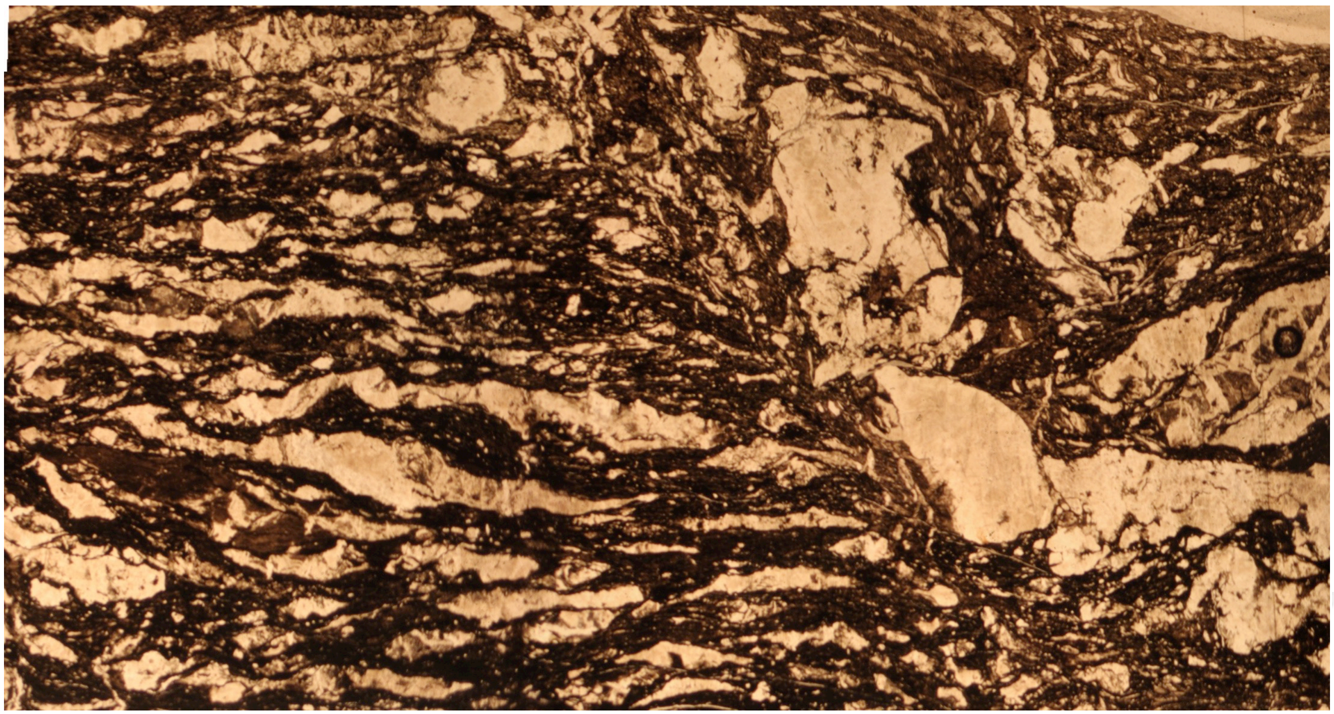
DENSE VEIN ARRAYS IN SUBDUCTION MELANGE EXHUMED FROM THE SEISMOGENIC ZONE: EVIDENCE FOR DIFFUSION OR ADVECTION?

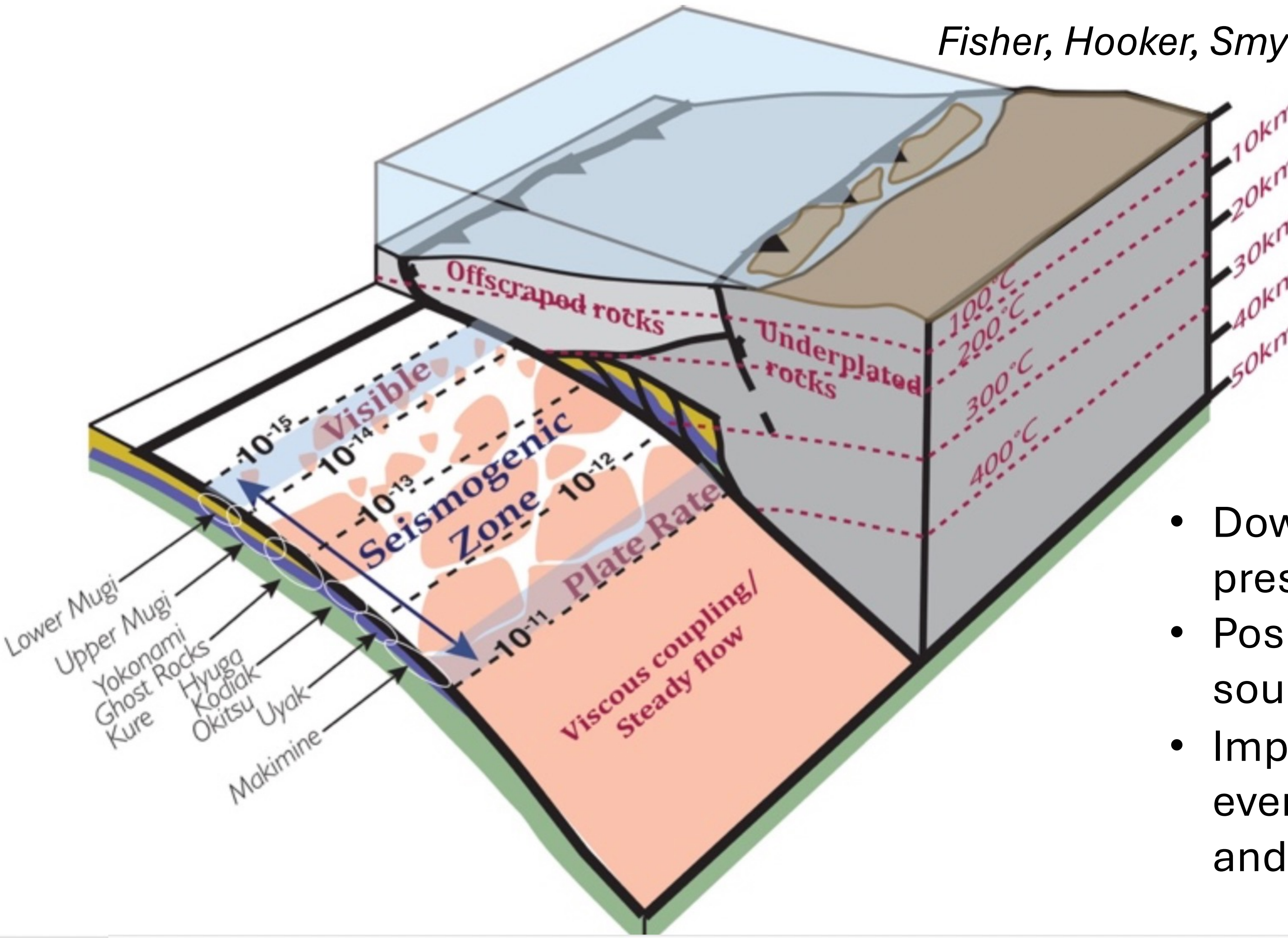


Donald Fisher, Penn State
Tsai-Wei Chen, Penn State*
Greg Hirth, Brown
John Hooker, UIW
Max Lloyd, Penn State
Andrew Smye, Penn State
Leah Youngquist, Penn State

***now at UWashington**

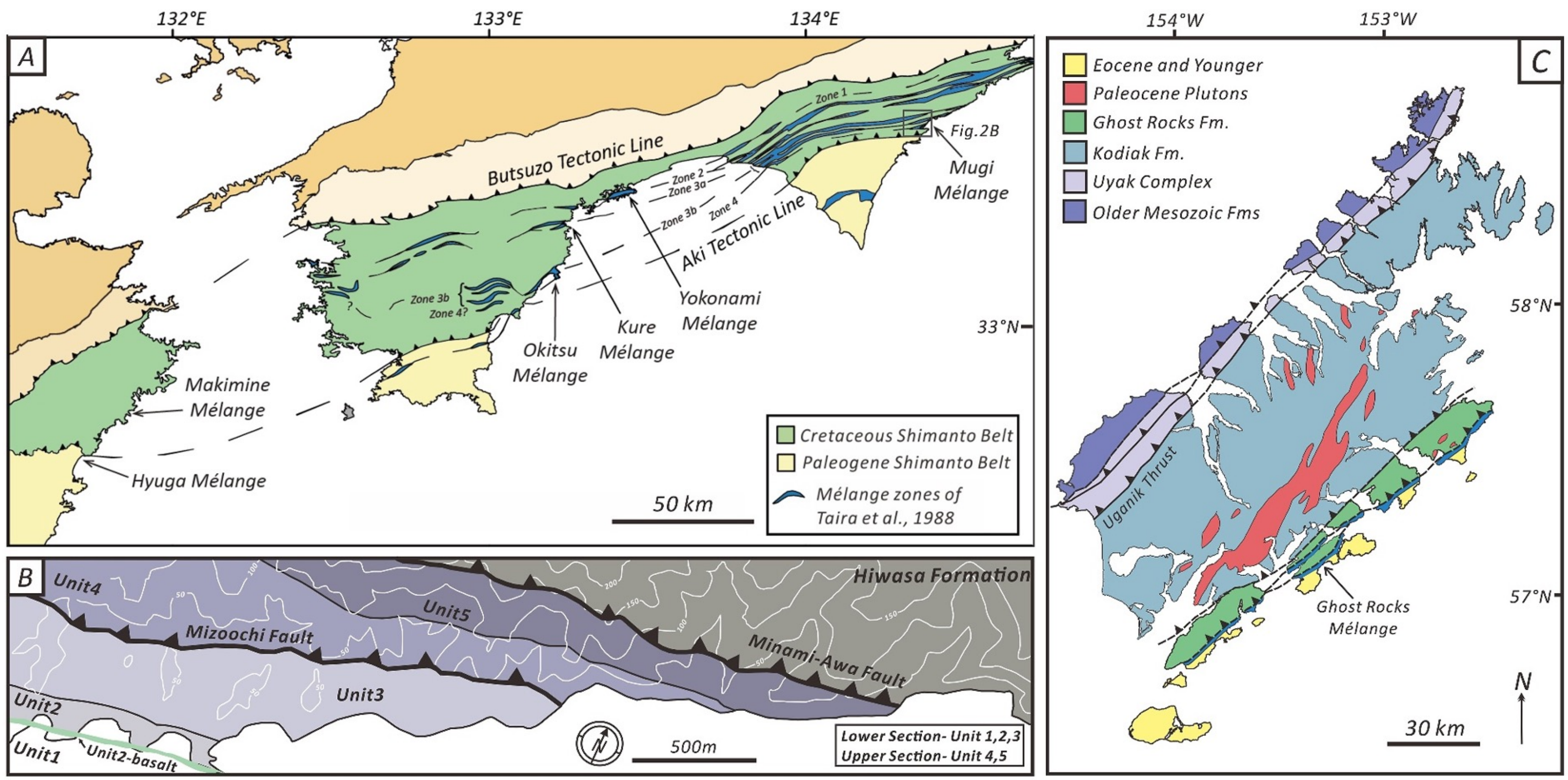
Funding: Tectonics program
National Science Foundation
WHERE DISCOVERIES BEGIN

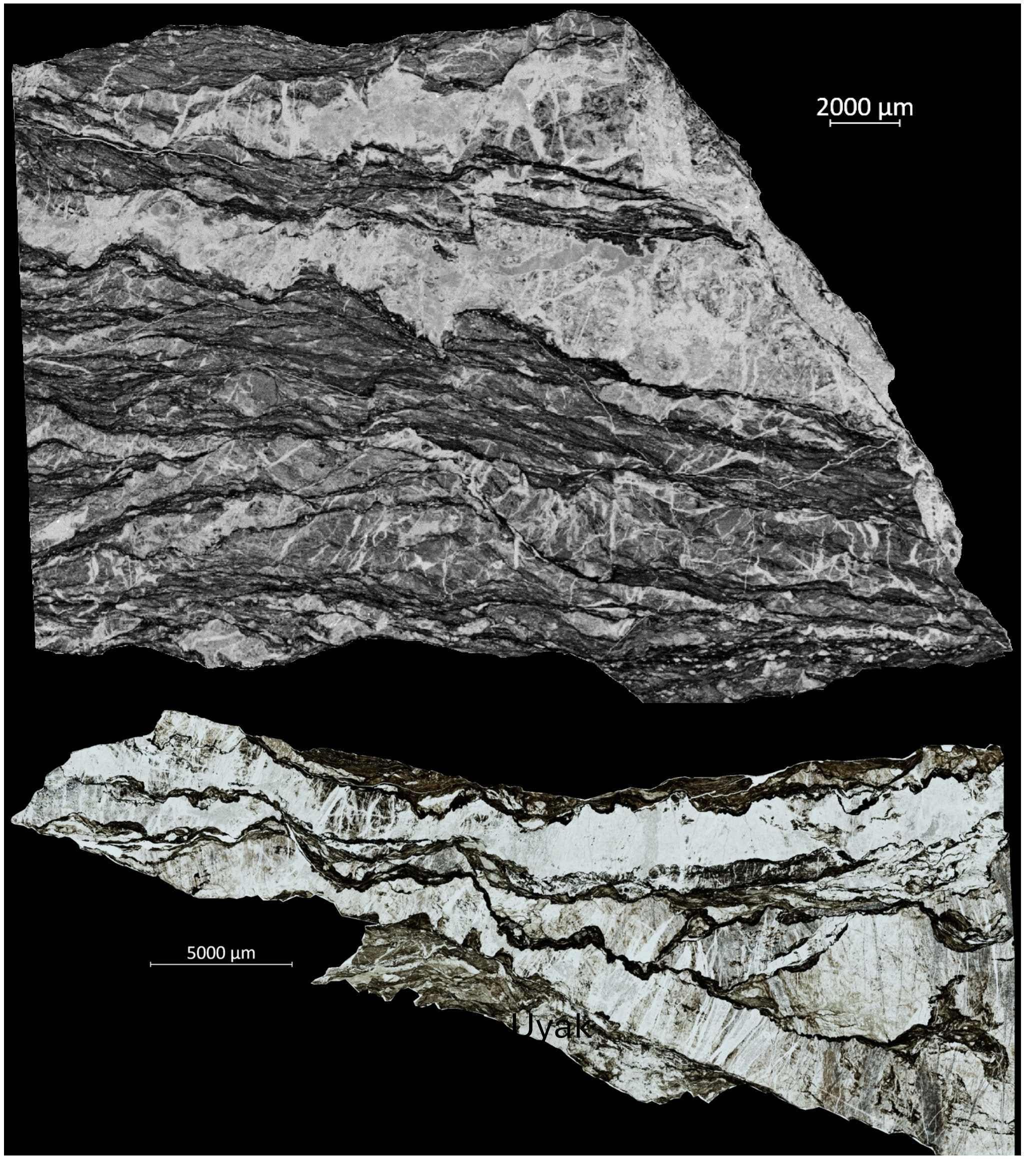
Fisher, Hooker, Smye, and Chen, 2021



- Downdip increases in pressure solution strain
- Positioning of fluid sources
- Impact of transient events related to EQs and slow EQs

Analog sites for the subduction interface



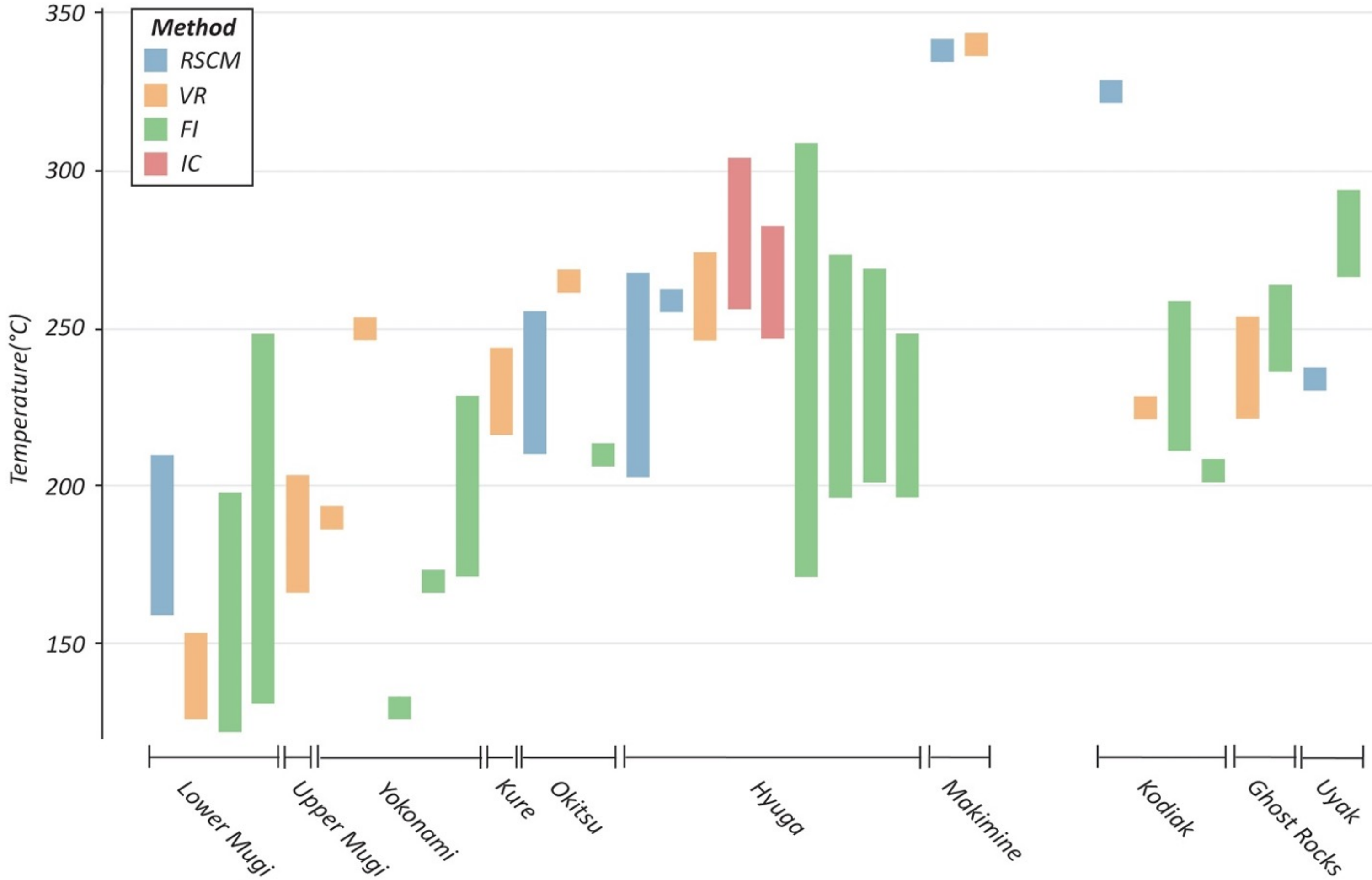


Upper Mugi

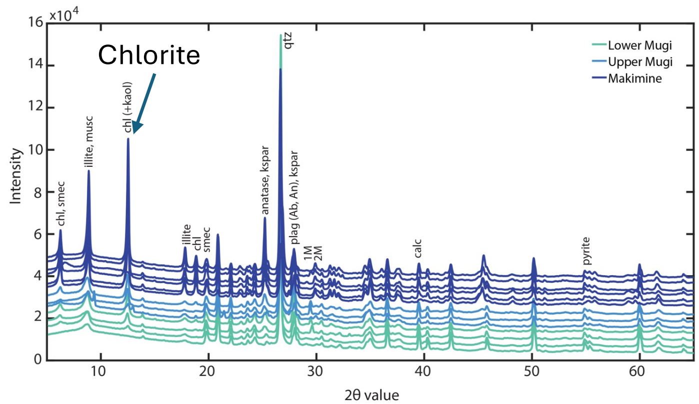
Uyak complex

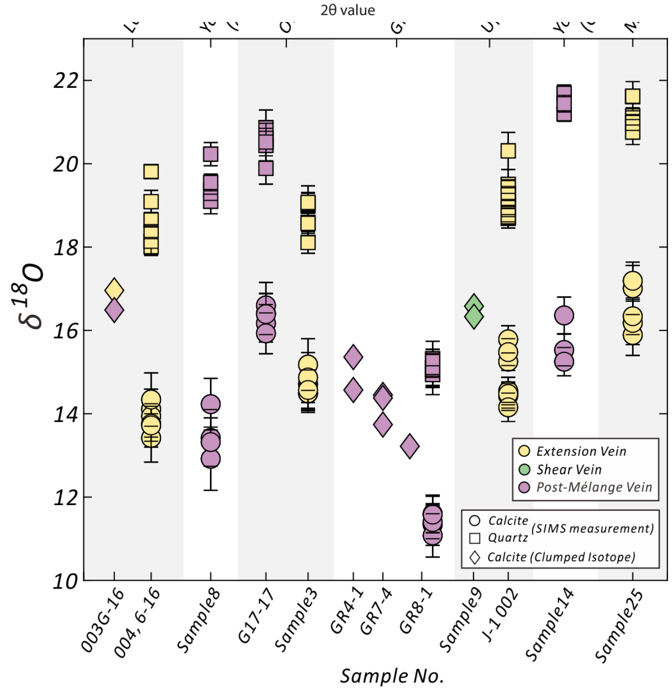
Paleotemperature

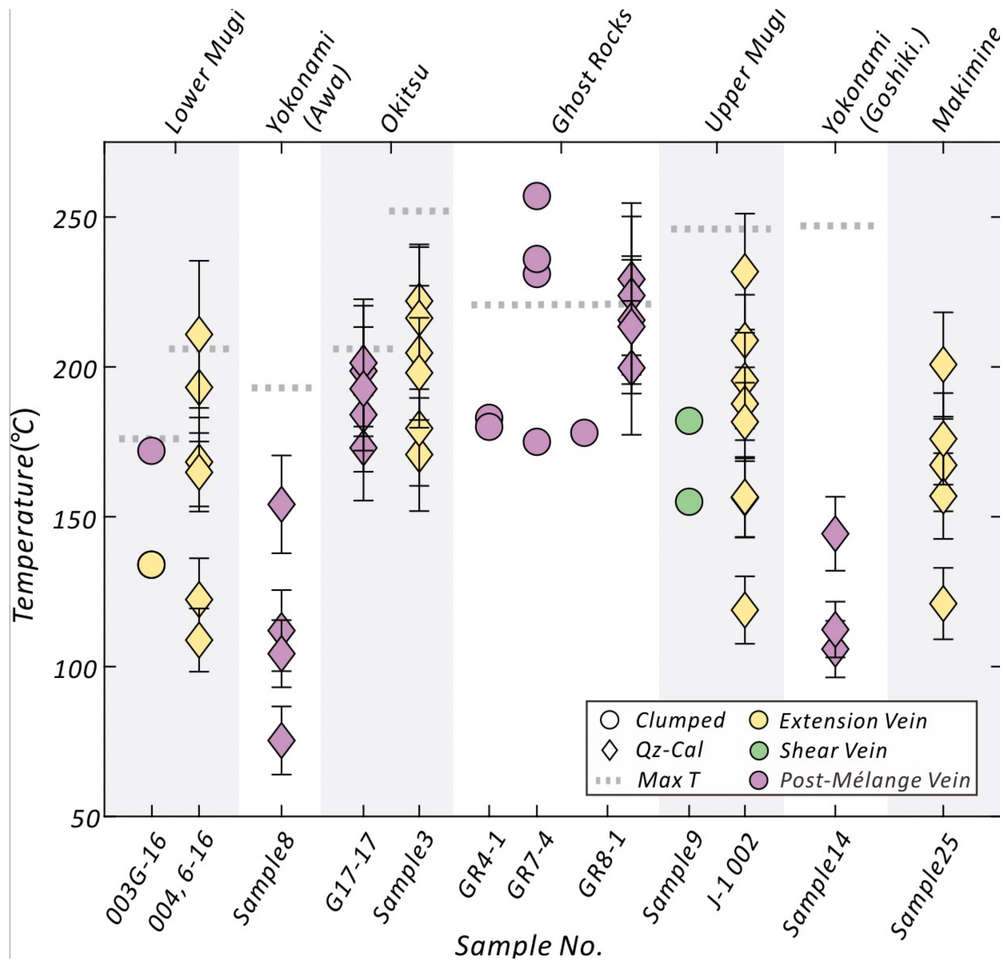
Chen, Smye, Lloyd, Fisher, and Hashimoto, 2024



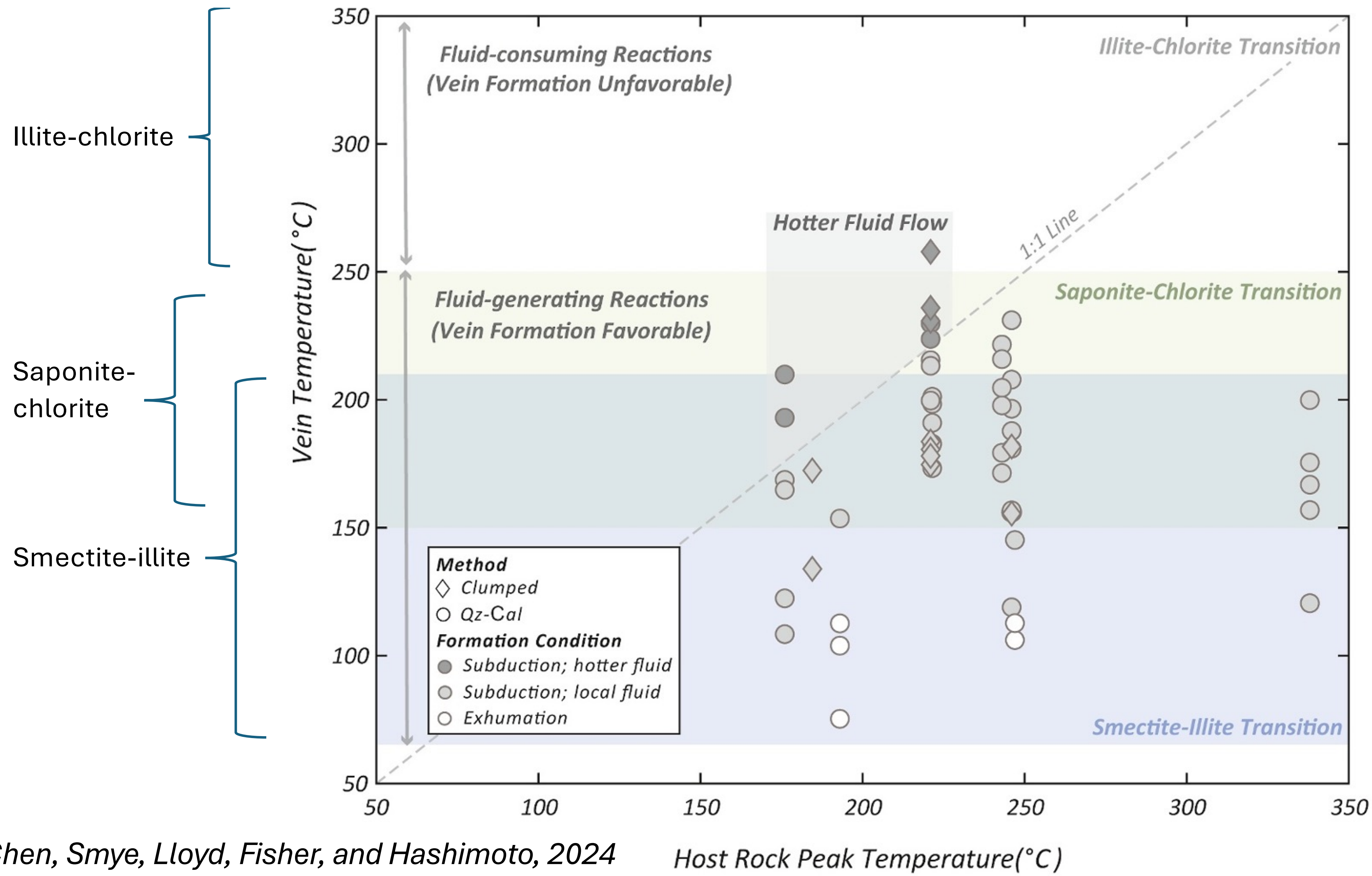
-Ikesawa et al., 2005
-Matsumura et al., 2003
-Raimbourg et al., 2019
-Mukoyoshi et al., 2006
-Vrolijk et al., 1988
Moore et al., 1983
-Raimbourg et al., 2021
-Sample & Moore, 1987
Myers & Vrolijk, 1986
Rajič et al., 2023
-Sakaguchi, 1996
Raimbourg et al., 2017
-Kondo et al., 2005
-Raimbourg et al., 2015
-Hara & Kimura., 2008
-Mukoyoshi et al., 2009
-Kiminami & Ohno, 1999
-Gutscher & Peacock, 2003
-Oleskevich et al., 1999
Rajic et al., 2023





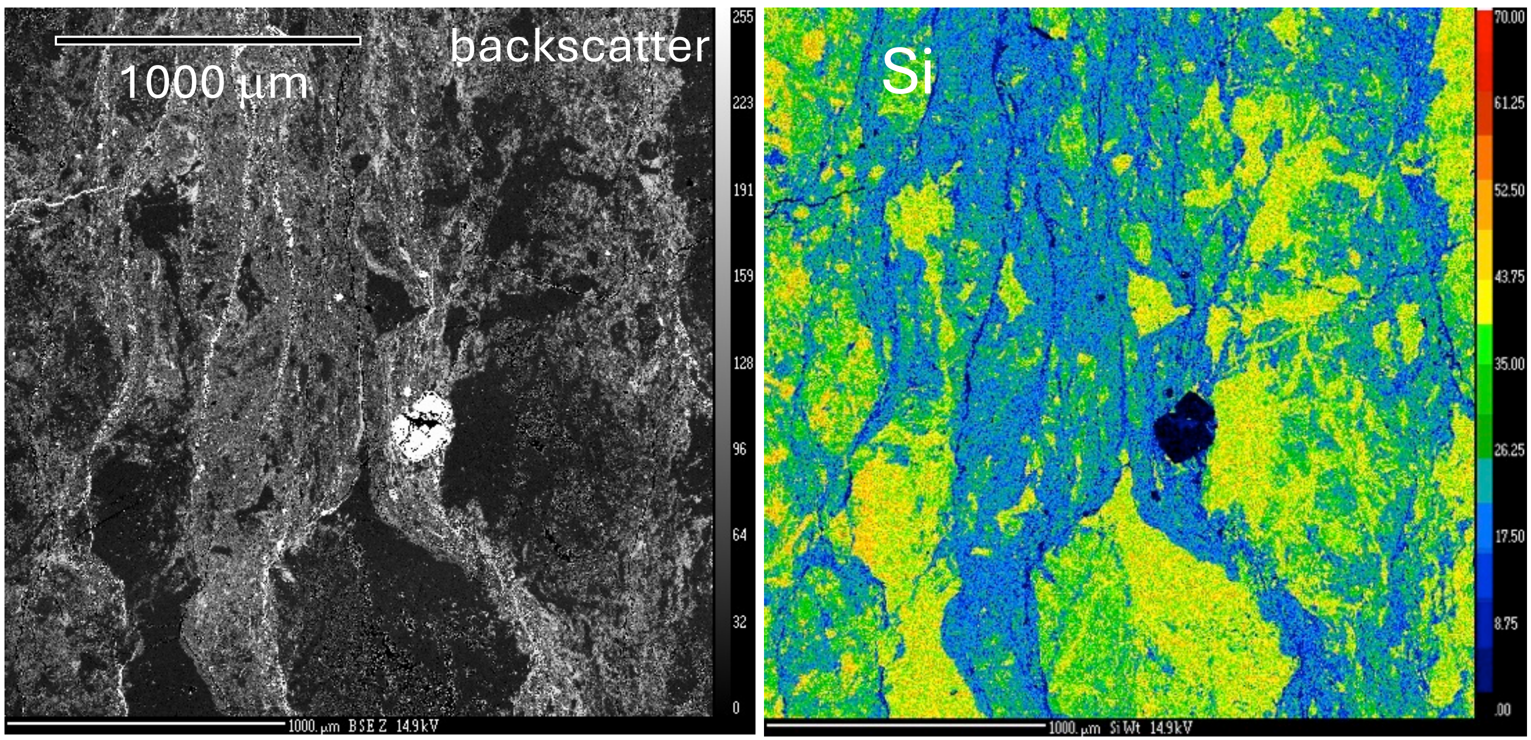


Chen, Smye, Lloyd, Fisher, and Hashimoto, 2024



Chen, Smye, Lloyd, Fisher, and Hashimoto, 2024

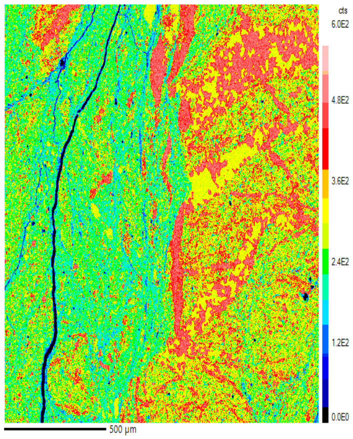
Scaly fabrics are Si depletion zones



Chen, Smye, Fisher, Hashimoto, Raimbourg, and Famin, 2024

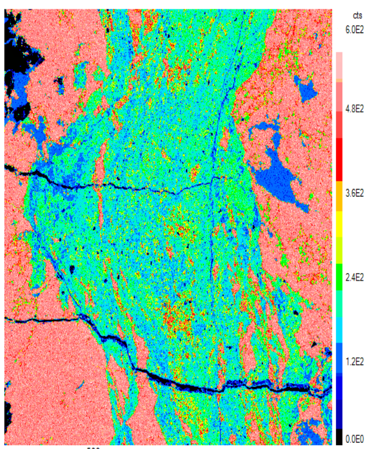
Si removal from Scaly fabric

Sample 9 (Upper Mugi)

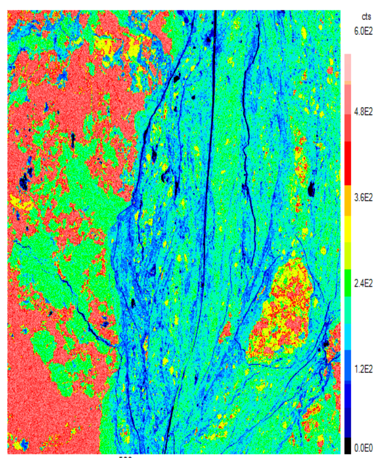


500 µm

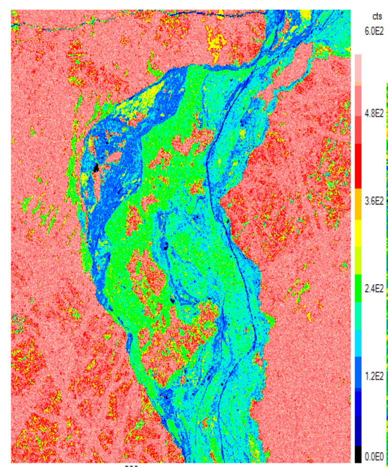
AL20 (Kodiak Fm.)



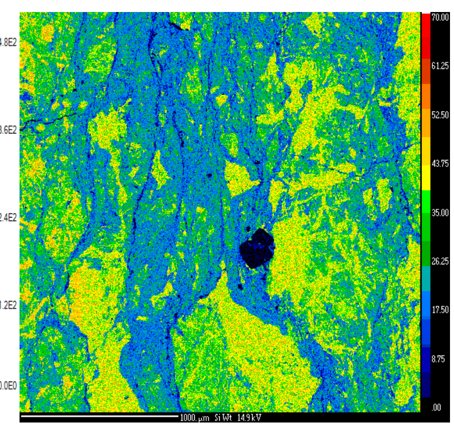
Sample 21 (Okitsu)



AL7-1(Uyak)

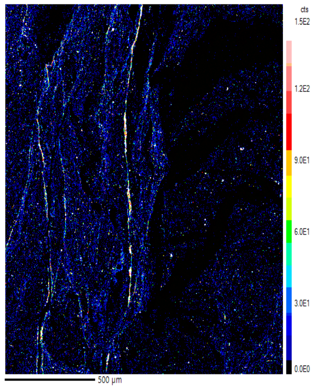


Sample 25 (Makimine)

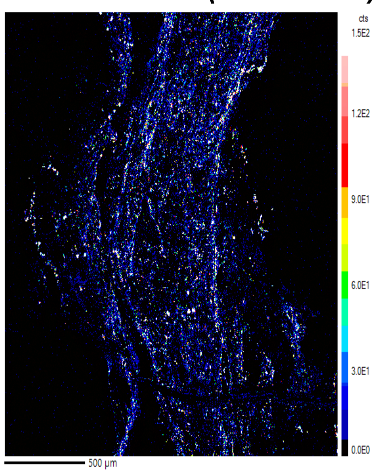


Ti enriched in the scaly fabric

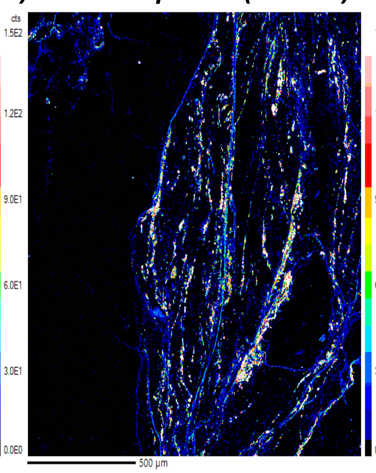
Sample 9 (Upper Mugi)



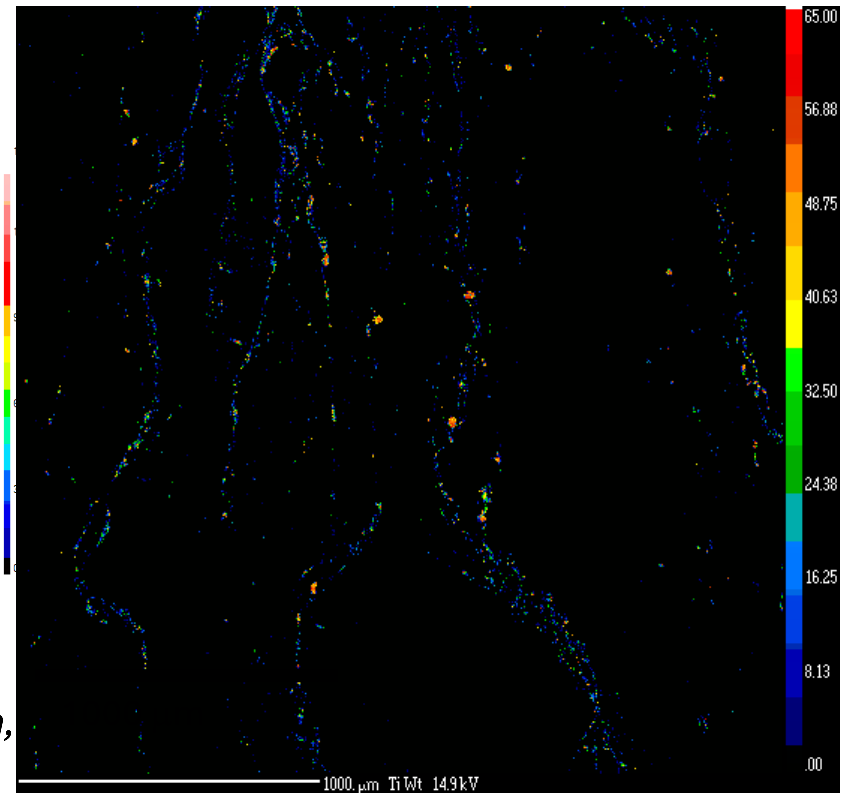
AL20 (Kodiak Fm.)



Sample 21 (Okitsu)



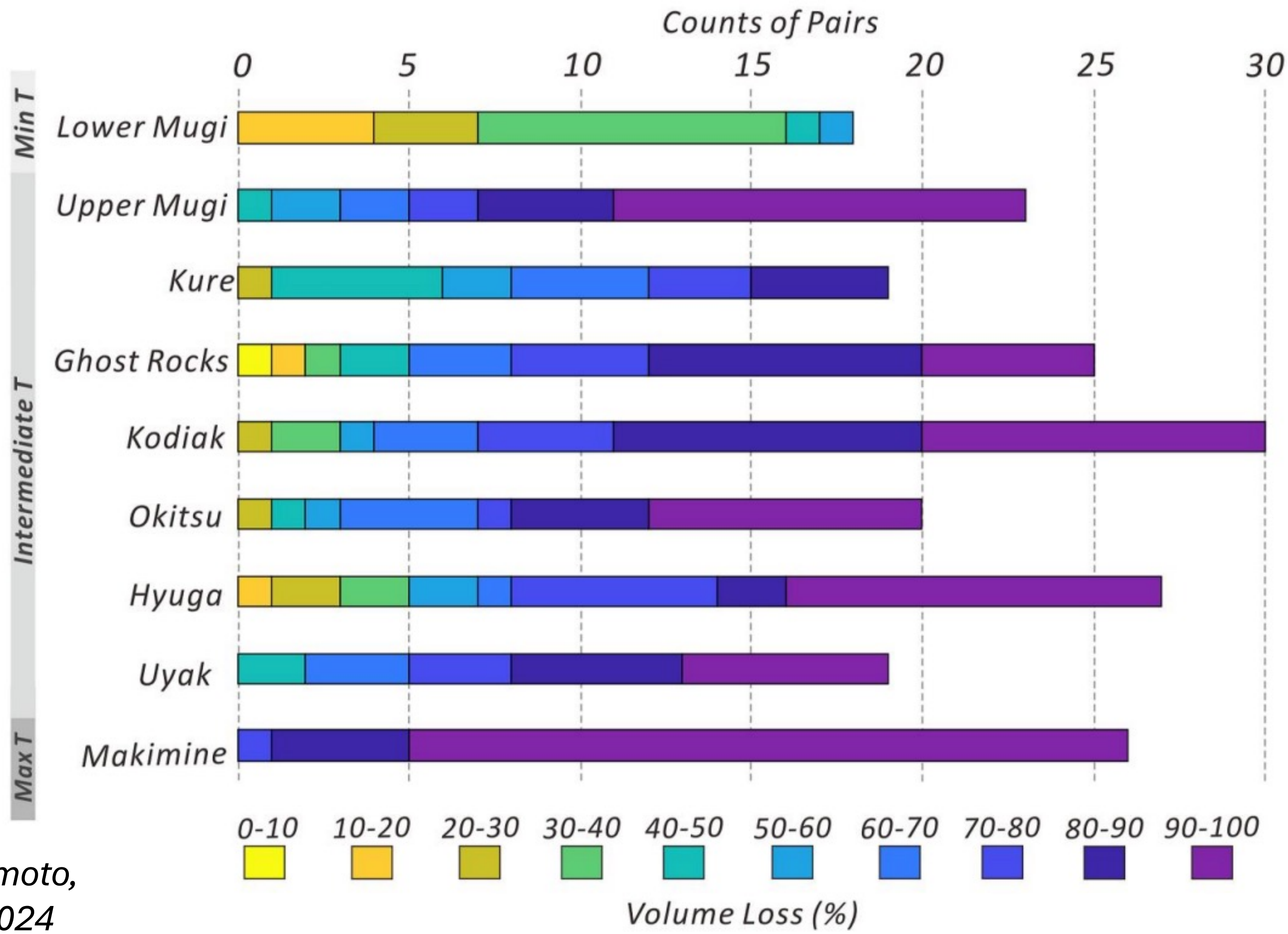
Sample 21 (Makimine)



500 µm

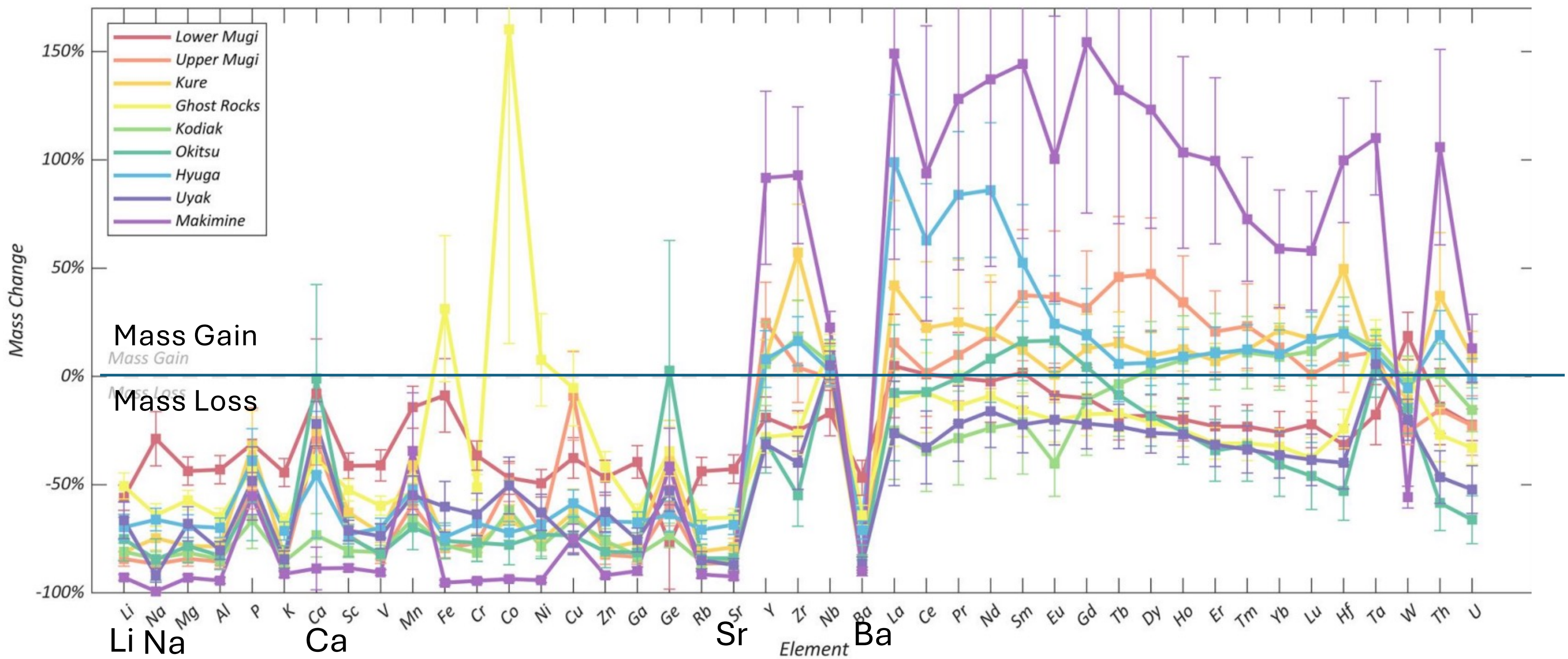
Chen, Smye, Fisher, Hashimoto, Raimbourg, and Famin, 2024

Volume loss
Scaly fabric



Chen, Smye, Fisher, Hashimoto, Raimbourg, and Famin, 2024

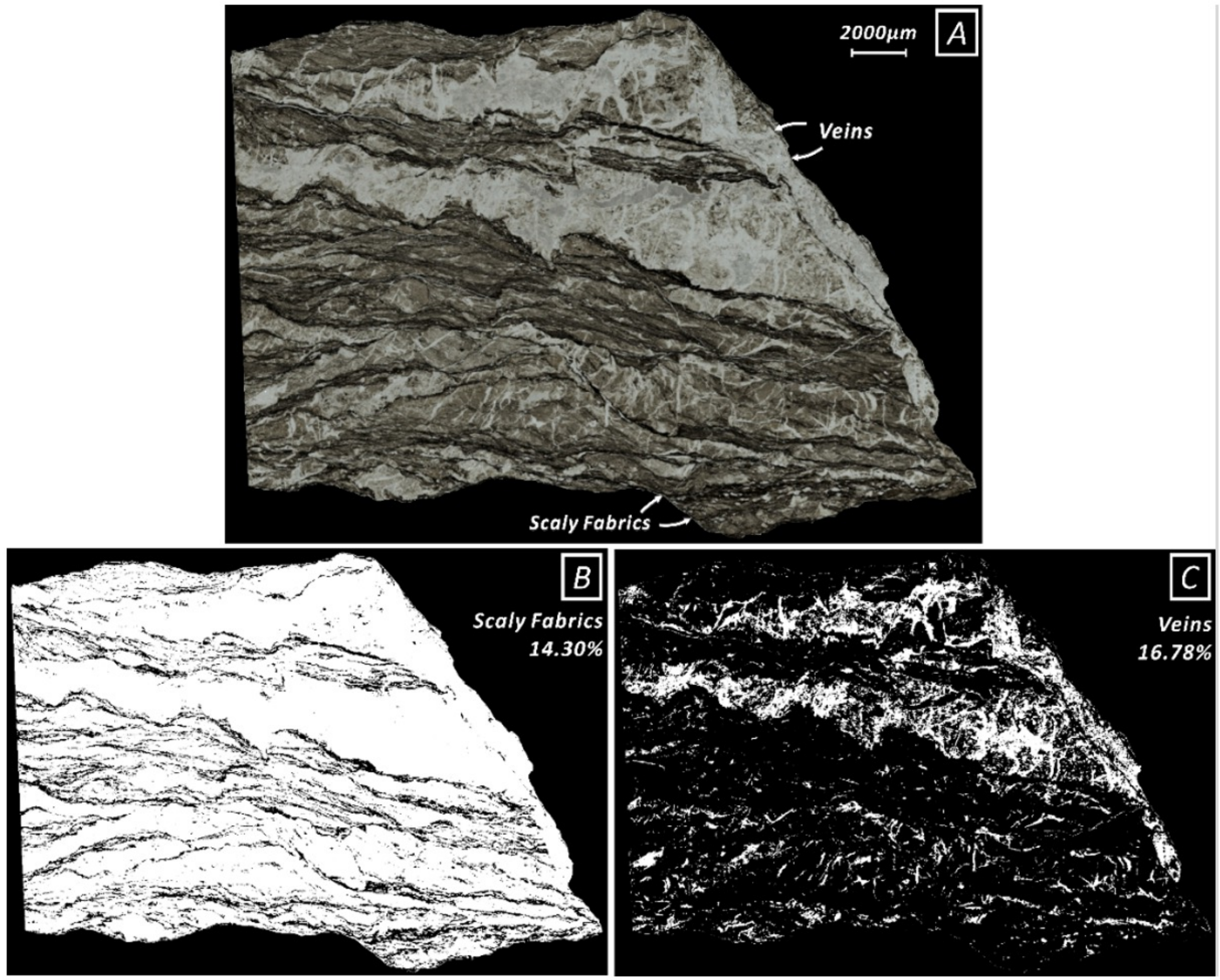
Elemental variations: scaly fabric material and microlithons (assuming Ti is conservative)



Chen, Smye, Fisher, Hashimoto, Raimbourg, and Famin, 2024

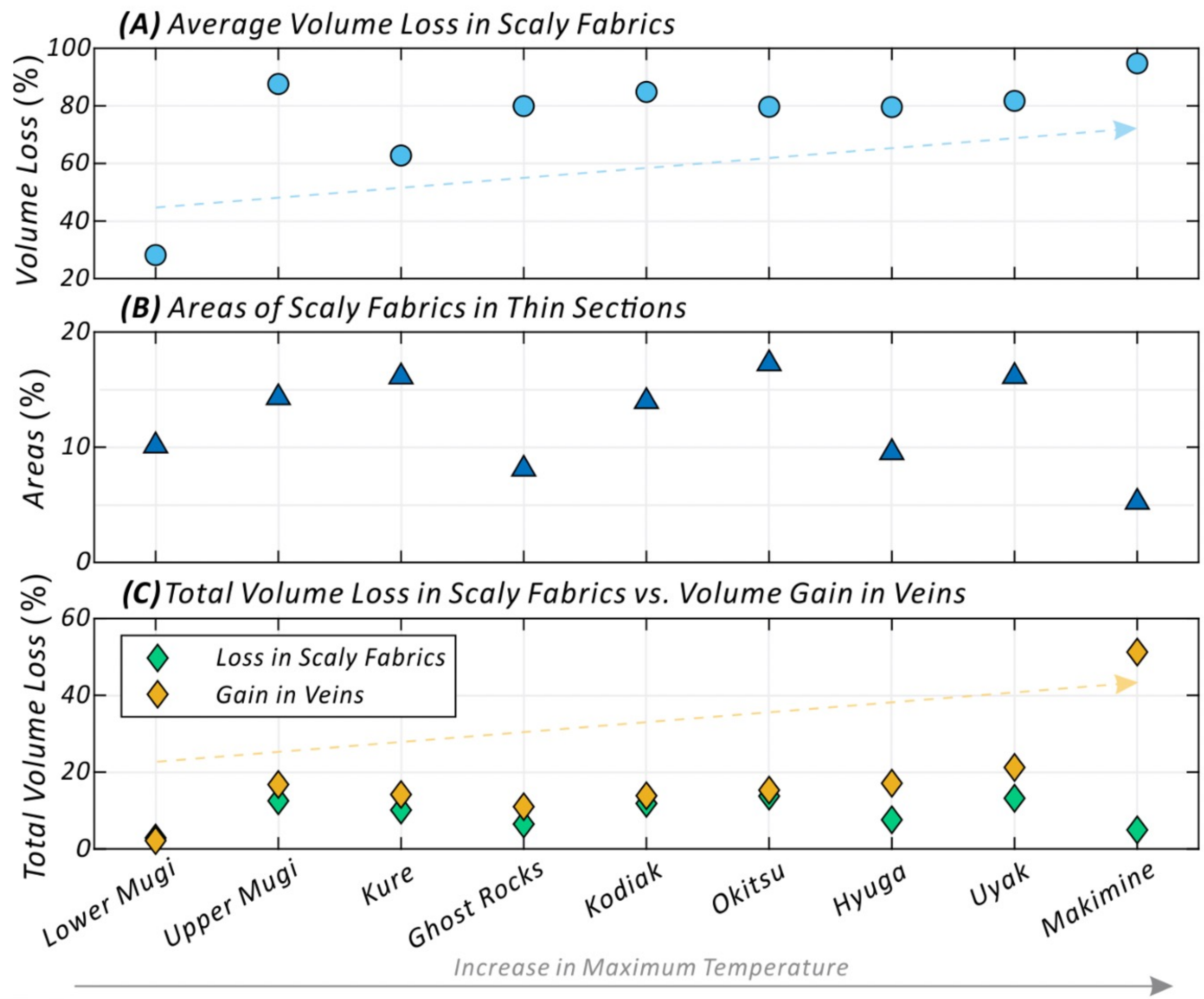
Image Analysis

Chen, Smye, Fisher, Hashimoto, Raimbourg, and Famin, 2024

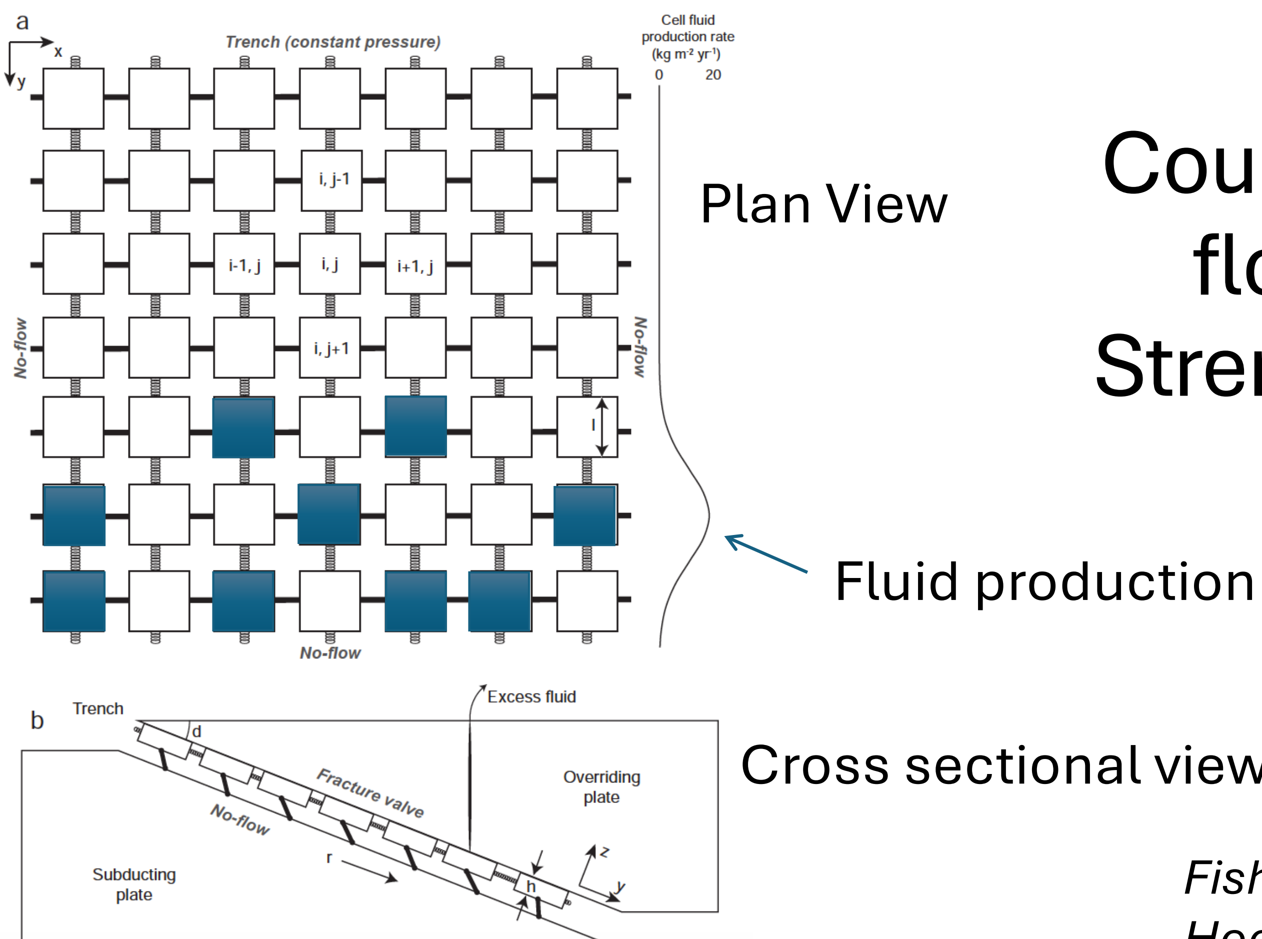


Volume strain: scaly fabric vs veins

Chen, Smye, Fisher, Hashimoto, Raimbourg, and Famin, 2024



MEFISTO, the Mineralization, Earthquake, and Fluid-flow Integrated SimulaTOr

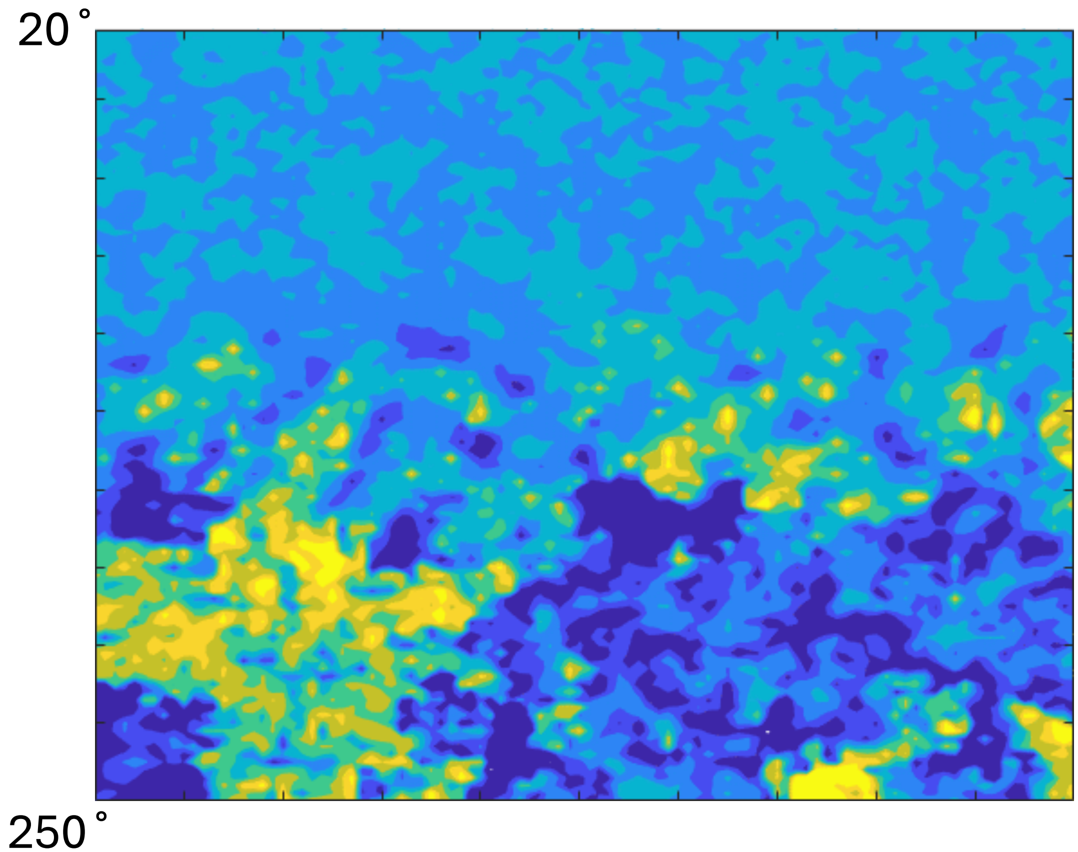


Coupled fluid flow and Strengthening

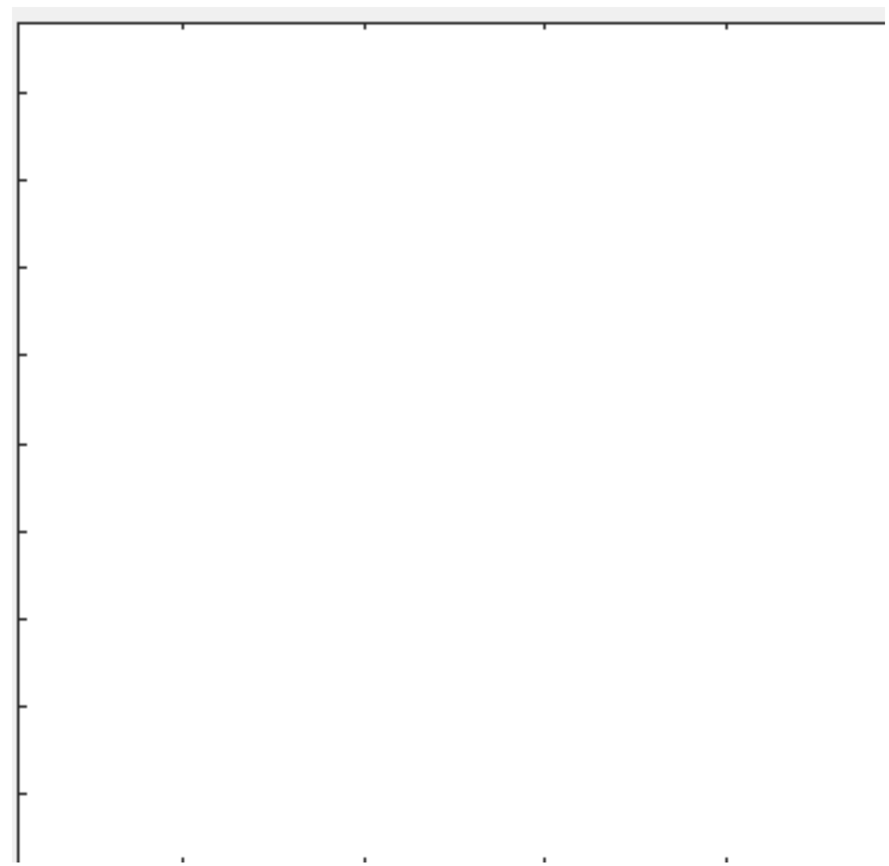
Fisher, Hooker, and Oakley, 2019
Hooker and Fisher, 2021

Fisher, Hooker, and Oakley, 2021

Thermally activated asperity nucleation

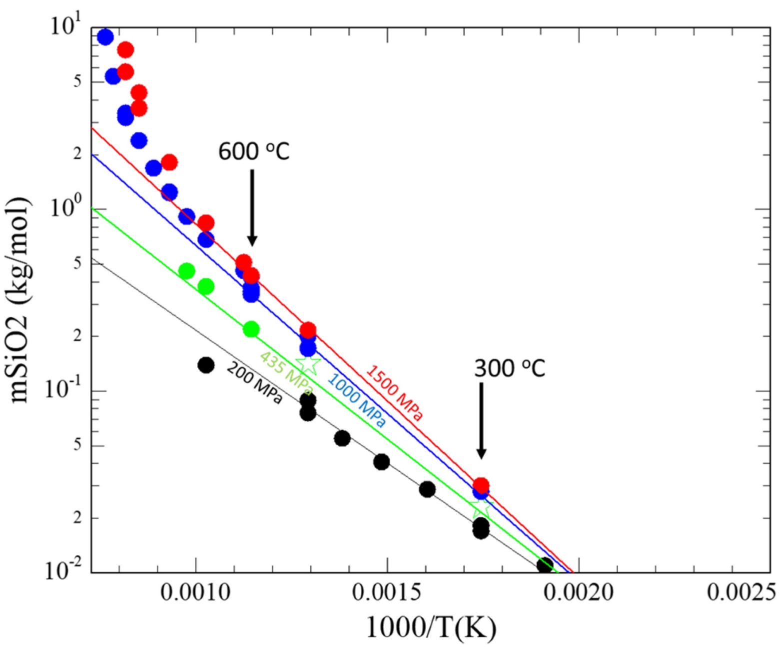


Fluid Flow



Solubility SiO2 = A*exp[-H(P)/R/T]

H fit at 1 GPa and 200 MPa to quantify H(P)
H = 28000+4500*ln(P/2e8); where 28000 is H at 200 MPa
A = 0.0037*exp[H(P)/R/(180+273)]



Solubility=C= f (T, P) (mol/kg)

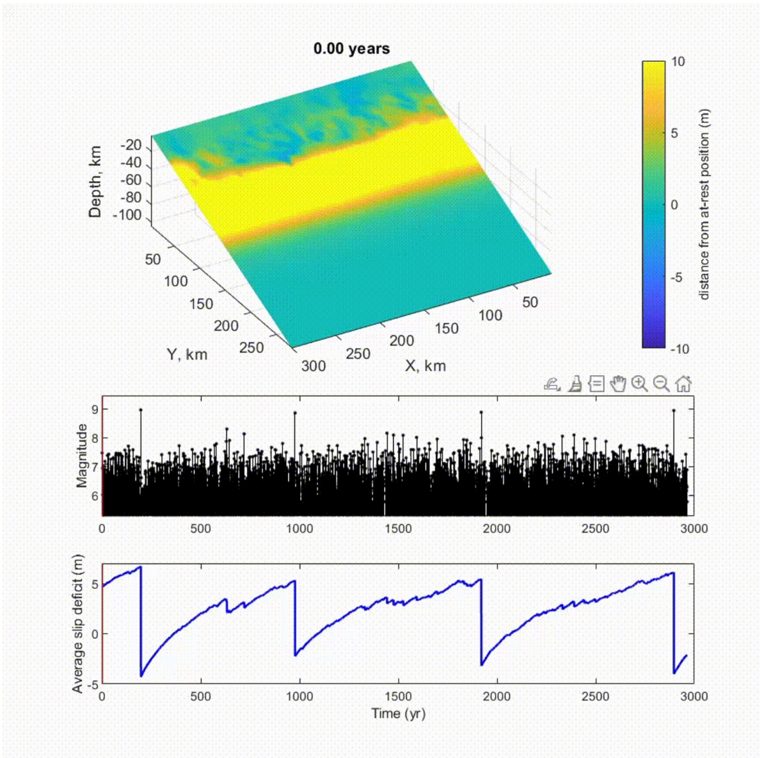
Experimental data from Manning, 1994

$$\dot{\varepsilon} = AC\sigma/d^3 \exp\left(-Q/RT\right)$$

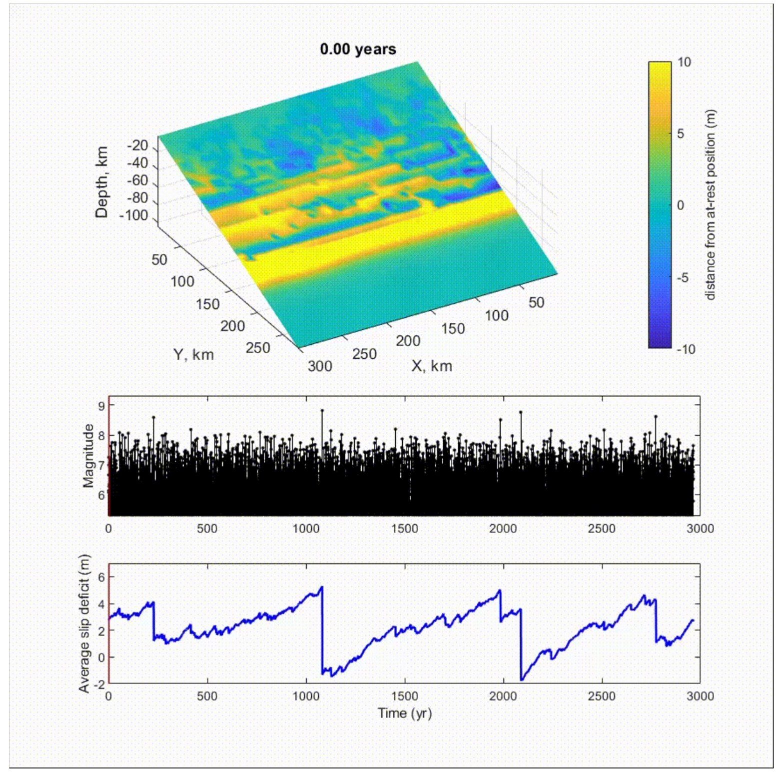
Fisher and Hirth, 2024

Shear heating

Lin, Fang, Lin, Armstrong, Mao, Zhuo, et al., 2023, CIDER Poject

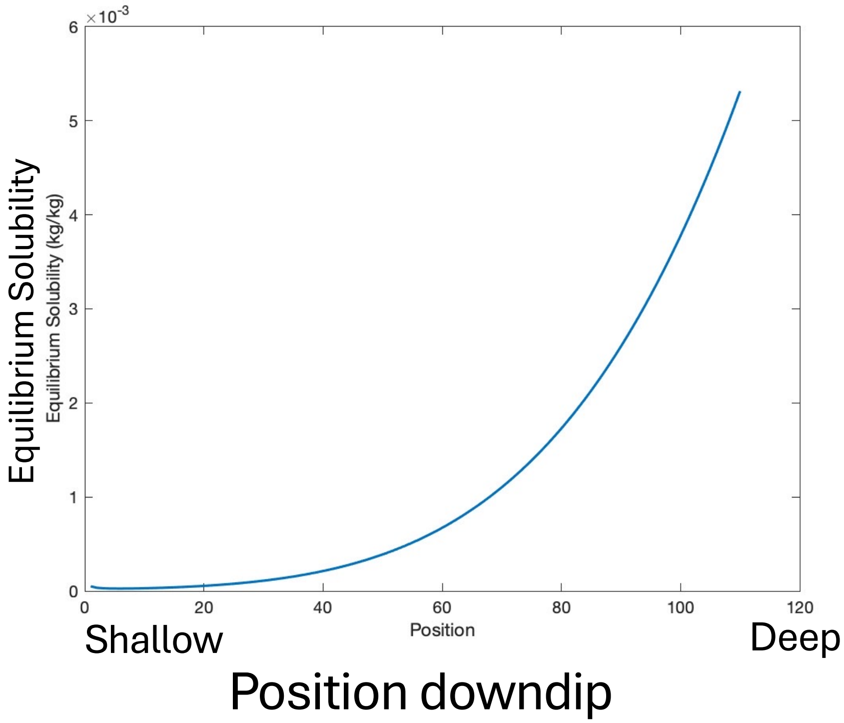


effective friction coefficient = 0.04

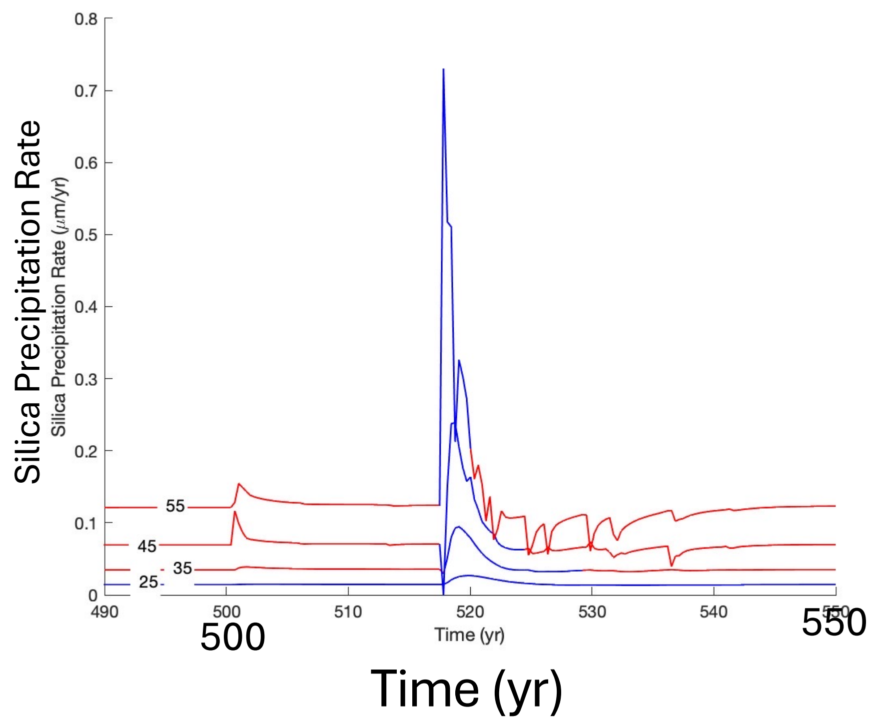


grain size = 10 μm
sediment thickness = 0.4 km

Solubility



Precipitation Rate



Conclusions

- Oxygen isotopes, Oxygen isotope thermometry, and clumped isotopes indicate buffering by rock, with temperatures of vein formation less than the max T, potentially related to lowT fluid-producing reactions.
- Volume loss recorded by scaly fabrics is dependent on T and is comparable to the amount of precipitated vein material at the scale of a thin section.
- Modeling using MEFISTO (the Mineralization, Earthquake, Fluid flow Simulator) and tracking of supersaturation rate during earthquake transients indicate modest precipitation rates (because of low solubility in the seismogenic zone) and rapid restoration to background levels after an earthquake.