

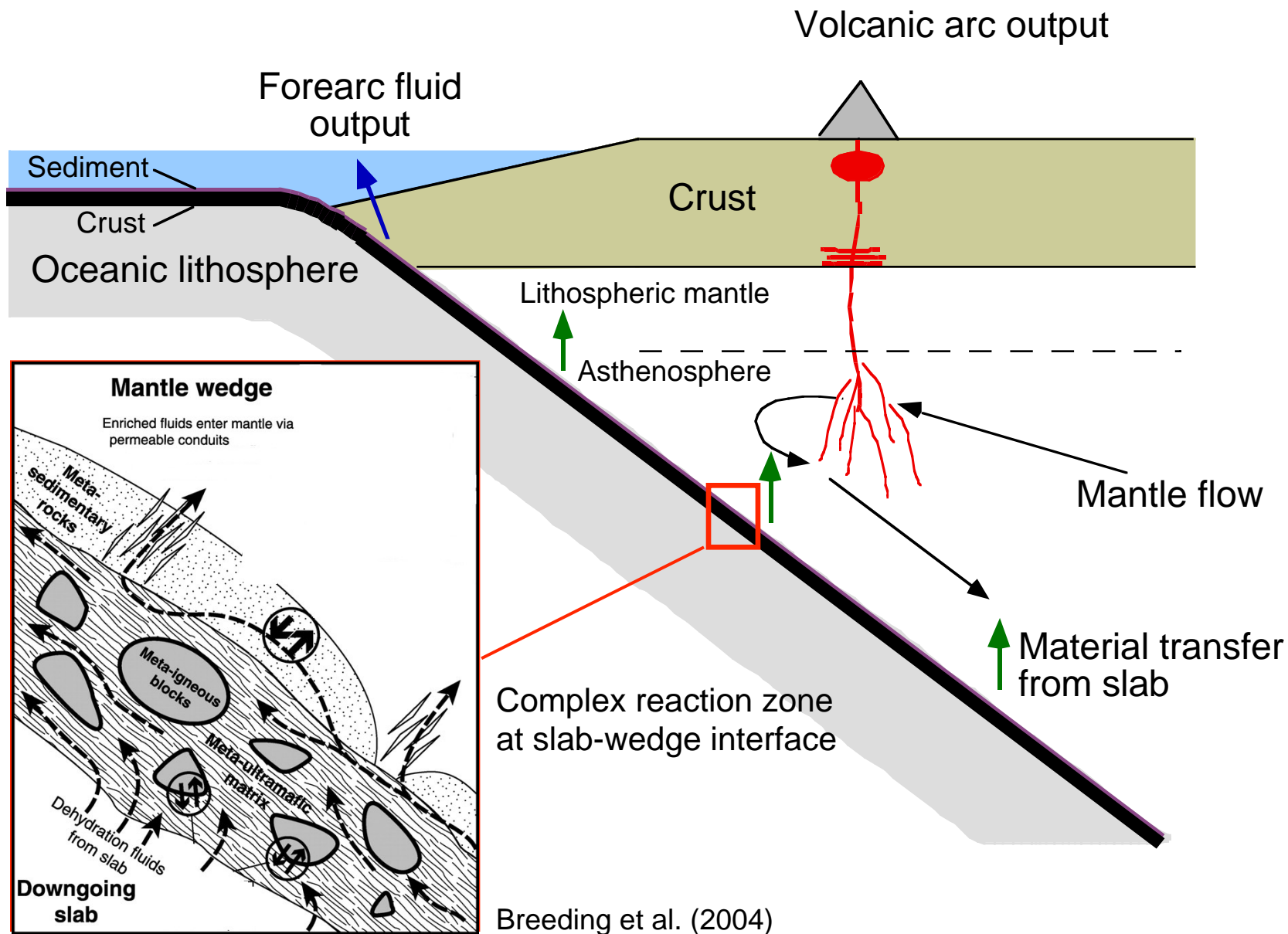


**Storage, Transfer & Release of Volatiles Through
Subduction Systems**

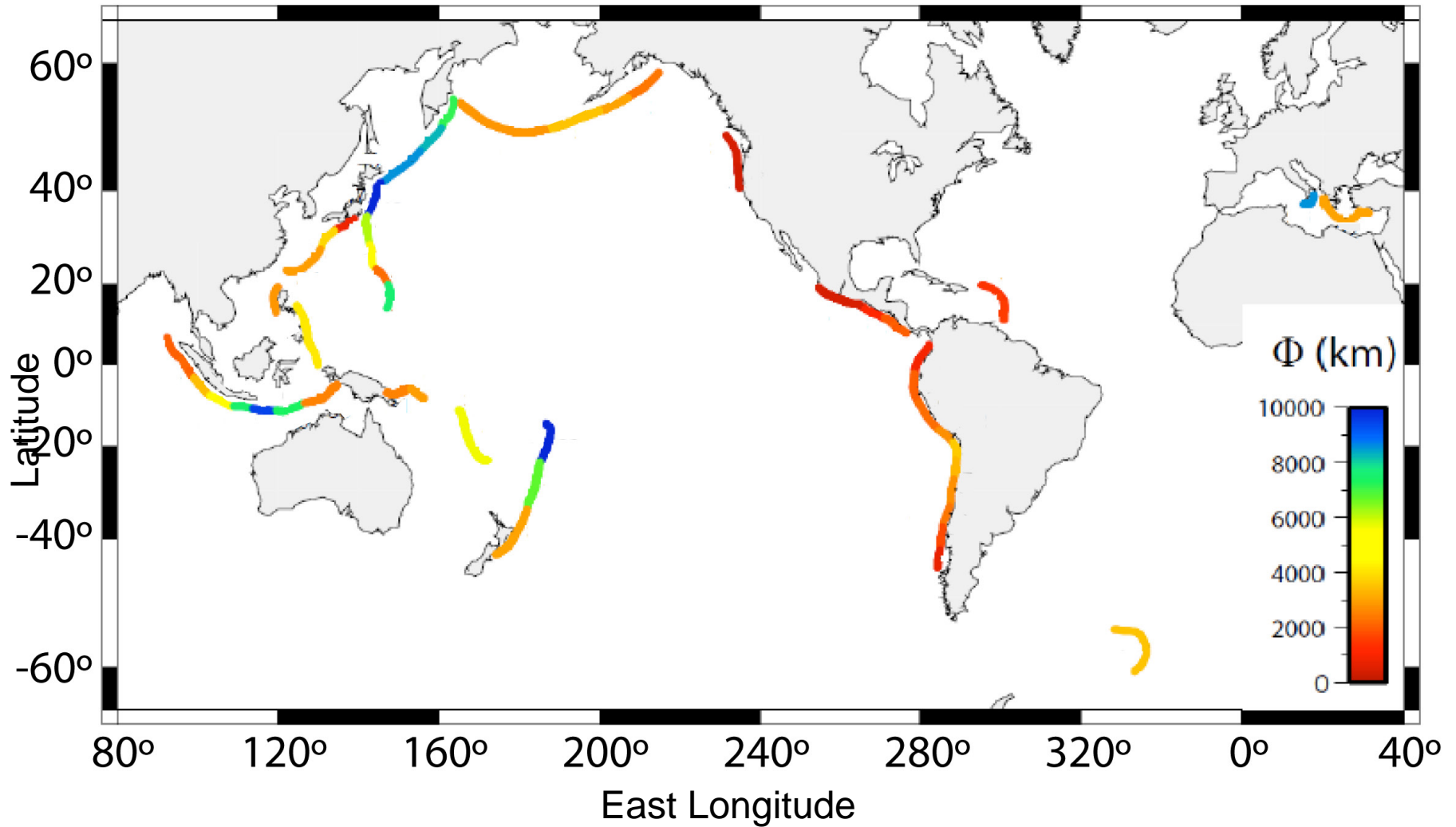
**Paul Wallace
Dan Ruscitto
University of Oregon**

Volcan Colima, Mexico

Volatile Recycling & Subduction Zone Magmatism

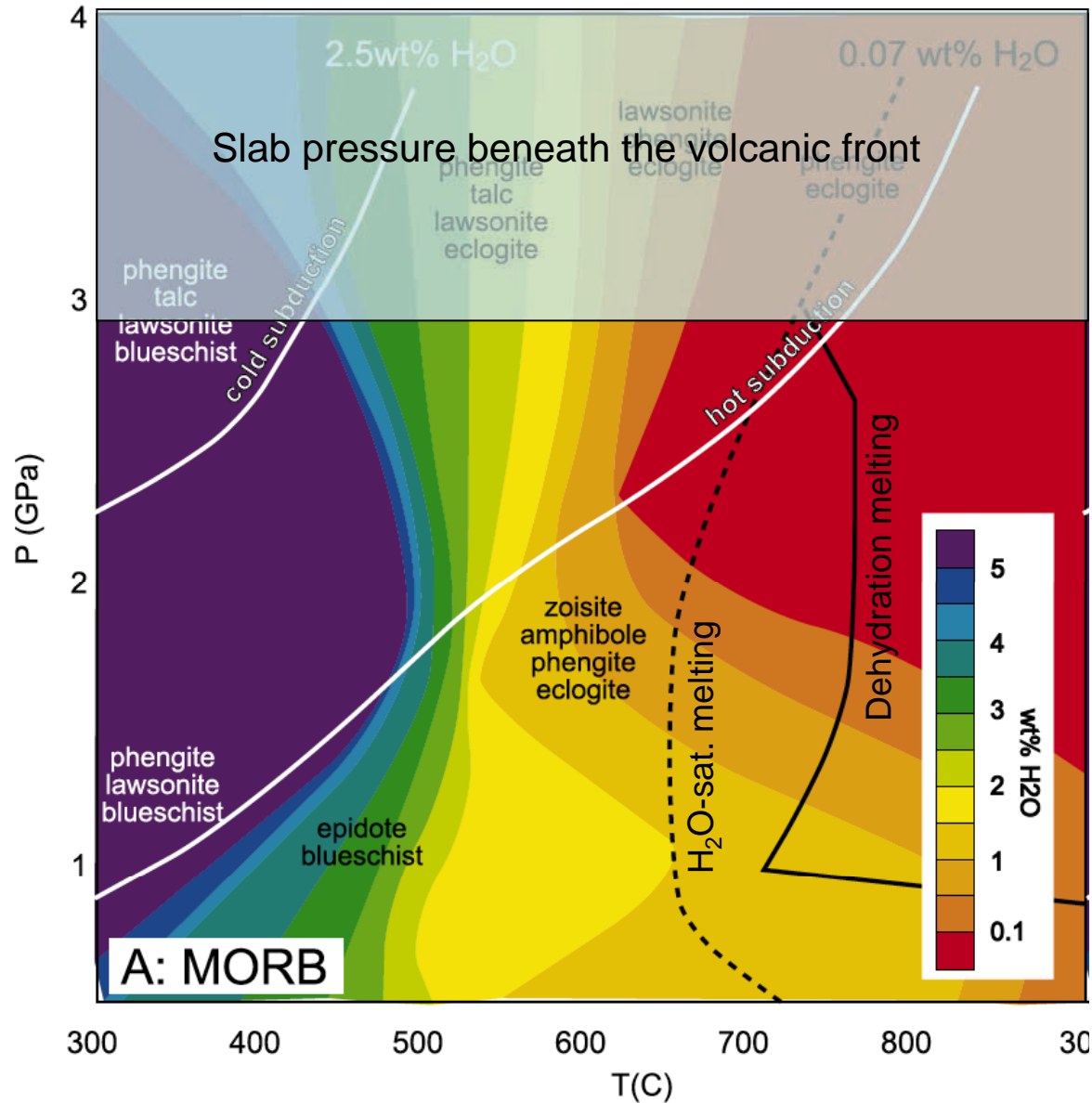


Global Arc Thermal Parameters

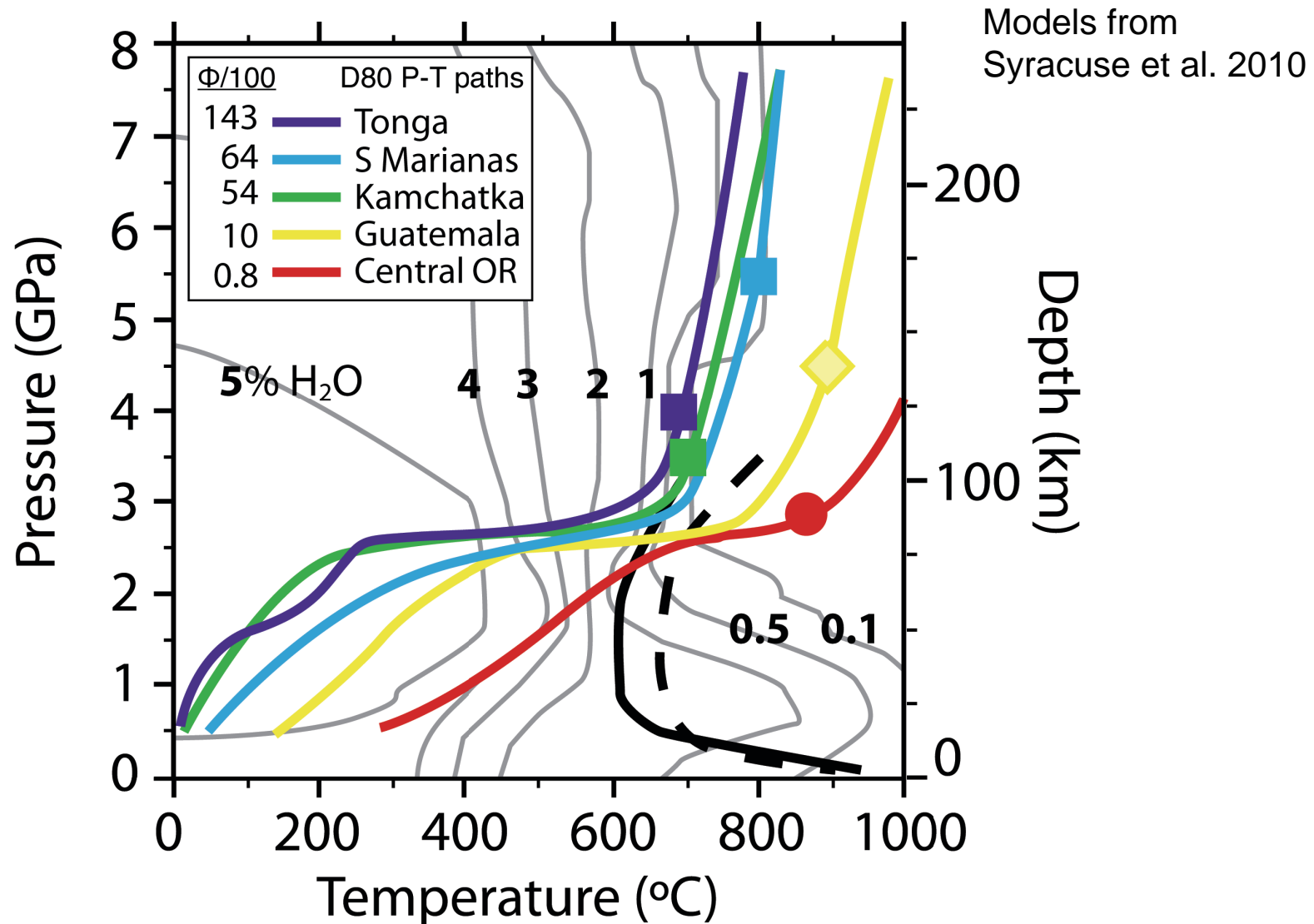


$$\Phi = V_c * \text{Age} * \sin \delta$$

Calculated Phase Diagrams & H₂O Contents for Subducted Oceanic Crust



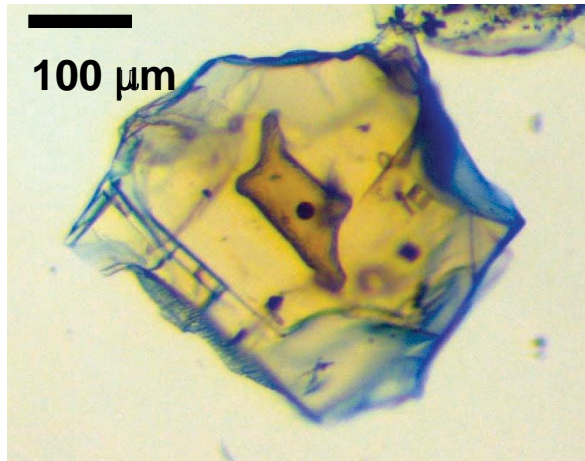
Slab Surface P-T Conditions from Geodynamic Models



Contours show max H₂O in hydrated MORB (Hacker, 2008)

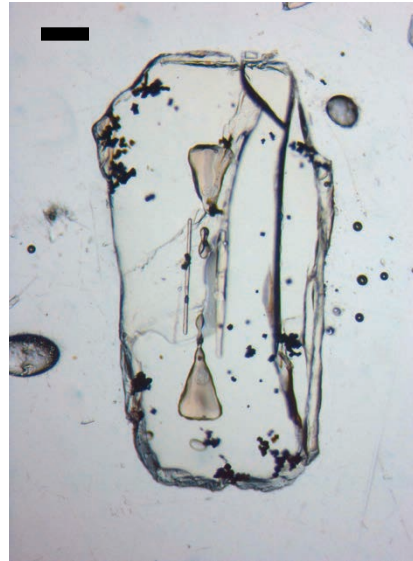
Melt Inclusions Provide a Record of Magmatic Volatile Contents

Polyhedral olivine (slow cooling)



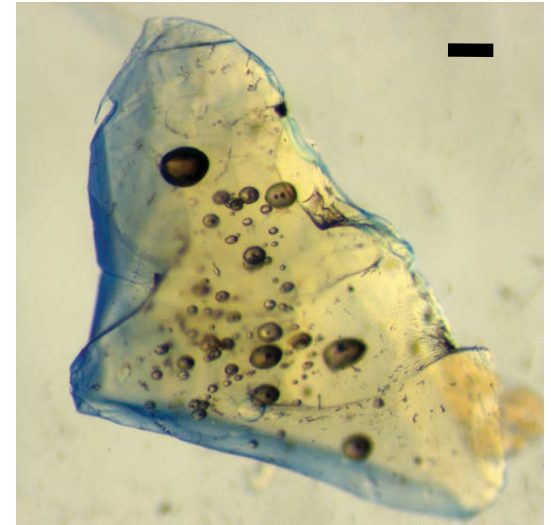
Jorullo Volcano, Mexico

Skeletal or hopper morphology olivine (faster cooling)



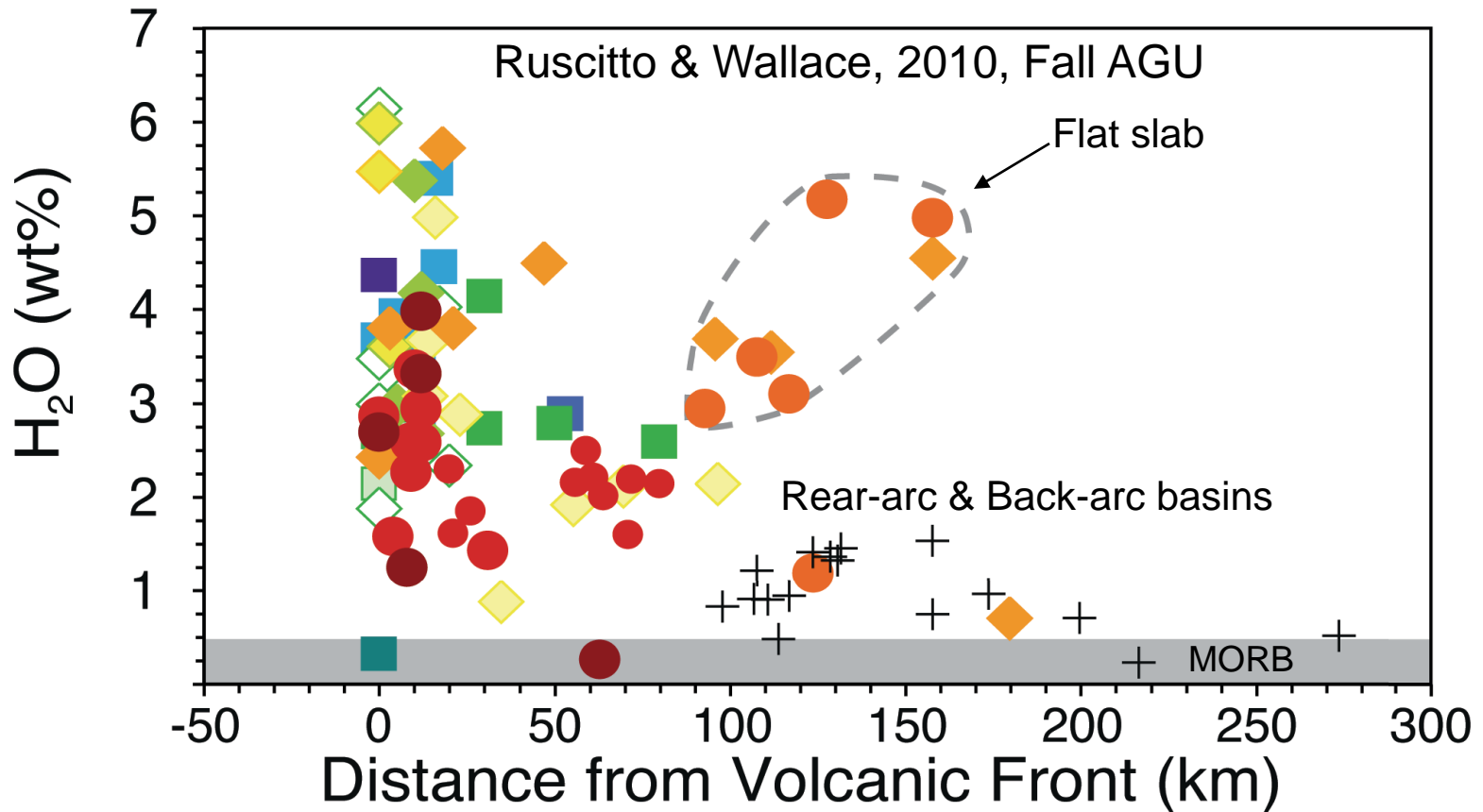
Paricutin, Mexico

Closed dendritic olivine (very fast cooling)



Blue Lake Maar, Oregon

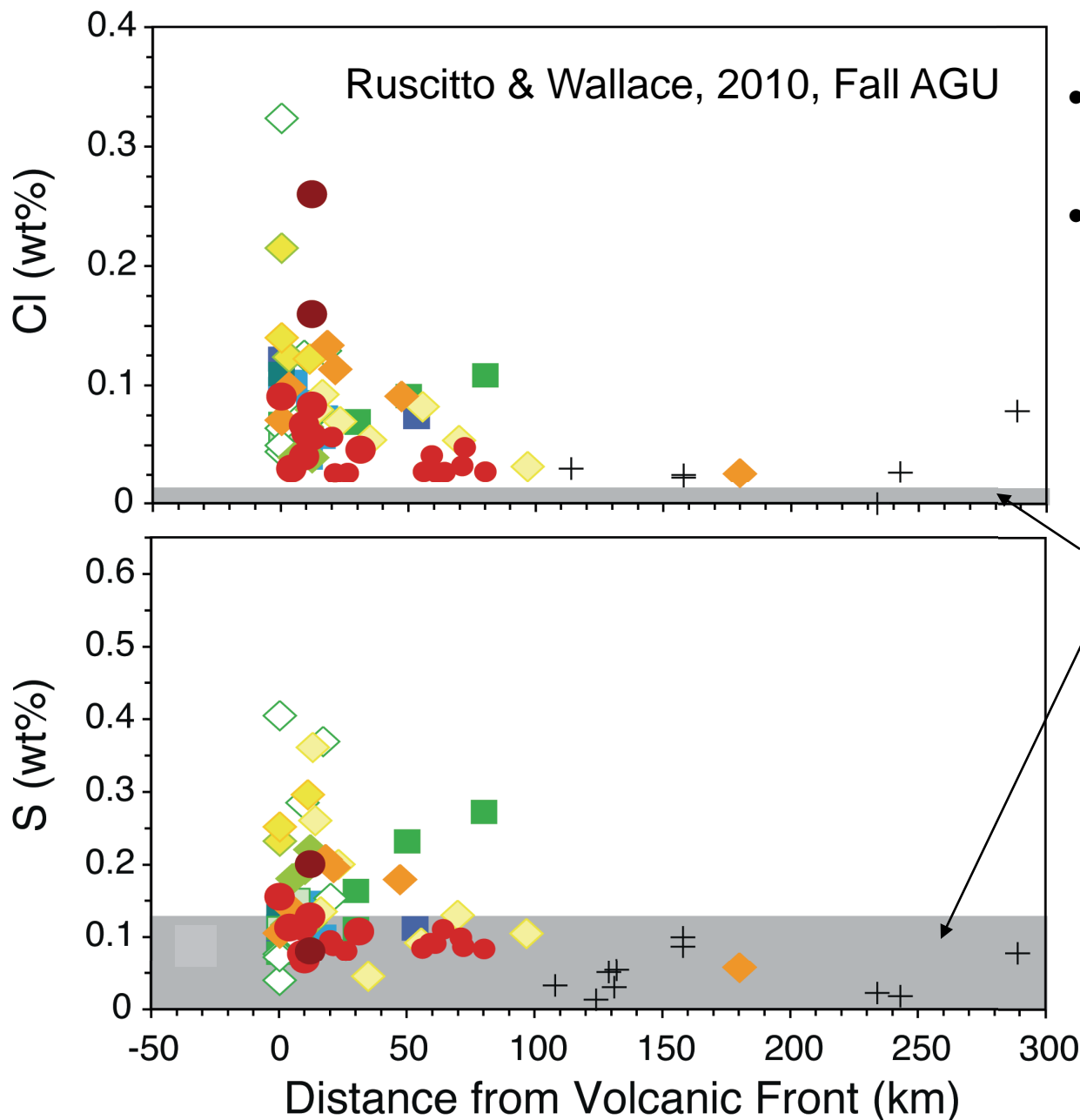
Global Across-Arc H₂O Variations



- Tonga
- Marianas
- Kurile
- Java
- Kamchatka
- Izu-Bonin
- ◇ Aleutians
- ◇ Nicaragua
- ◇ L. Antilles
- ◇ Costa Rica
- ◇ Guat/El Salv
- ◇ Mexico: MGVF
- Mexico: CVF
- Cascades: Oregon
- Cascades: Shasta
- + Back-arc Basins

All H₂O values are recalculated for melts in equilibrium with Fo90-91 olivine

Global Across-Arc S & Cl Variations



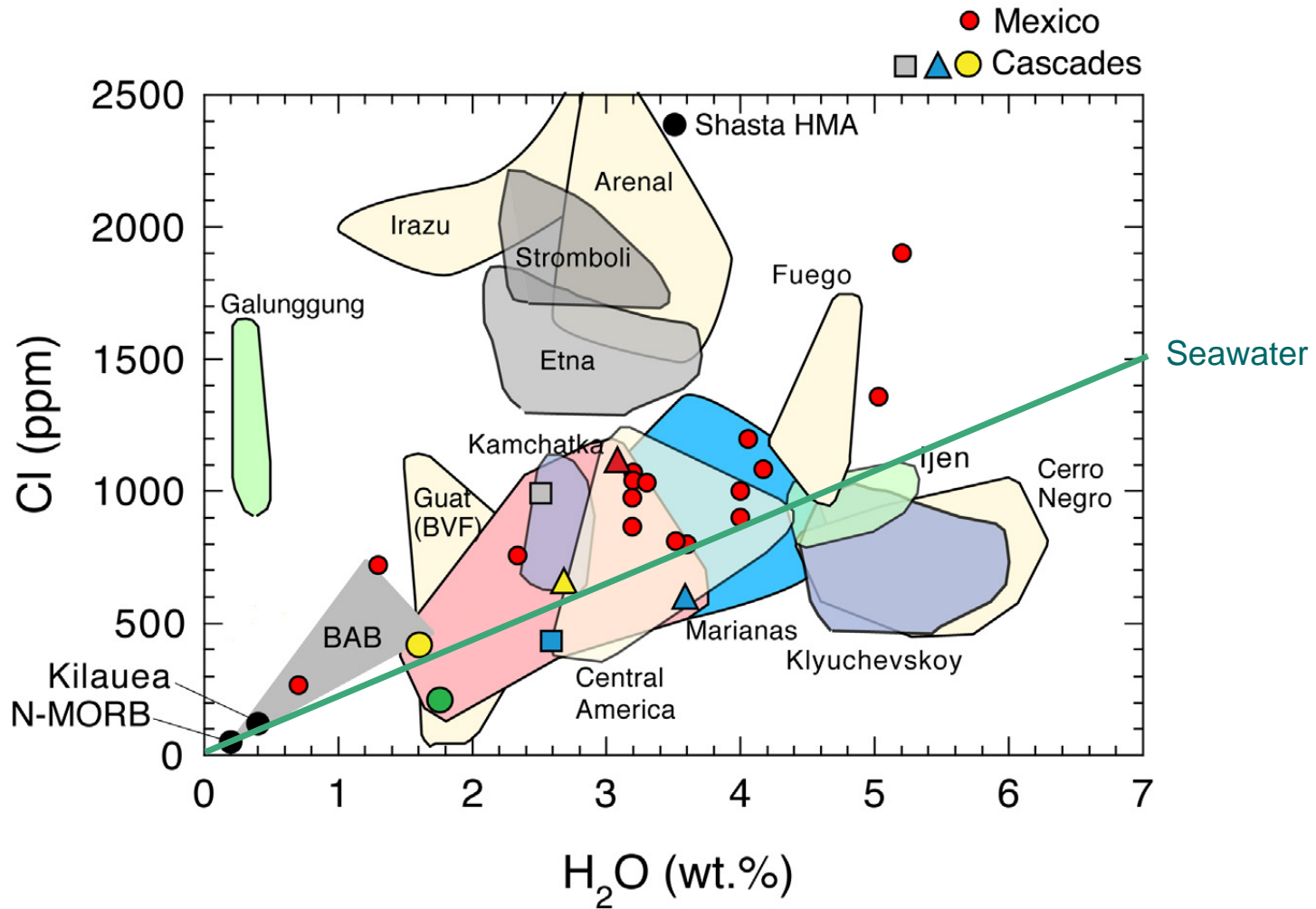
- Similar trends in Cl, S, H₂O
- Trends indicate that H₂O, Cl, and some S are added from the subducting plate

MORB



Values at Fo90-91

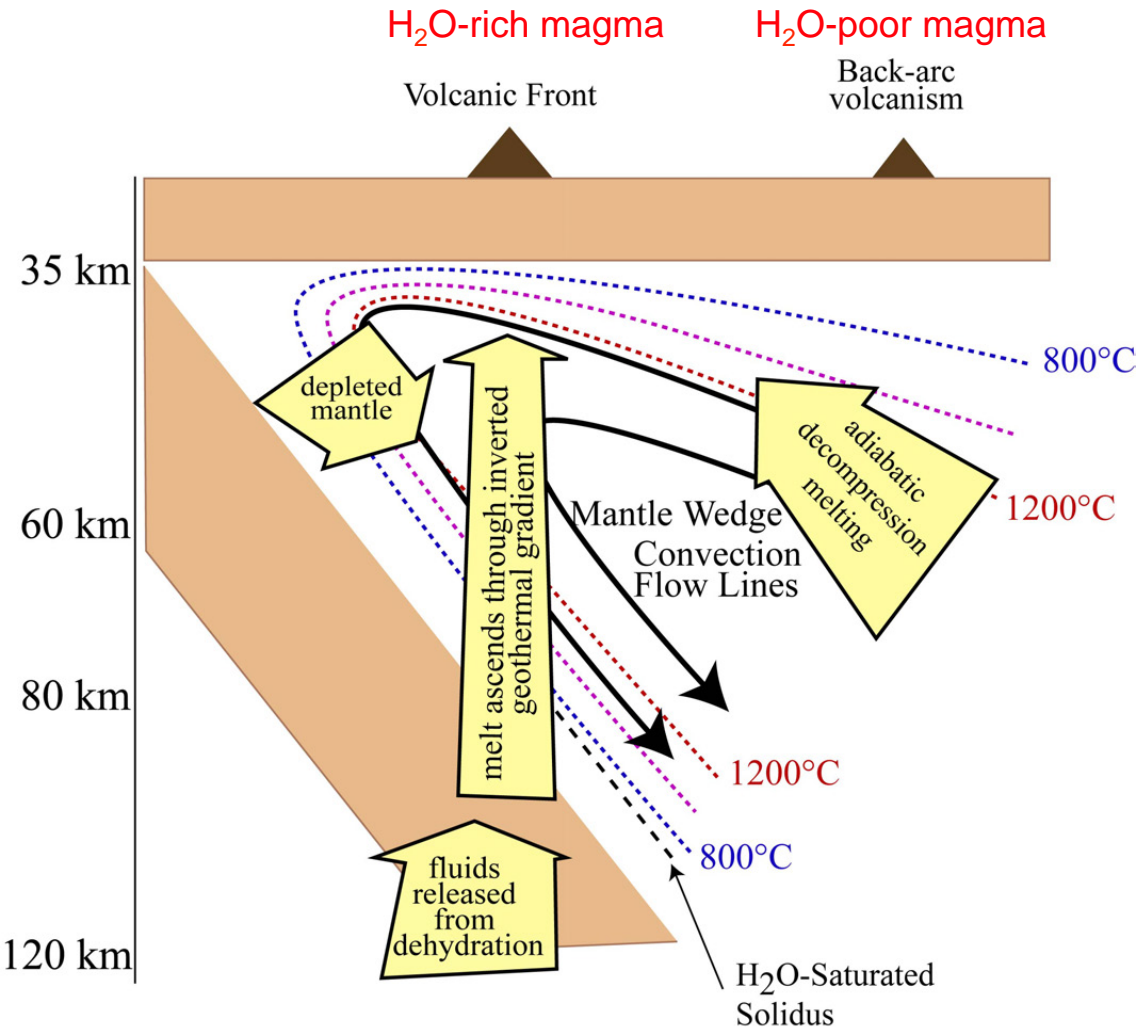
H₂O vs. Cl - the Seawater Connection



Mexico data (Johnson et al., 2009)

Cascades & Shasta (Ruscitto et al., 2010, EPSL & CMP)

Two Endmembers for Mantle Melting in Subduction Zones



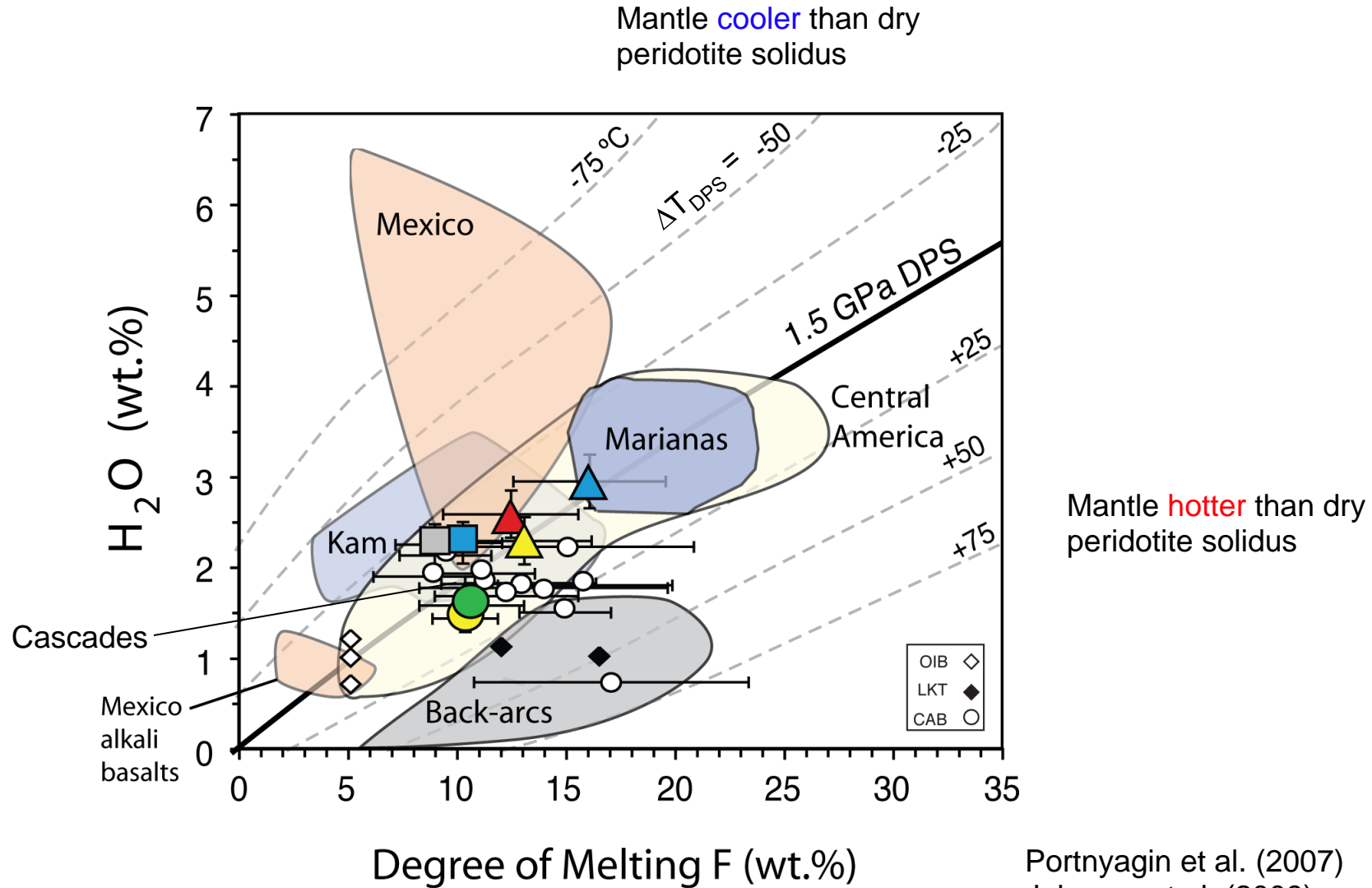
- H₂O-rich magmas form as fluids or hydrous melts percolate upward through the inverted thermal gradient in the mantle wedge

- H₂O-poor magmas form by upwelling induced decompression melting driven by corner flow

- Upwelling may also be related to tectonic extension

Grove et al. (2006)

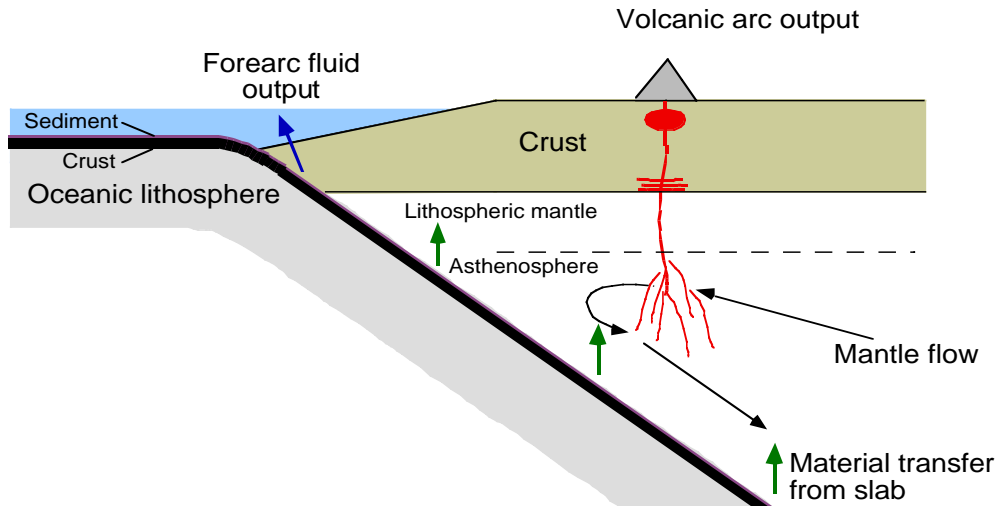
Inferring Mantle Temperatures Using Melt Inclusion Data



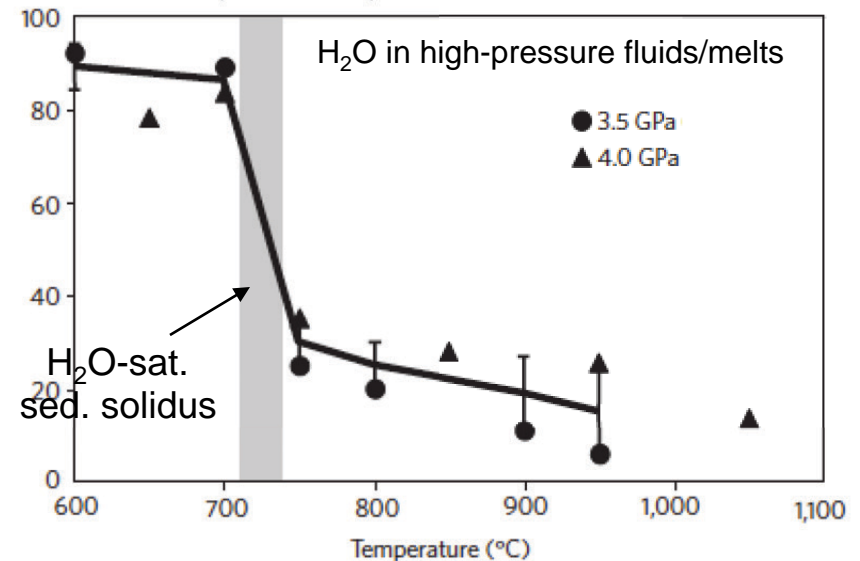
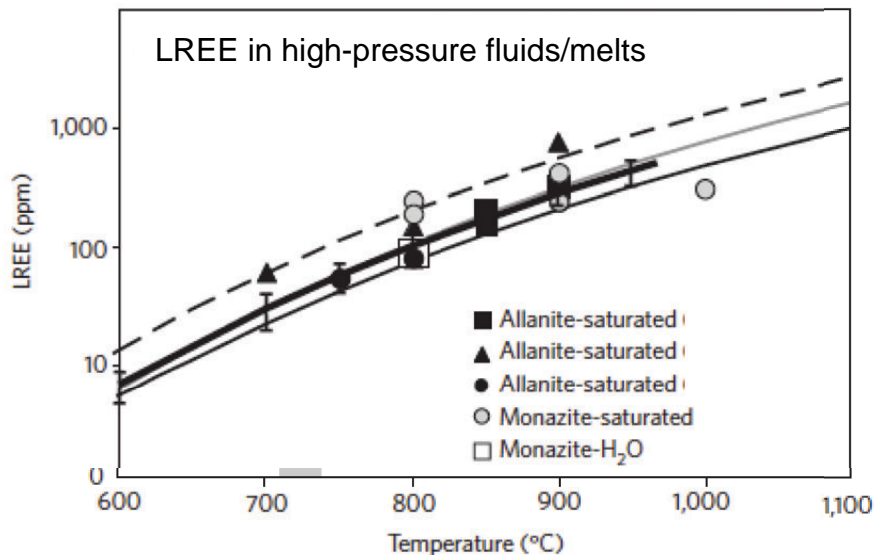
Portnyagin et al. (2007)
 Johnson et al. (2009)
 Kelley et al. (2006, 2010)
 Ruscitto et al. (2010)

Figure modified from Ruscitto et al., 2010, EPSL

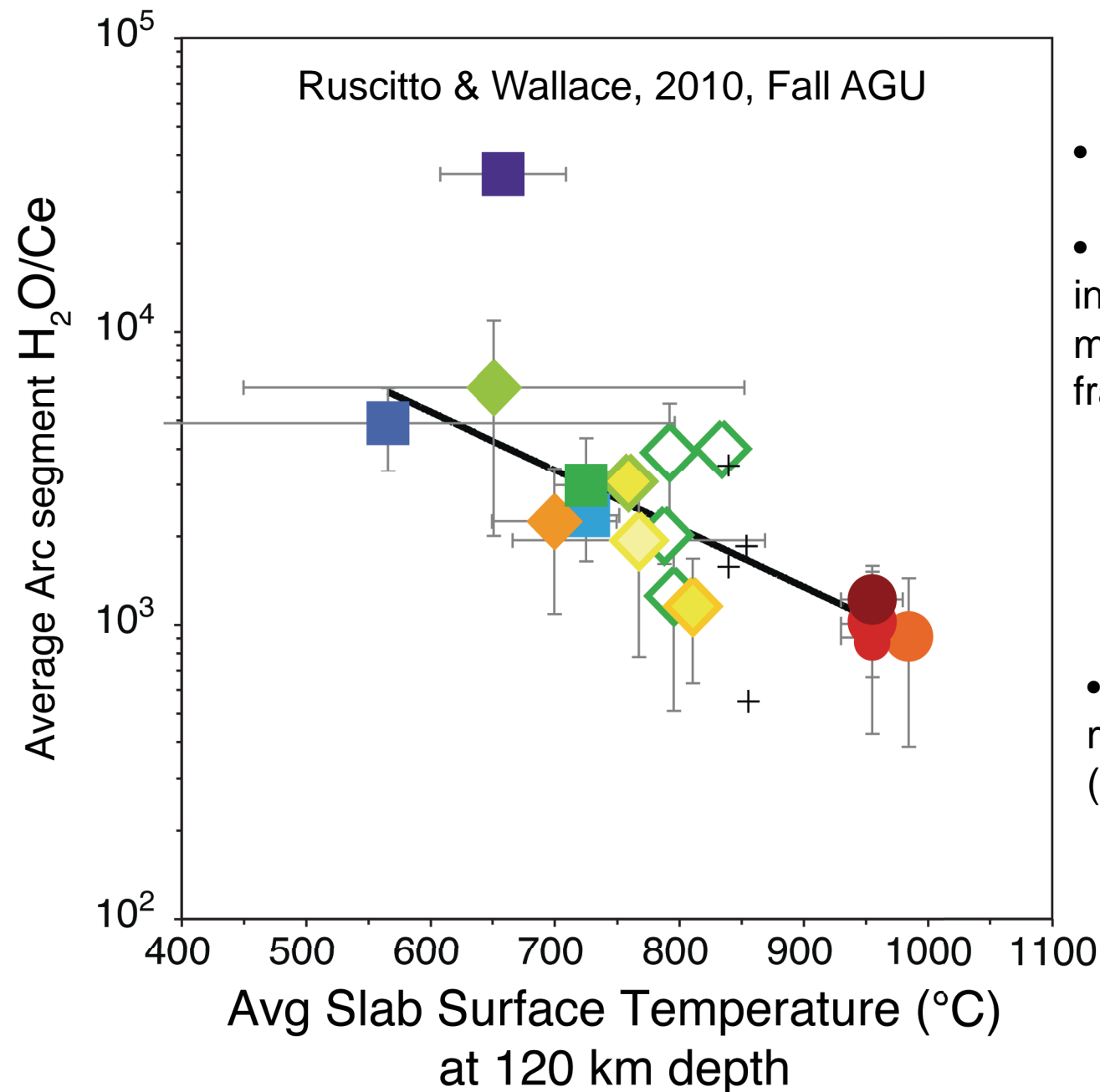
Slab Fluid Geothermometer (Plank et al. 2009)



- Increasing solute concentrations in slab-derived fluids/melts as T increases.
- LREE contents controlled by allanite/monazite saturation in slab residuum



H₂O/Ce vs Slab Surface Temperature

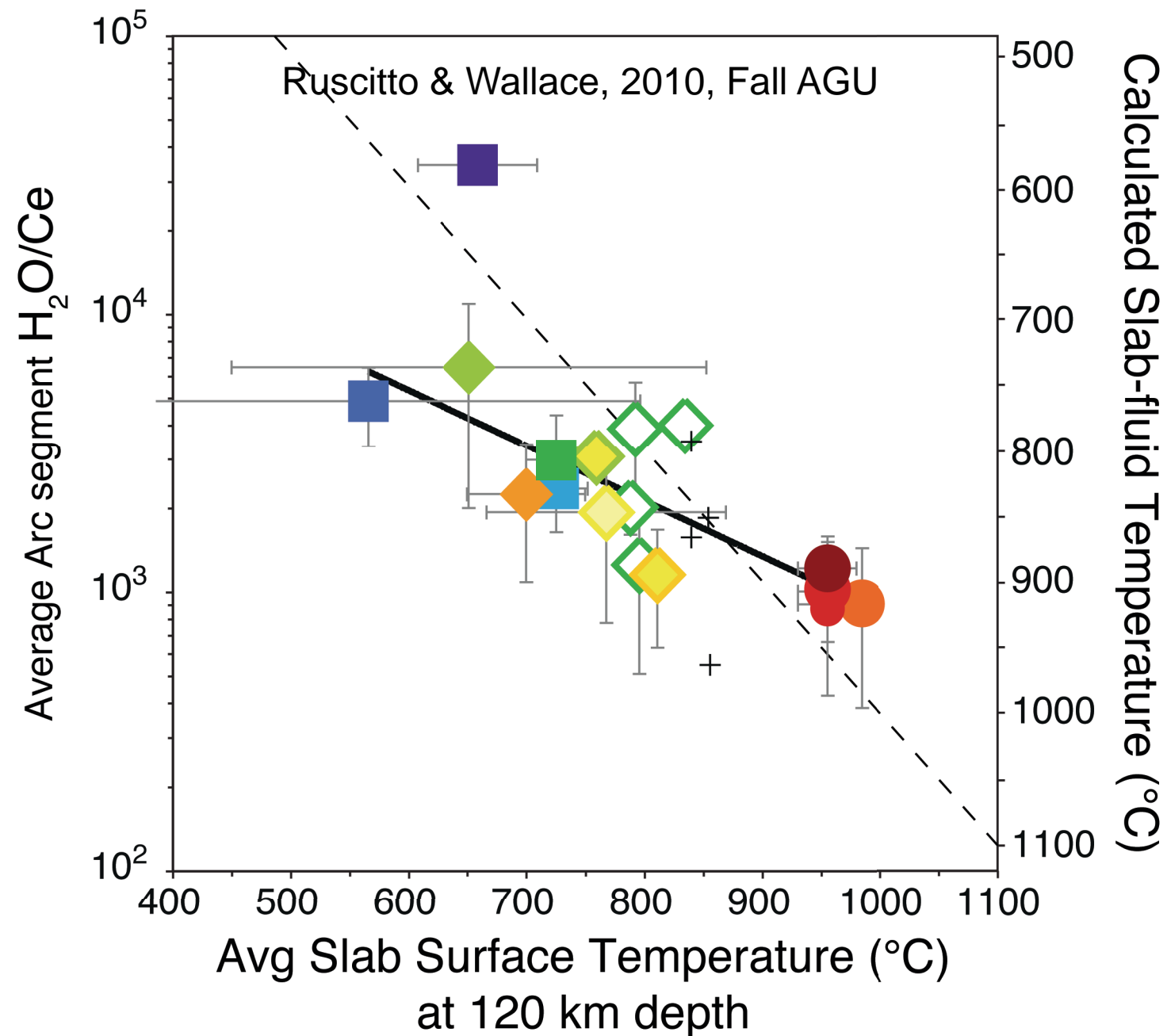


- Similar D for H₂O & Ce

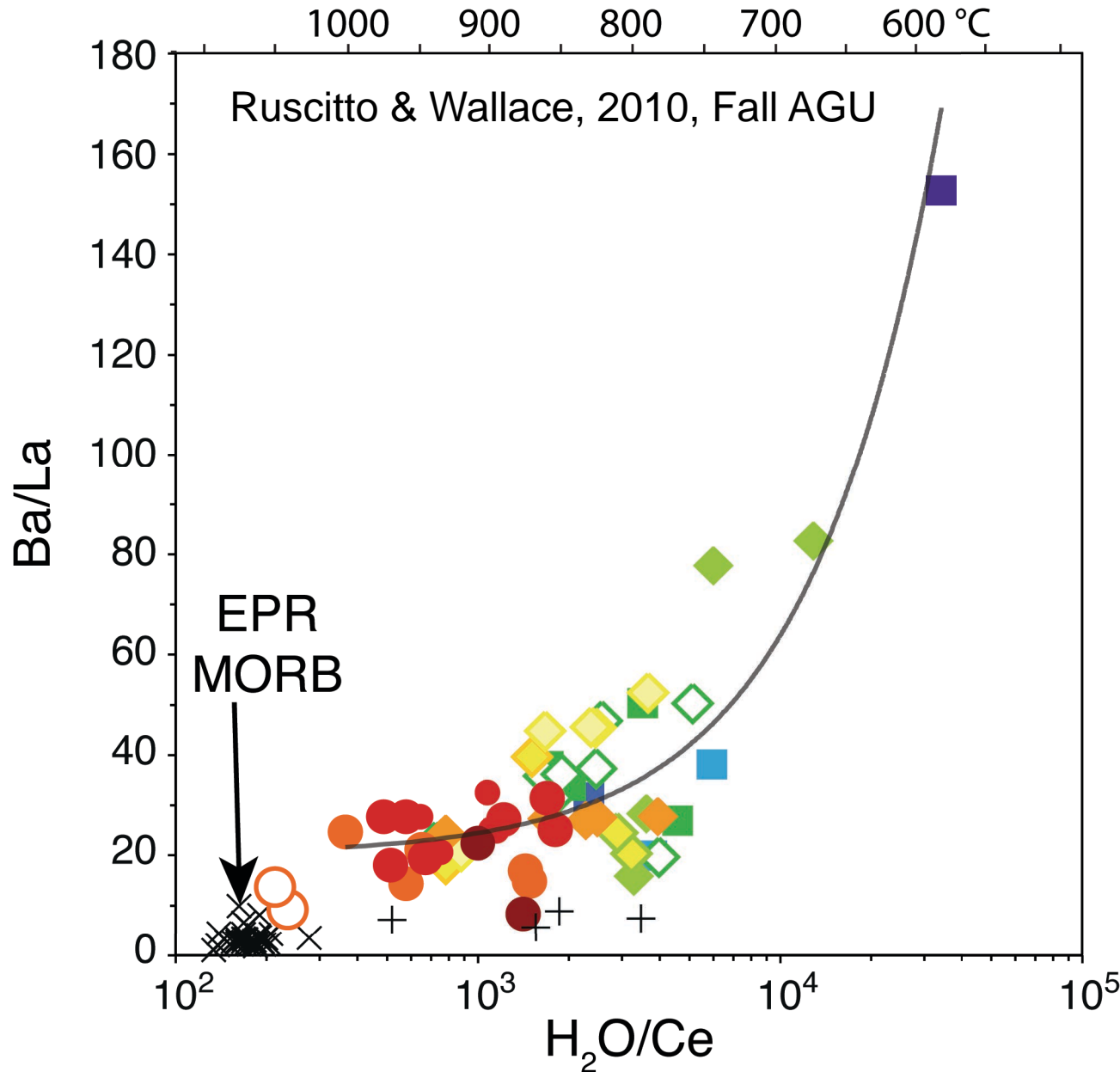
- Ratio should be insensitive to mantle melting & crystal fractionation

- Slab temperatures from models of Syracuse et al. (2010)

H₂O/Ce vs Slab Surface Temperature



H₂O/Ce vs Ba/La

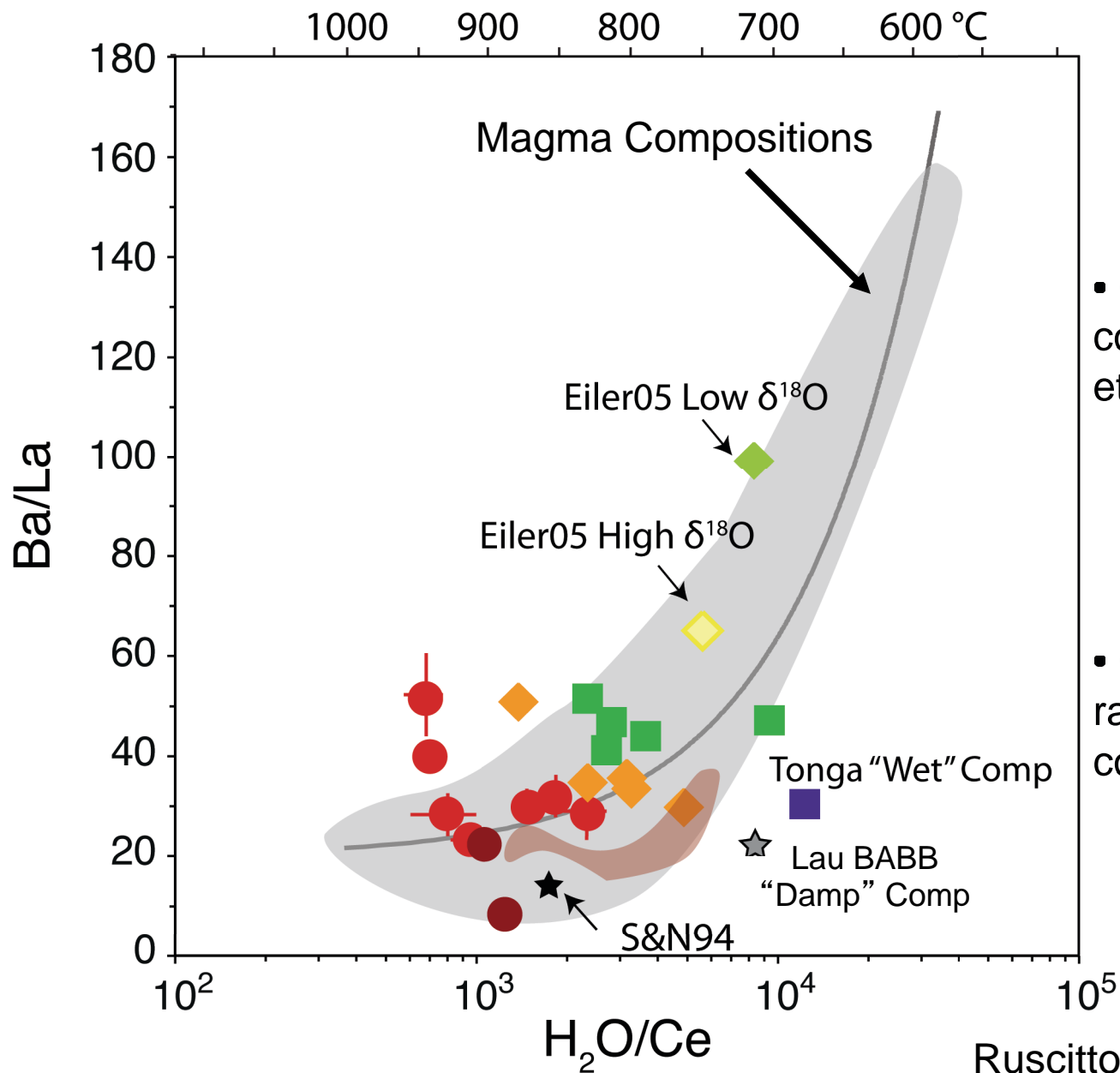


- Positive correlation with a traditional slab tracer.

- Magma compositions as proxies for slab fluids/melts assumes that mantle contributions are small.

- What do the actual slab fluid/melt compositions look like?

Slab 'Fluid' Compositions

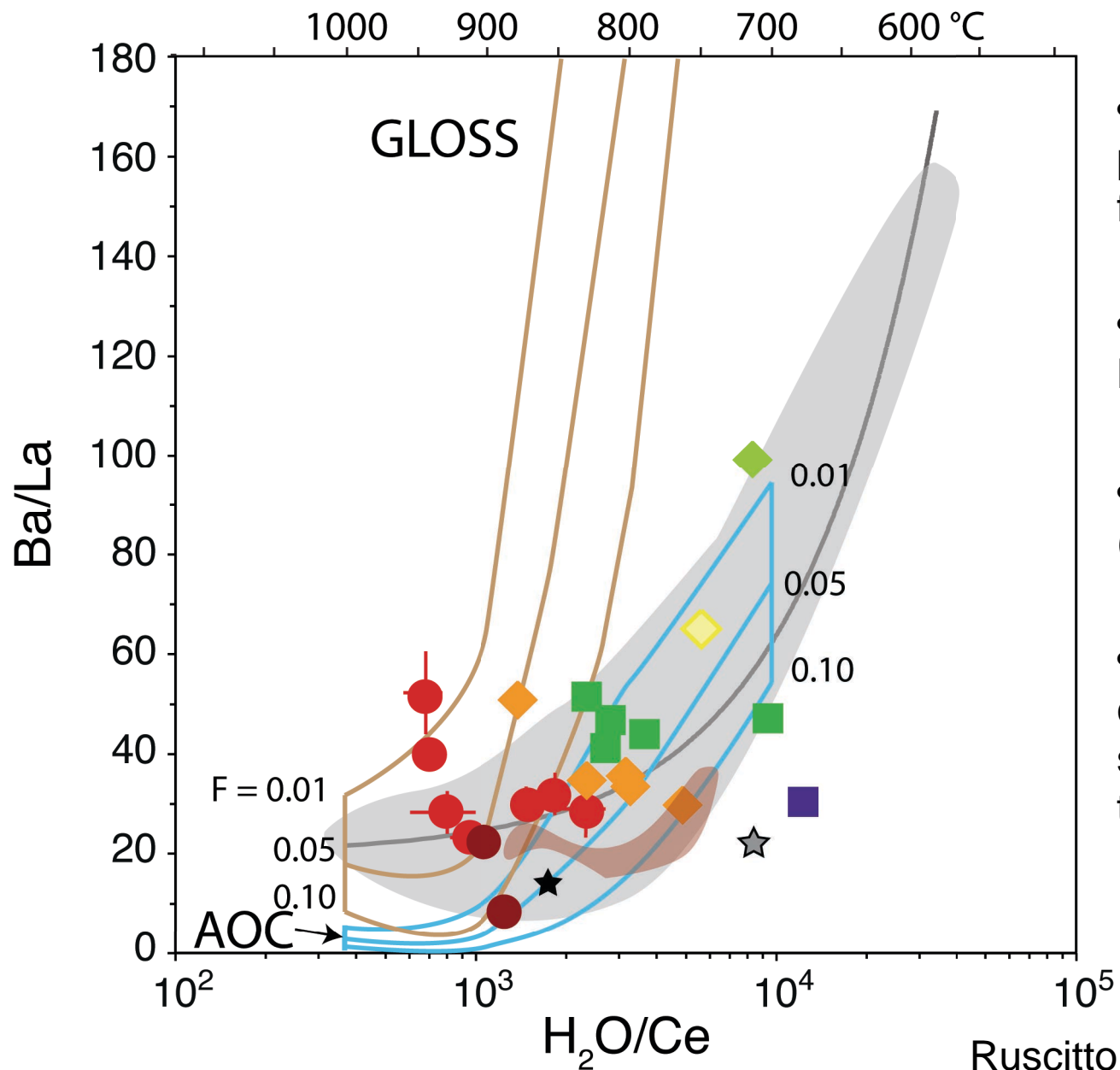


- Calculate slab fluid compositions after Portnyagin et al. (2007)

- Degree of melting constrained by Ti, Y, and HREEs

- Calculated slab component ratios are similar to magma compositions

Slab 'Fluid' Sources



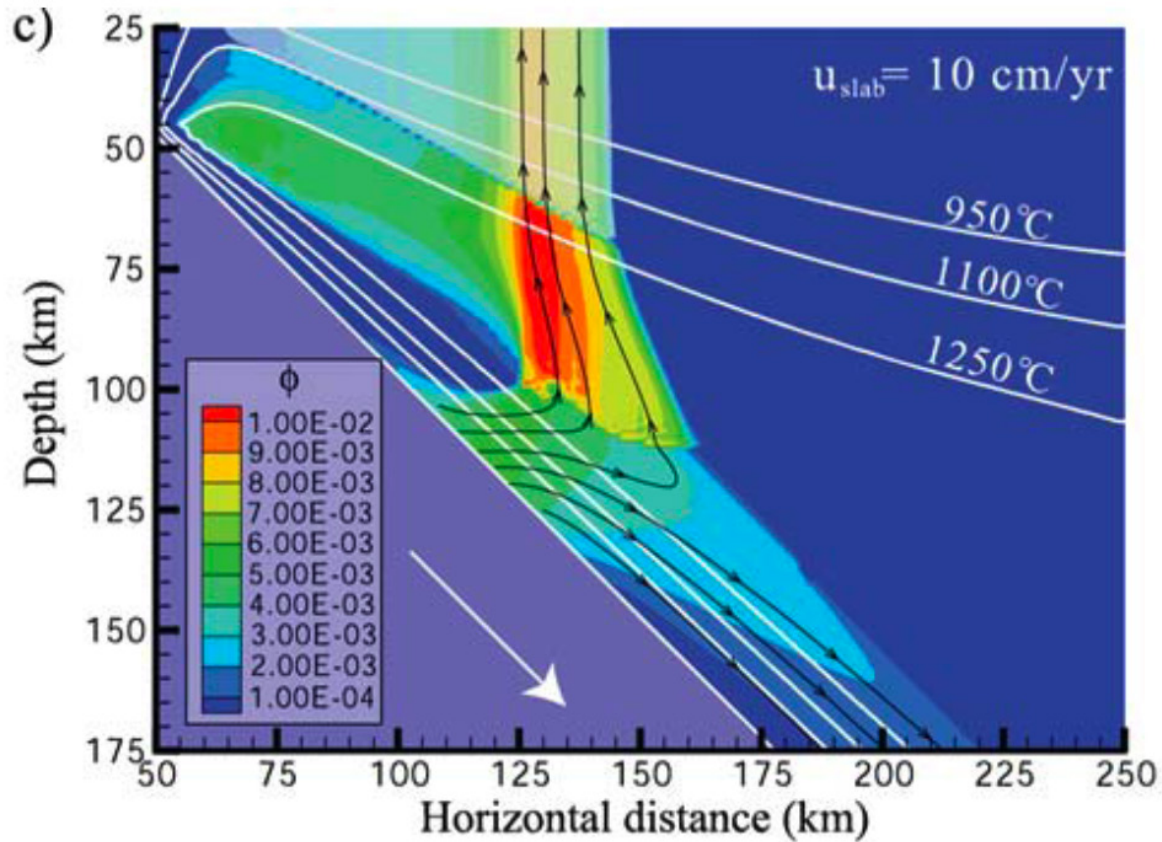
- Using fluid-solid partitioning at 4 GPa from Kessel et al. (2005).

- GLOSS from Plank & Langmuir (1998)

- AOC from Kelley et al. (2003)

- Do sediment melts contribute more to the subduction component at the high Temp end?

How do fluids & melts move through the wedge?



Effects of solid mantle flow on the distribution of fluid & melt in the wedge

Outstanding Questions

How does arc-parallel flow vs. corner flow in mantle affect fluid & melt movement?

What are fluid pathways like in slab & wedge? Porous vs. channelized flow. Diapirs?

How important is serpentinite in mantle of the downgoing slab?

Does bend faulting and hydration of the plate also cause substantial cooling?

What happens to hydrated forearc mantle?

Is metastability of hydrous phases important?

What is the role of dehydration melting of subducted crust by phengite breakdown?

What is the role of volatile storage in lithospheric mantle?

How do input & output fluxes of volatiles compare? Problem of intrusive magma flux.

Role of arc crust, amphibolite “sponge”, volatiles in evolved magma, eruption explosivity?

