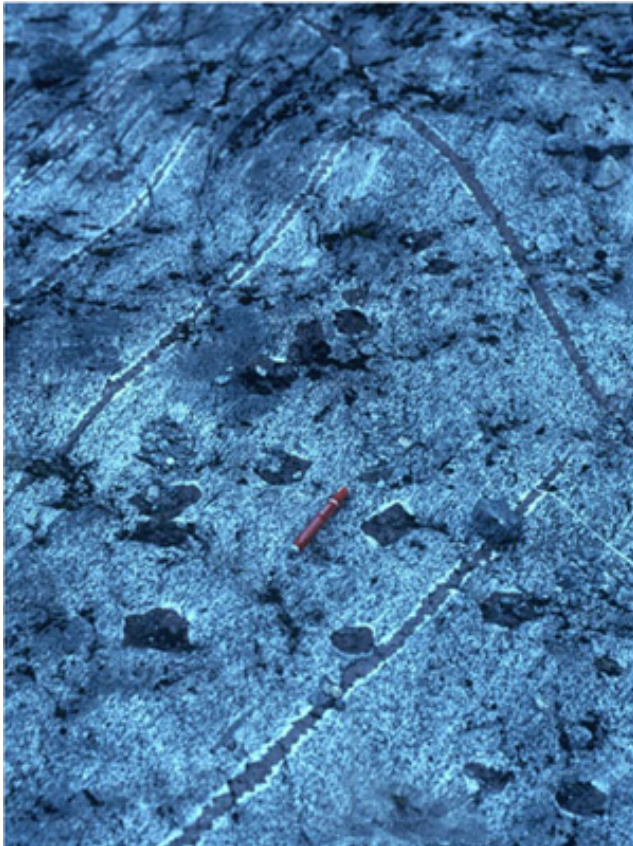


Intrusion depth
 ● 30 km; crust is amphibolite
 + random; crust is amphibolite
 ▲ 20 km; crust is pelite
 △ 20 km; crust is greywacke

Continental crust formation by lower crust delamination



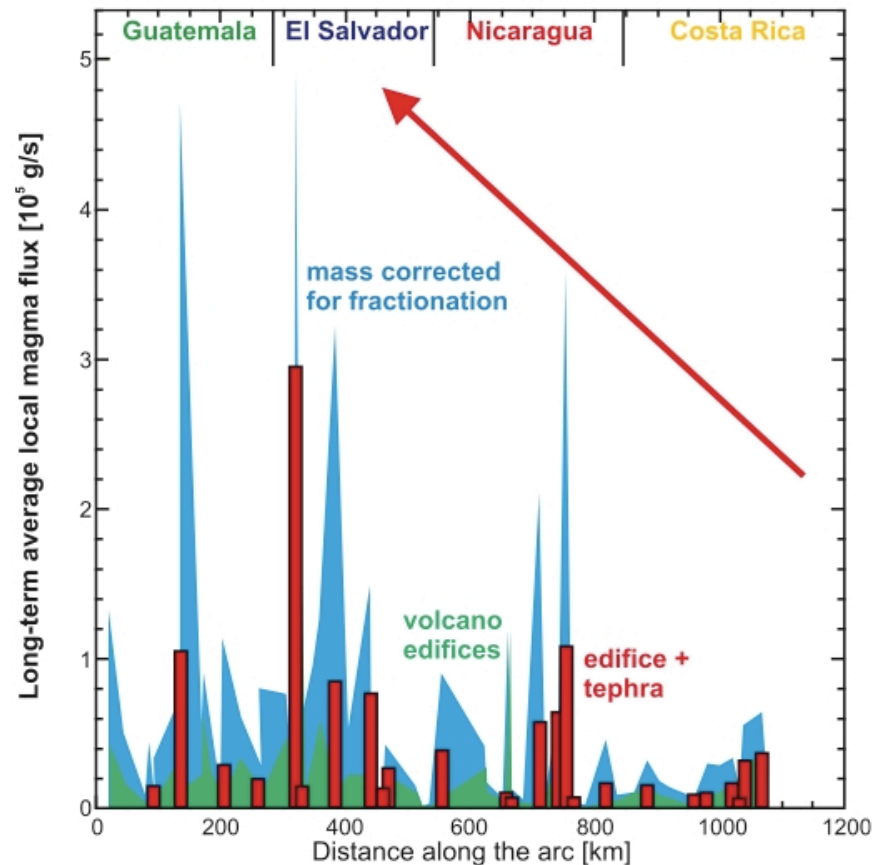
TTG formation in lower crust Fiordland, New Zealand



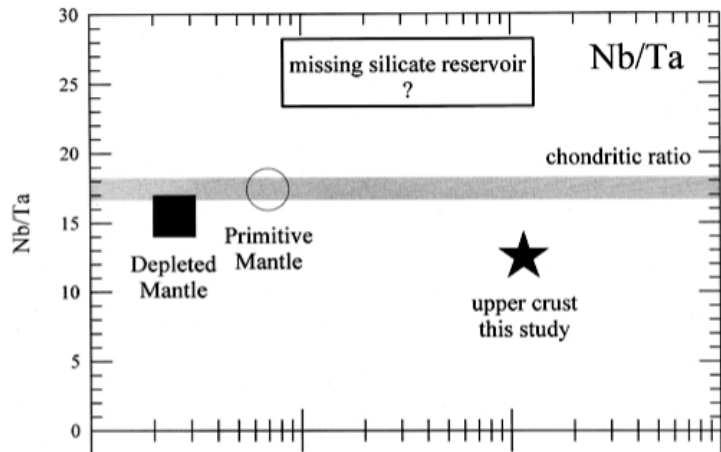
Mass balance issues:

Volcanic fluxes

- how well do erupted volumes represent mass transfer from mantle to crust?



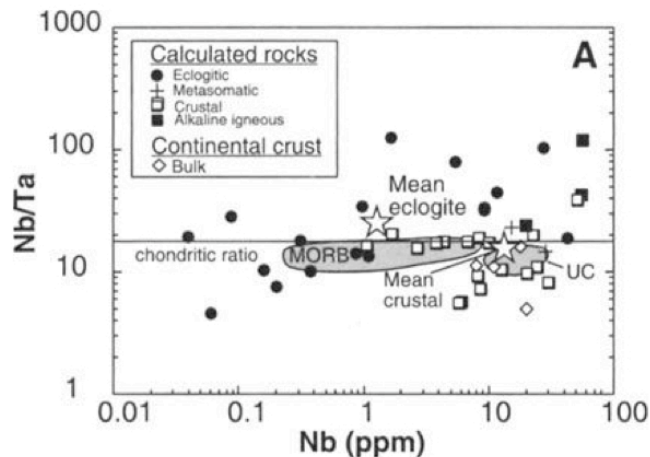
Mass balance issues: Hidden reservoirs



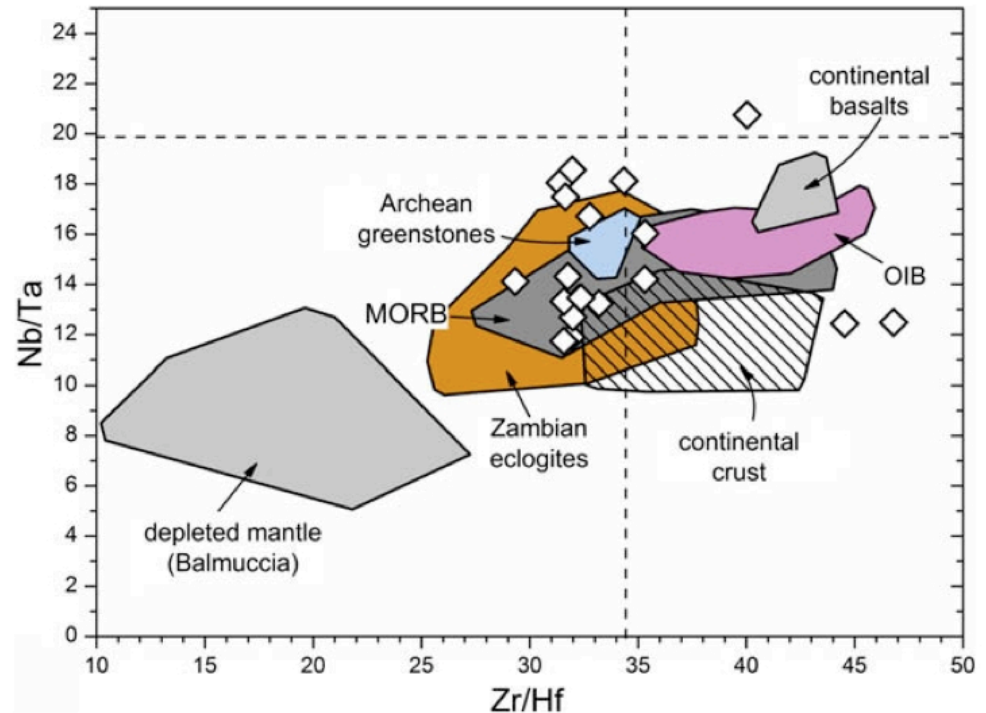
Barth et al 2000

Study of 19 eclogite localities reveals

- little HFSE fractionation in eclogite relative to MORB;
- lack of superchondritic Nb/Ta reservoir

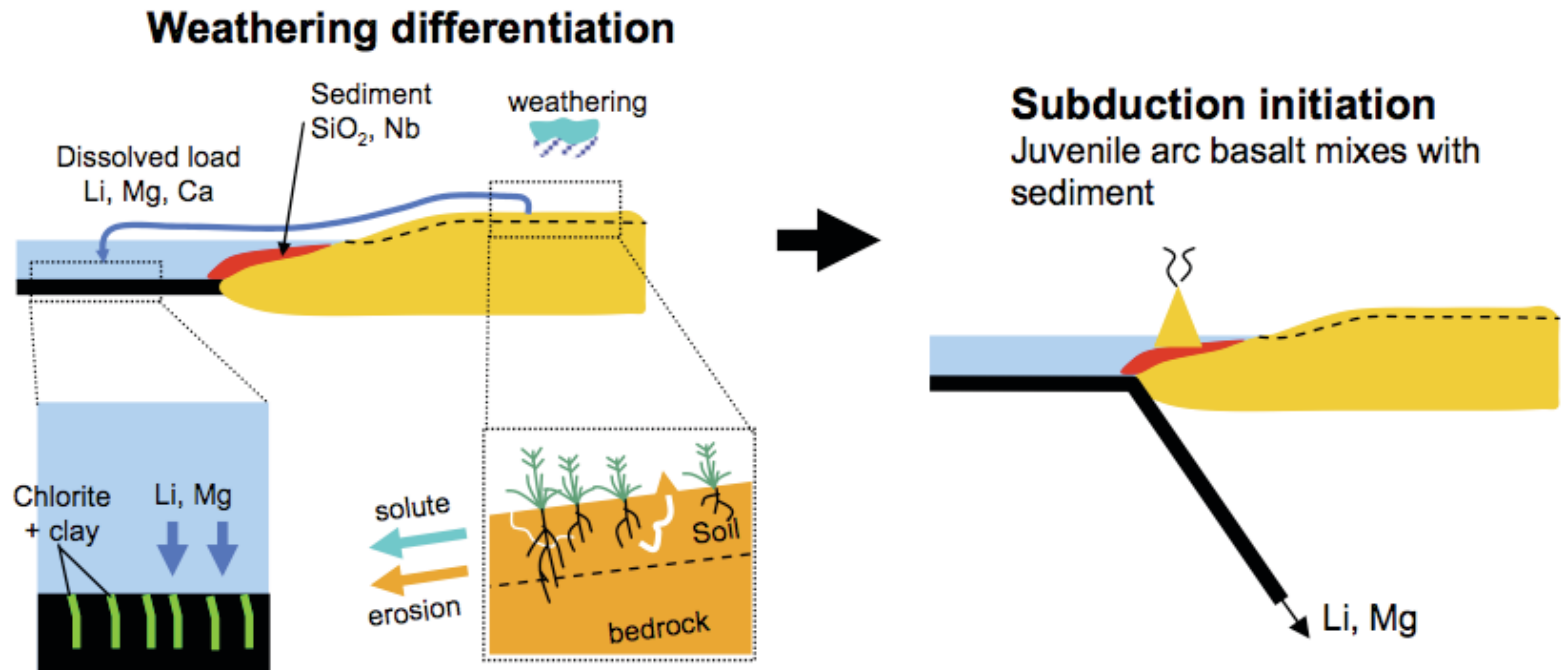


Rudnick et al 2000



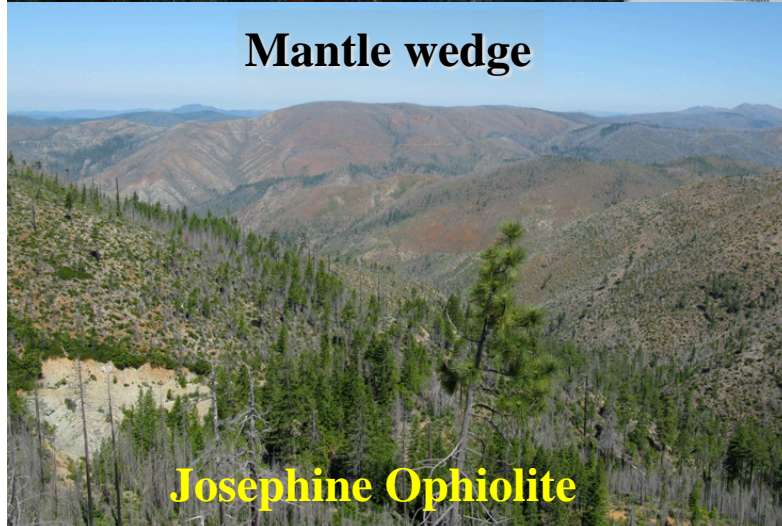
Schmidt et al 2009

- What role does weathering and erosion play in the compositional and dynamic evolution of volcanoes and volcanic arcs?



New directions

- How can direct observations of exhumed arc components inform our study of active arcs?



New directions

- Focus on integrated, managed datasets for selected suites of samples, eg:
 - Petrography
 - Major elements
 - Trace elements
 - Radiogenic isotopes
 - Stable / non-traditional isotopes
 - Mineral compositions and zoning

Sample / Data Management

Field area: _____

[illegible]

Laboratory:

Contact person:

Analytical method:

[illegible]

Overarching Question

- What is the mass and composition of subduction zone products we *can't* observe at the surface?
 - “New” subduction tracers (i.e. non-traditional light stable isotopes) in OIB
 - Exhumed margins
 - Seismic studies

Implementation

- Look beyond “focus sites” to put emphasis on coordinated efforts, comprehensive data sets, and organized data management
- Postmortem assessment - study exhumed components of “dead” arcs to illuminate processes deep within active arcs