Understanding drivers of geohazards using geochemical methods

(Jaime D. Barnes, University of Texas at Austin)

Fluids and fluid migration

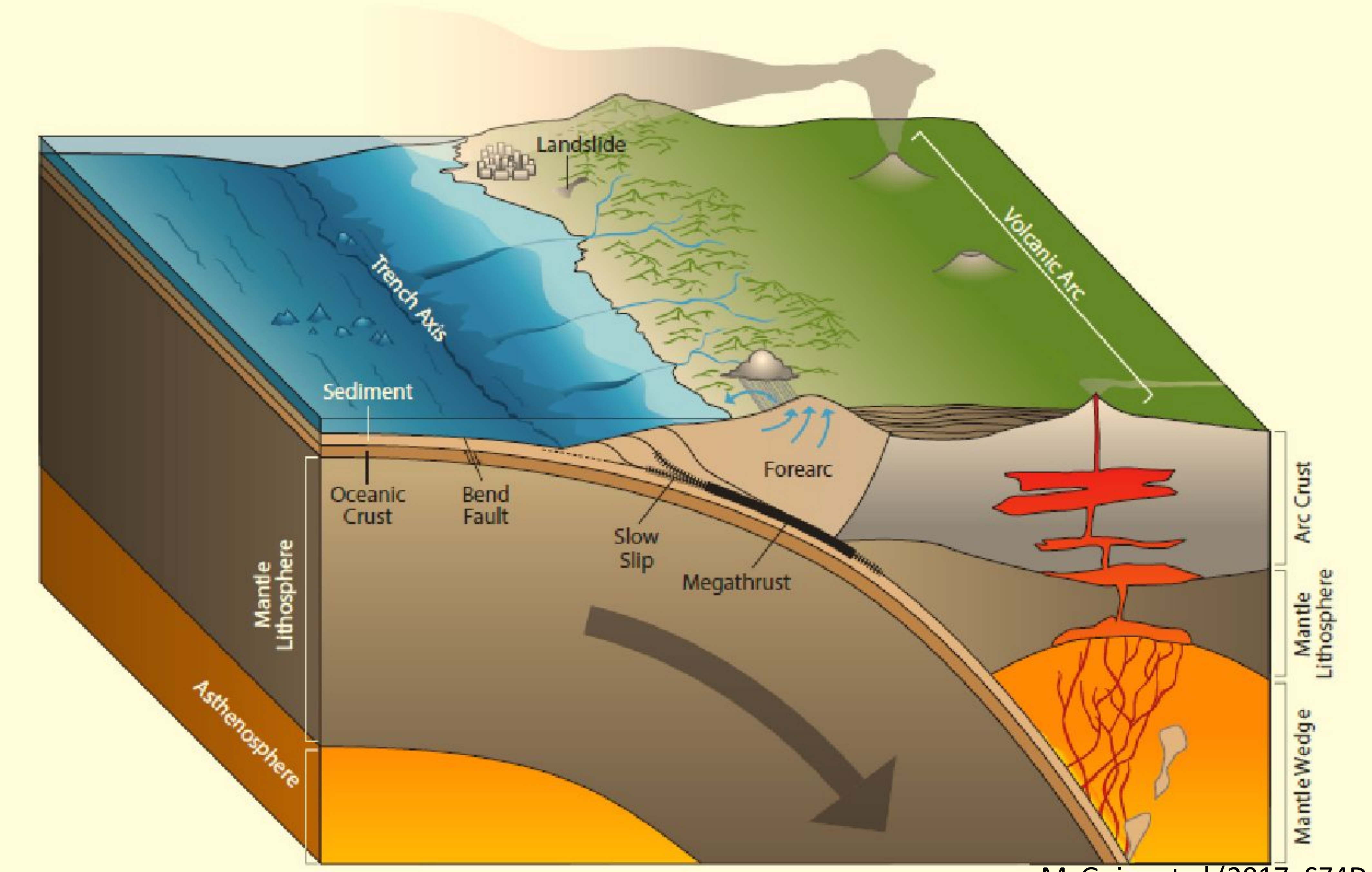
How does fluid migration influence hazards and material transport across the entire subduction system?

Fluids play a critical role in subduction zones:

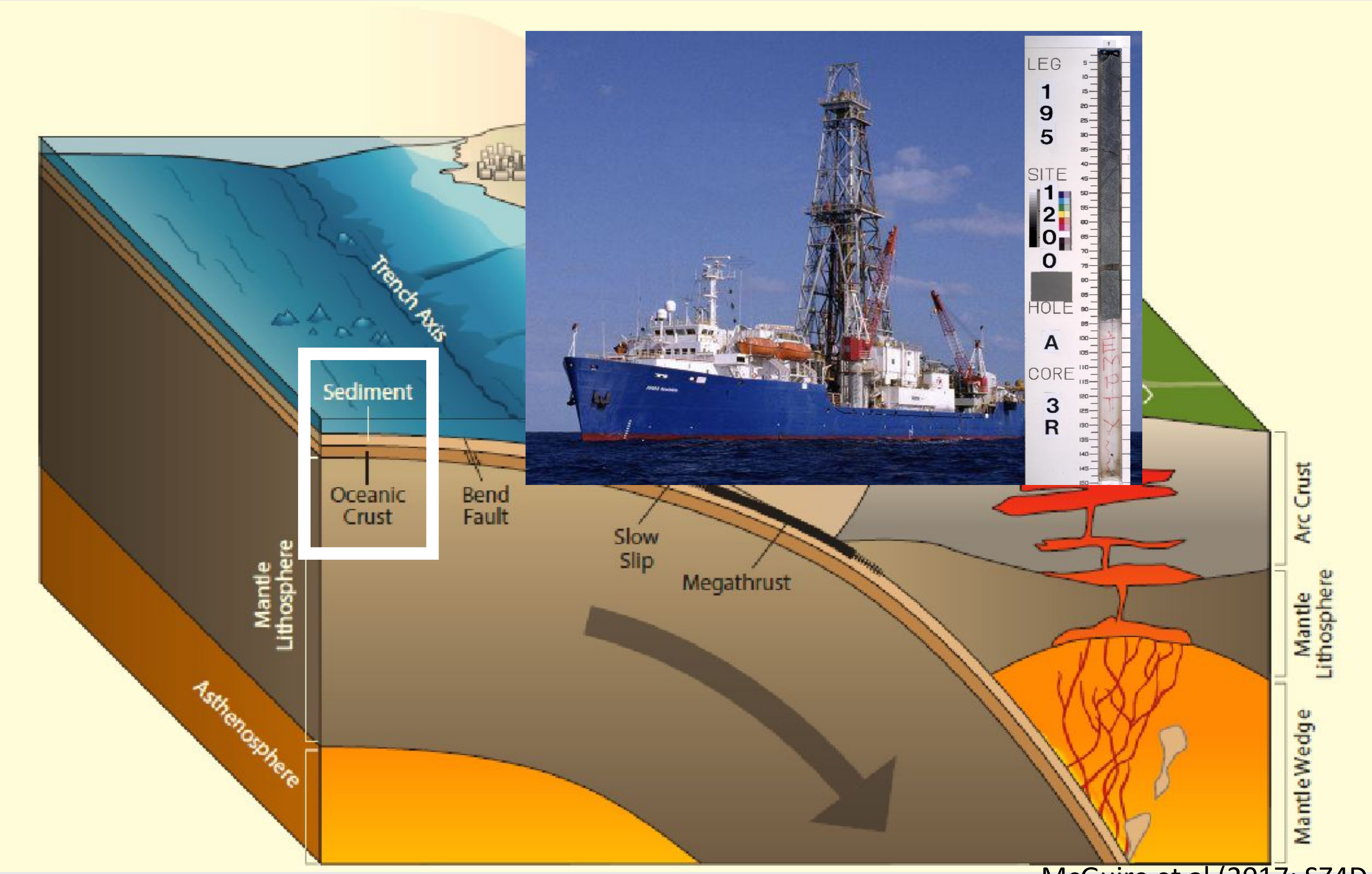
1) Nature of seismic behavior along the megathrust (& associated faults)
2) Rock rheology and strain localization
3) Volcanic eruptive behavior
4) Resources: geothermal to critical metals

- **fluids/volatiles/FME – amount? source? pathway?**

elemental concentrations, ratio, isotopic composition



McGuire et al (2017; SZ4D Initiative)



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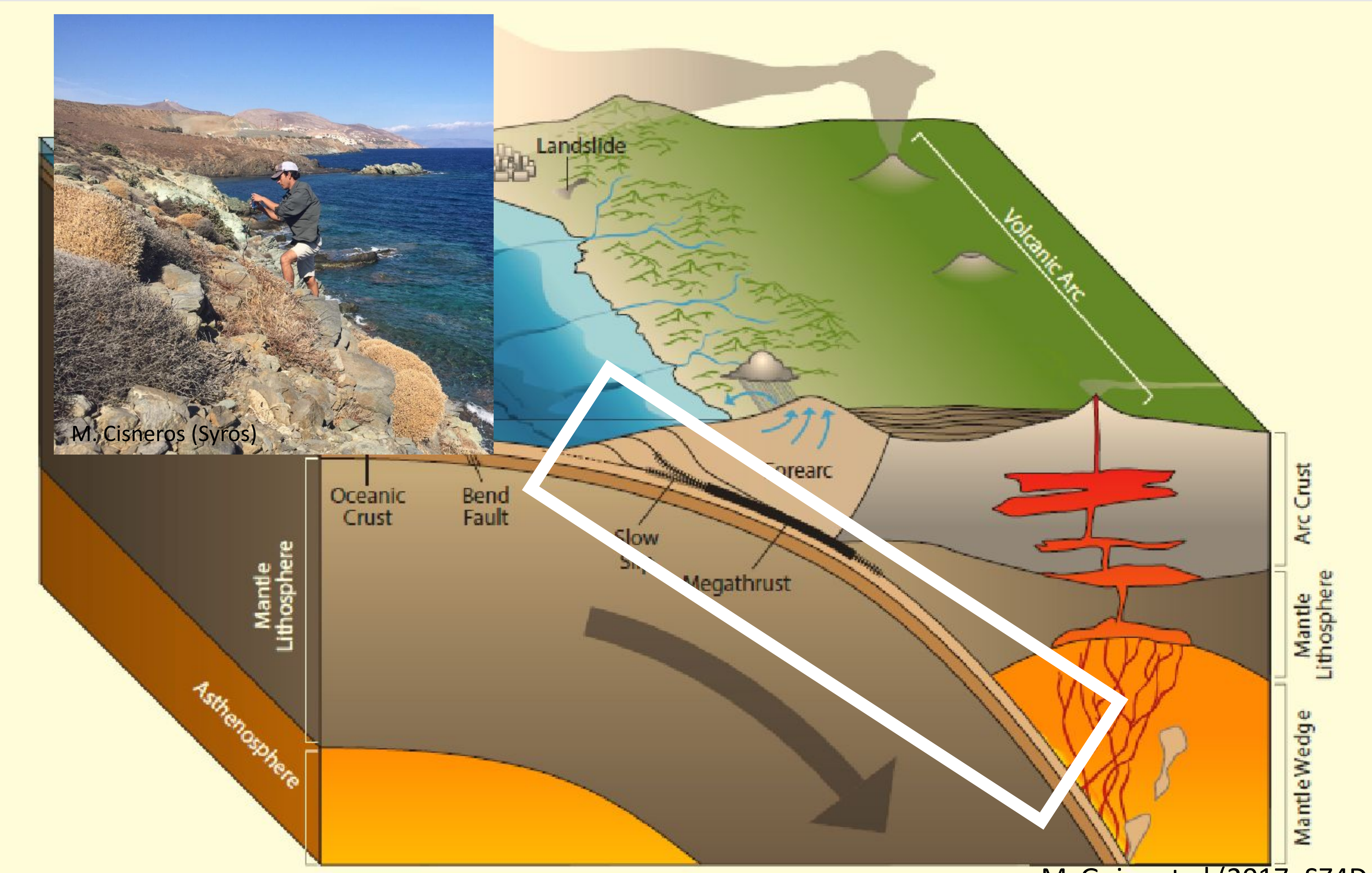
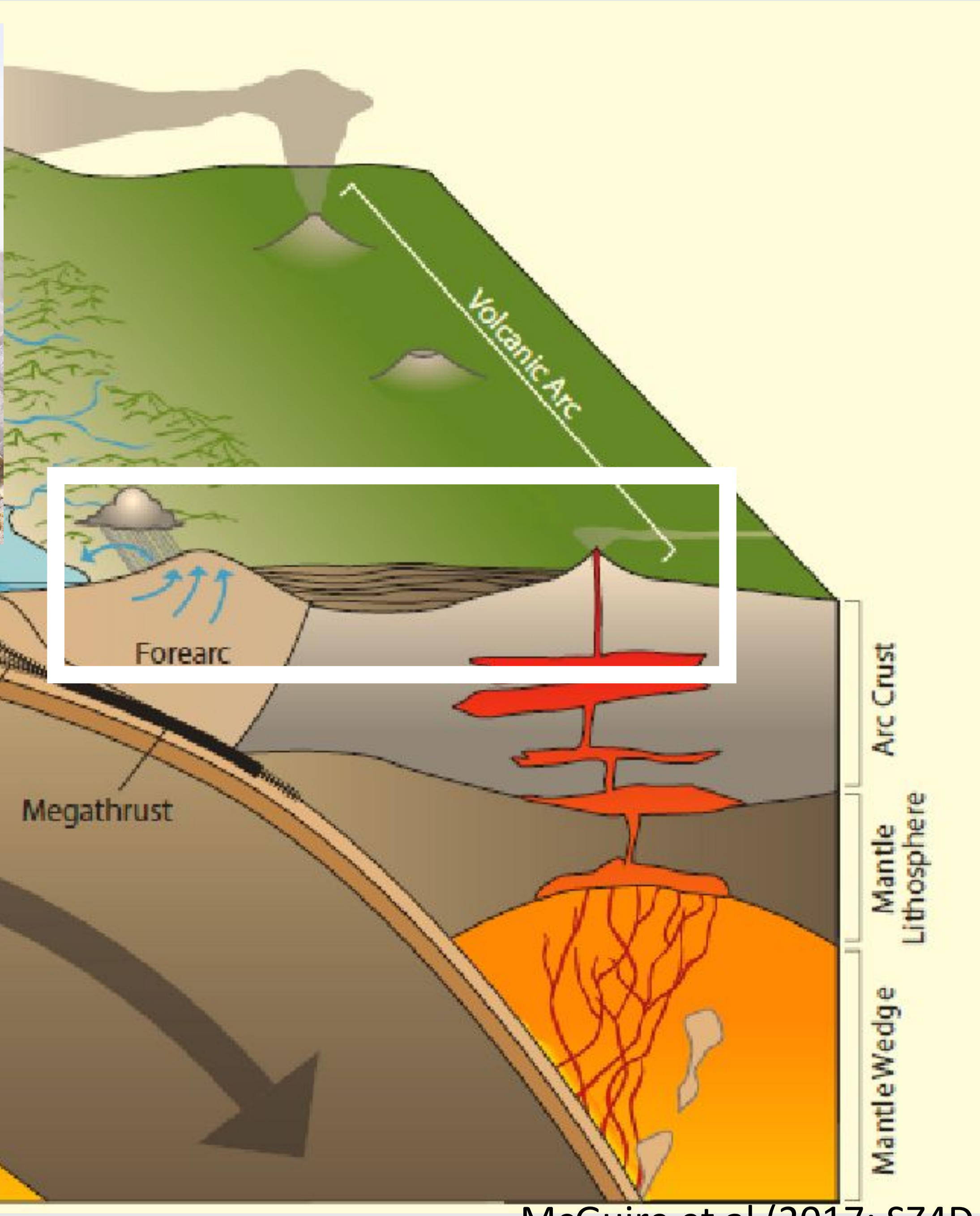


McGuire et al (2017; SZ4D Initiative)

M de Moor (Chile)
photograph for *Nature* by J. Pasotti (June 2022)

Mangapakeha, New Zealand



McGuire et al (2017; SZ4D Initiative)


Thermo
MAT 253

Stable Isotope Geochemistry

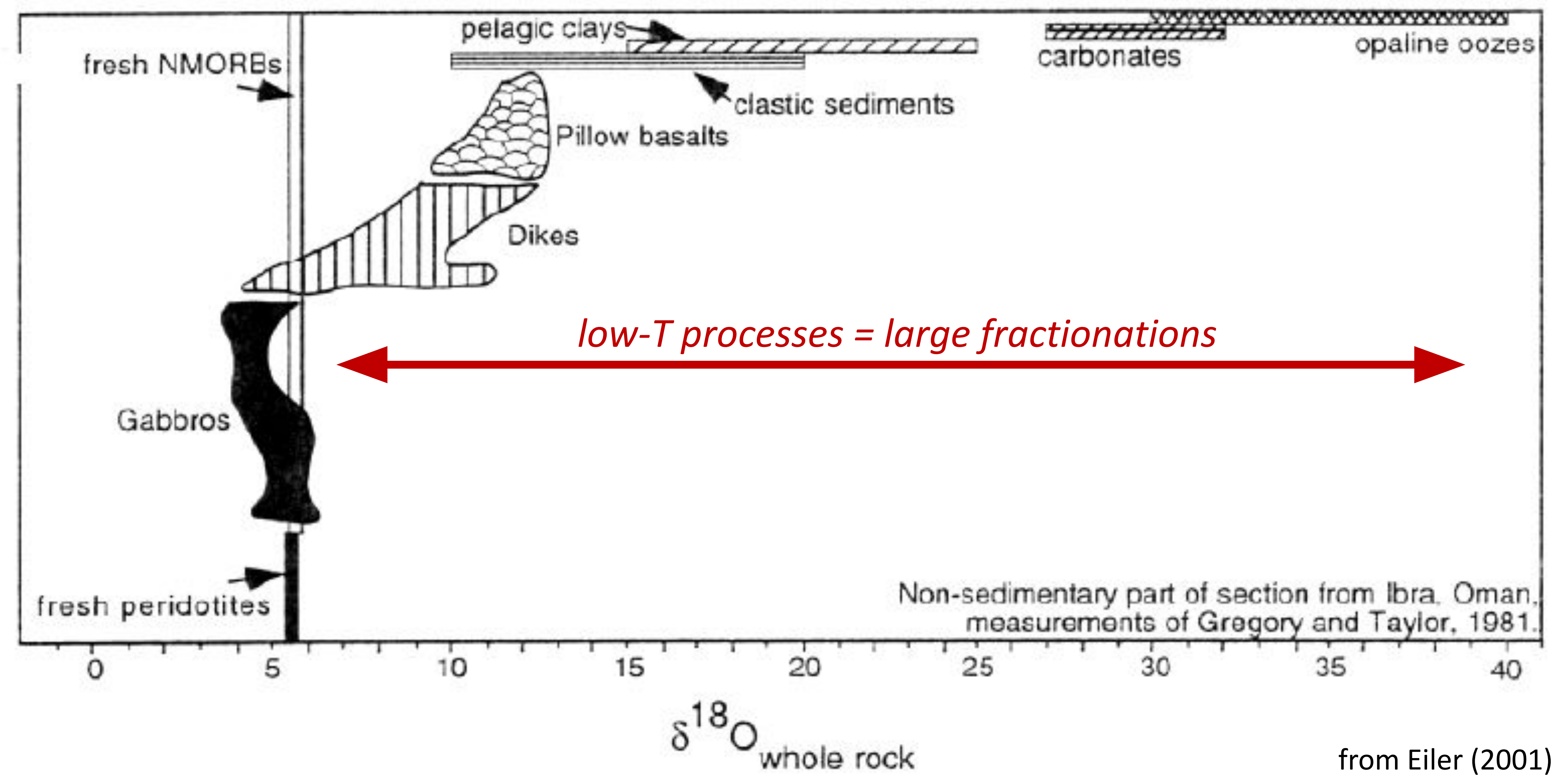
$$\delta^7\text{Li} = \left(\frac{{}^7Li/{}^6Li_{sample}}{{}^7Li/{}^6Li_{standard}} - 1 \right) x\ 1000$$

 measured on a mass spectrometer

Traditional: O, H, C, N, S

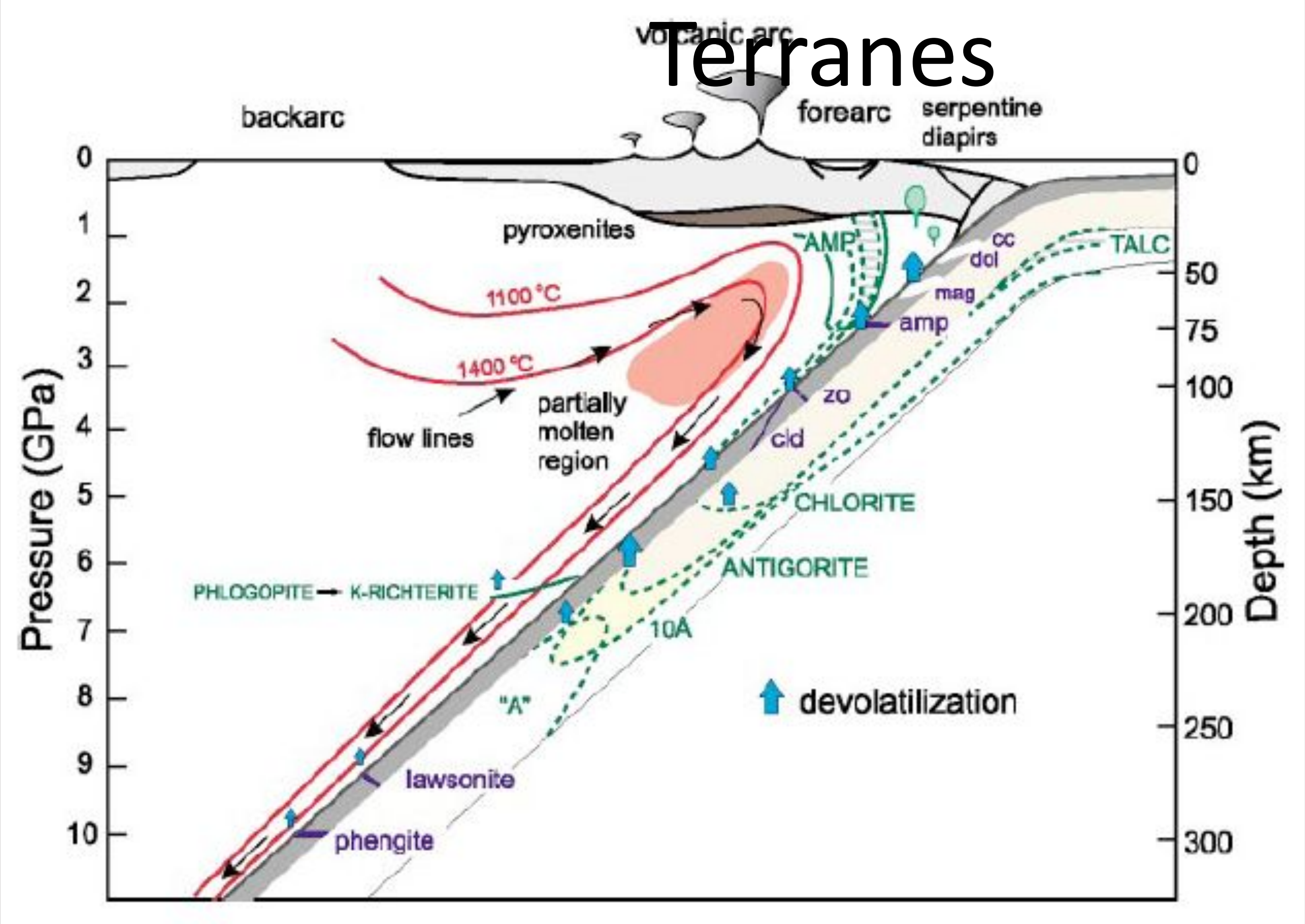
Non-traditional: Cl, Li, B, Ca, Fe, Cu, Zn…

Inputs



from Eiler (2001)

Exhumed Terranes

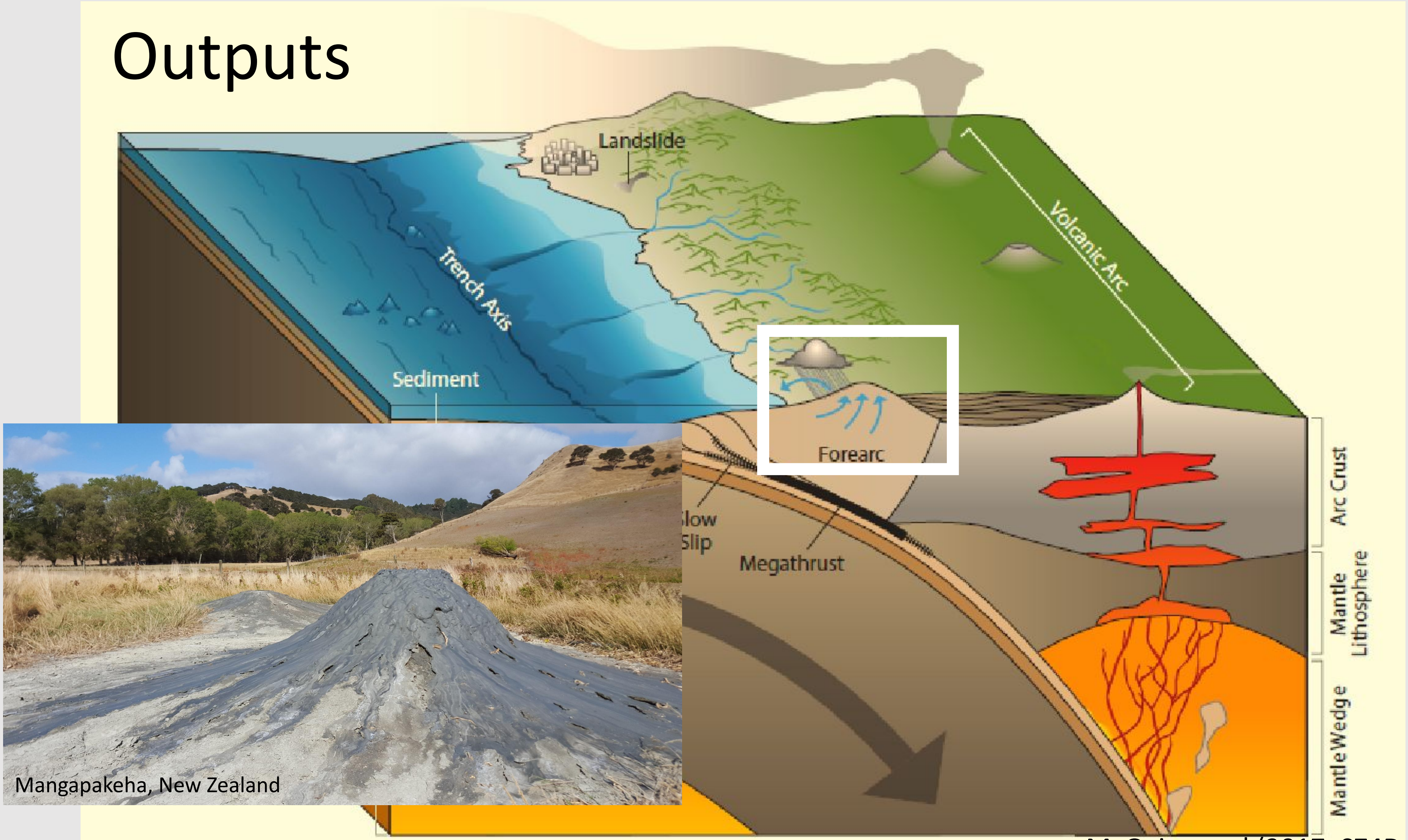


(Poli and Schmidt, 2002)

What is being lost where?
- concentrations
- elemental ratios
- isotopic compositions

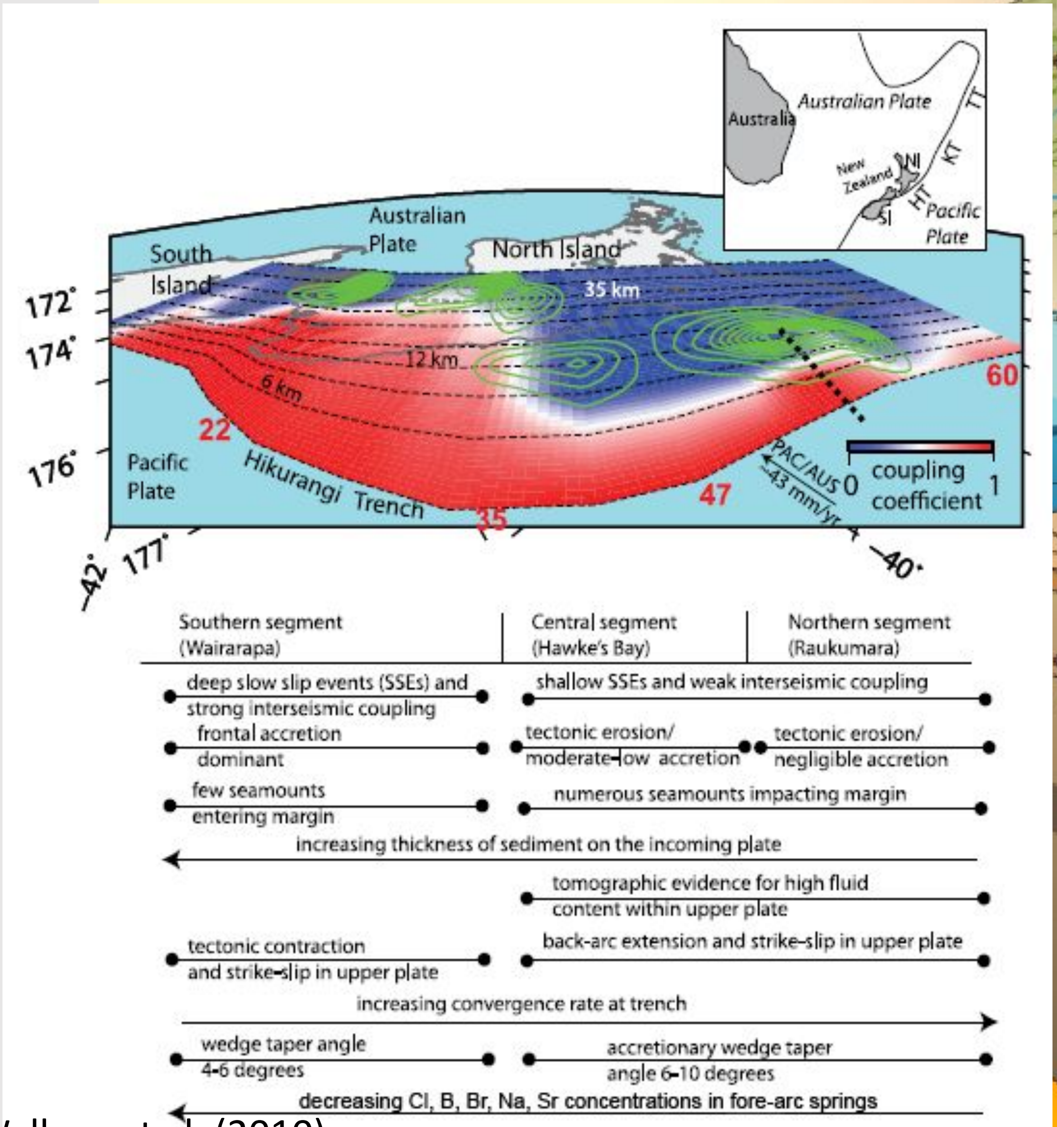
@ high-T fractionations are small trace source

Outputs

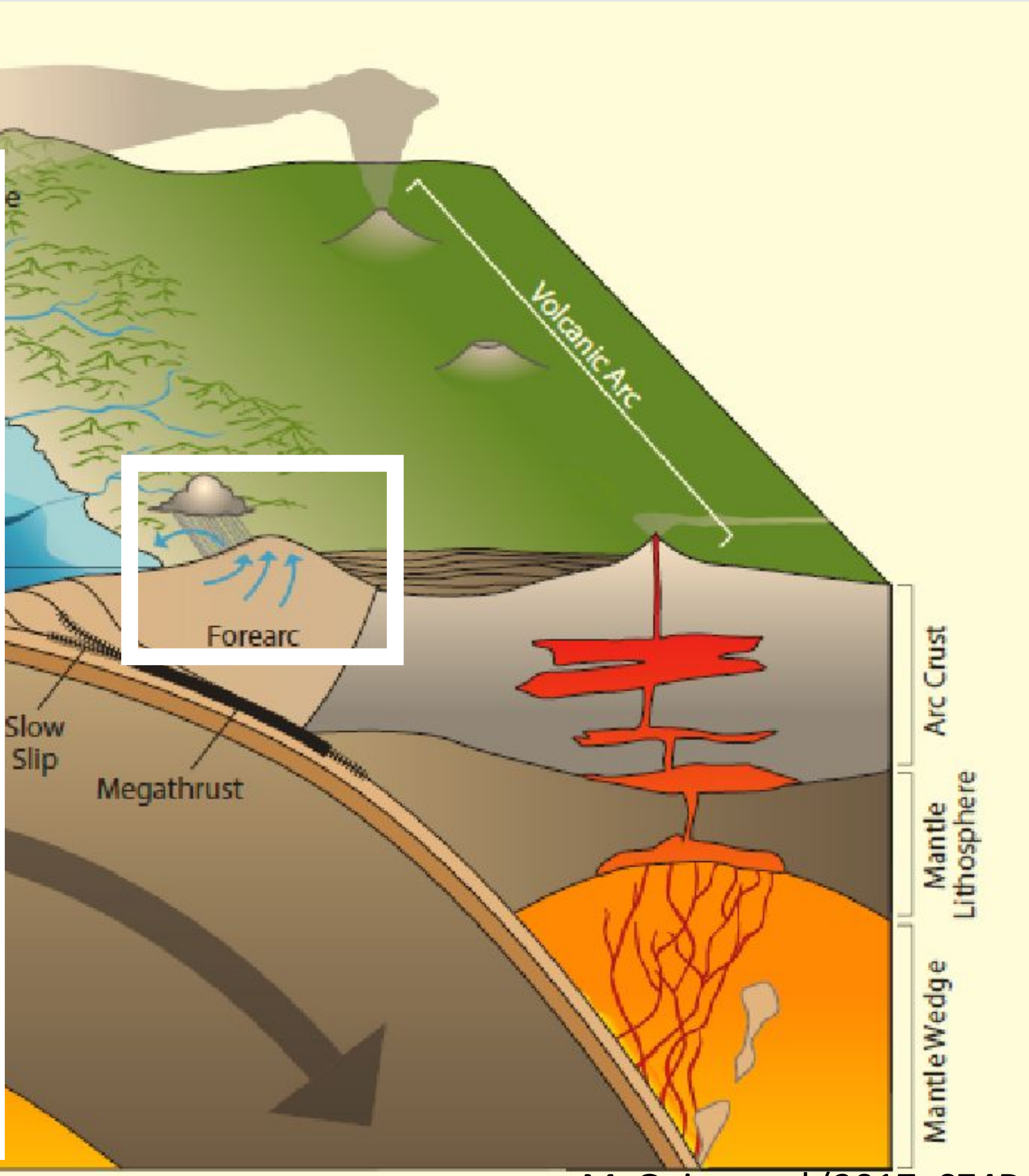


McGuire et al (2017; SZ4D Initiative)

Outputs



Wallace et al. (2010)



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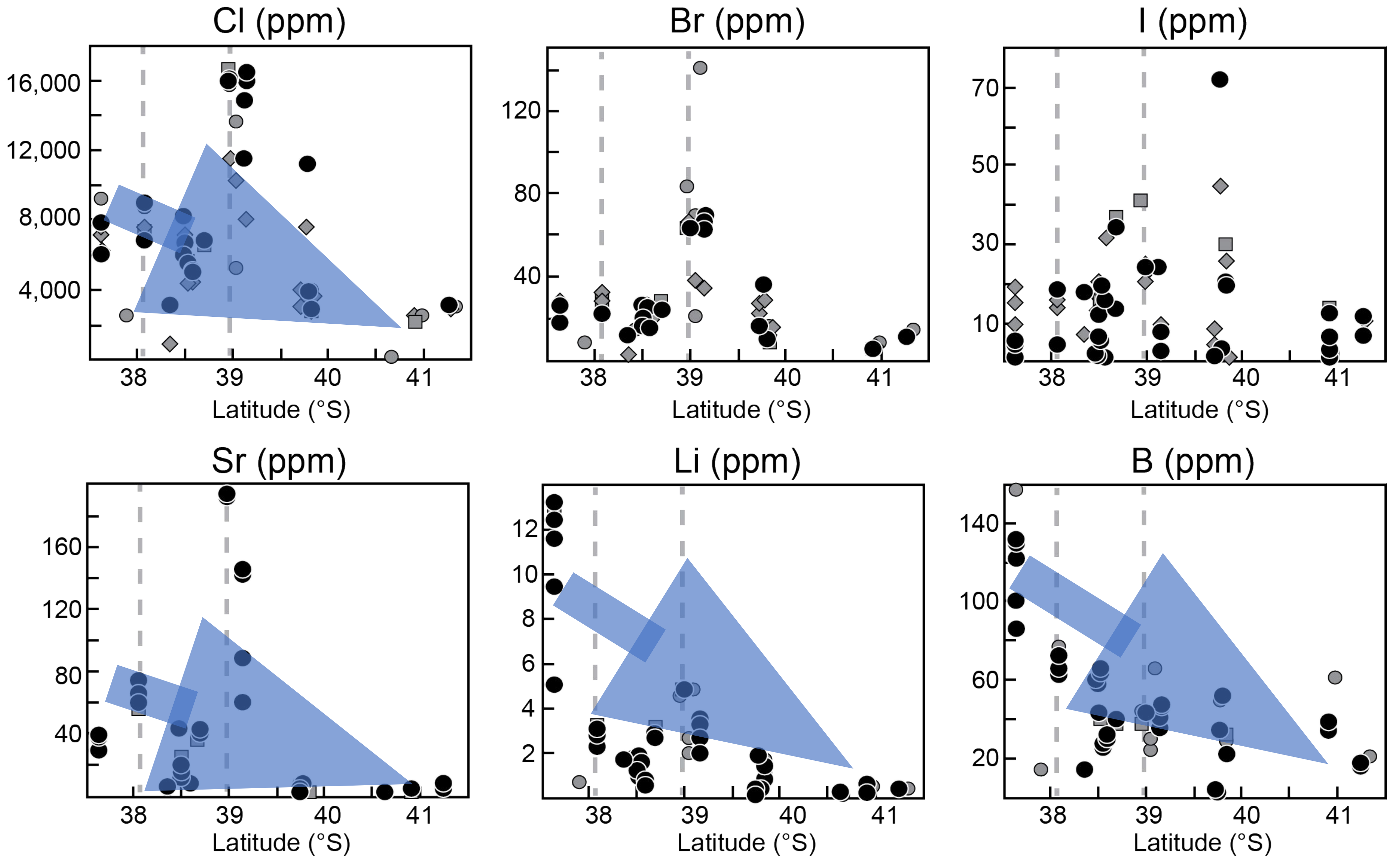
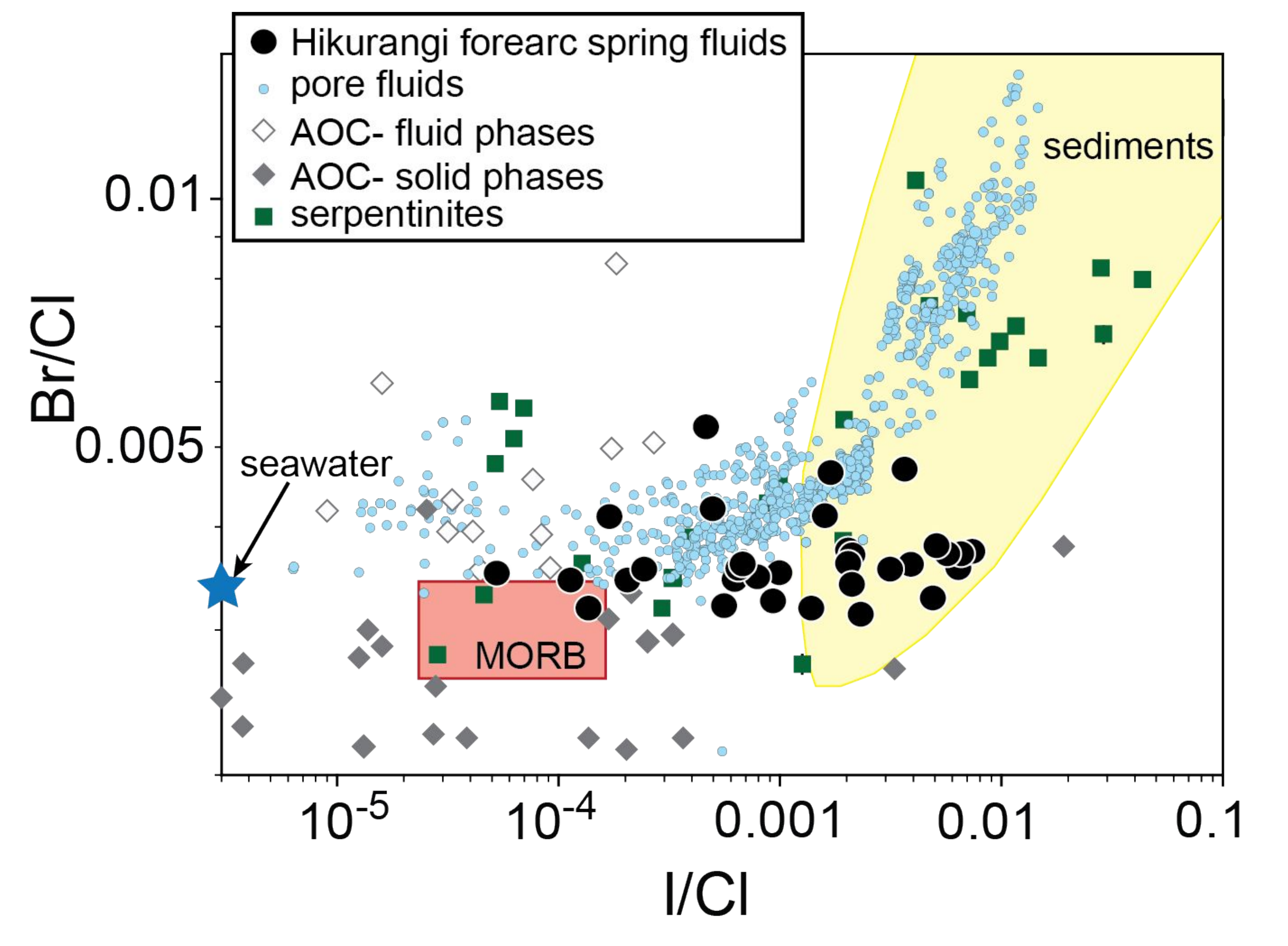
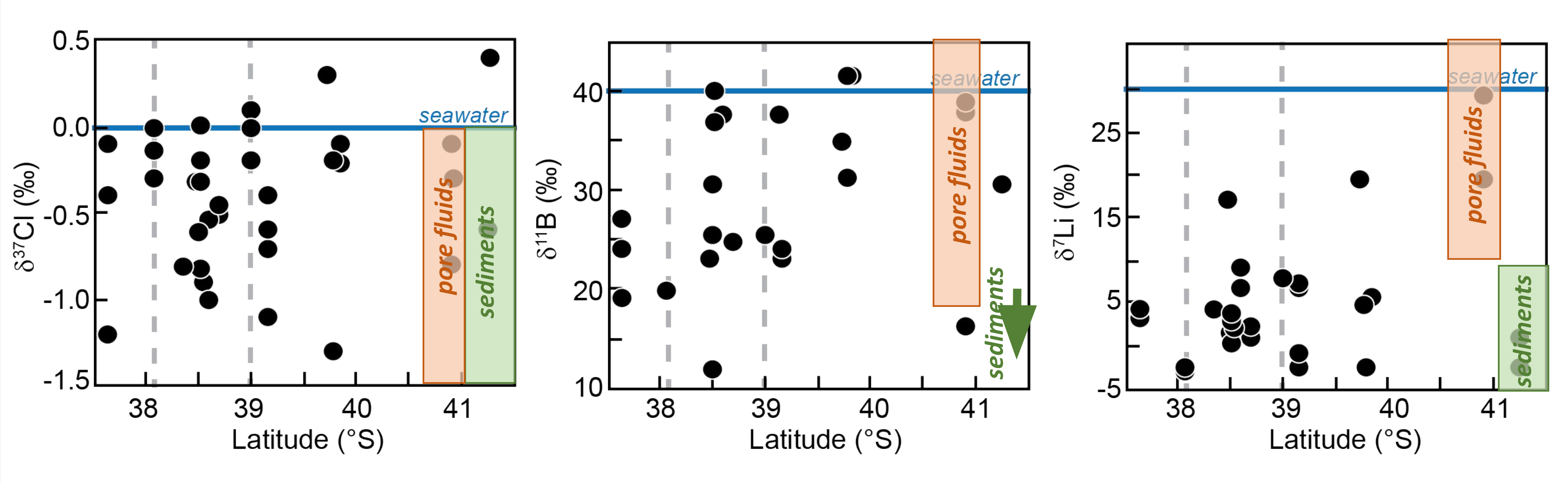


Barnes et al (2019)



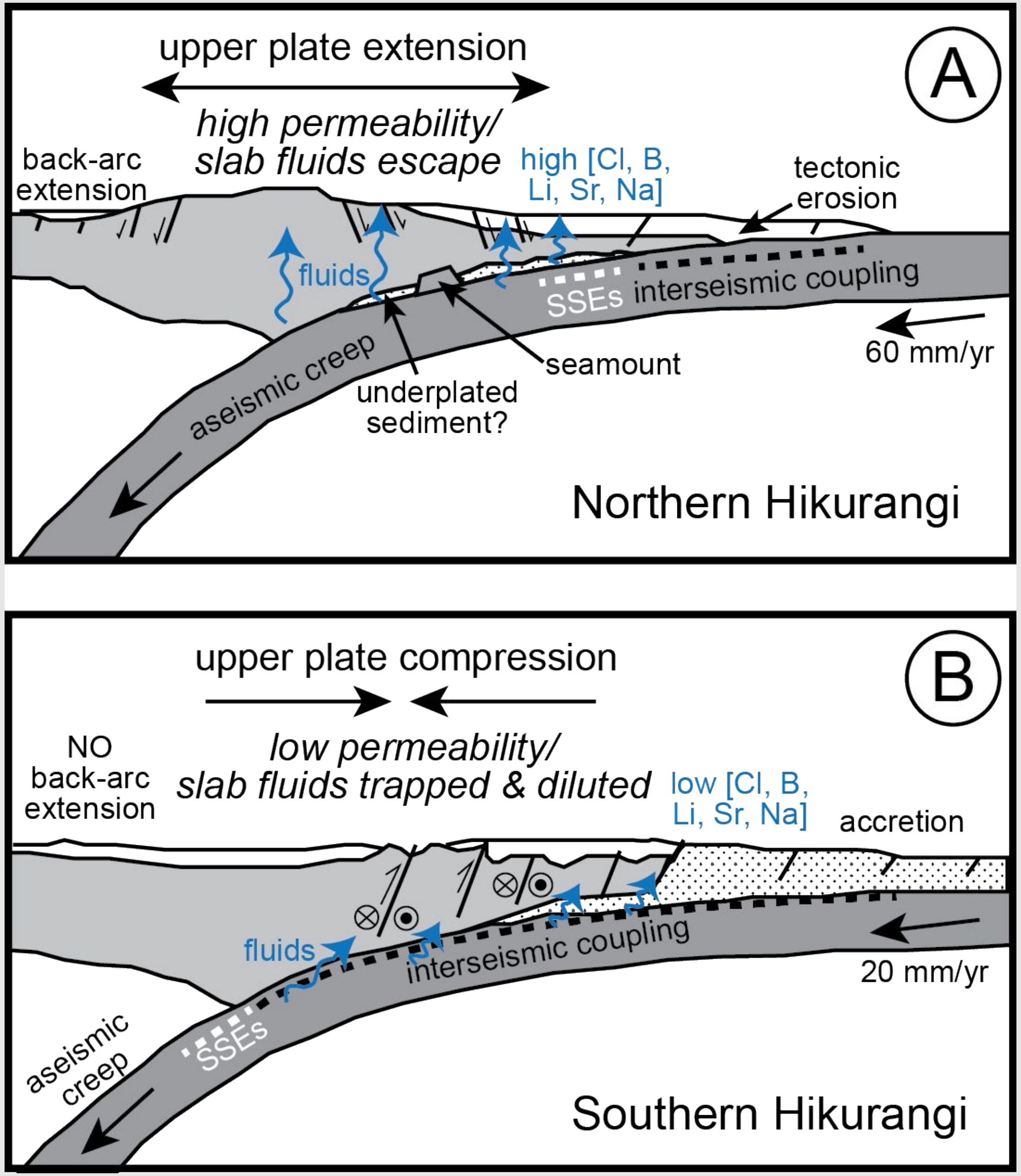
modified from Kendrick et al (2013); additional data from John et al. (2011); Chavrit et al (2016)



Barnes et al (2019)

Stable isotope data and elemental ratio data seawater and sedimentary pore fluids

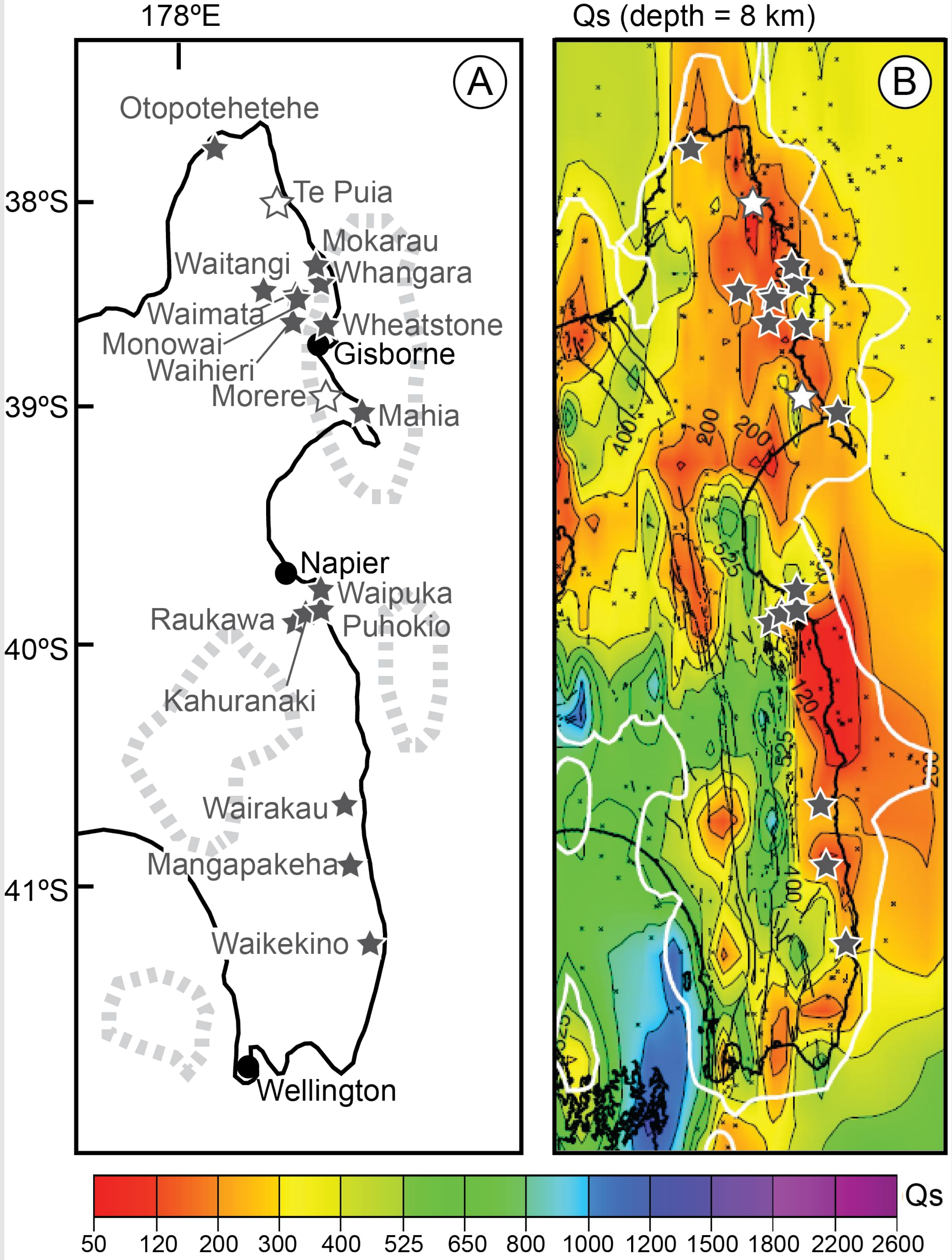
Not a change in fluid source, but rather fluid flux



Extensional in the North
Higher permeability of upper plate
Larger fluid flux

Compressional in the South
Lower permeability of upper plate
Lower fluid flux

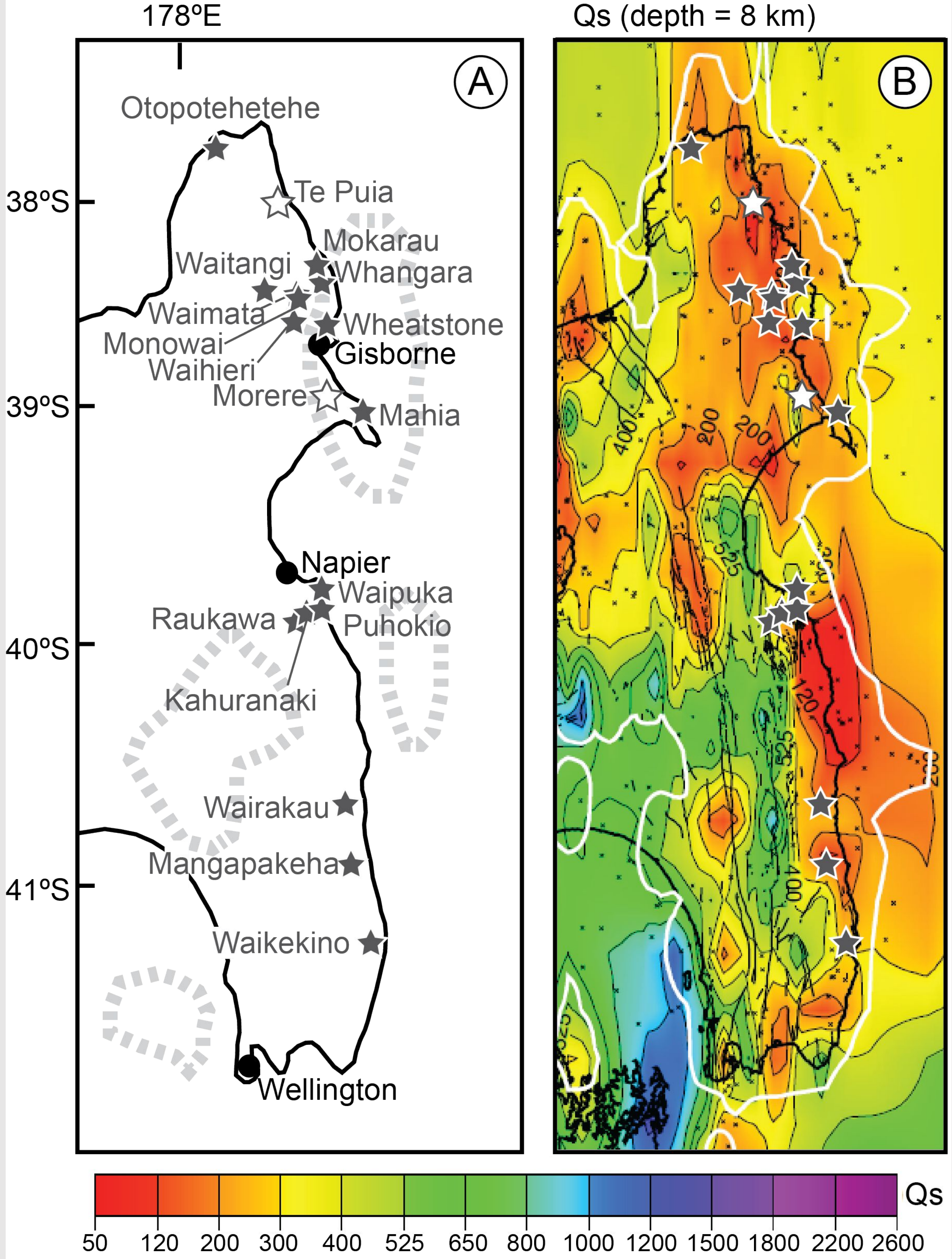
Barnes et al (2019)



Low Q (inverse of seismic attenuation) □ high fluid content

Distinct concentration highs correlate with low Q

Eberhart-Phillips et al (2017)



Low Q (inverse of seismic attenuation) high fluid content

Distinct concentration highs correlate with low Q

** integration of geochemical data with other data (e.g., geophysical, mechanics)**

Eberhart-Phillips et al (2017)

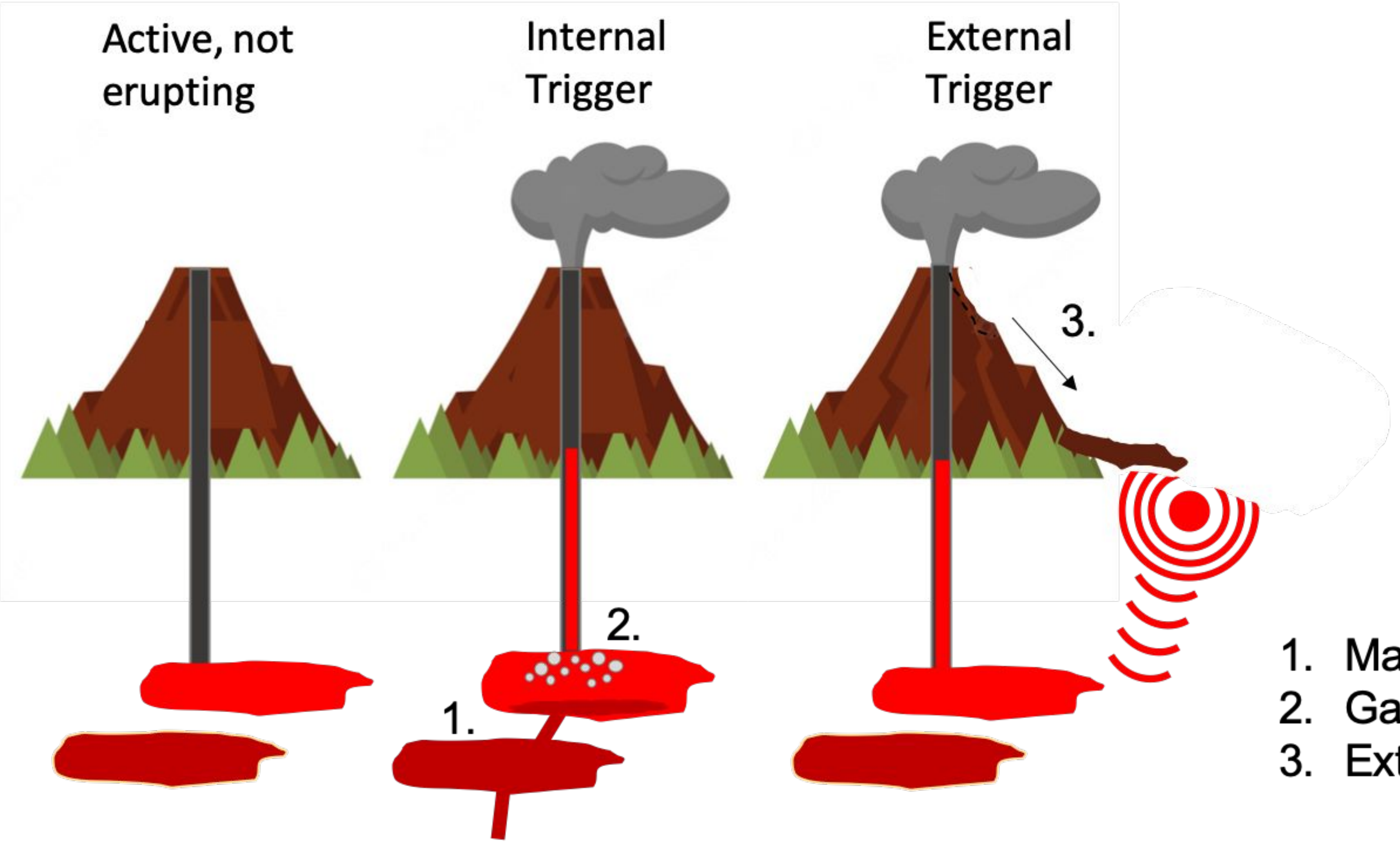
Understanding drivers of geohazards using geochemical methods

(Madison Myers, Montana State University)

Magmas, Melts, and Gases

How do we use the erupted materials from volcanic systems to understand the processes and timescales for triggering volcanic eruptions

Sidebar 3: What drives a volcanic eruption?



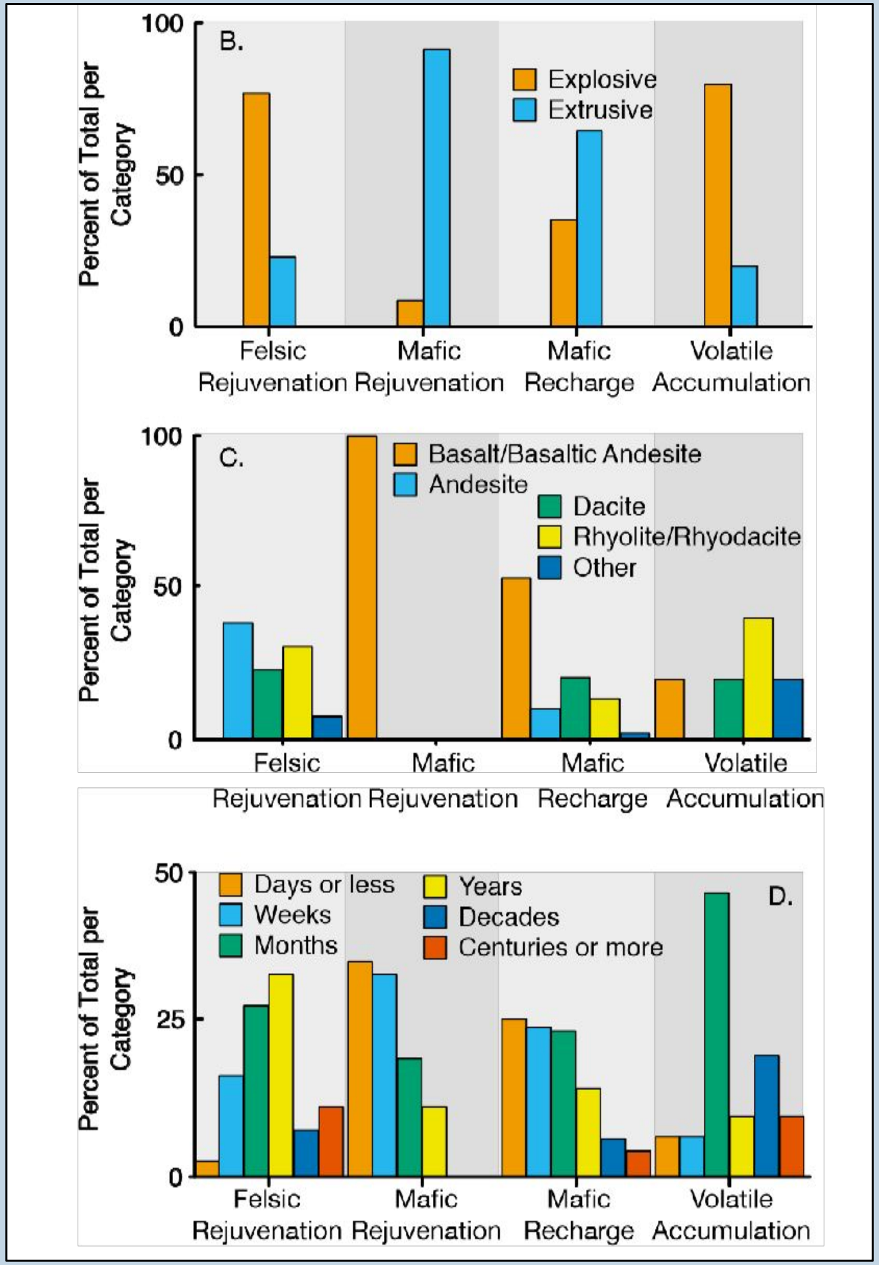
1. Magma injection
2. Gas pressurization (bubbles)
3. External trigger (landslide)

Volcanic eruptions are triggered by both internal processes (from within the magma or magmatic system) and external process (e.g., landslides, earthquake). The most common mechanism for triggering eruptions in arc settings is deeper, hotter magma entering a shallower magma storage region, but eruptions can also be initiated by buildup of gas pressure related to crystallization. One open question volcanologists are trying to constrain is how much time will elapse between the triggering event, and the physical eruption.

Geochemistry, volatiles and petrology can inform on:

1) What triggers and eruption to occur and over what timescale?
2) Integrate petrological and geochemical data with geophysics
3) Improve our models (diffusion, ascent, overpressurization, etc.) to represent processes
4) Measurement, solubility and volatile pathways
5) Real time collection and processing

1) What triggers and eruption to occur and over what timescale?



Kent et al. 2020

eartharxiv.org

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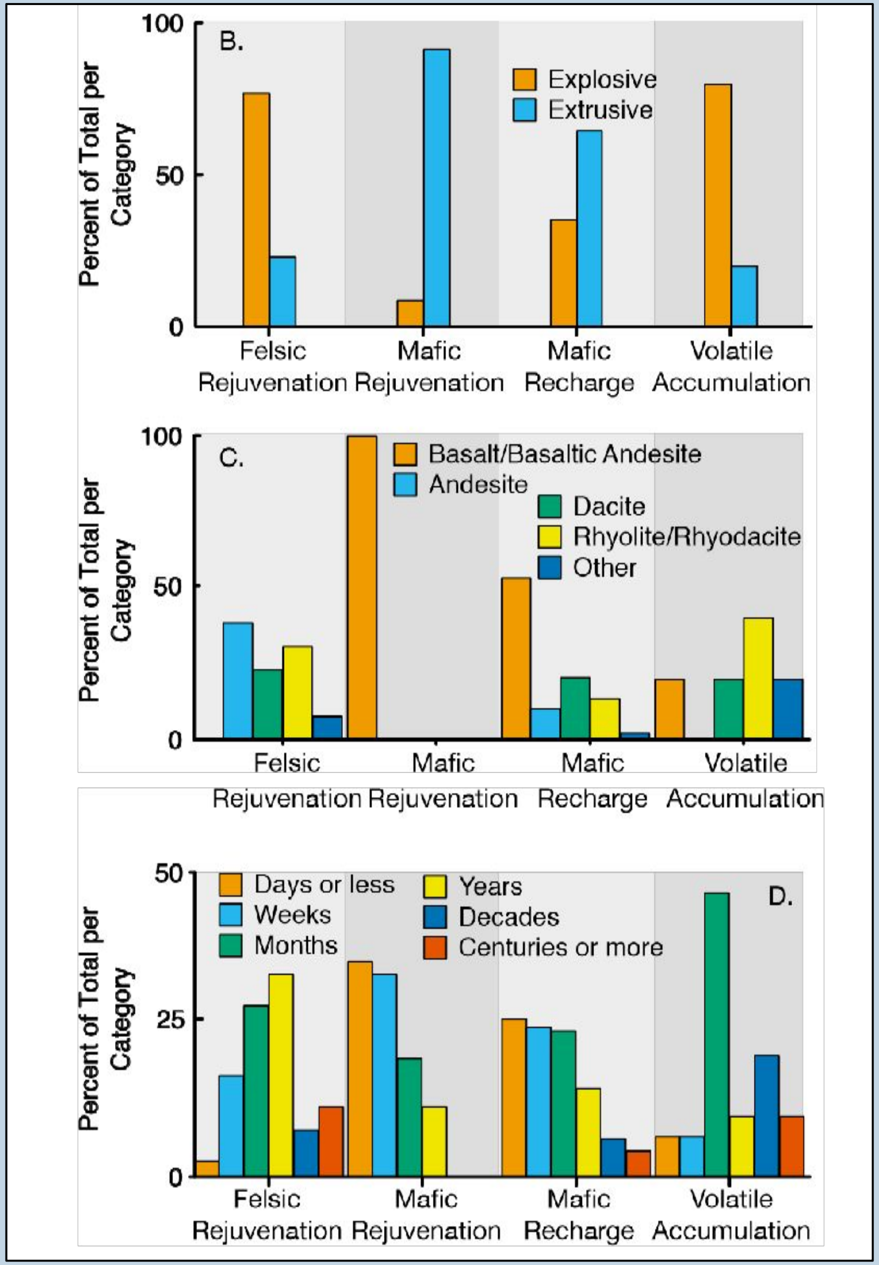
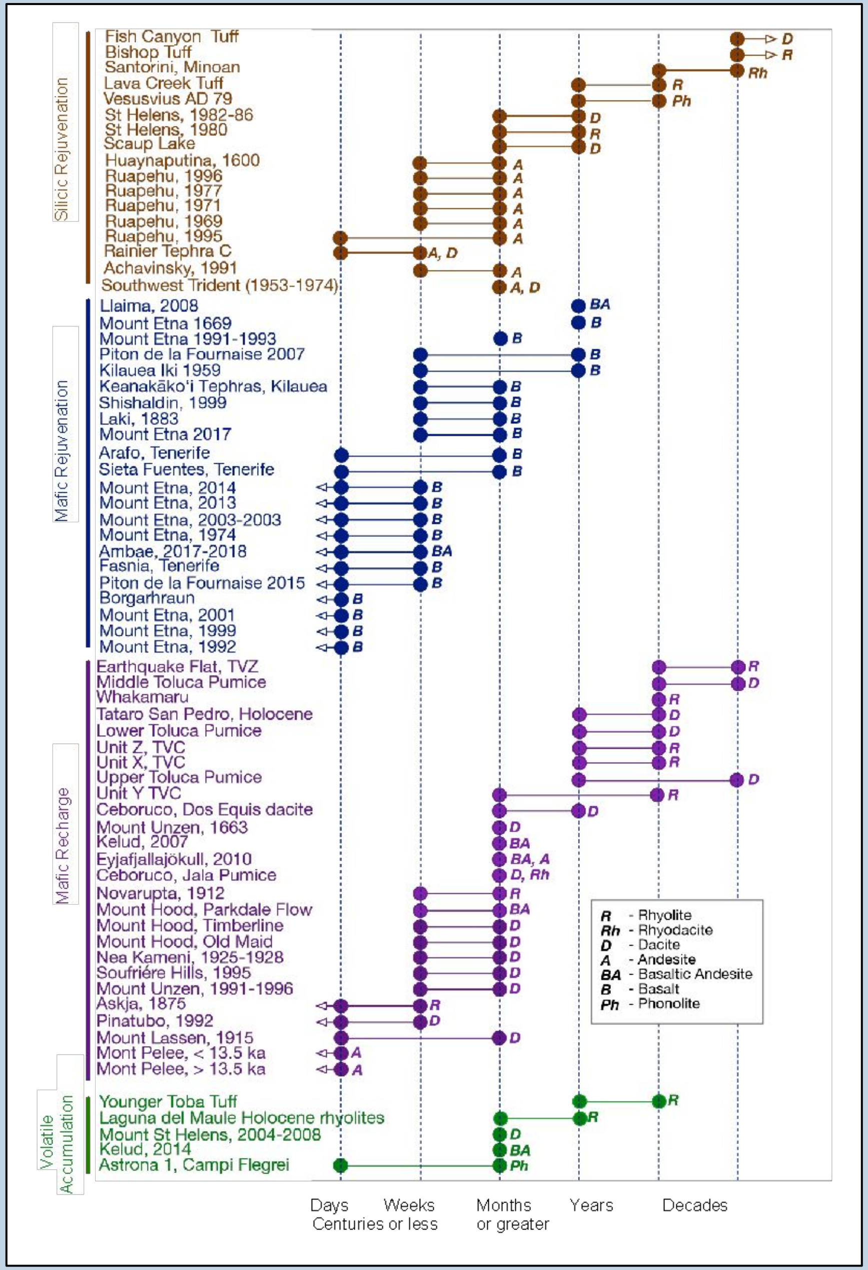
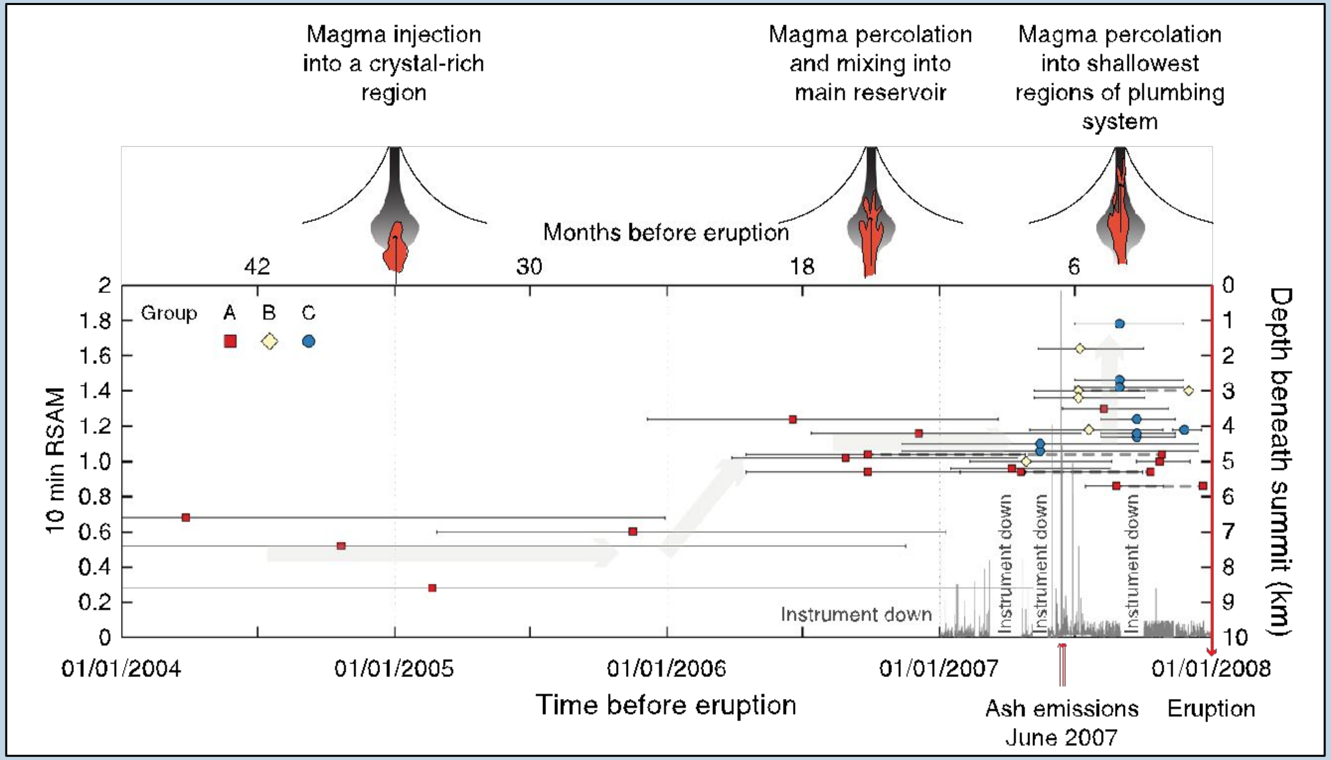




Kent et al. 2020

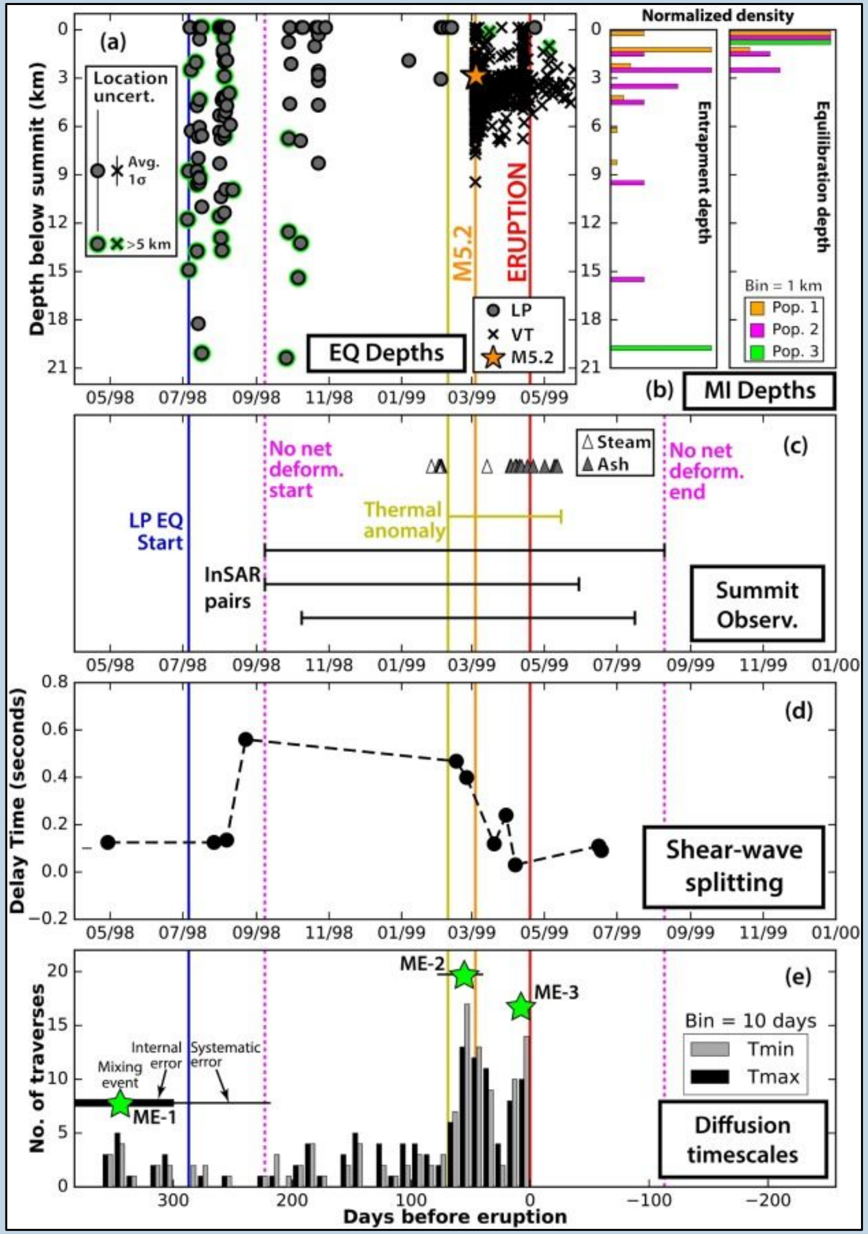
eartharxiv.org

2) Integrate petrological and geochemical data with geophysics



Ruth et al. 2018

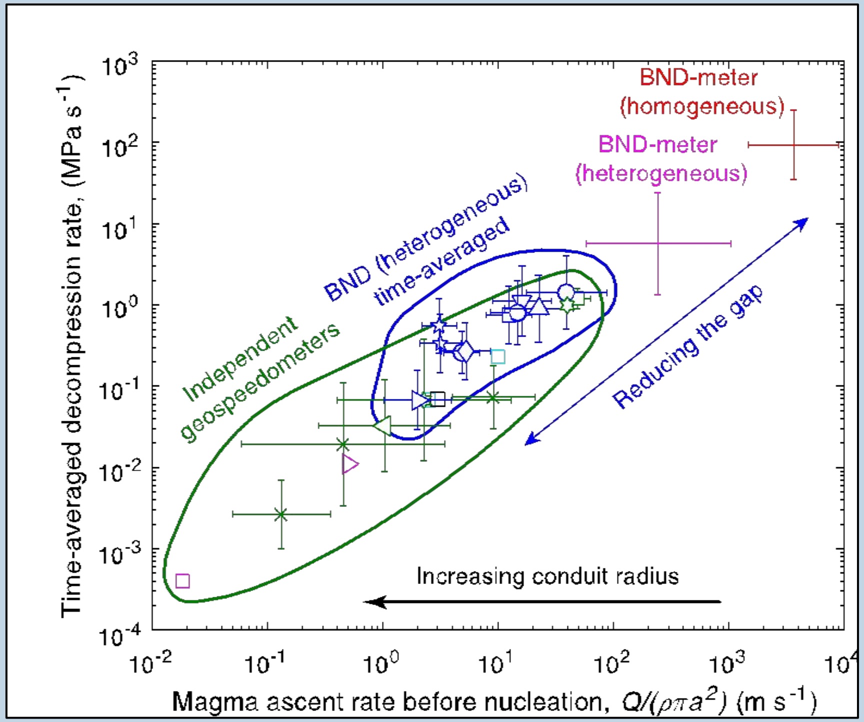
Nature



Rasmussen et al. 2018

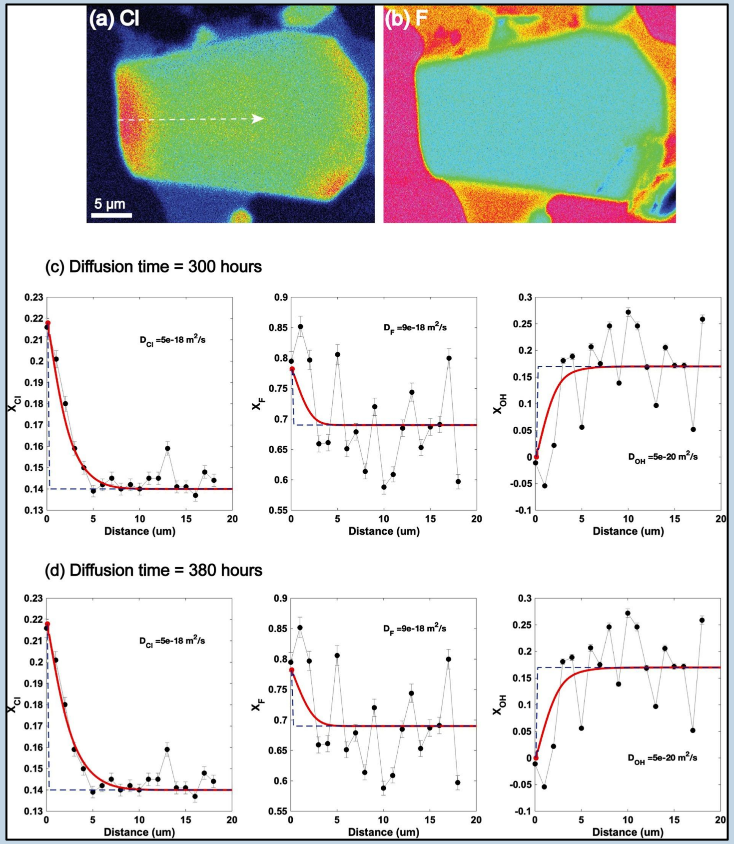
EPSL

3) Improve our models (diffusion, ascent, overpressurization, etc.) to represent processes



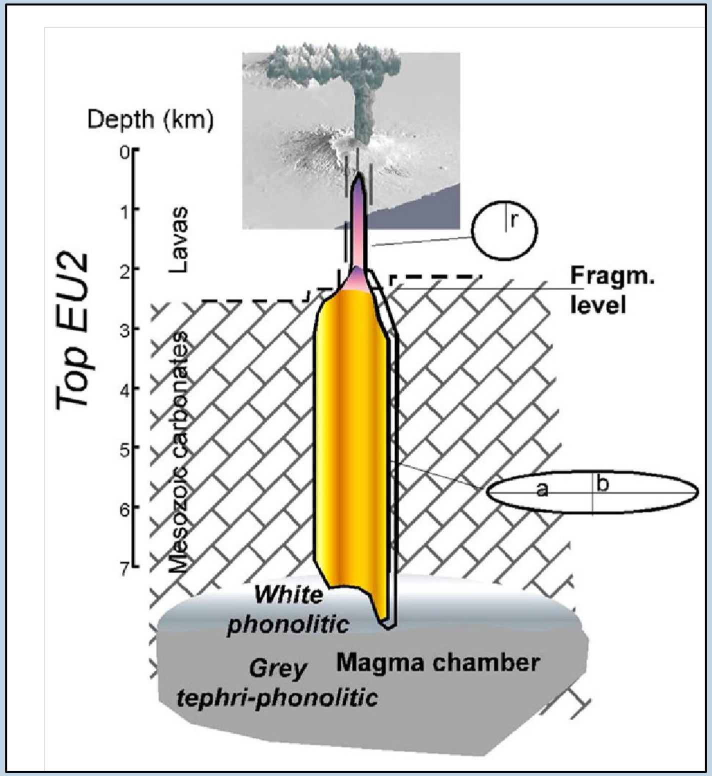
Hajimirza et al. 2021

Nature



Li et al. 2020

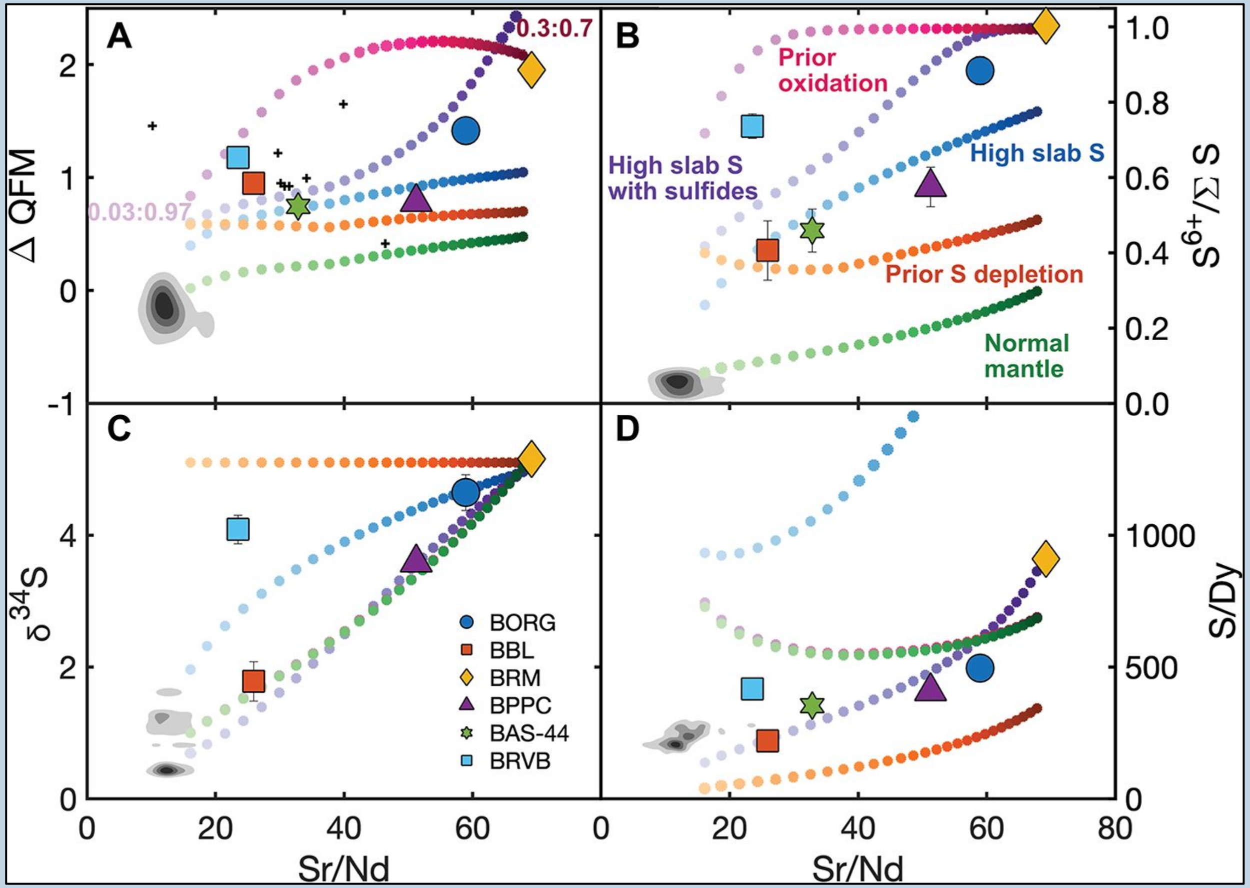
EPSL

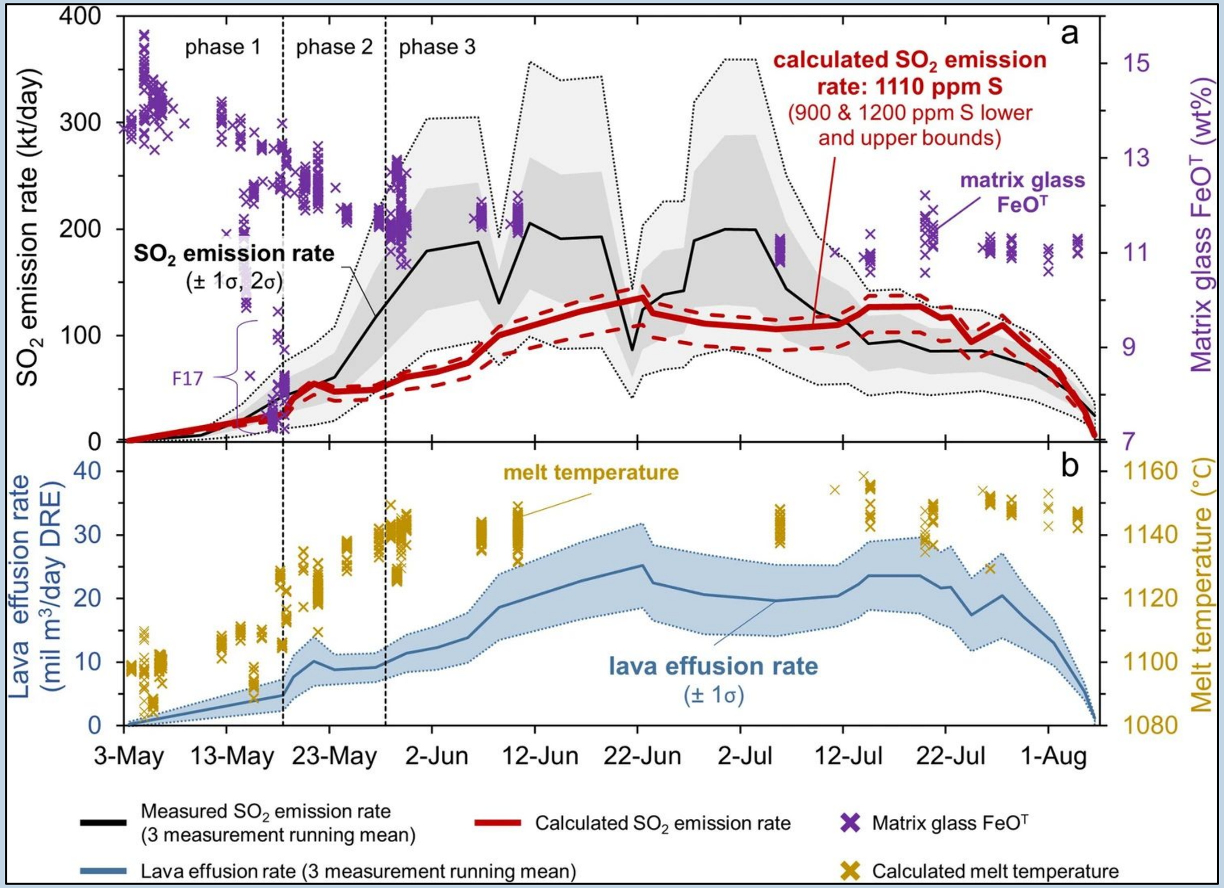


Massaro et al. 2018

EPSL

4) Measurements, solubility and volatile pathways





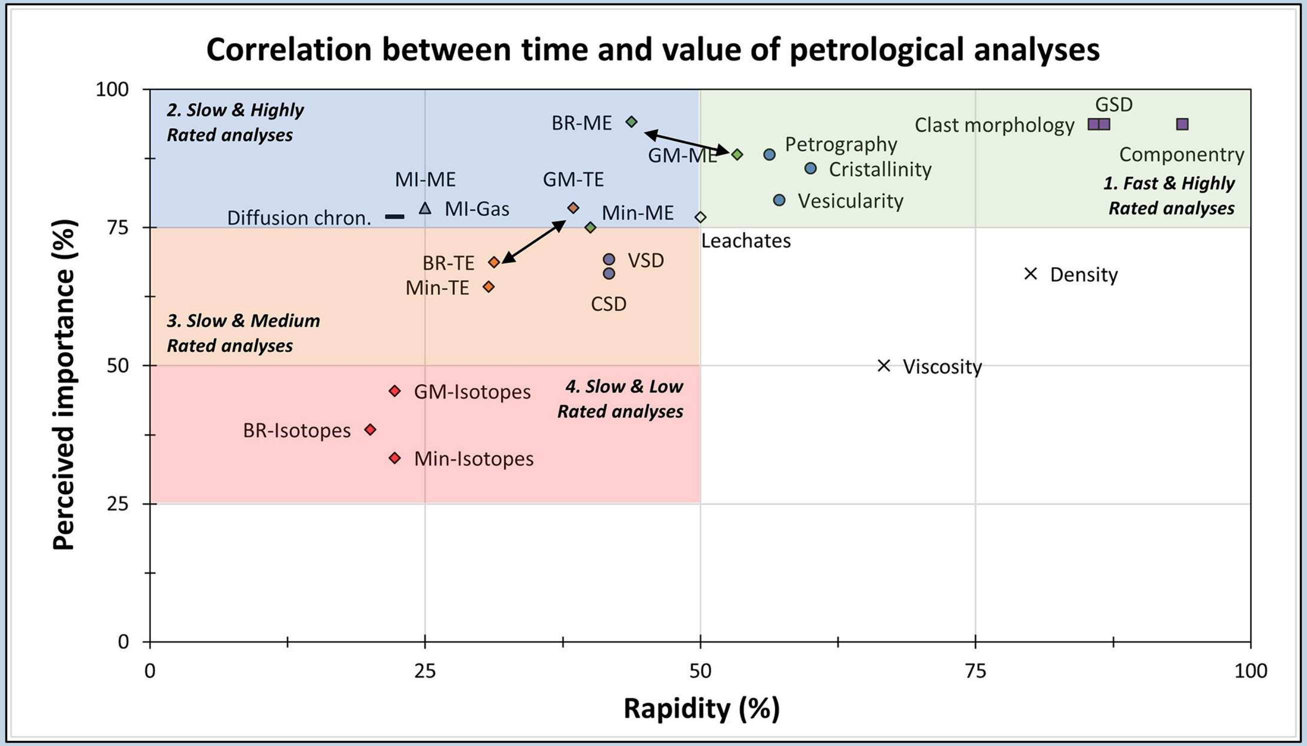
Muth and Wallace 2021

Geology

Lerner et al. 2021

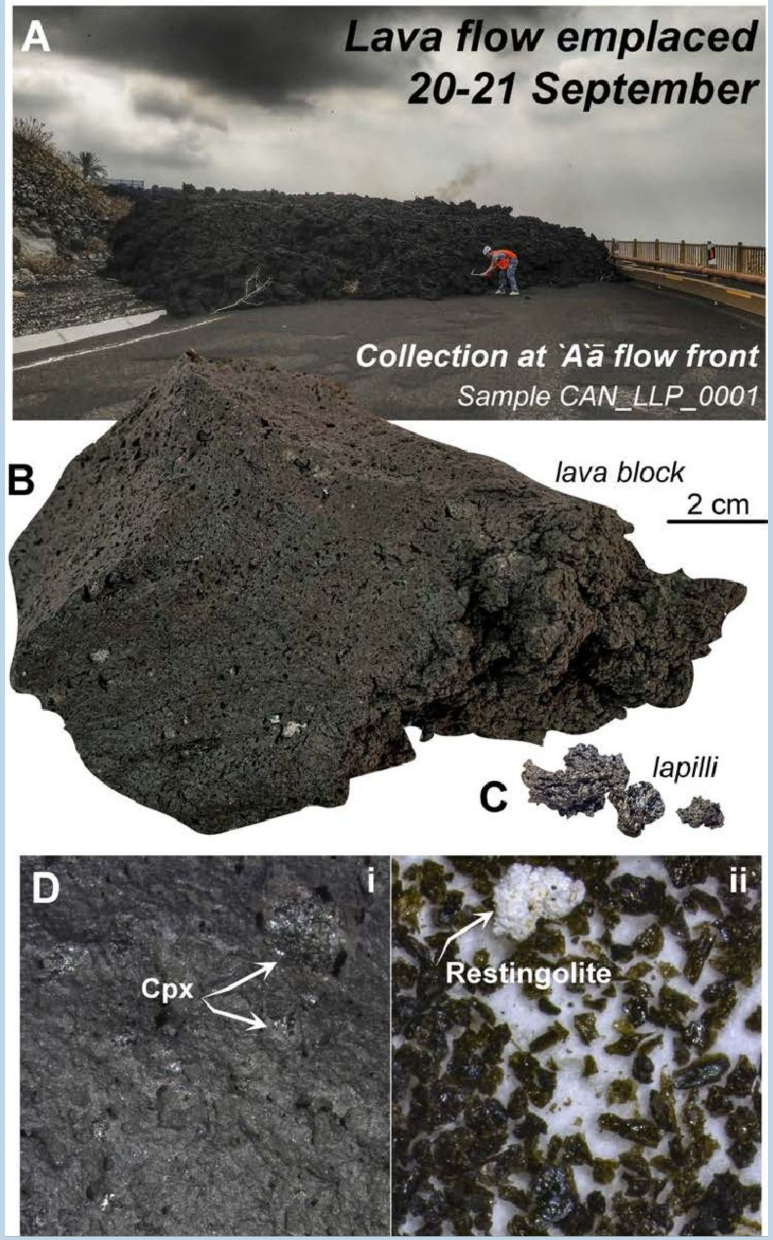
Bull Volc

5) Real time collection and processing



Re et al. 2021

JVGR



Pankhurst et al. 2022

Volcanica

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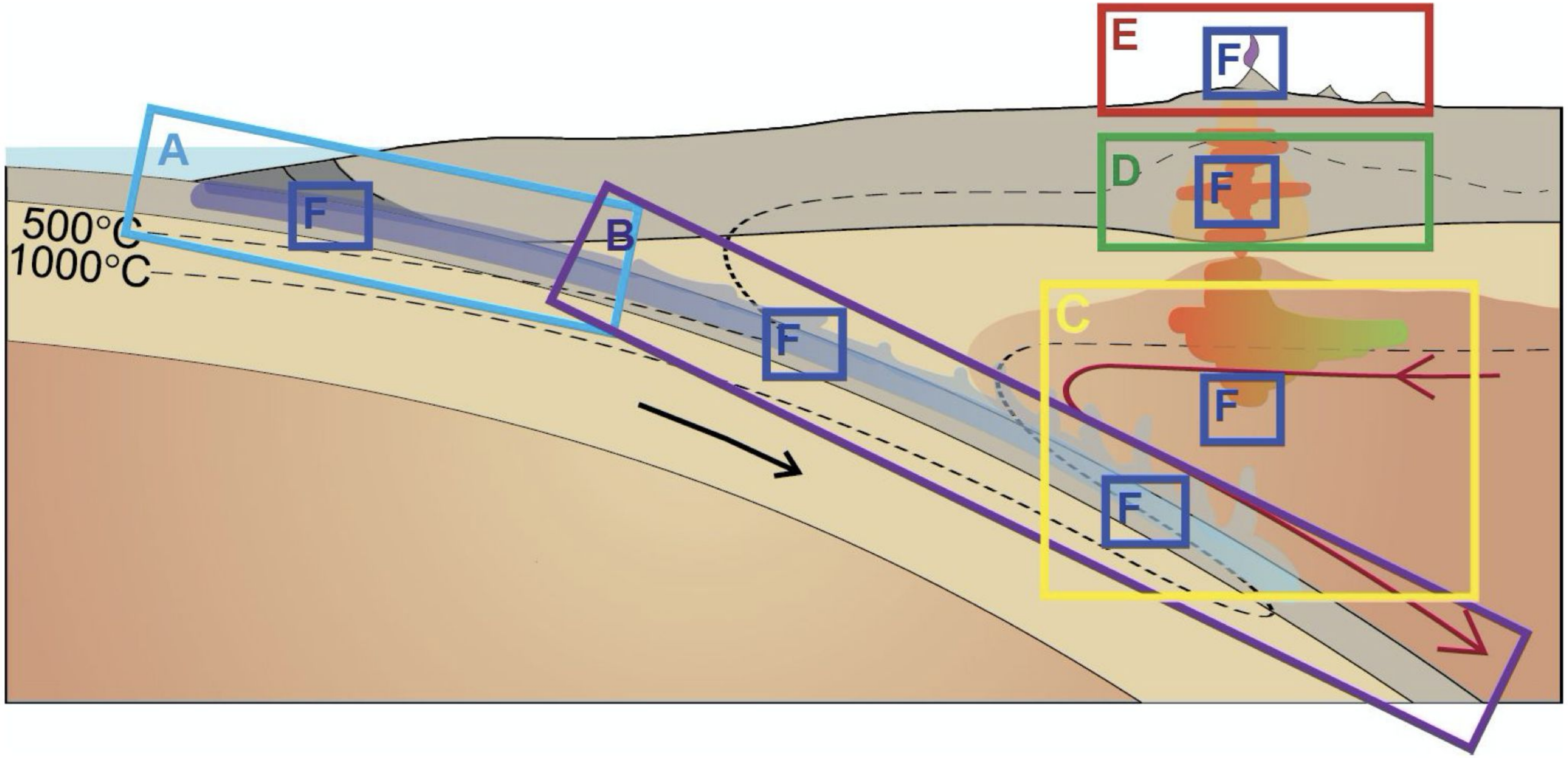

Figure 4. Schematic diagram illustrating the key components of a subduction system and domains (colored boxes with labels **A** to **F**) that are commonly investigated as an isolated system of fluid migration. Boxes **F** indicate example regions where microscopic and/or short-time-scale problems have been investigated.