

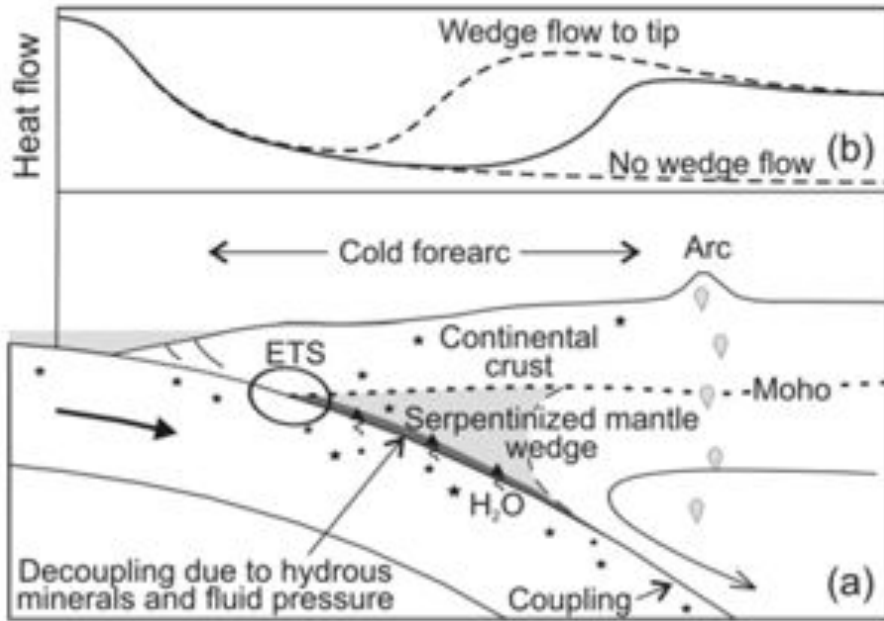


BROWN

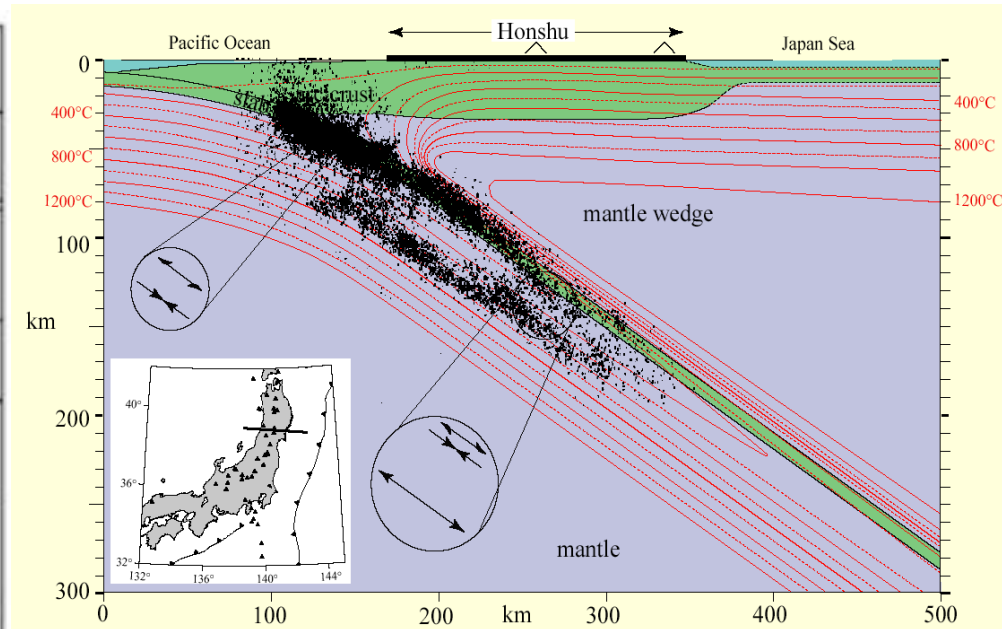


Antigorite Rheology: Implications for Spectrum of Slip Behavior

Greg Hirth, Brown University



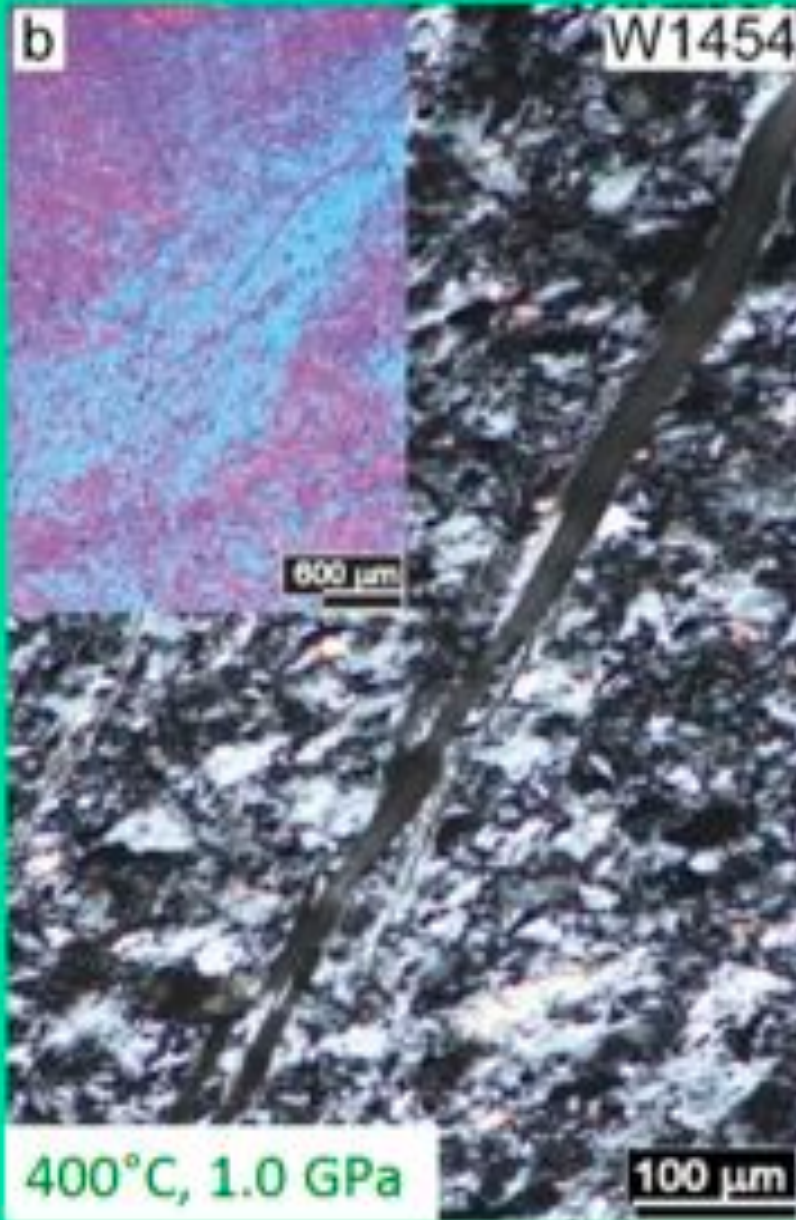
Wada et al. 2008



Hacker

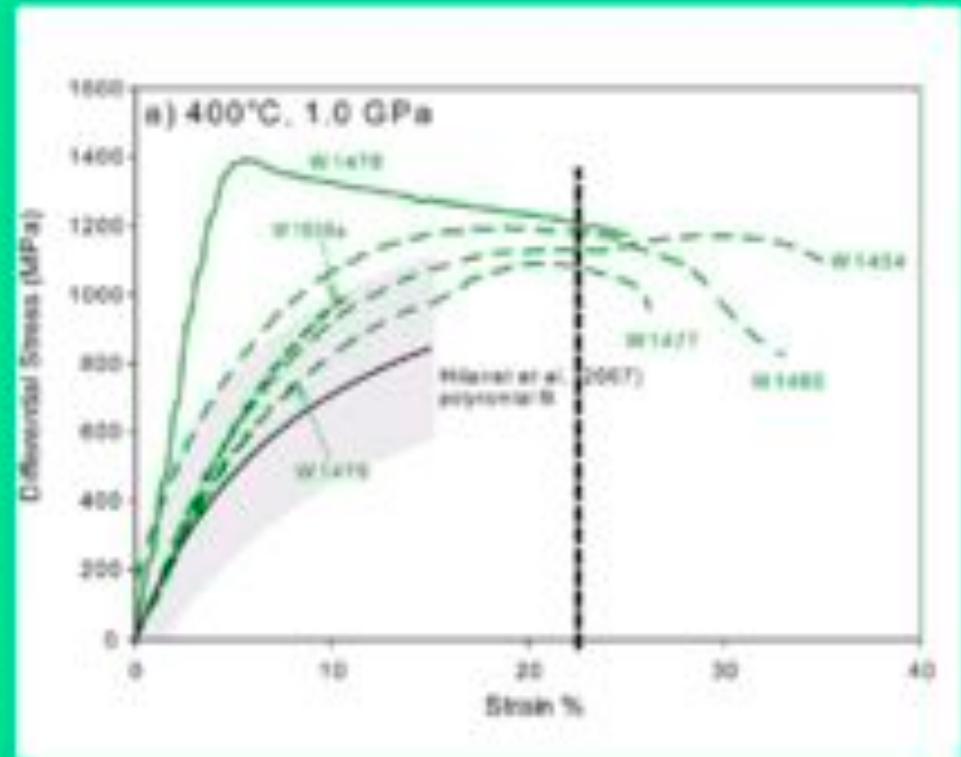
Linda Chernak & Arjun Kohli,
David Goldsby & Terry Tullis

Localization Within Stability Field

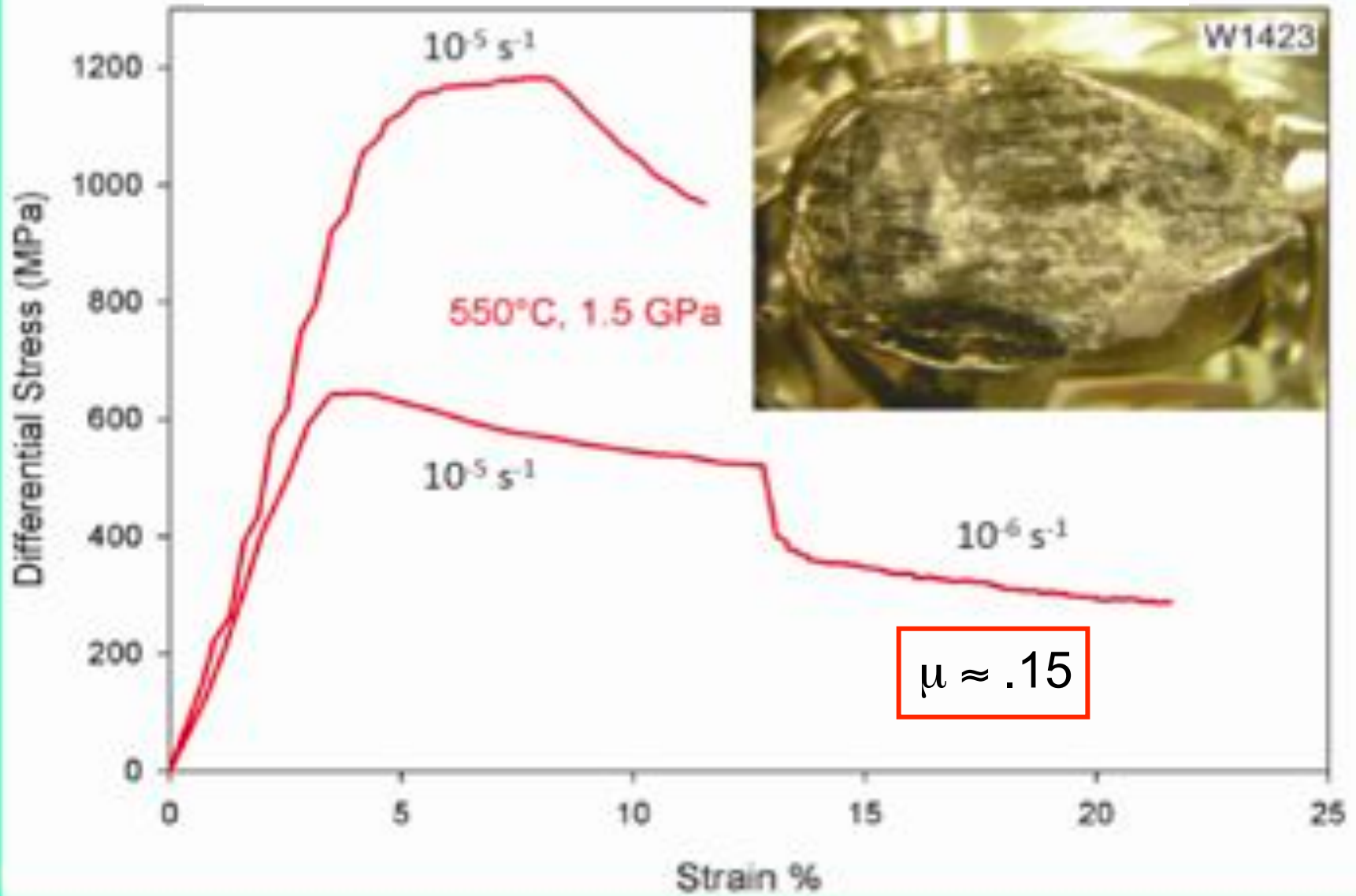


Semi-brittle, localizes
at strain of 20-25%,
von-Mises criterion not satisfied

Chernak & Hirth, 2010



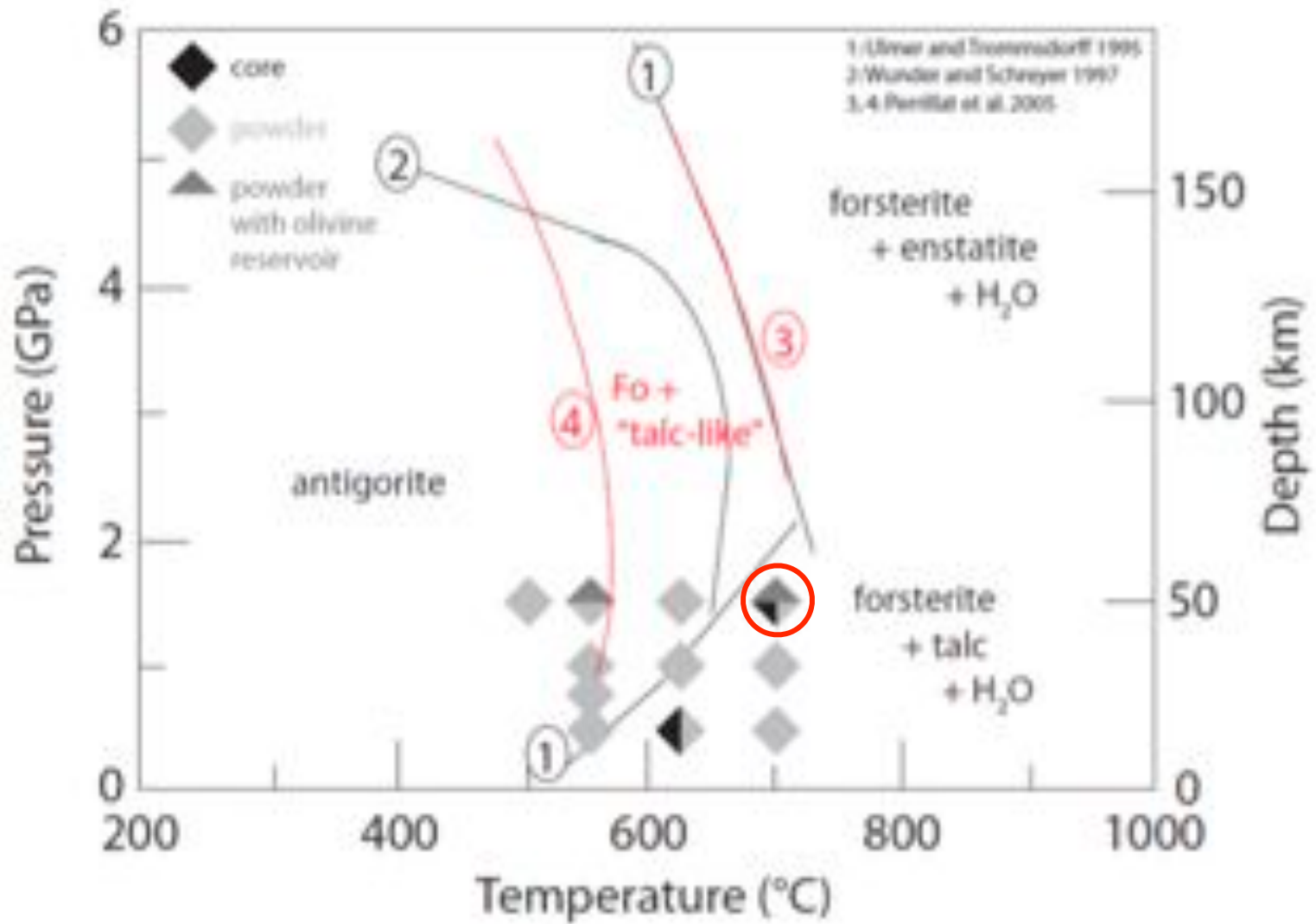
Velocity Strengthening and localized



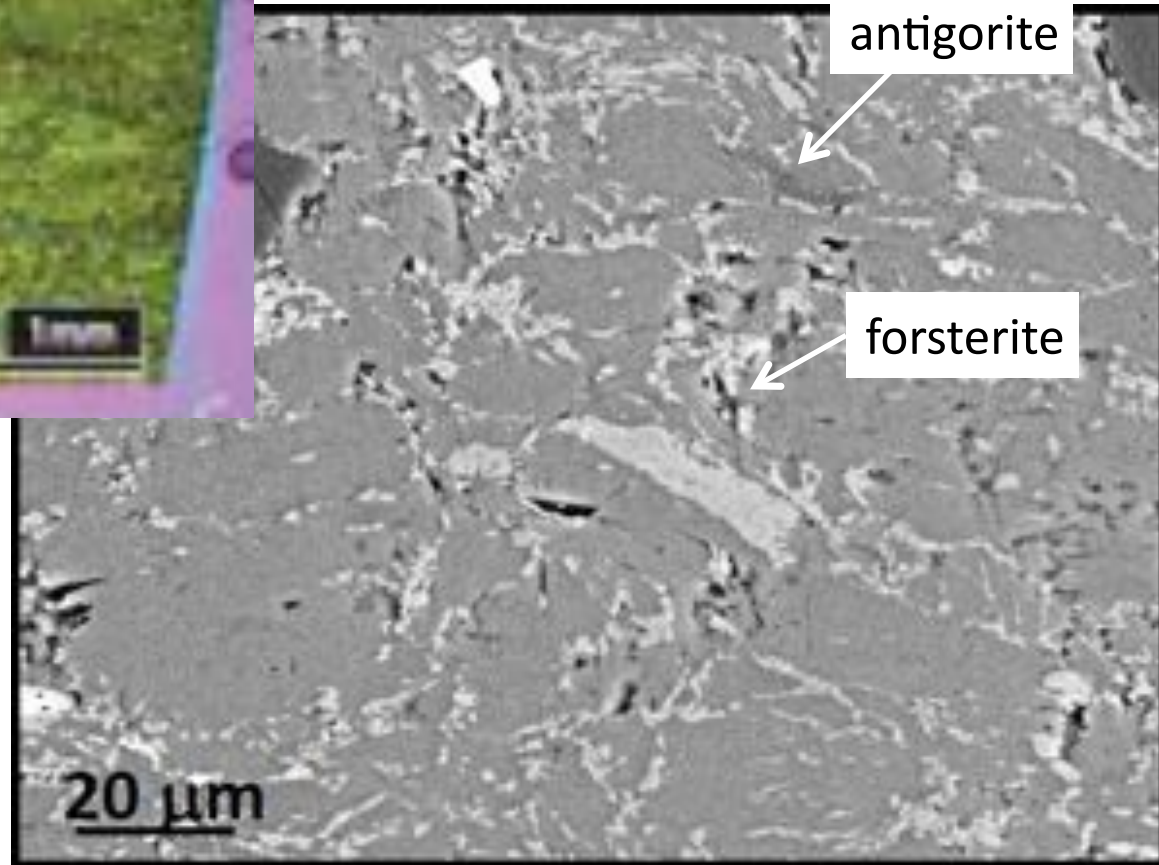
Chernak & Hirth, 2010



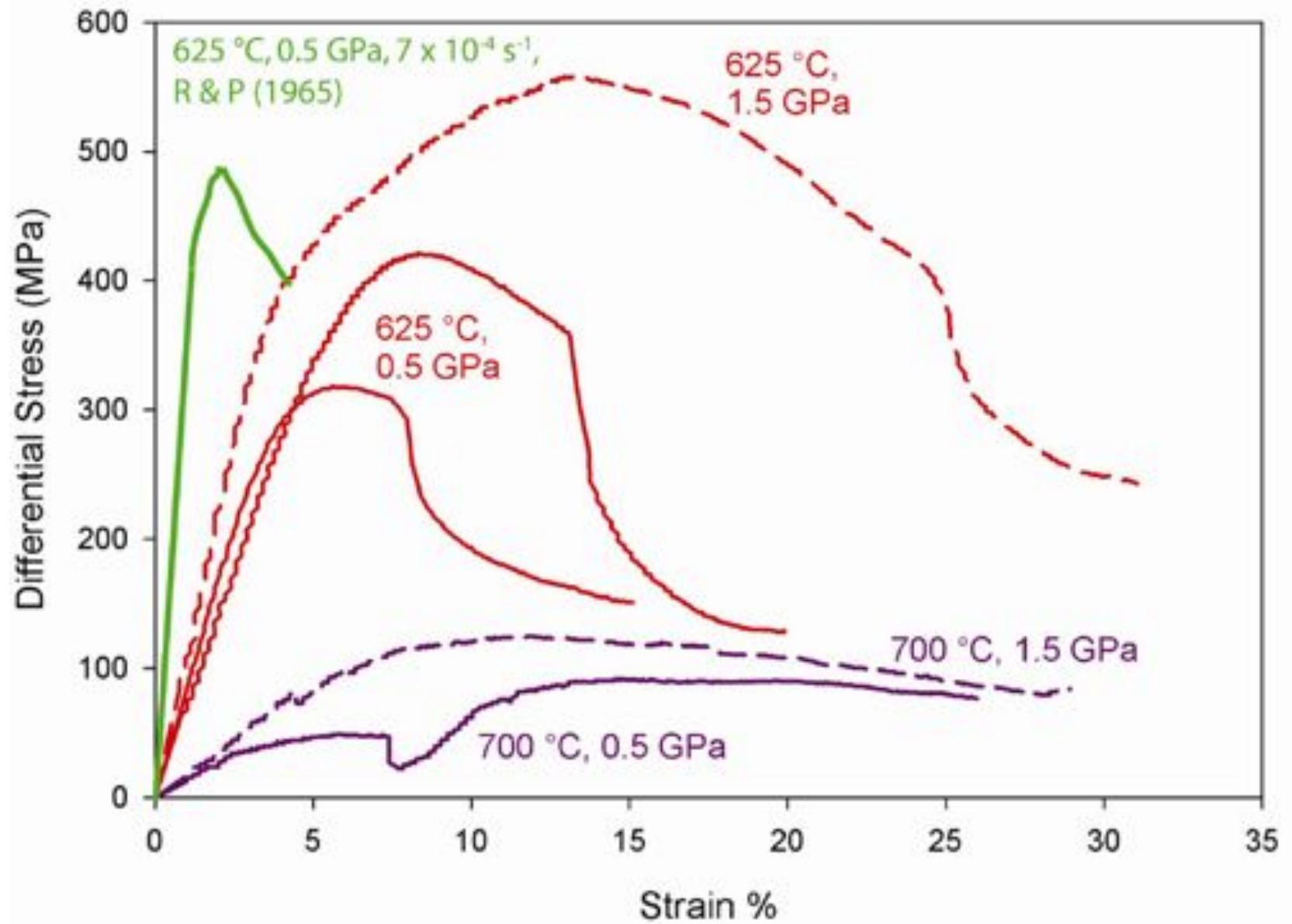
Monday, November 1, 2010



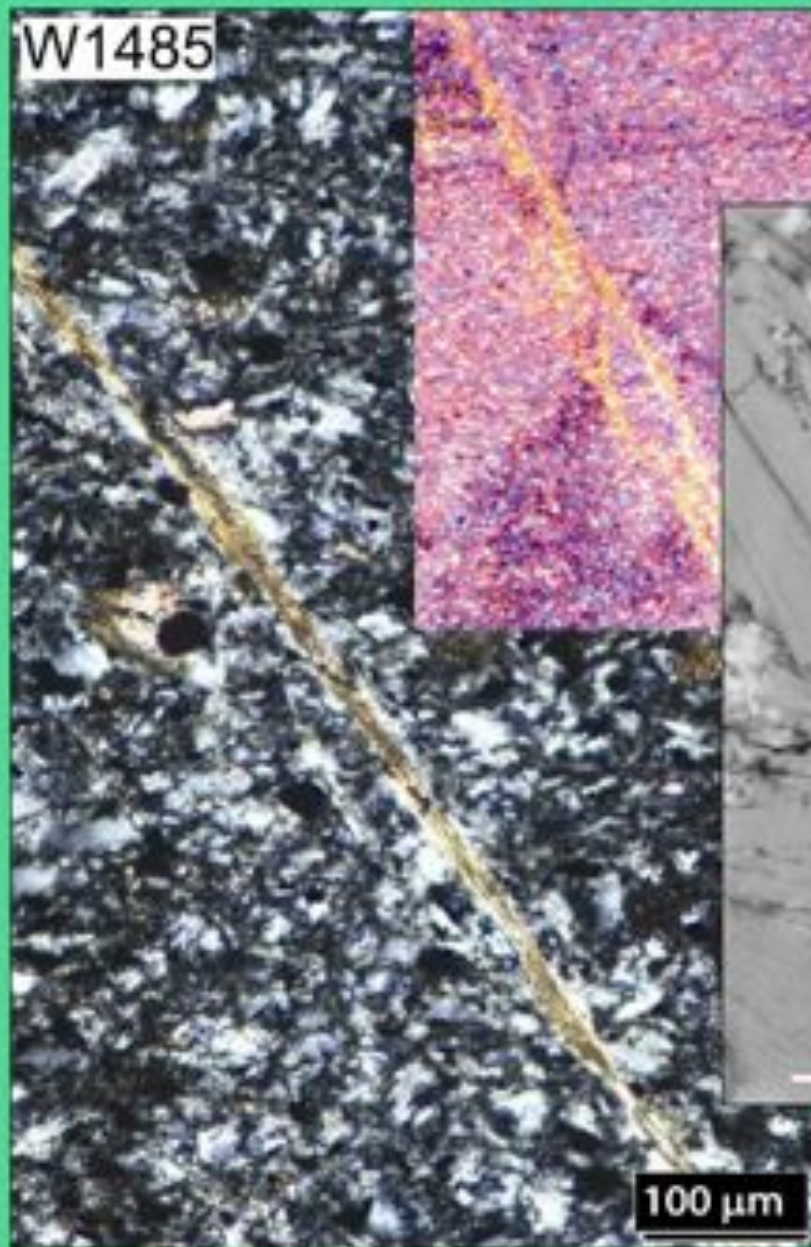
700°C, 1.5 GPa



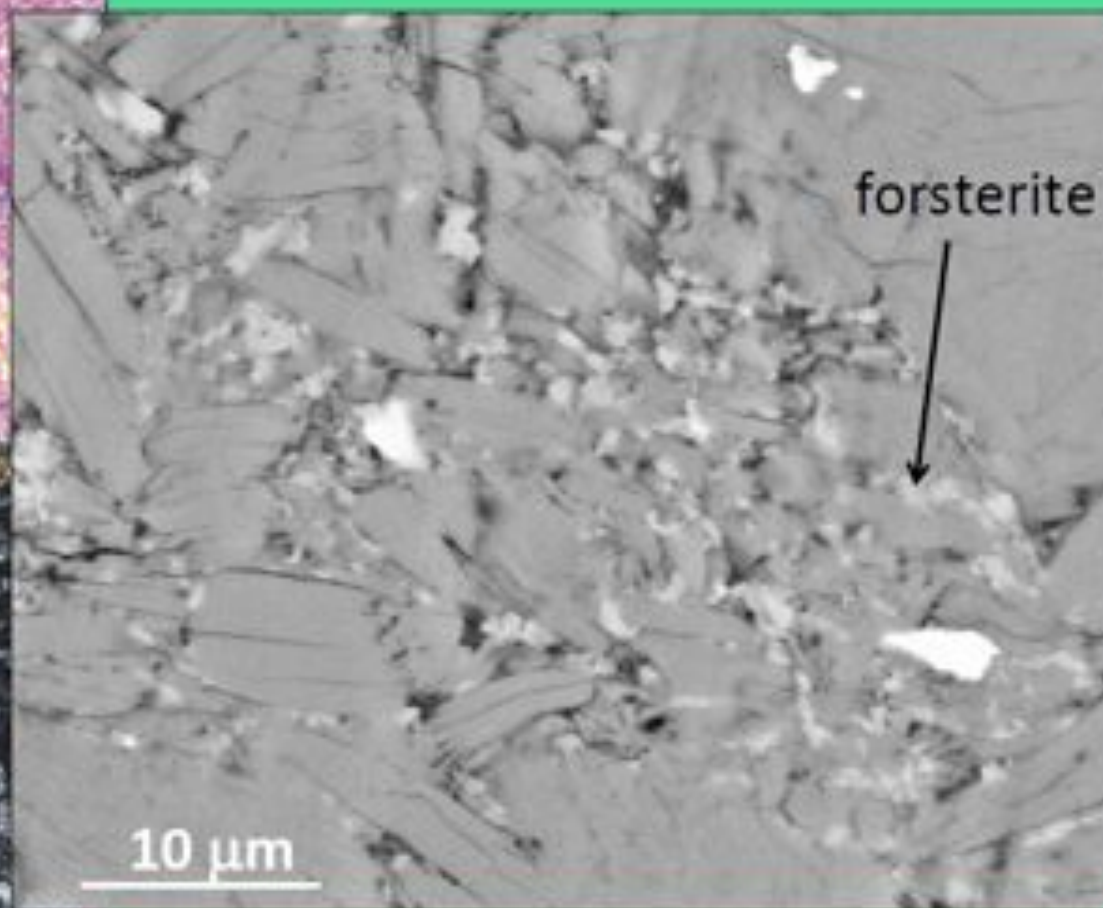
Chernak & Hirth, 2010



Where Dehydration is Expected: Low P

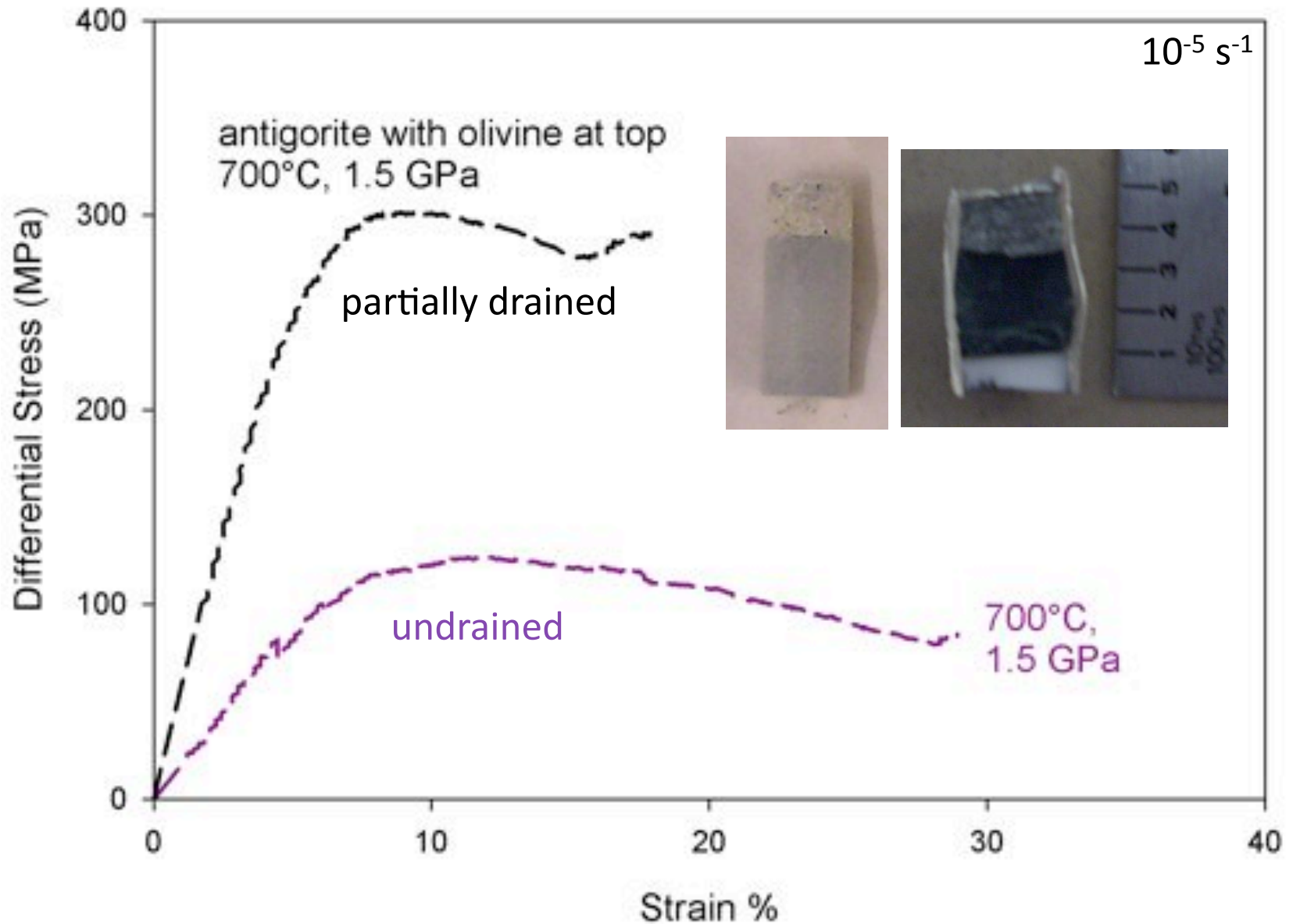


625°C, 0.5 GPa

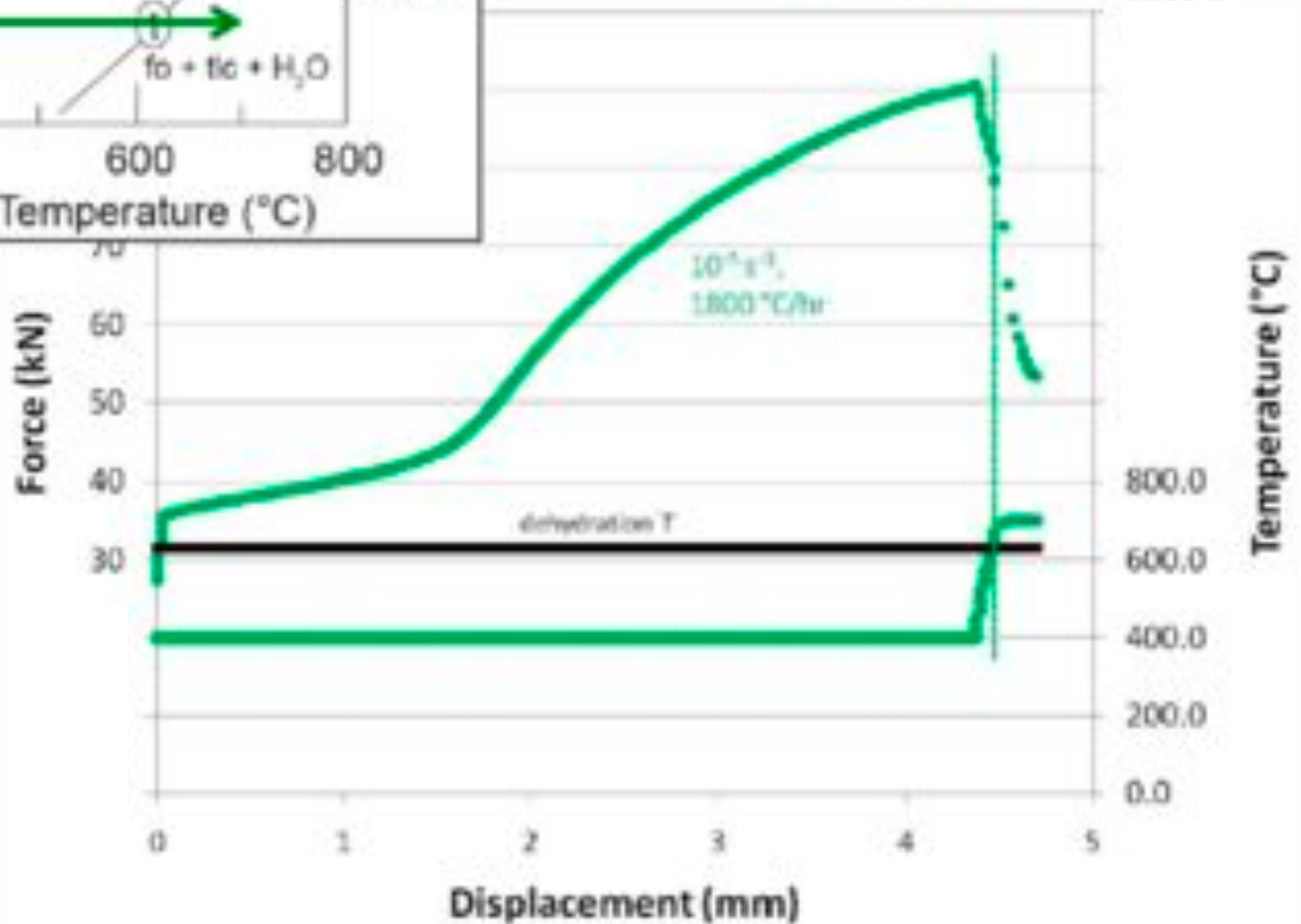
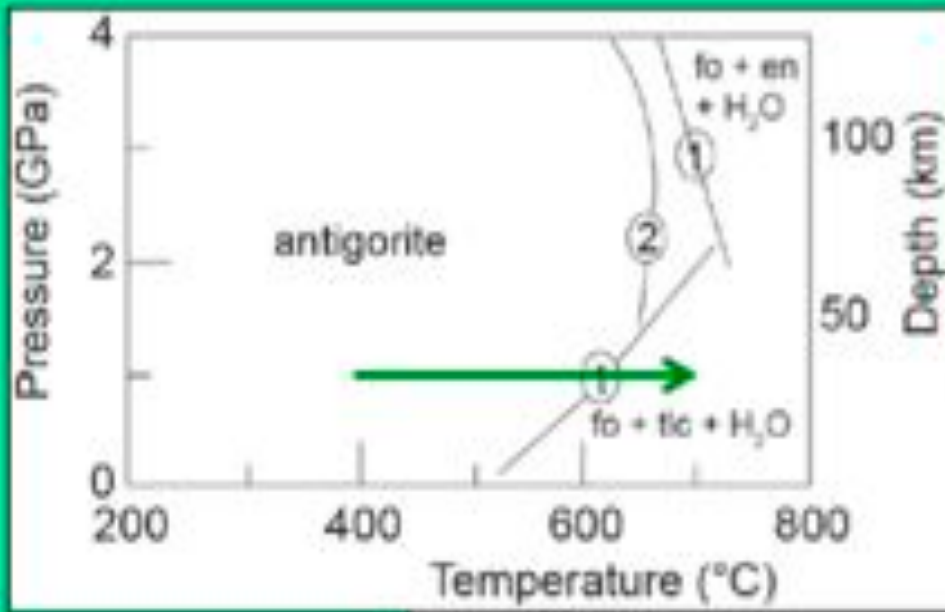


localized deformation

Role of Effective Pressure

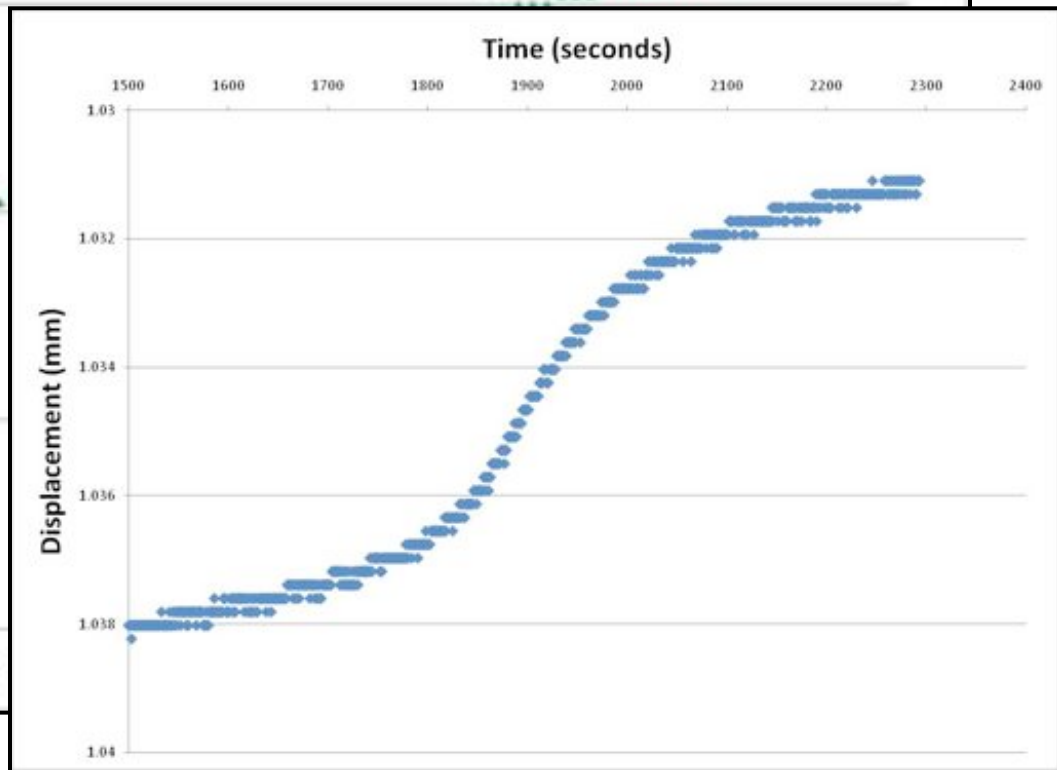
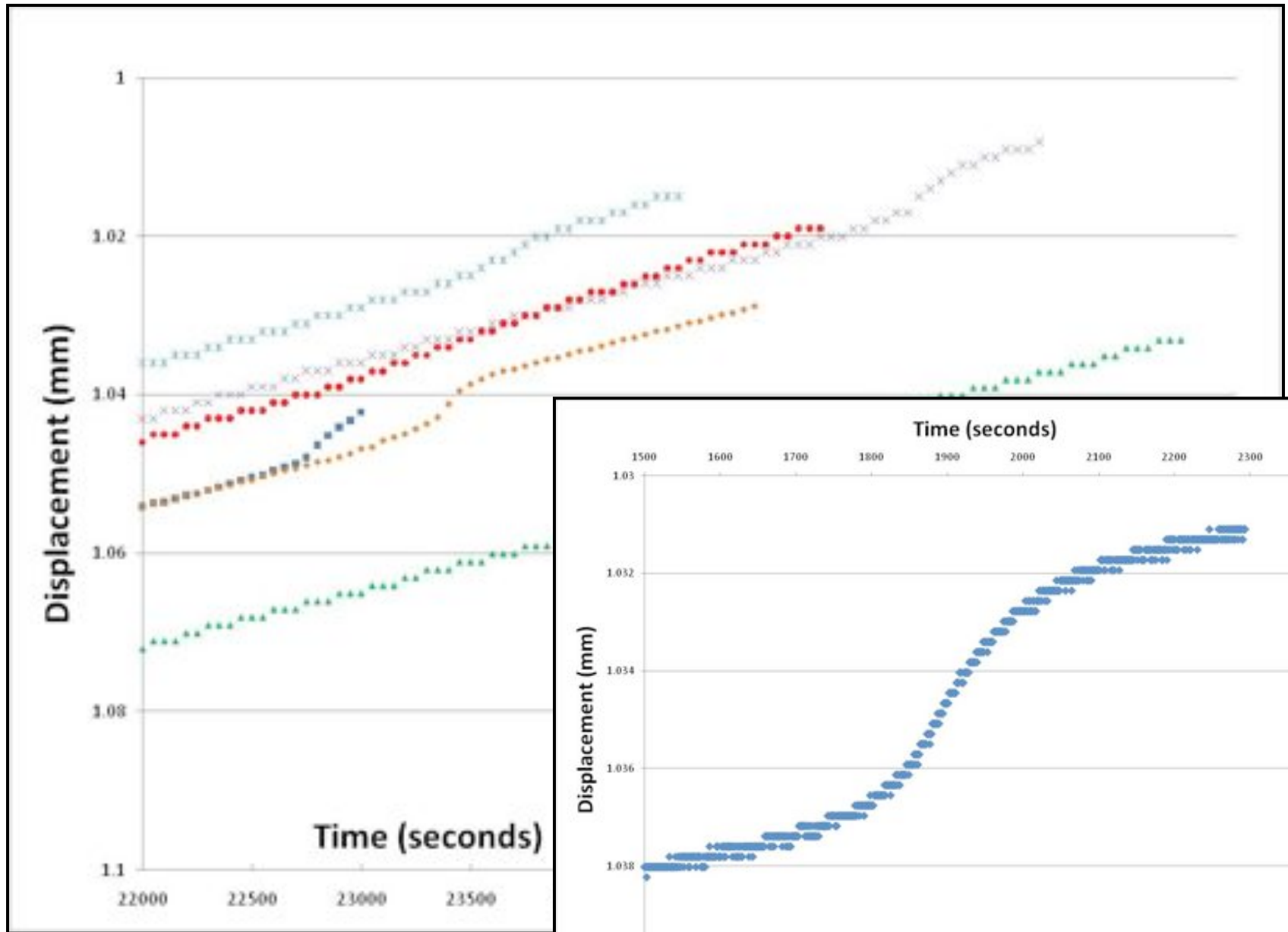


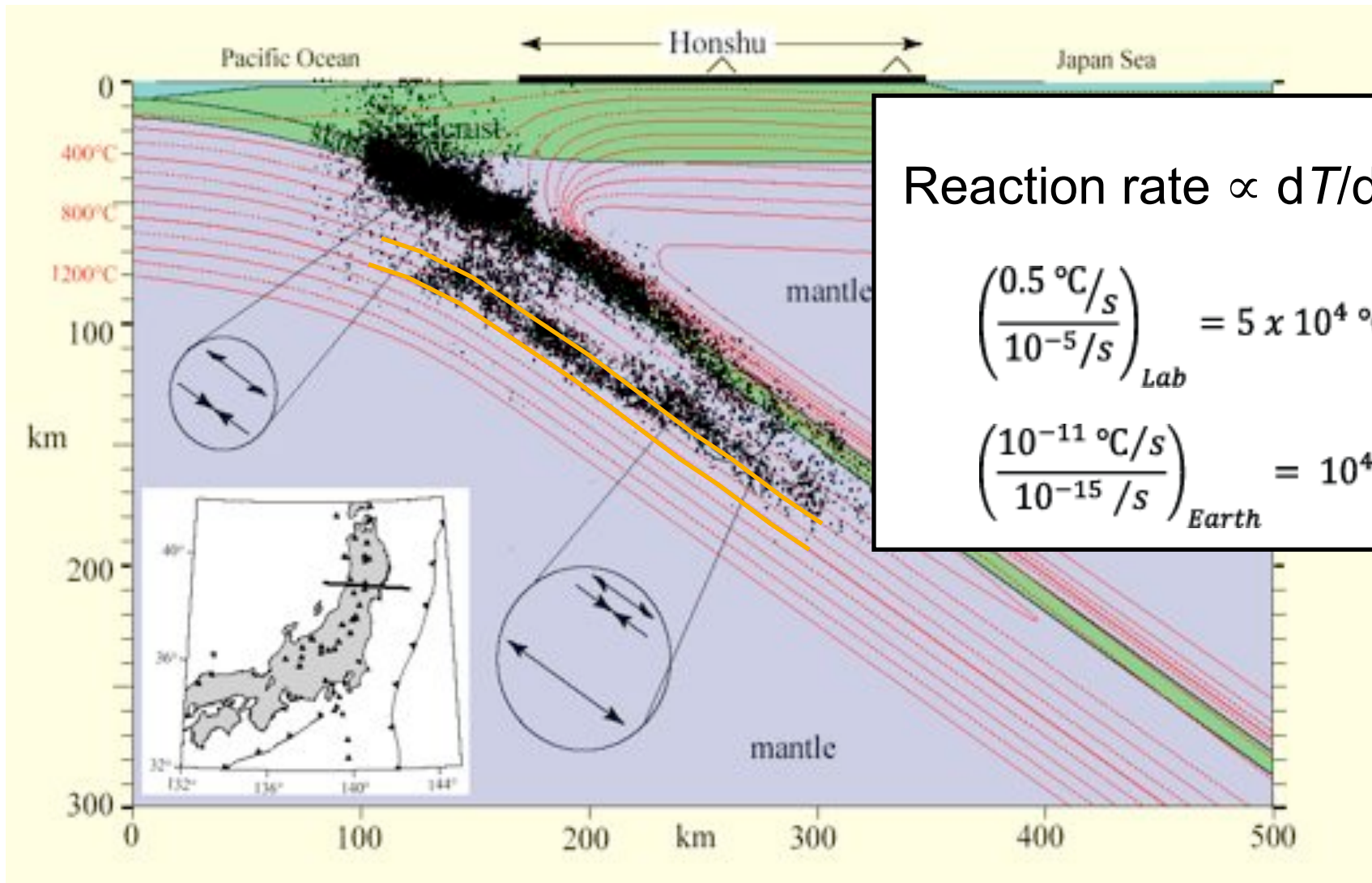
Undrained pore fluid
Localized before reaction
Large “elastic strain”



strain rate:
 10^{-5} s^{-1}

ramp rate:
 1800 °C/hr

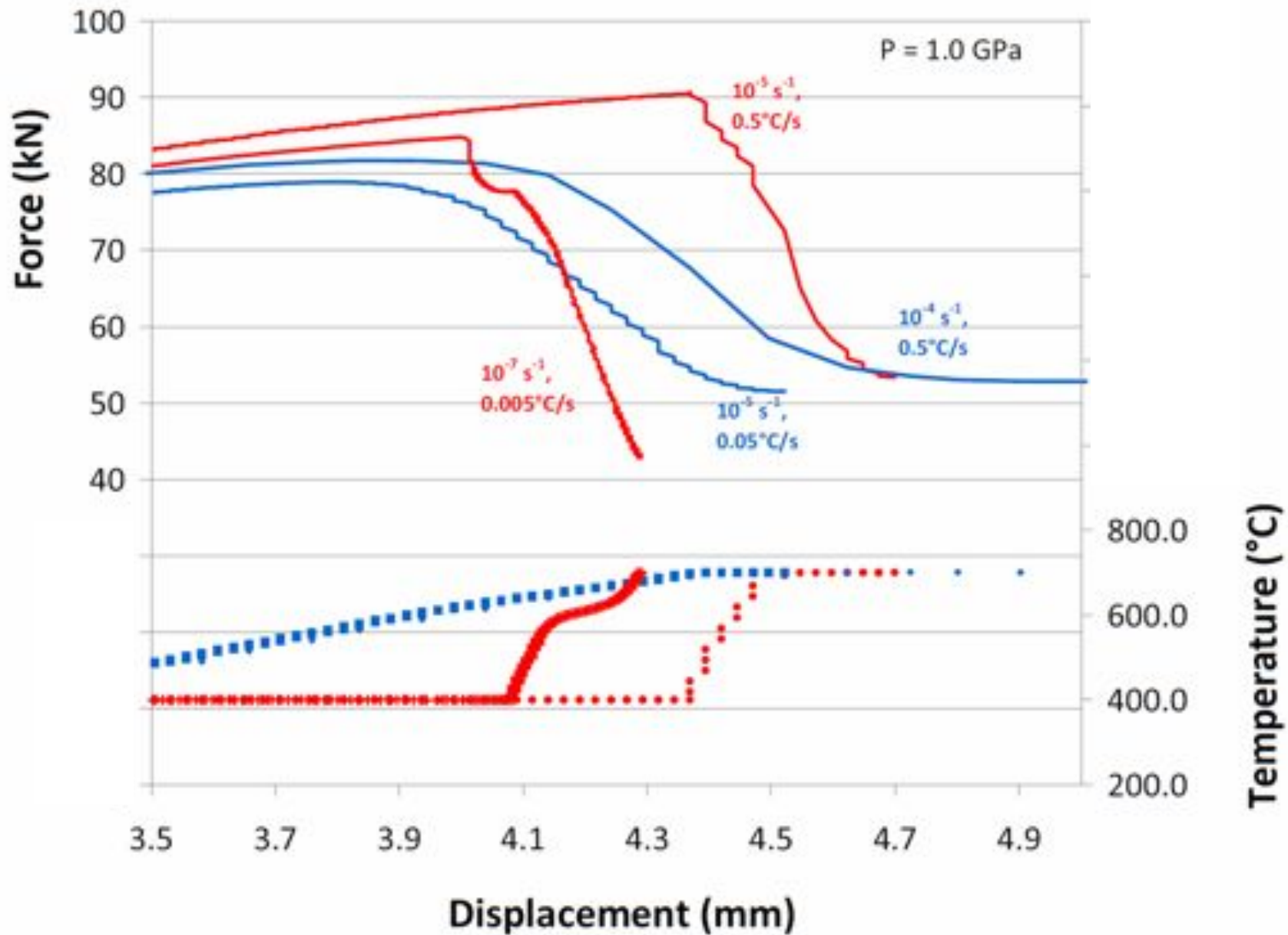


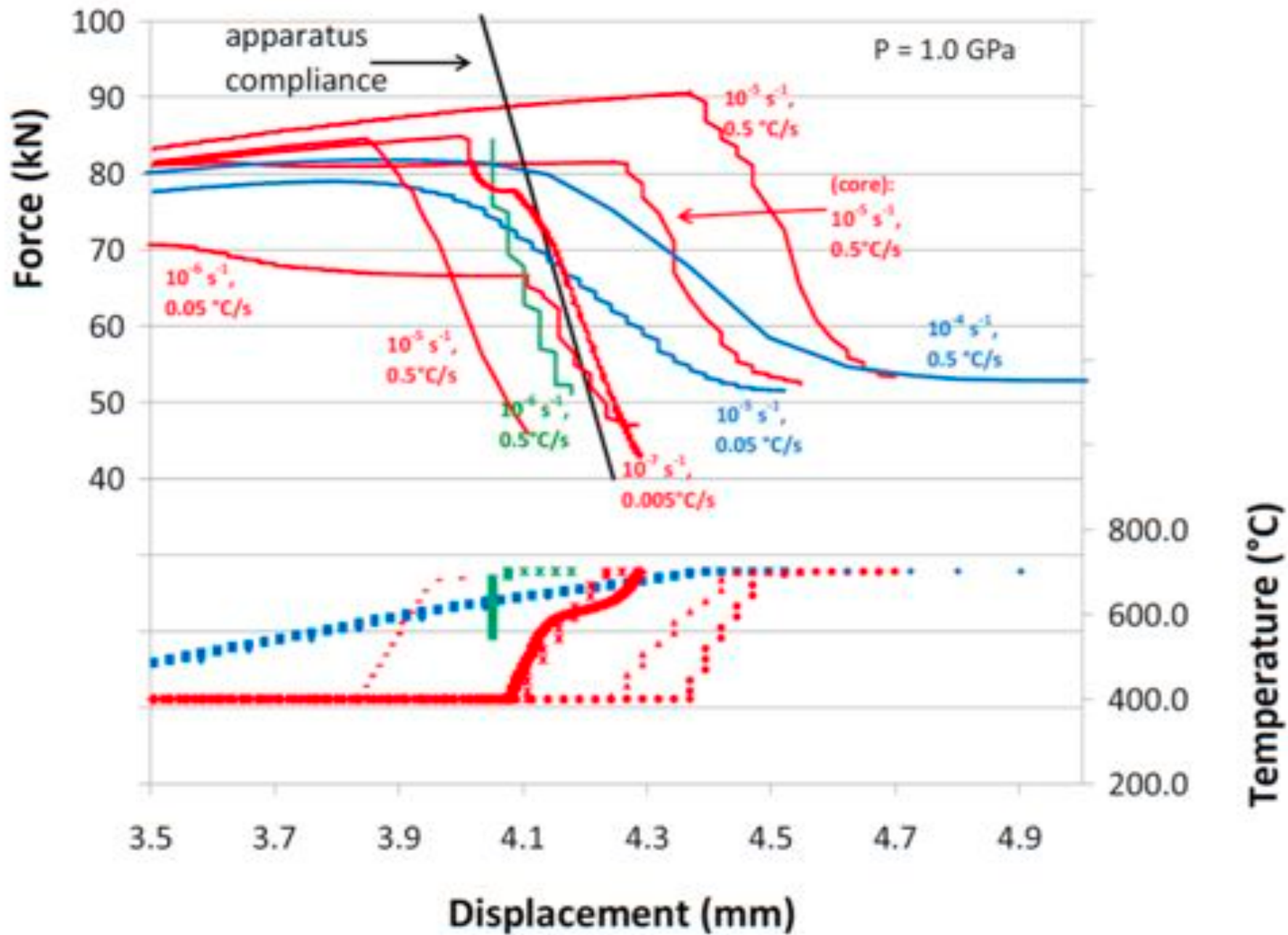


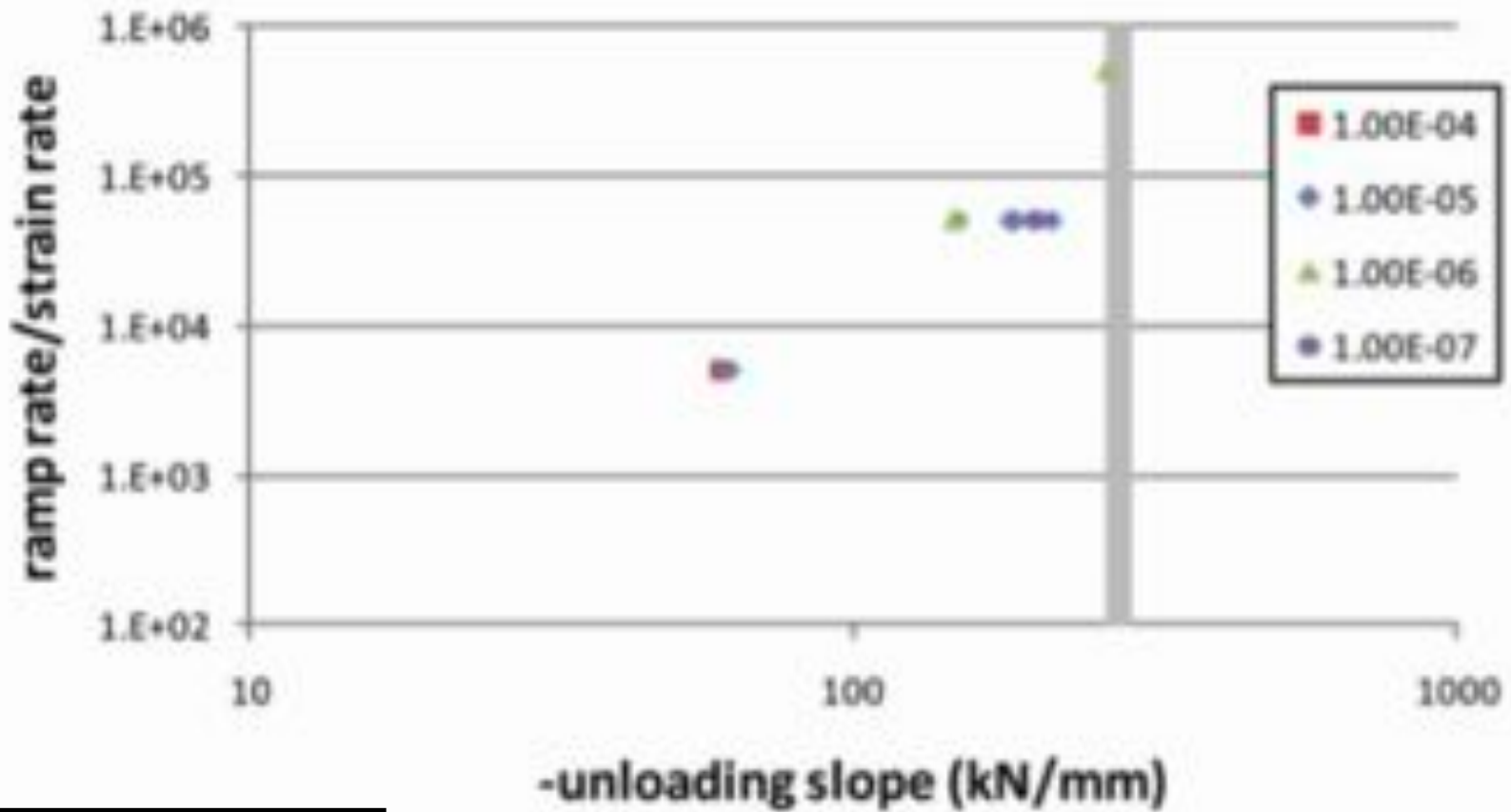
Reaction rate $\propto dT/dt$

$$\left(\frac{0.5 \text{ } ^\circ\text{C}/\text{s}}{10^{-5}/\text{s}} \right)_{\text{Lab}} = 5 \times 10^4 \text{ } ^\circ\text{C}$$

$$\left(\frac{10^{-11} \text{ } ^\circ\text{C}/\text{s}}{10^{-15}/\text{s}} \right)_{\text{Earth}} = 10^4 \text{ } ^\circ\text{C}$$



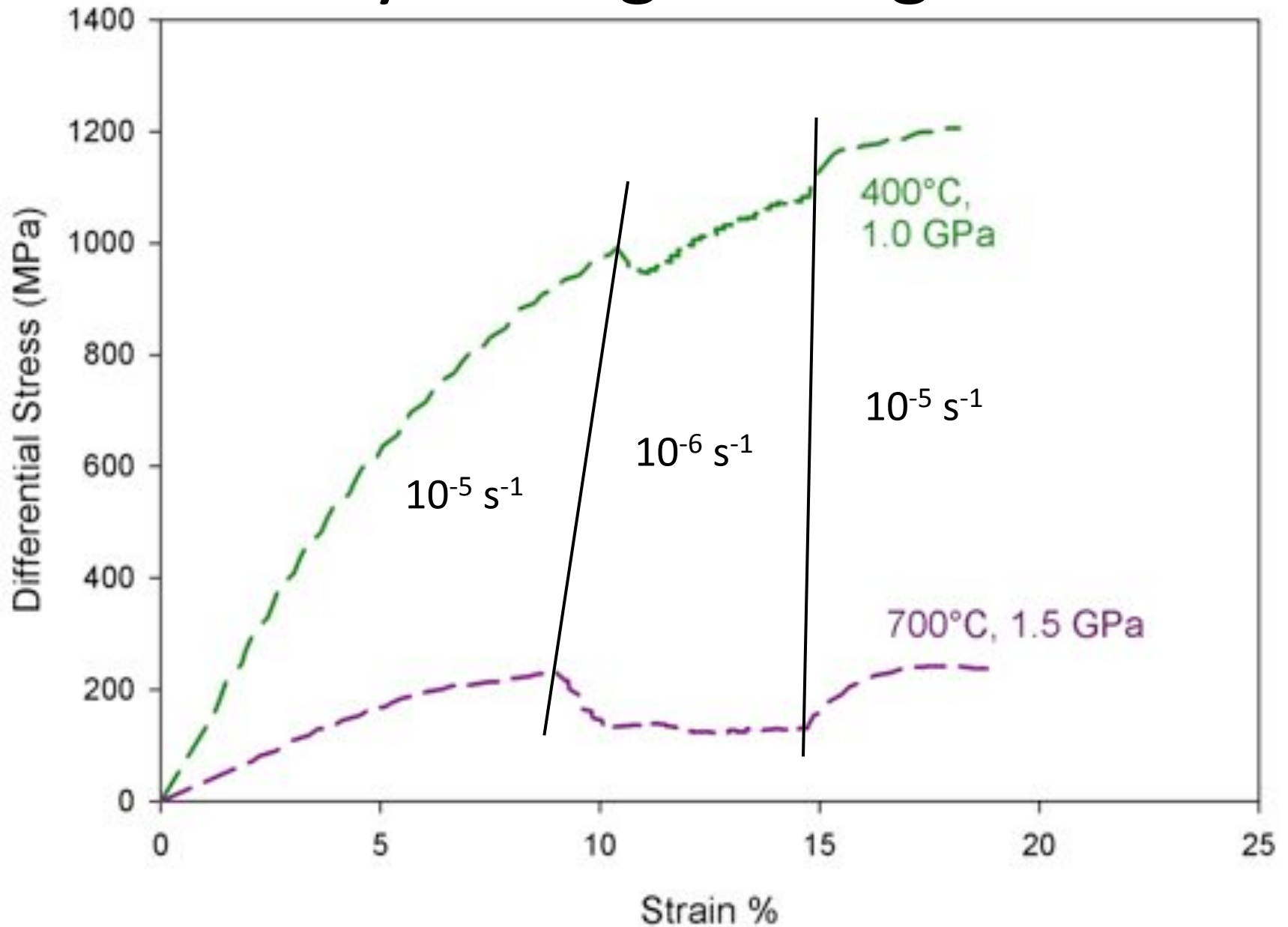


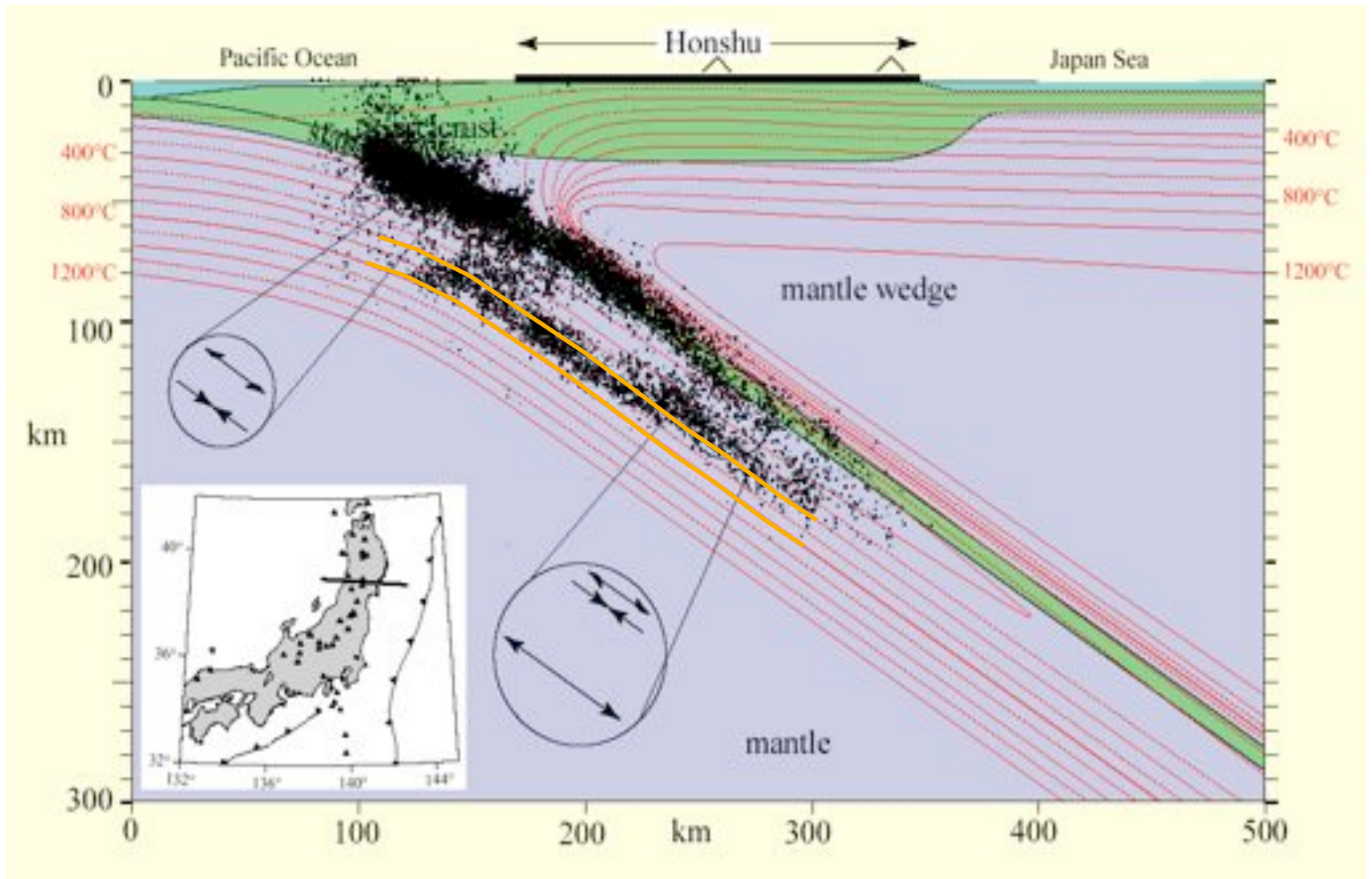


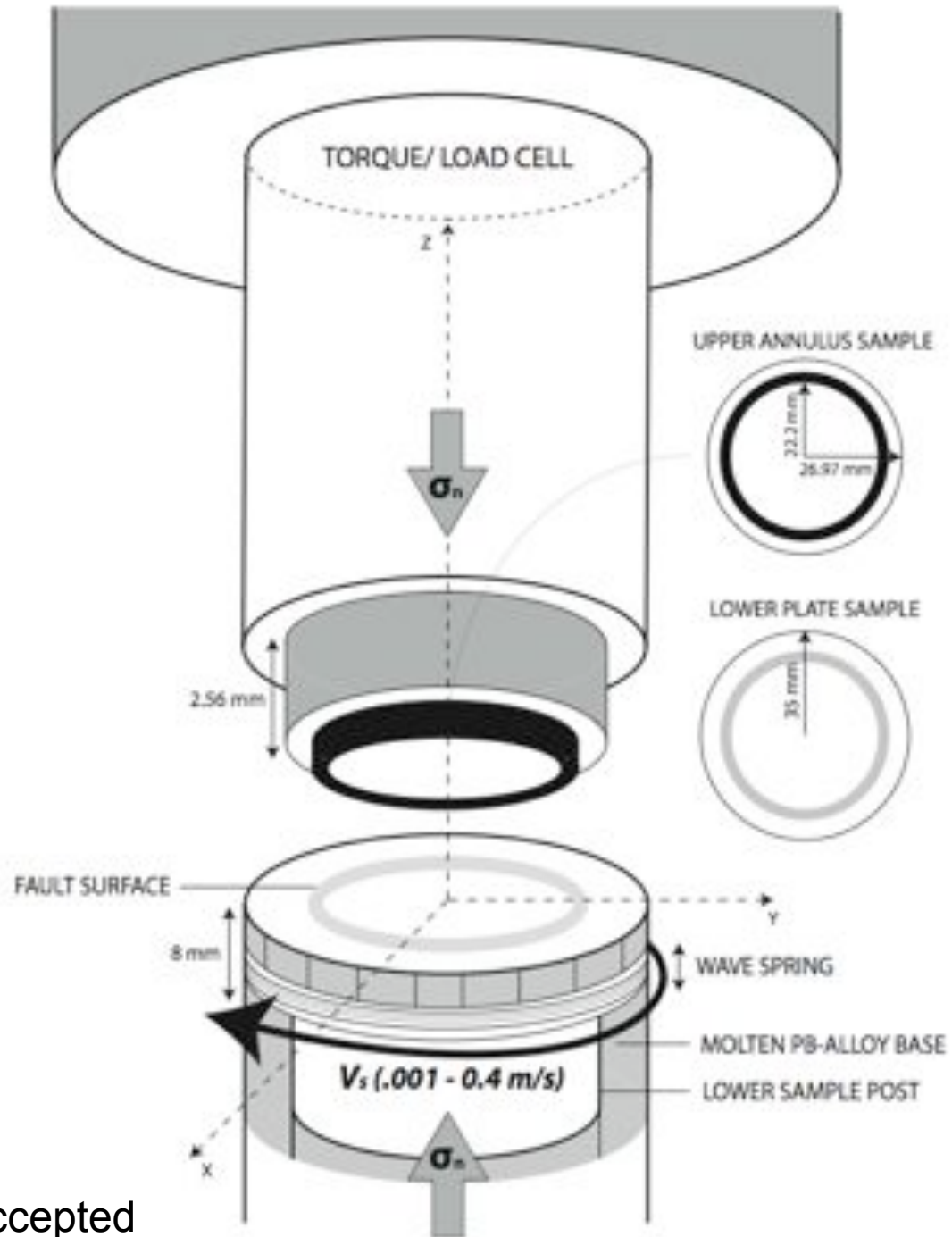
$$\left(\frac{0.5 \text{ } ^\circ\text{C}/\text{s}}{10^{-5} / \text{s}} \right)_{\text{Lab}} = 5 \times 10^4 \text{ } ^\circ\text{C}$$

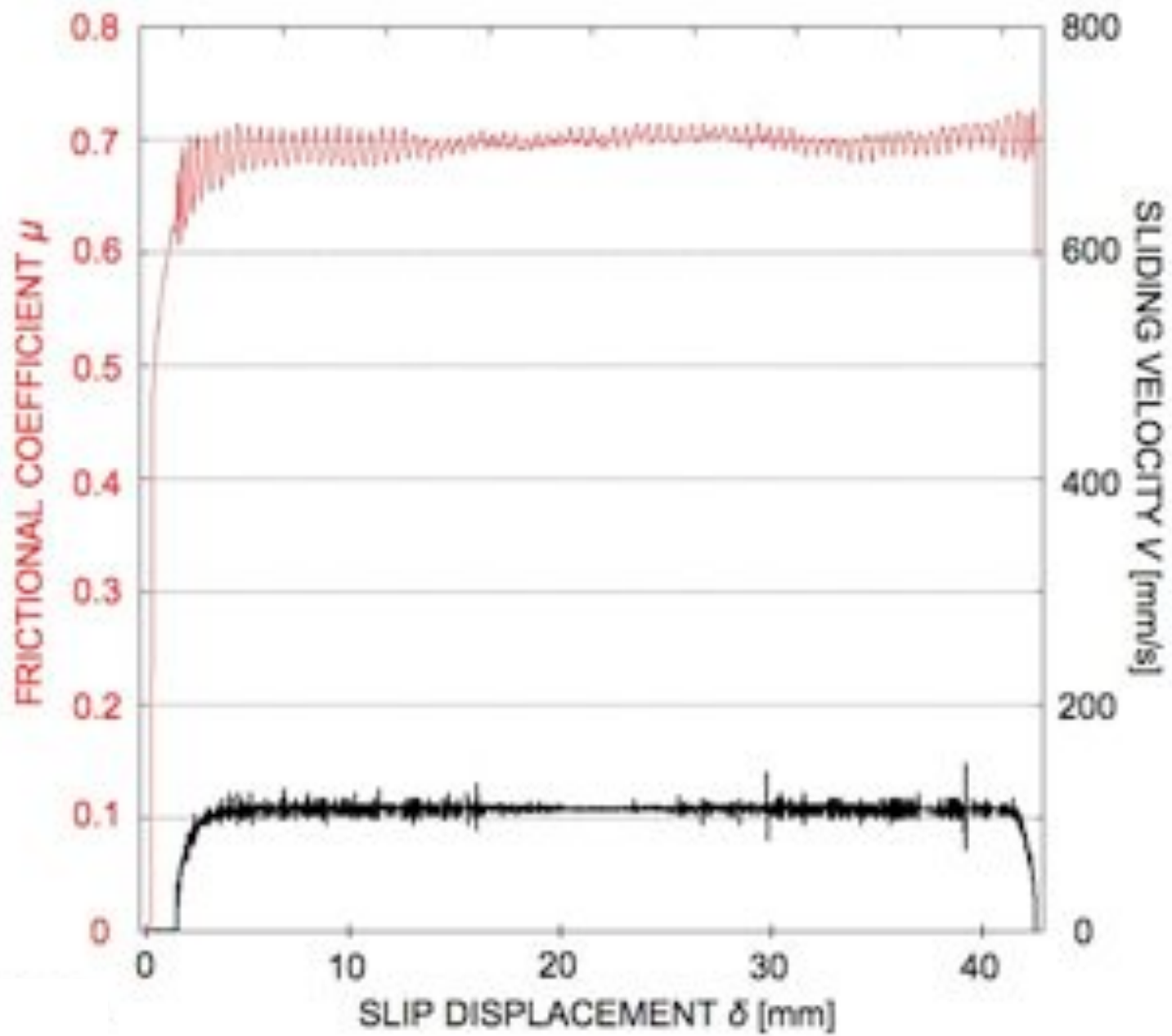
$$\left(\frac{10^{-11} \text{ } ^\circ\text{C}/\text{s}}{10^{-15} / \text{s}} \right)_{\text{Earth}} = 10^4 \text{ } ^\circ\text{C}$$

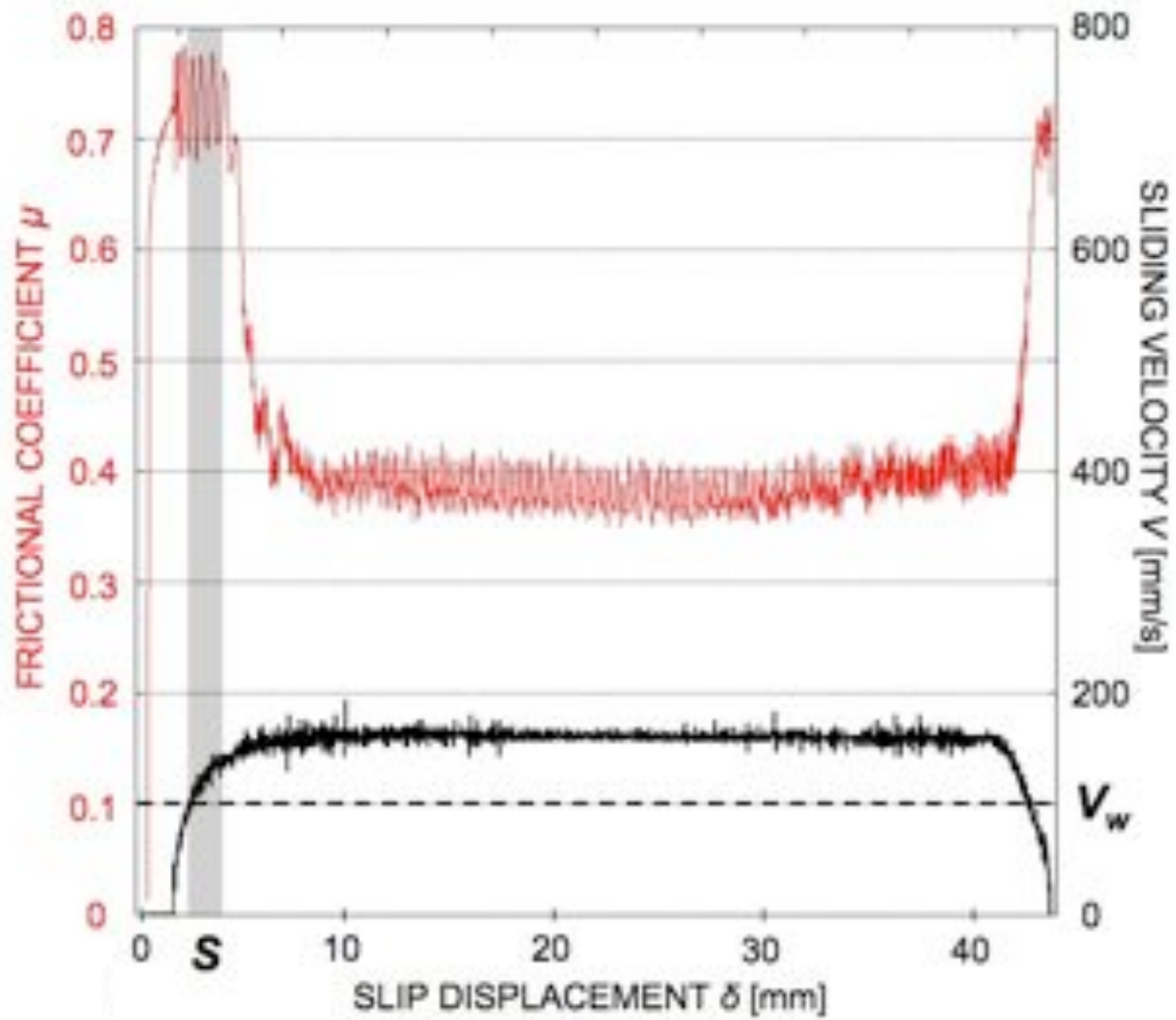
Velocity Strengthening Behavior



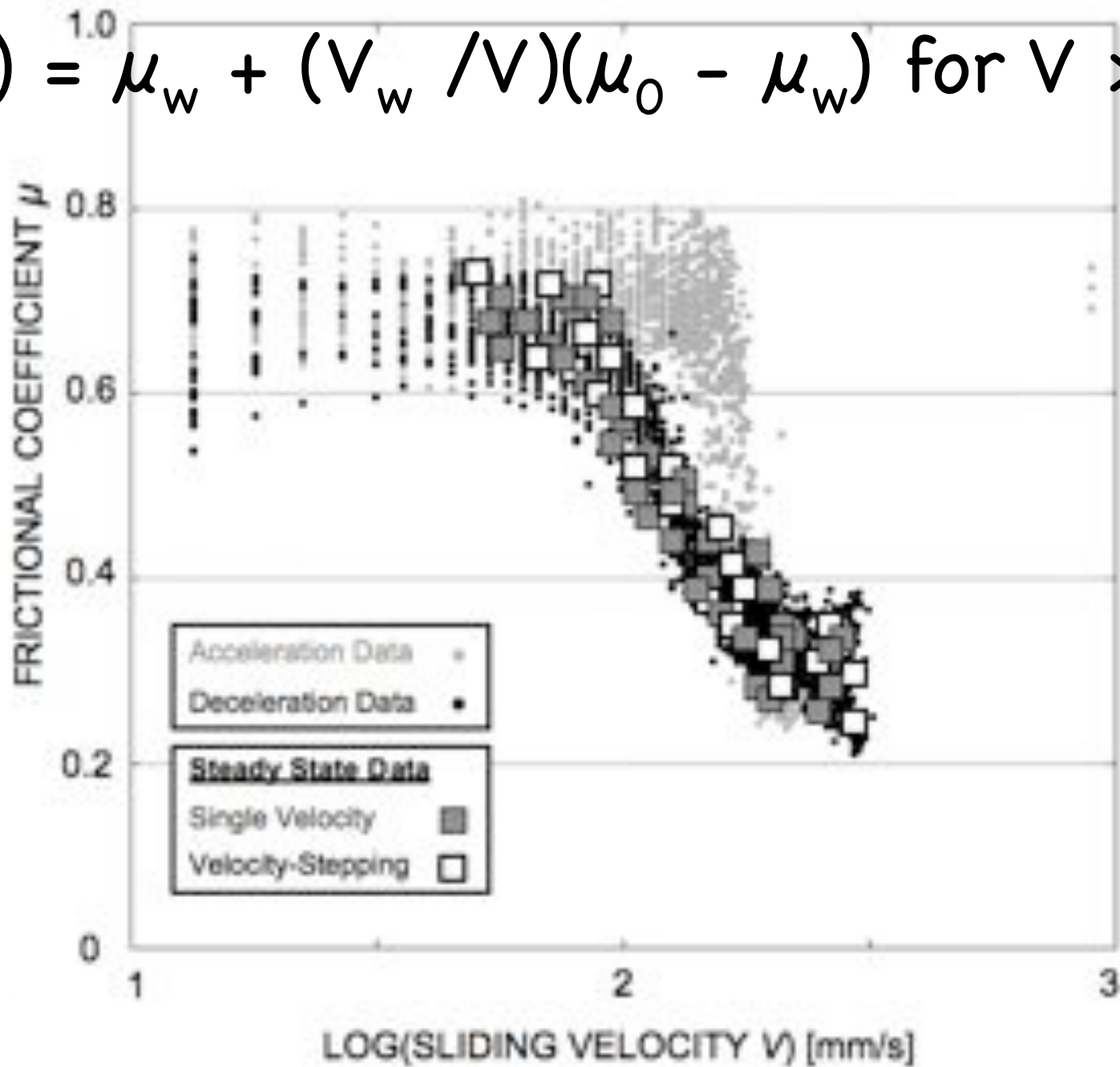


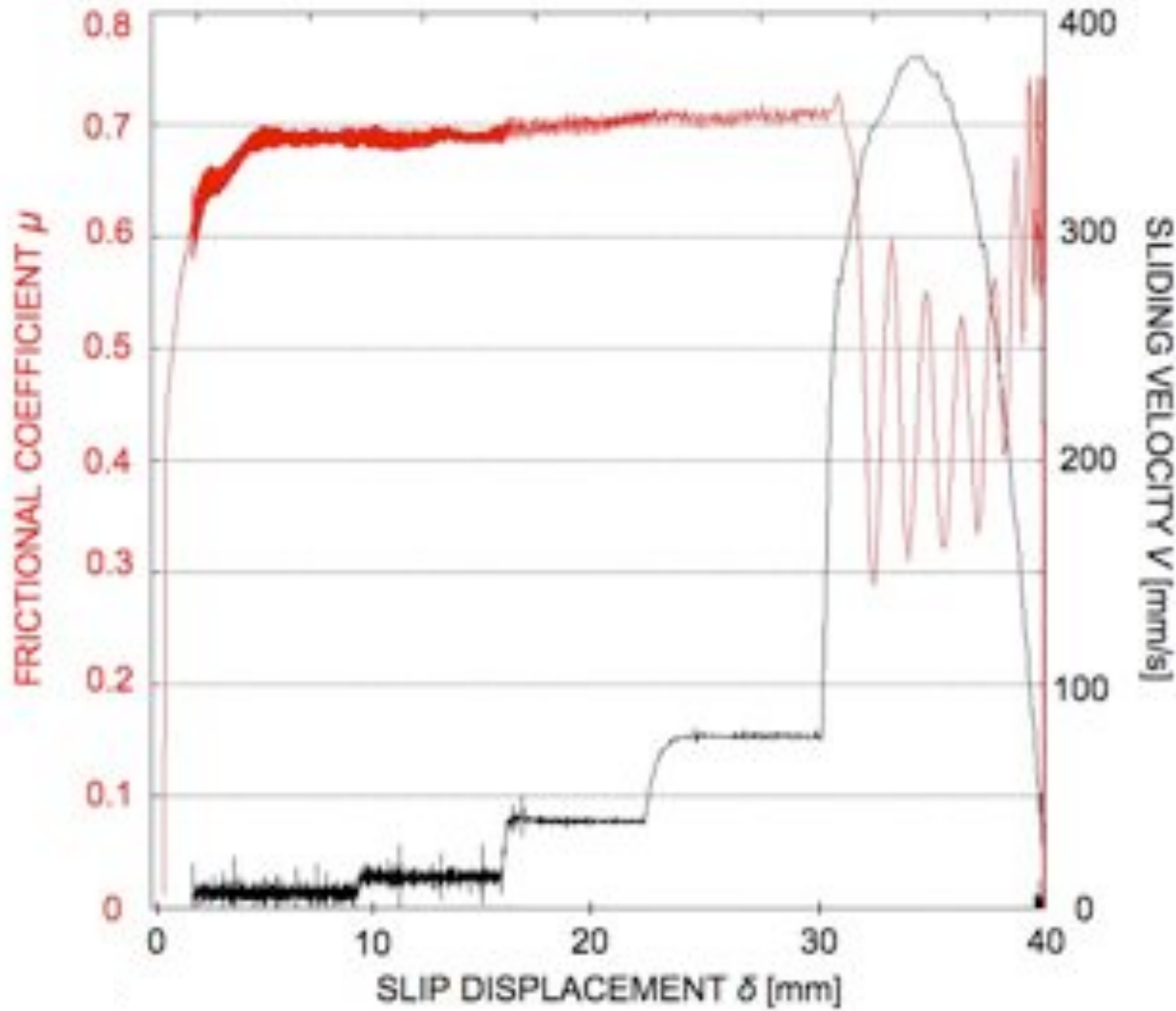


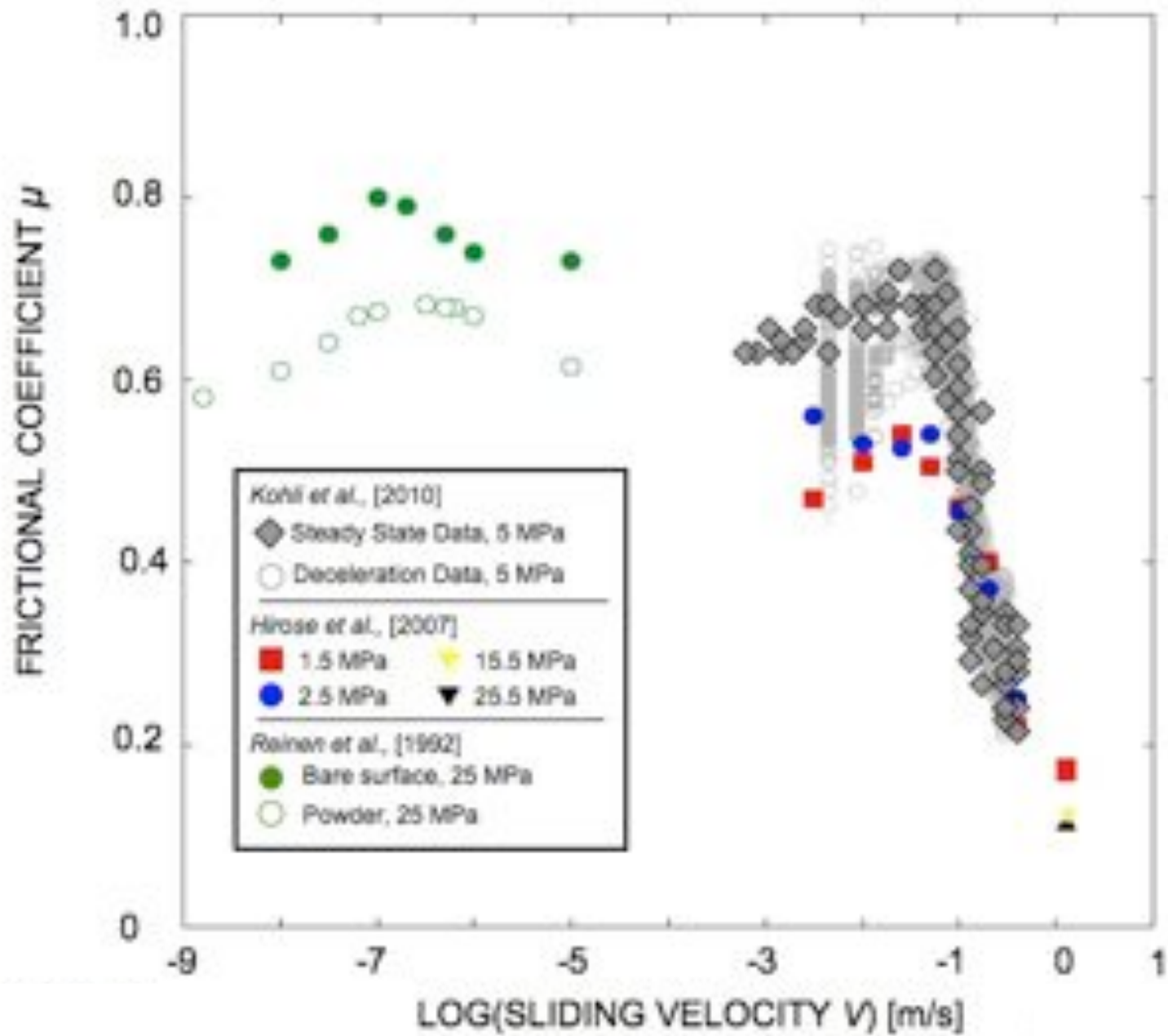


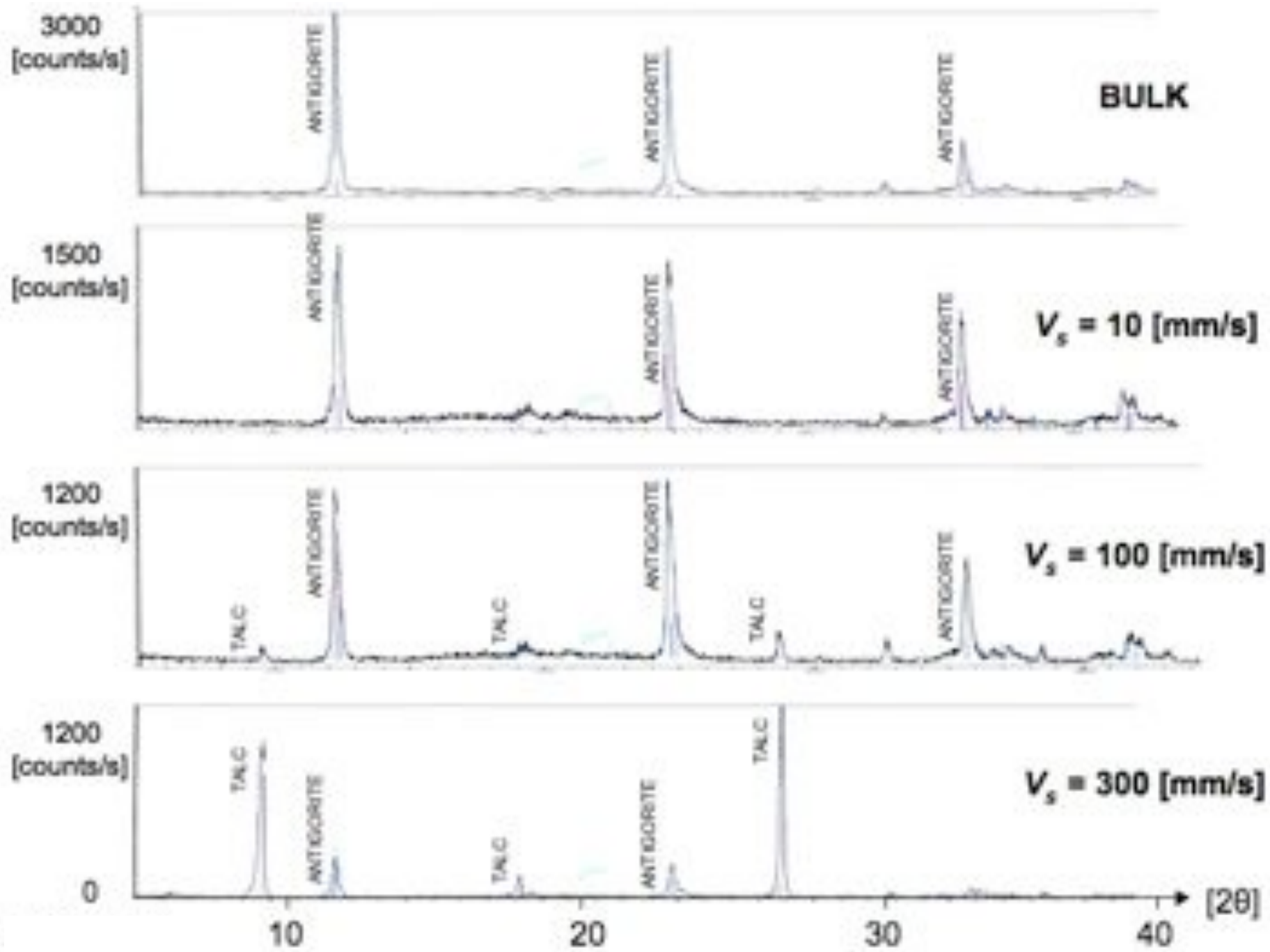


$$\mu(V) = \mu_w + (V_w / V)(\mu_0 - \mu_w) \text{ for } V > V_w$$





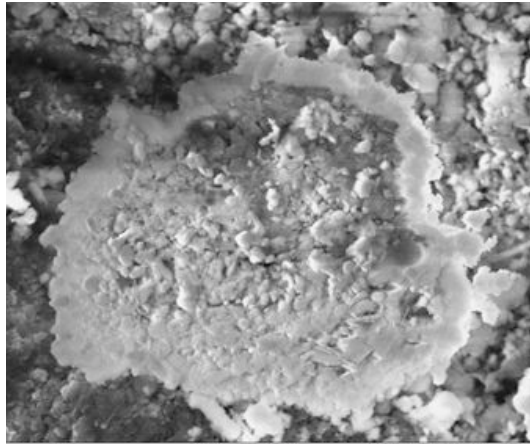




Flash Weakening at Asperities

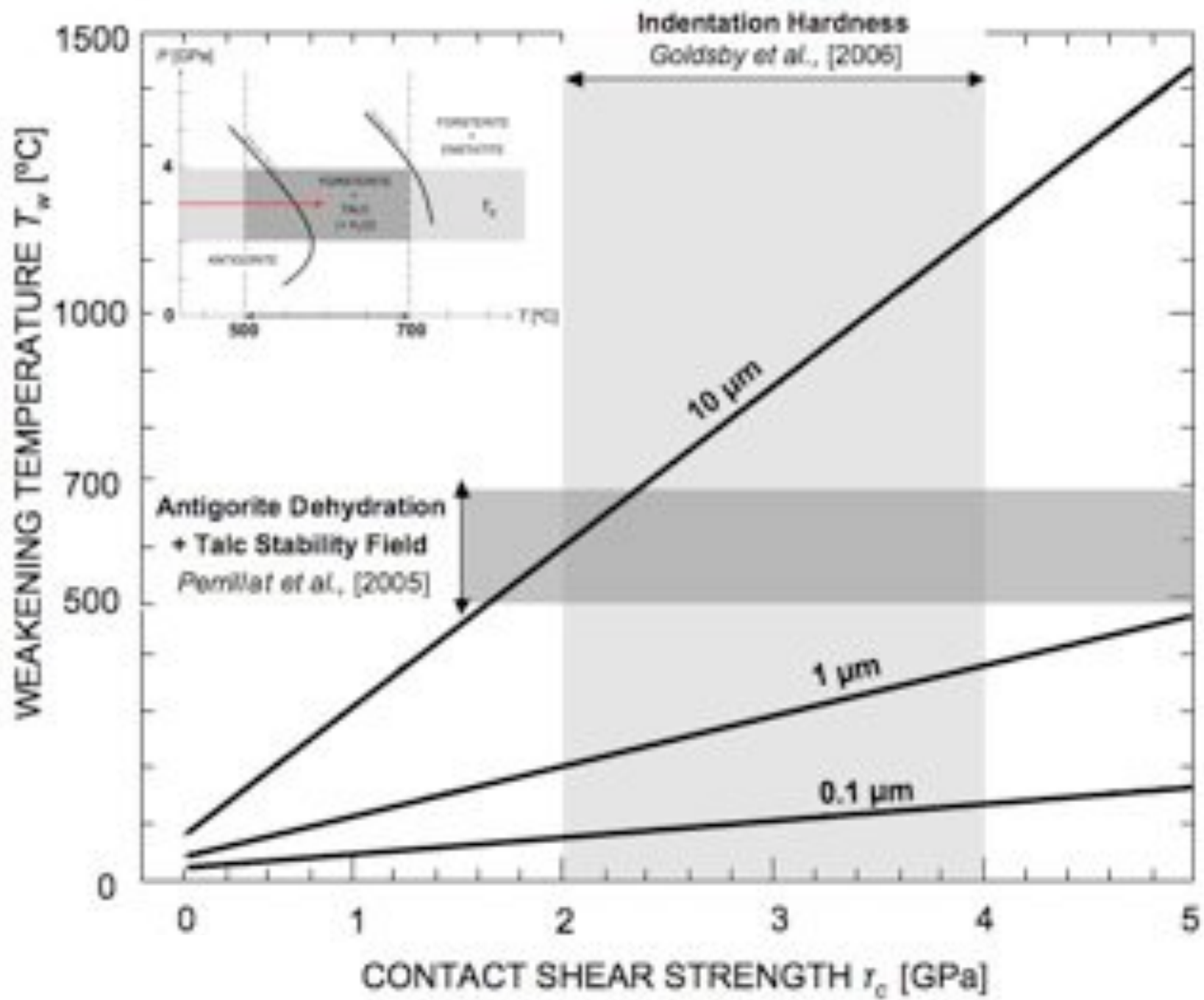
$$\mu(V) = \mu_w + (V_w / V)(\mu_0 - \mu_w) \text{ for } V > V_w$$

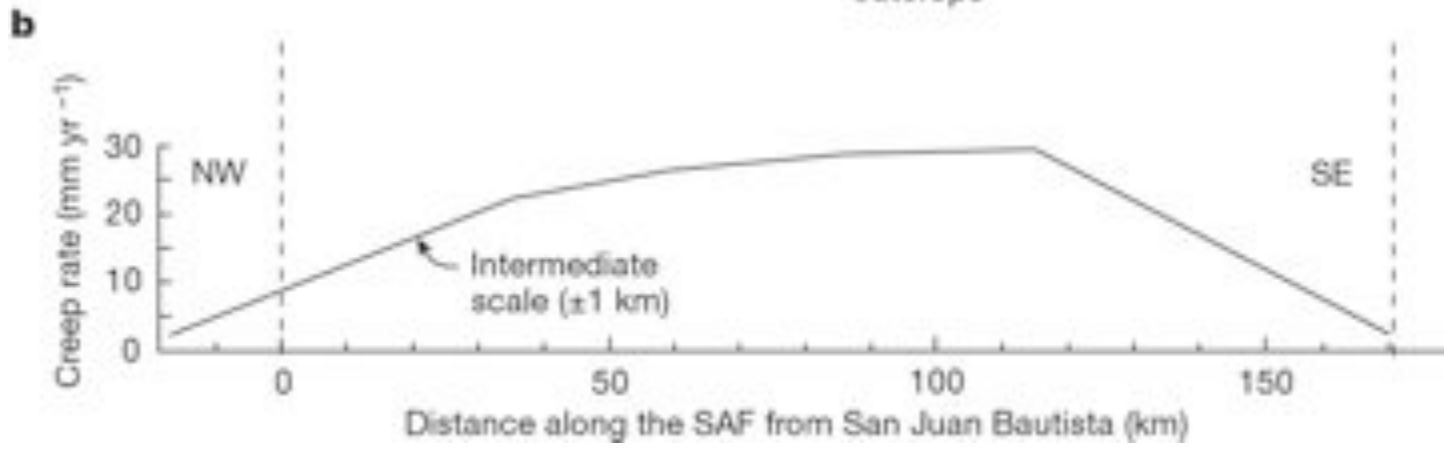
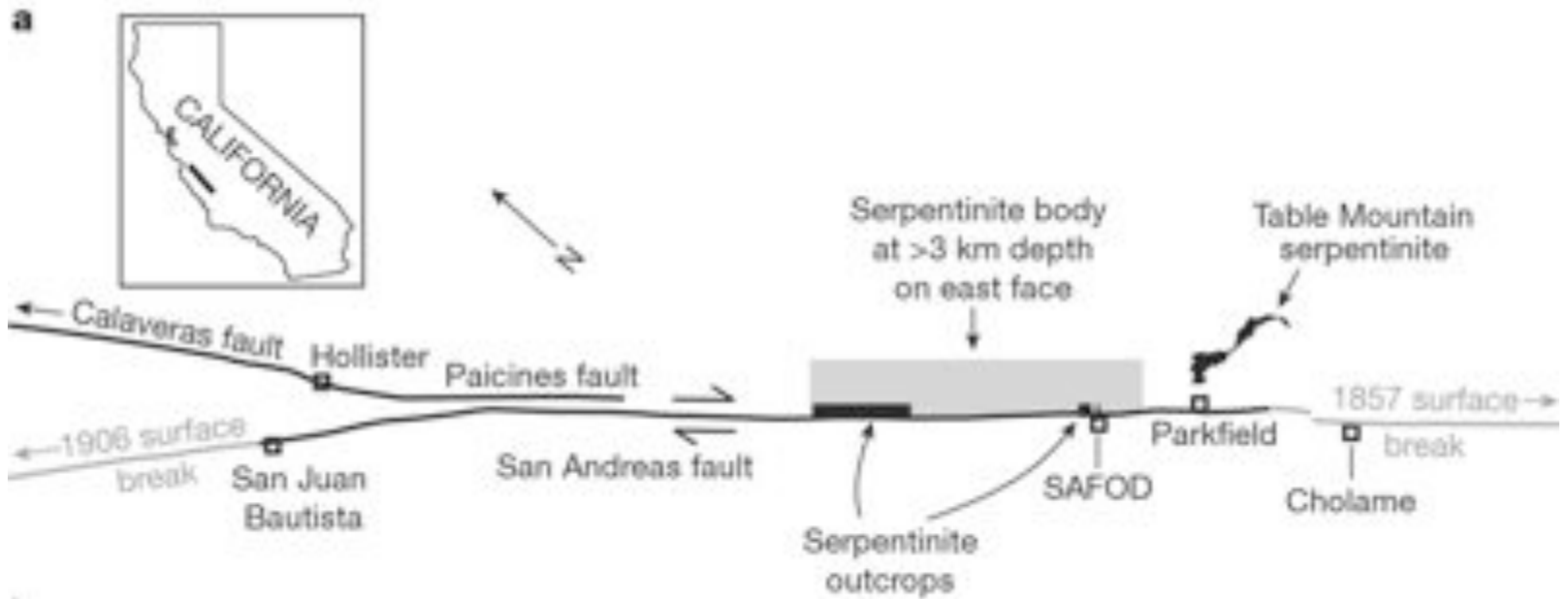
$$V_w = \left(\frac{\pi\alpha}{L} \right) \left[\frac{\rho c (T_w - T_f)}{\tau_c} \right]^2$$



← 10 microns →

Rice, 1999
Rice & Cocco, 2007
Beeler et al., 2008

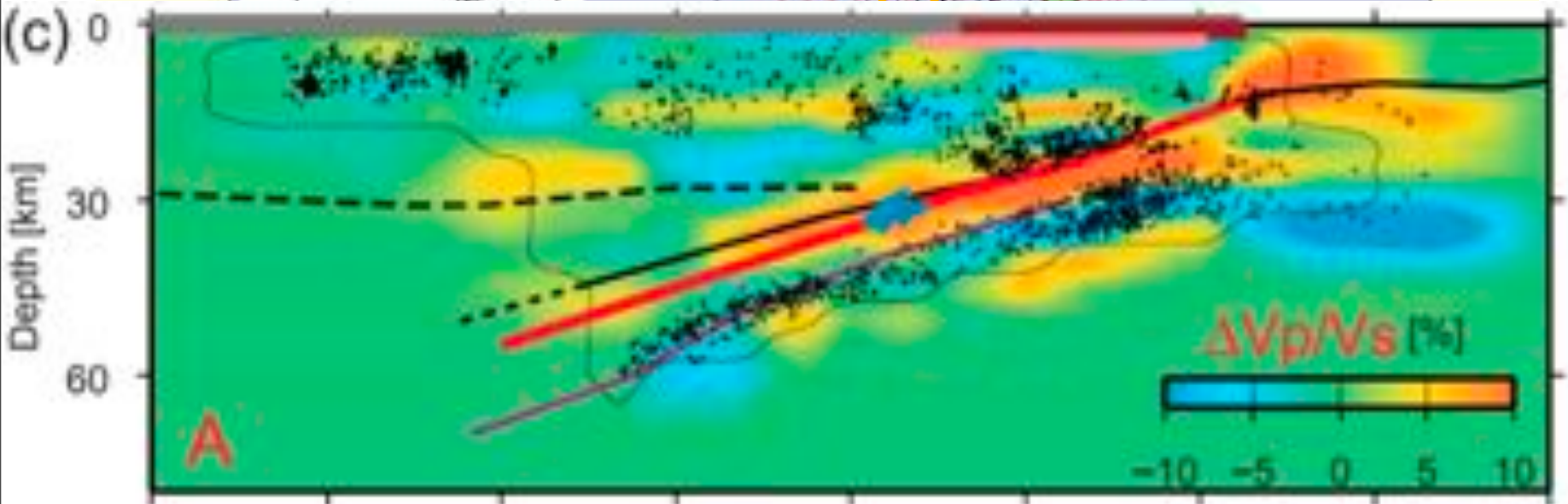
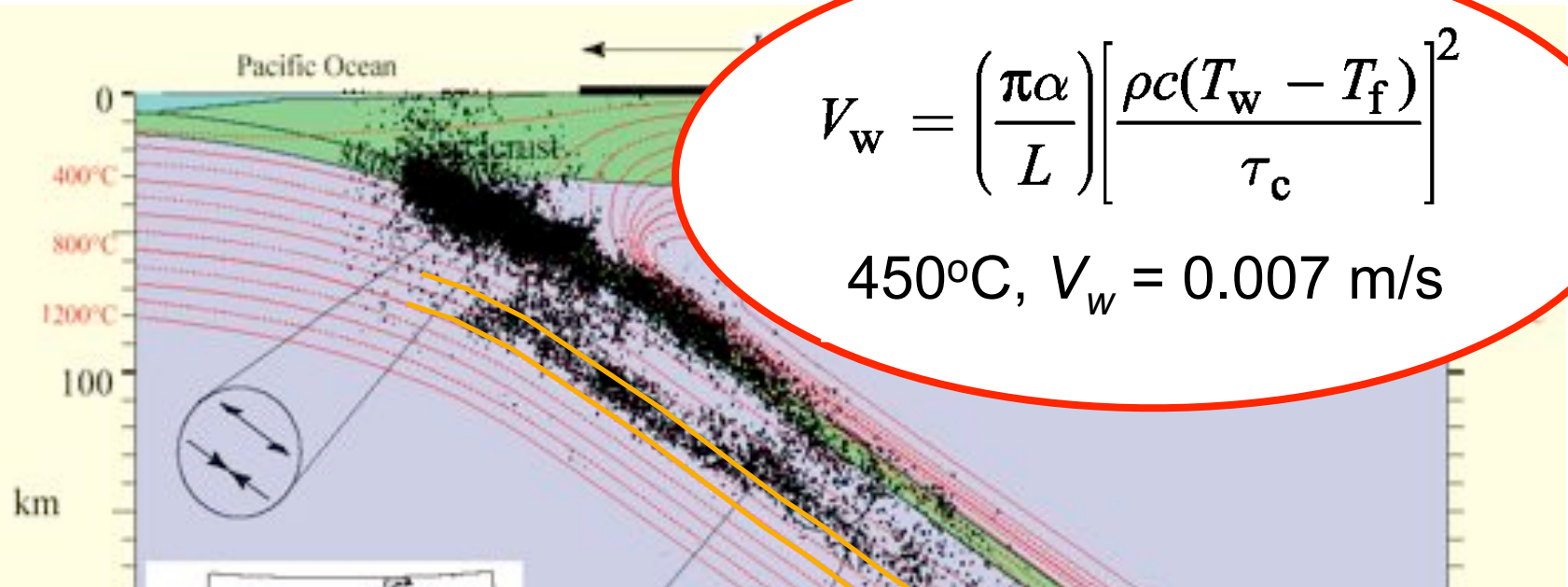




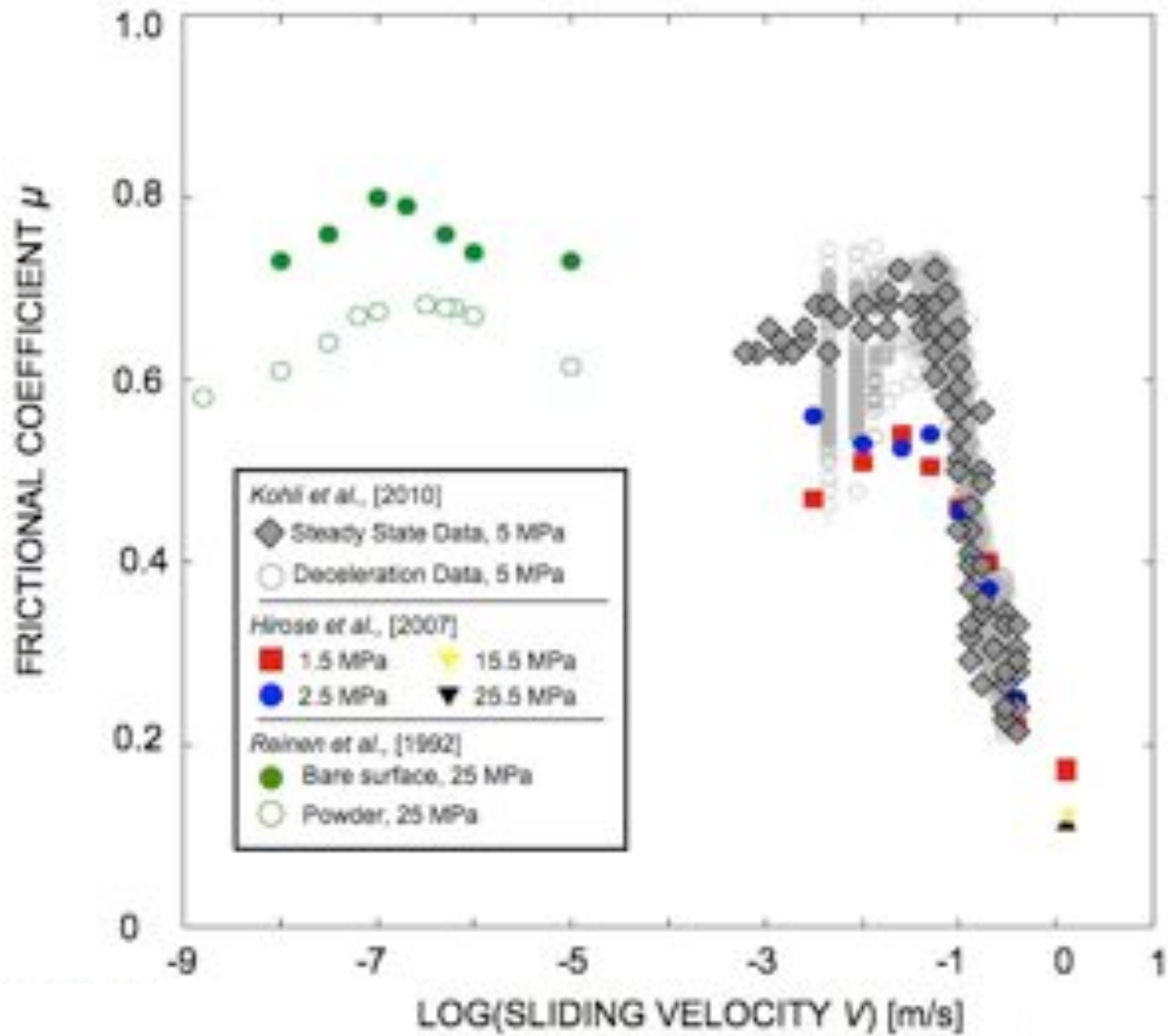
Moore & Rymer, 2007

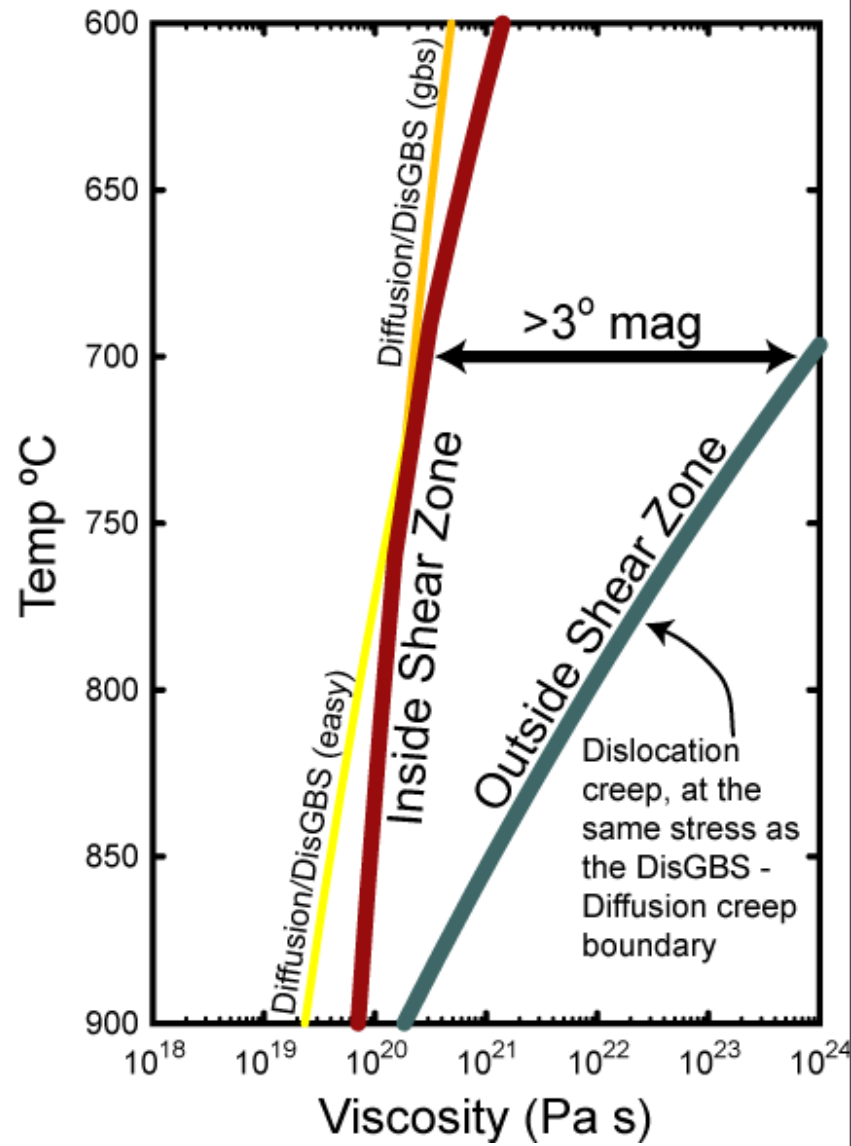
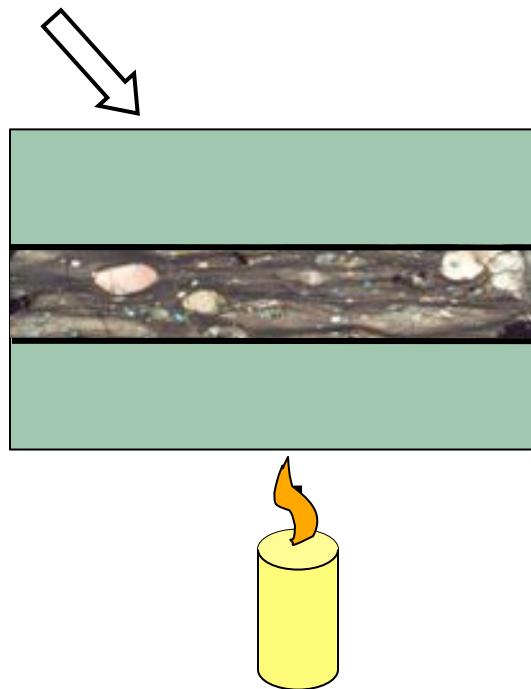
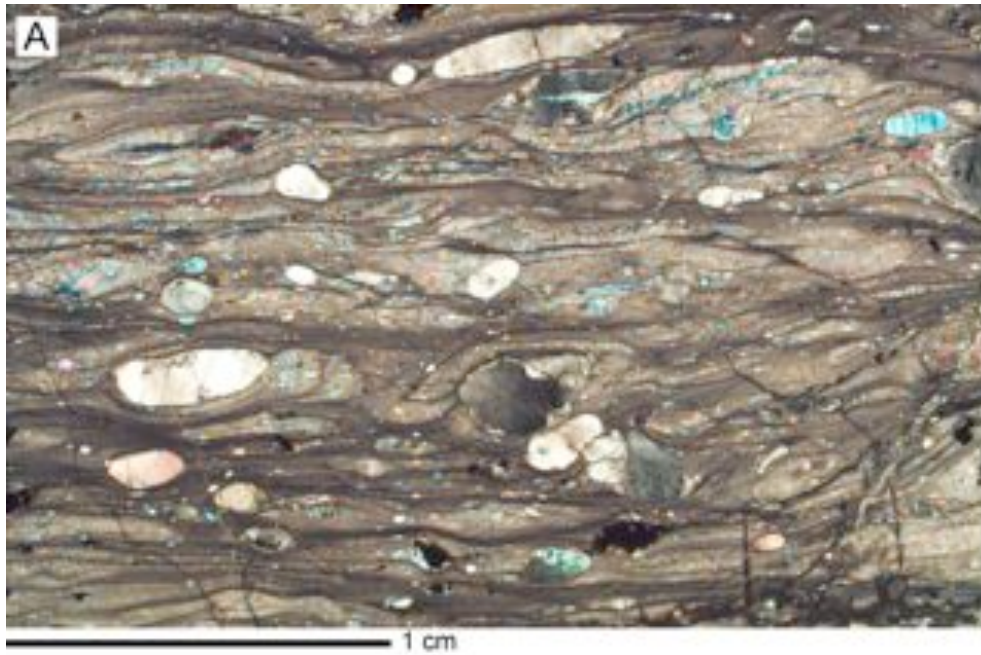
$$V_w = \left(\frac{\pi \alpha}{L} \right) \left[\frac{\rho c (T_w - T_f)}{\tau_c} \right]^2$$

$$450^\circ\text{C}, V_w = 0.007 \text{ m/s}$$

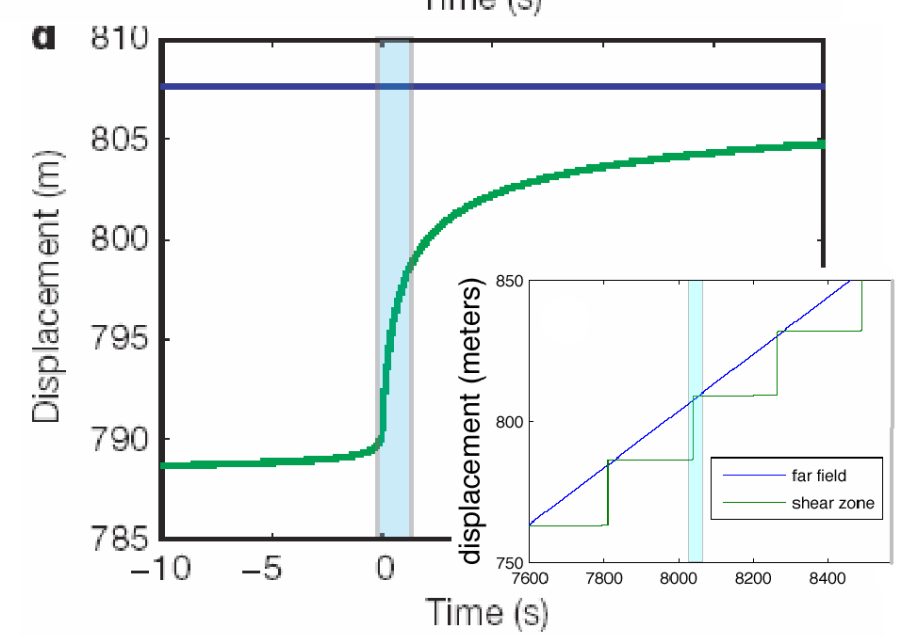
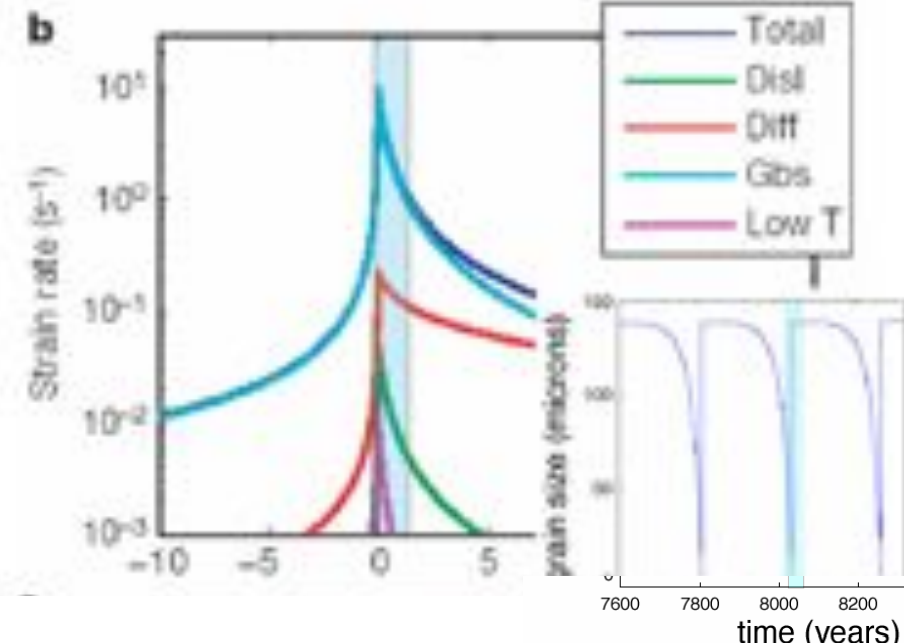
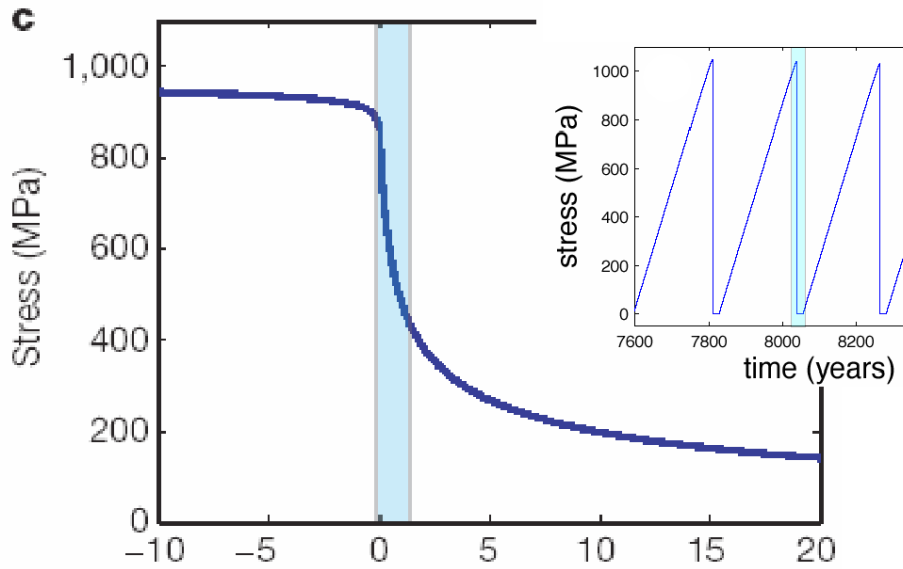
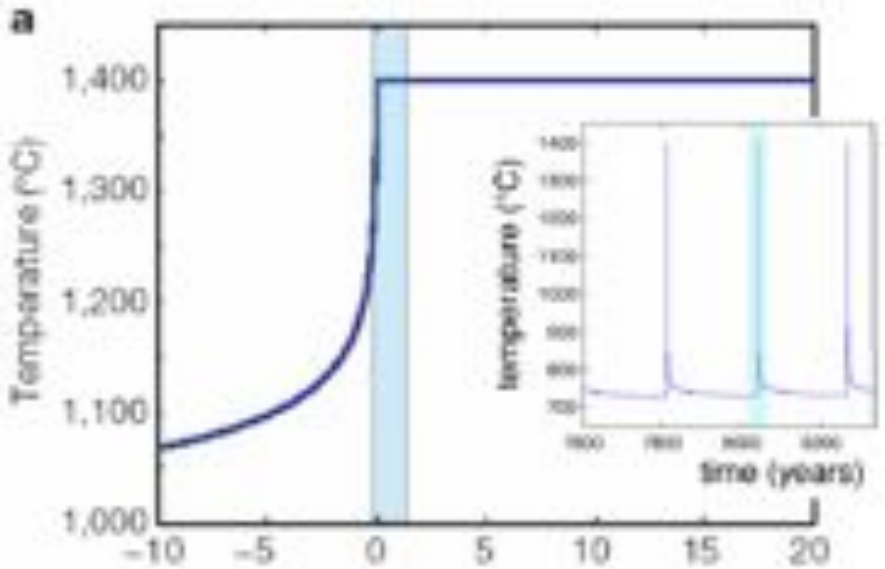


Hirose et al., 2008



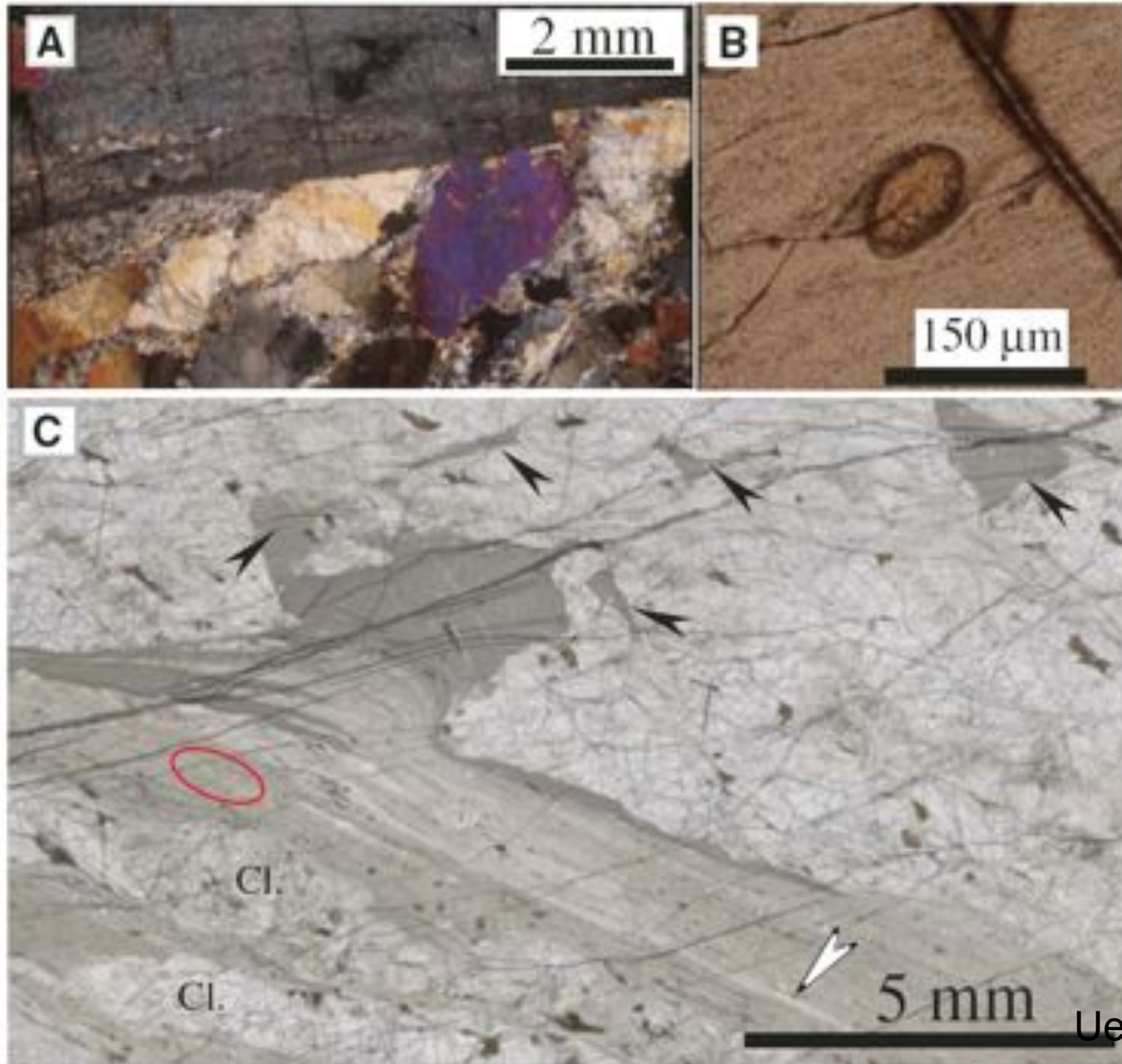


Warren & Hirth, 2006



Kelemen & Hirth, 2007

Pseudotachylytes from Balmuccia peridotite



Ueda et al., 2008

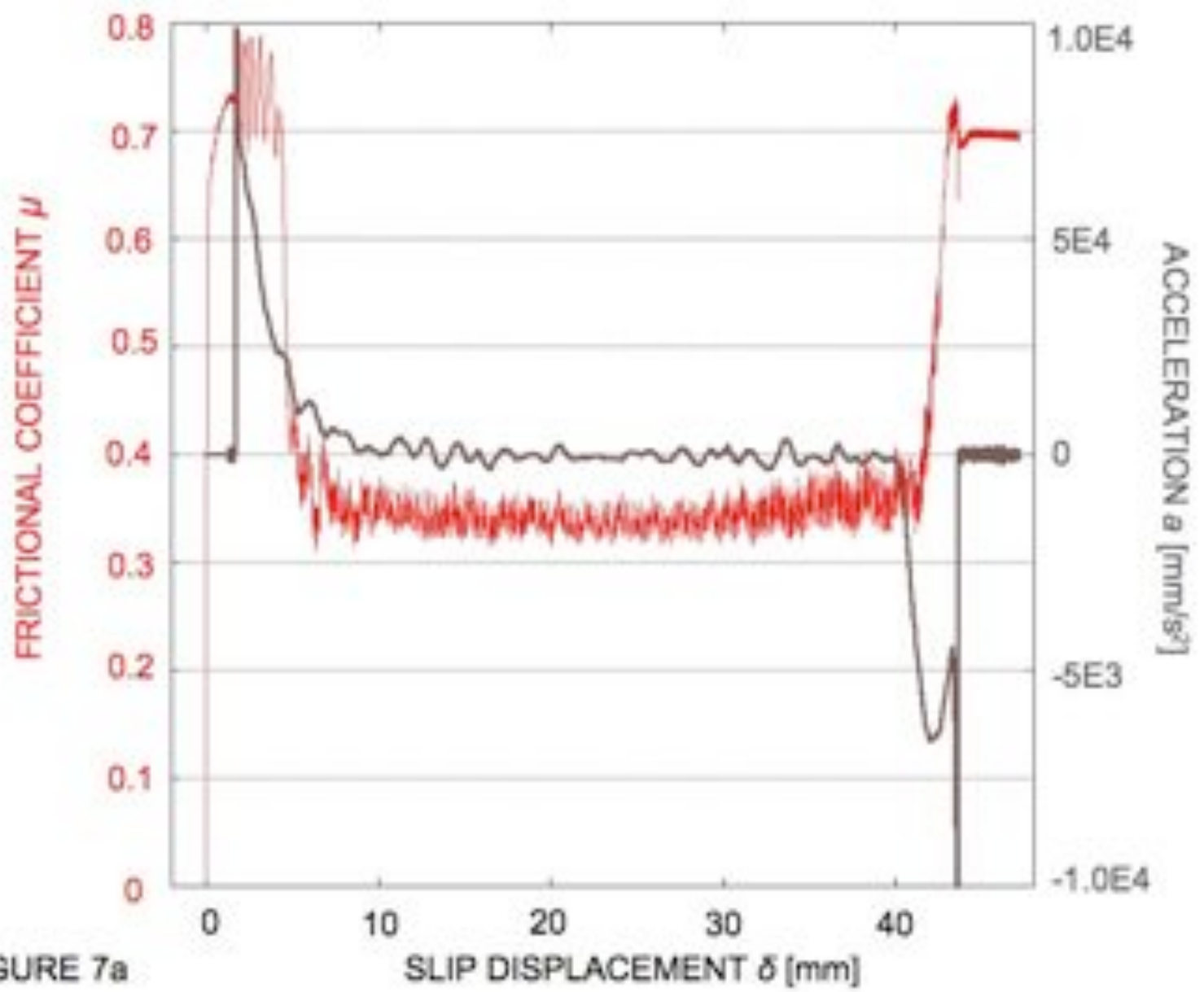
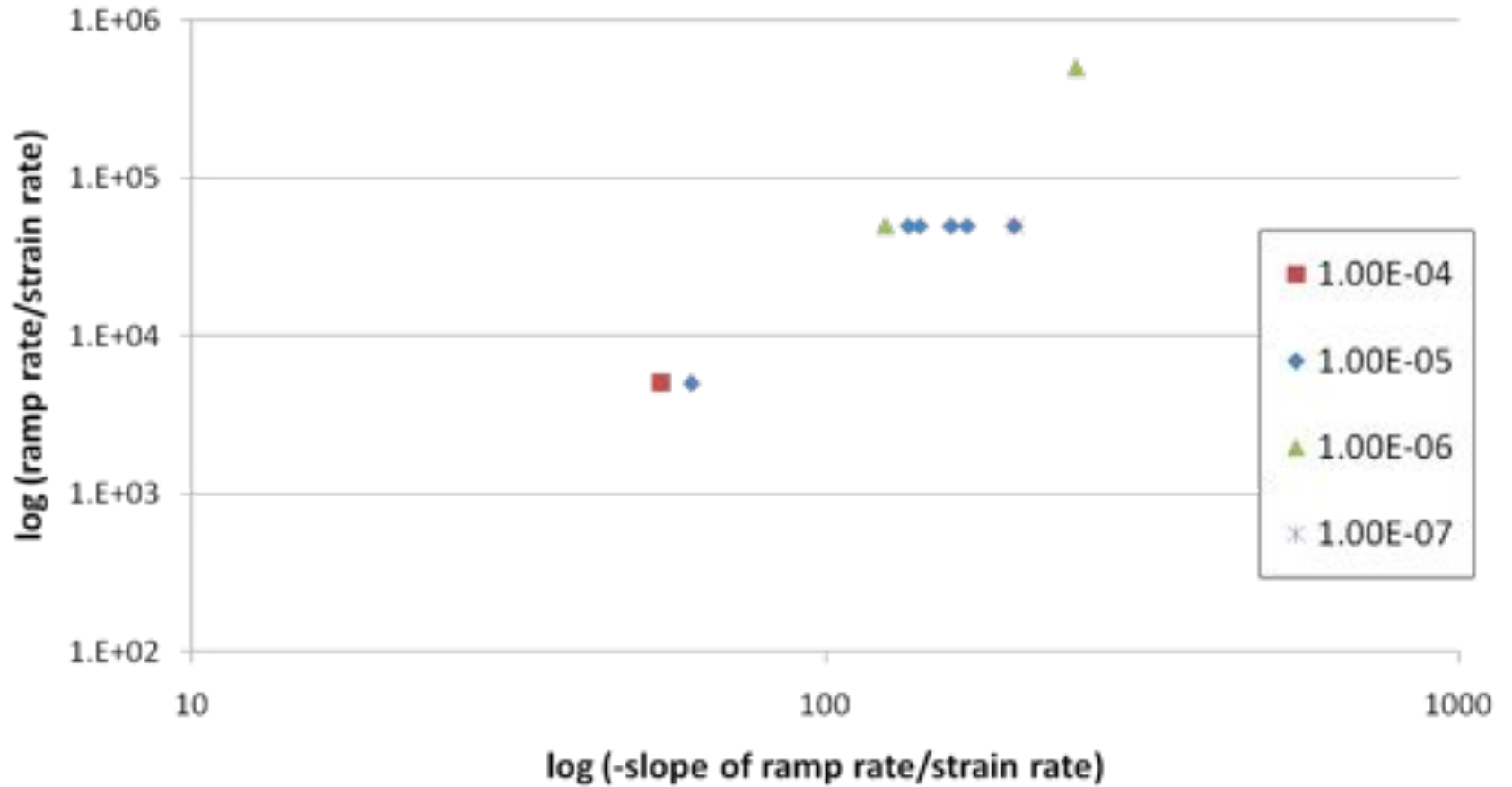
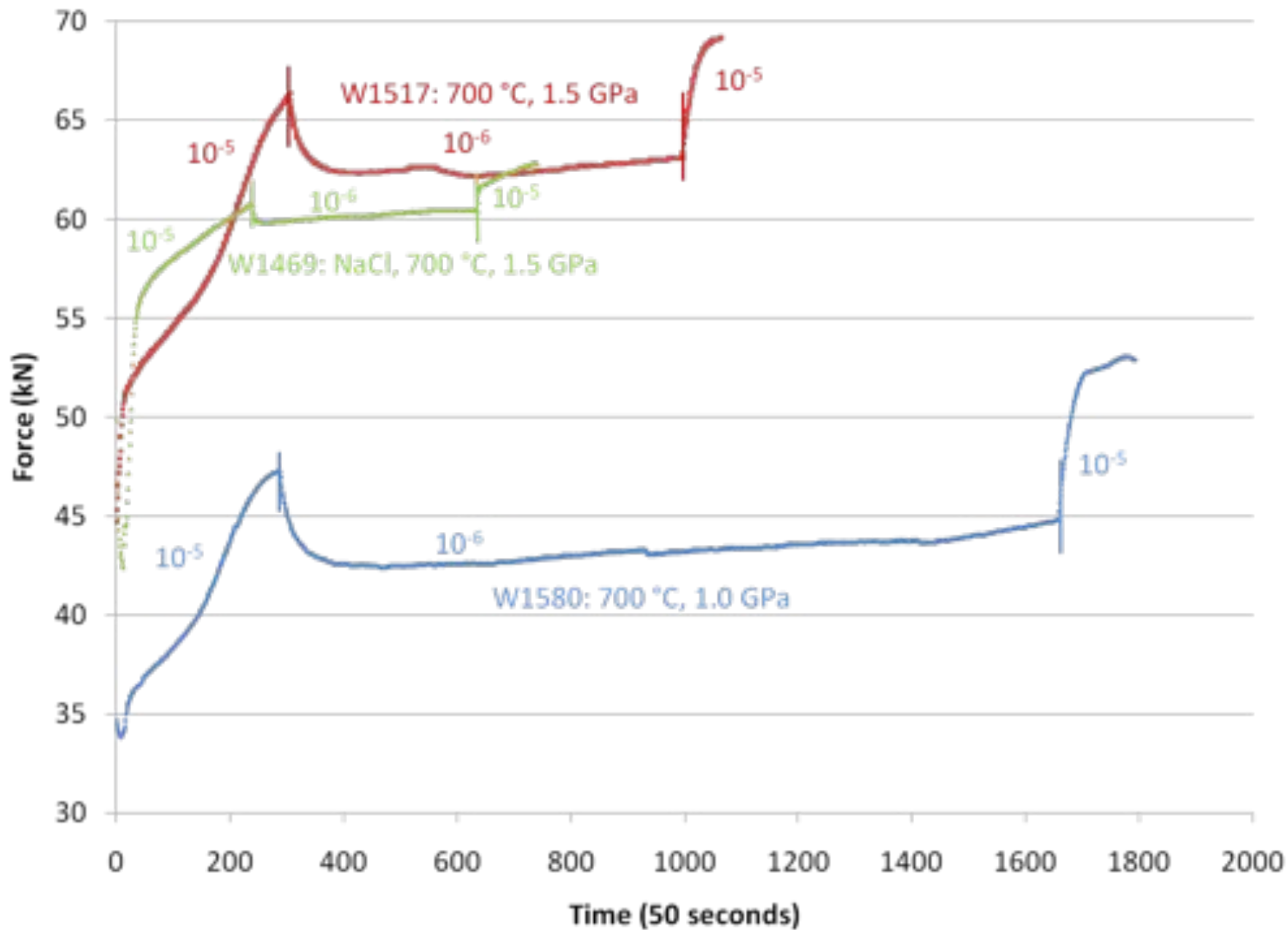


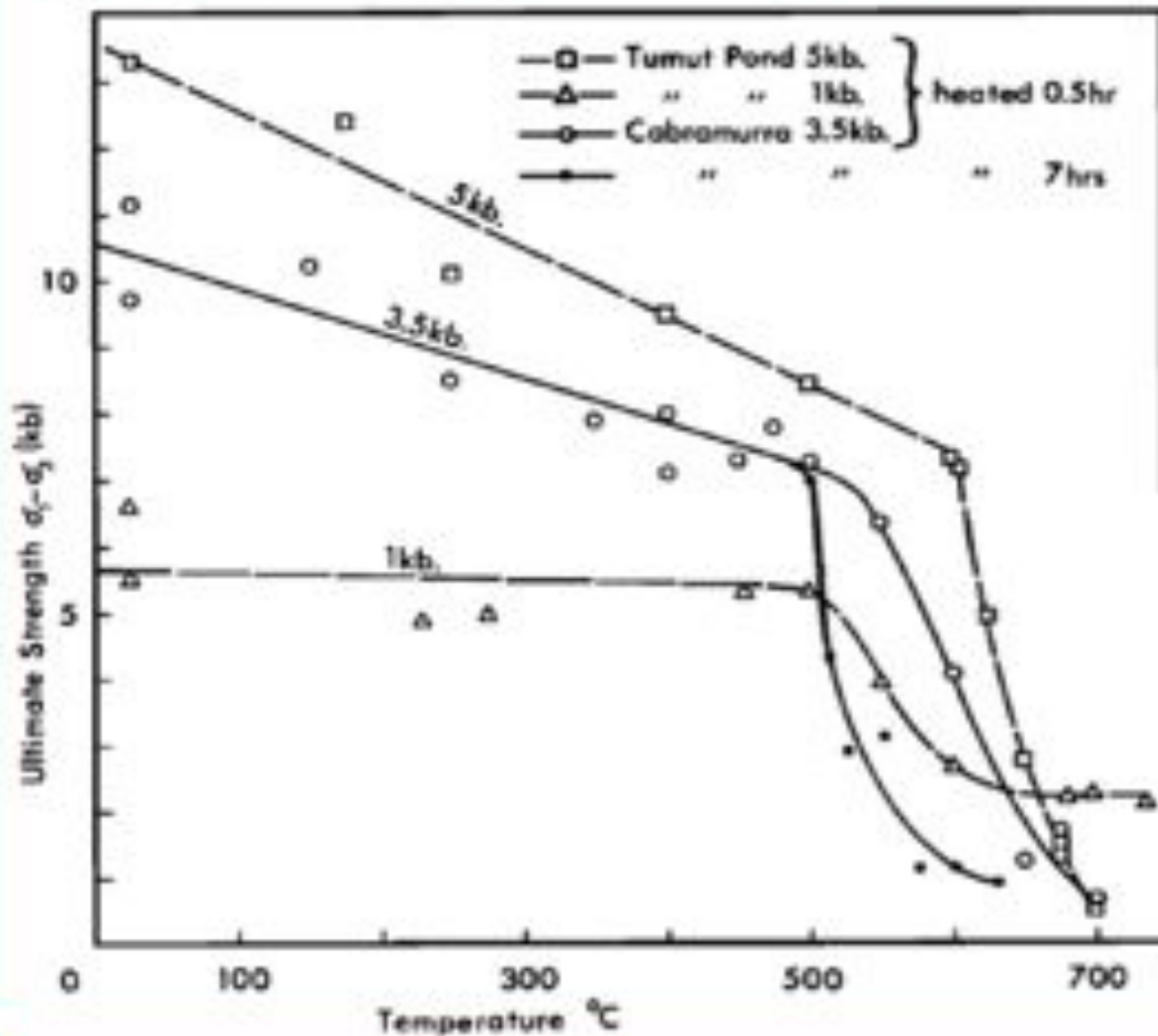
FIGURE 7a

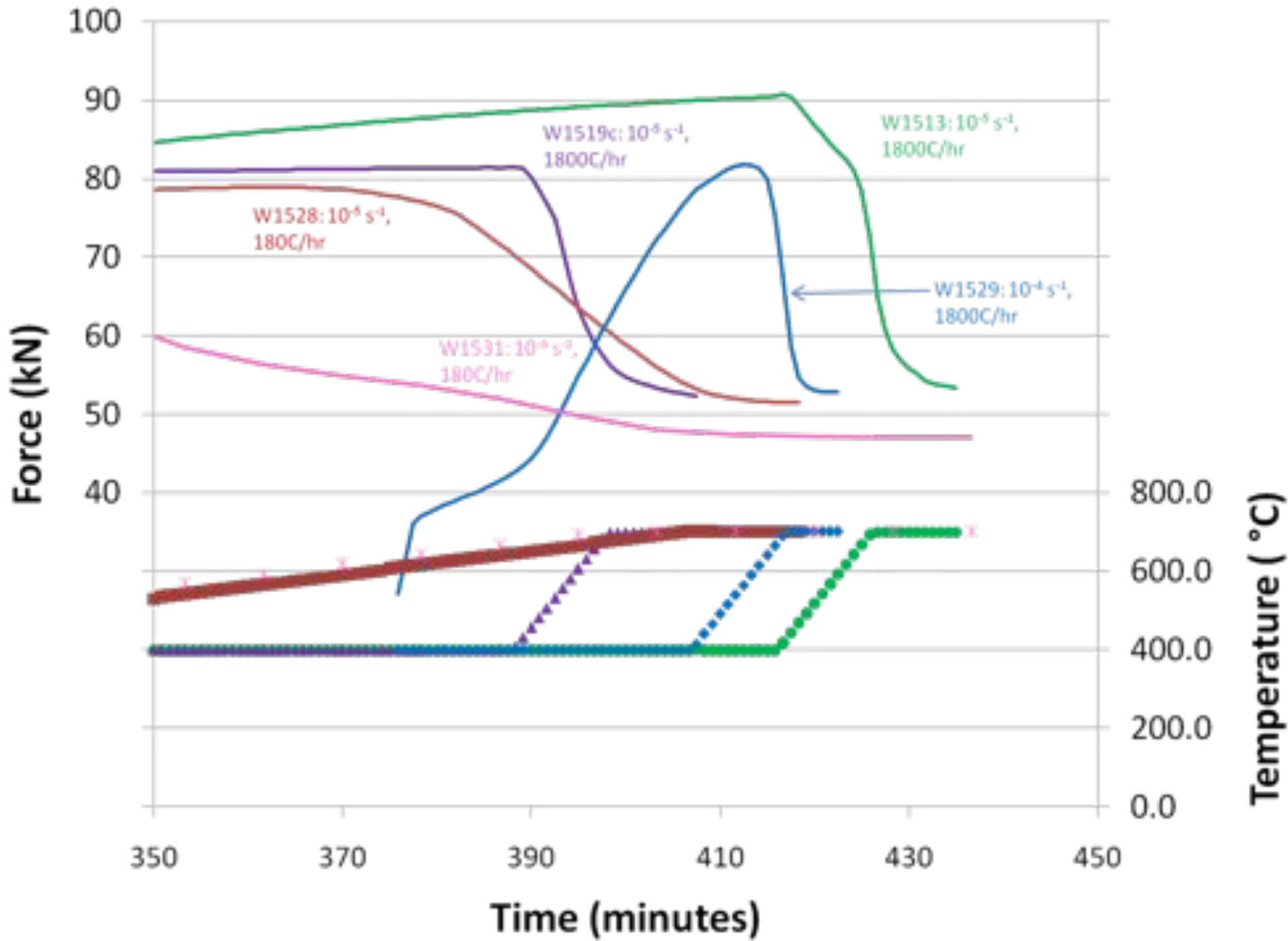
- (ramp rate/strain rate) slope



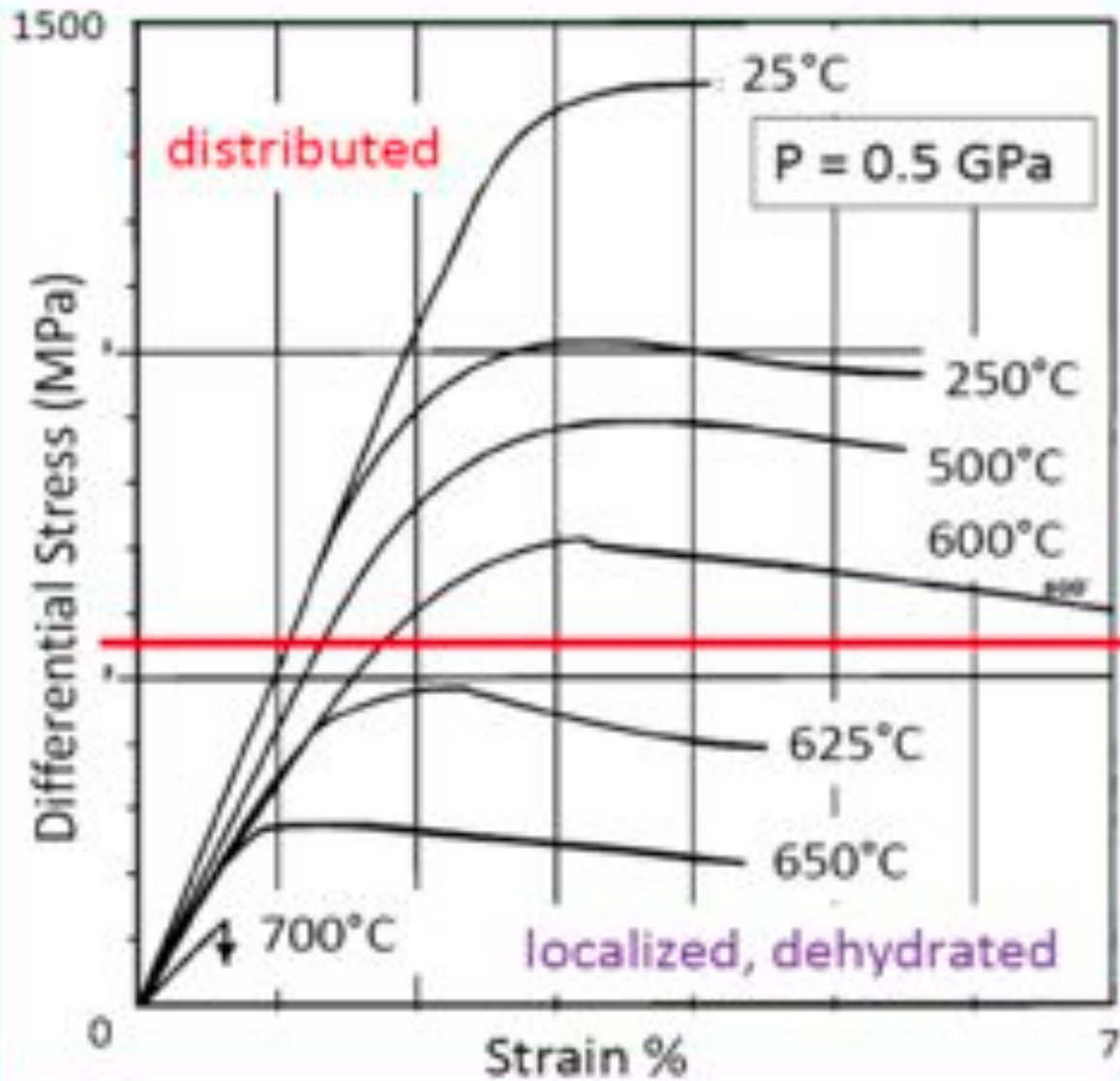


Raleigh and Paterson (1965)

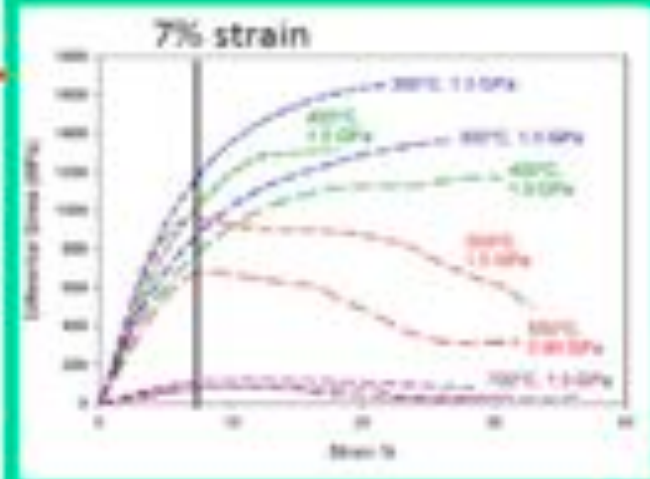




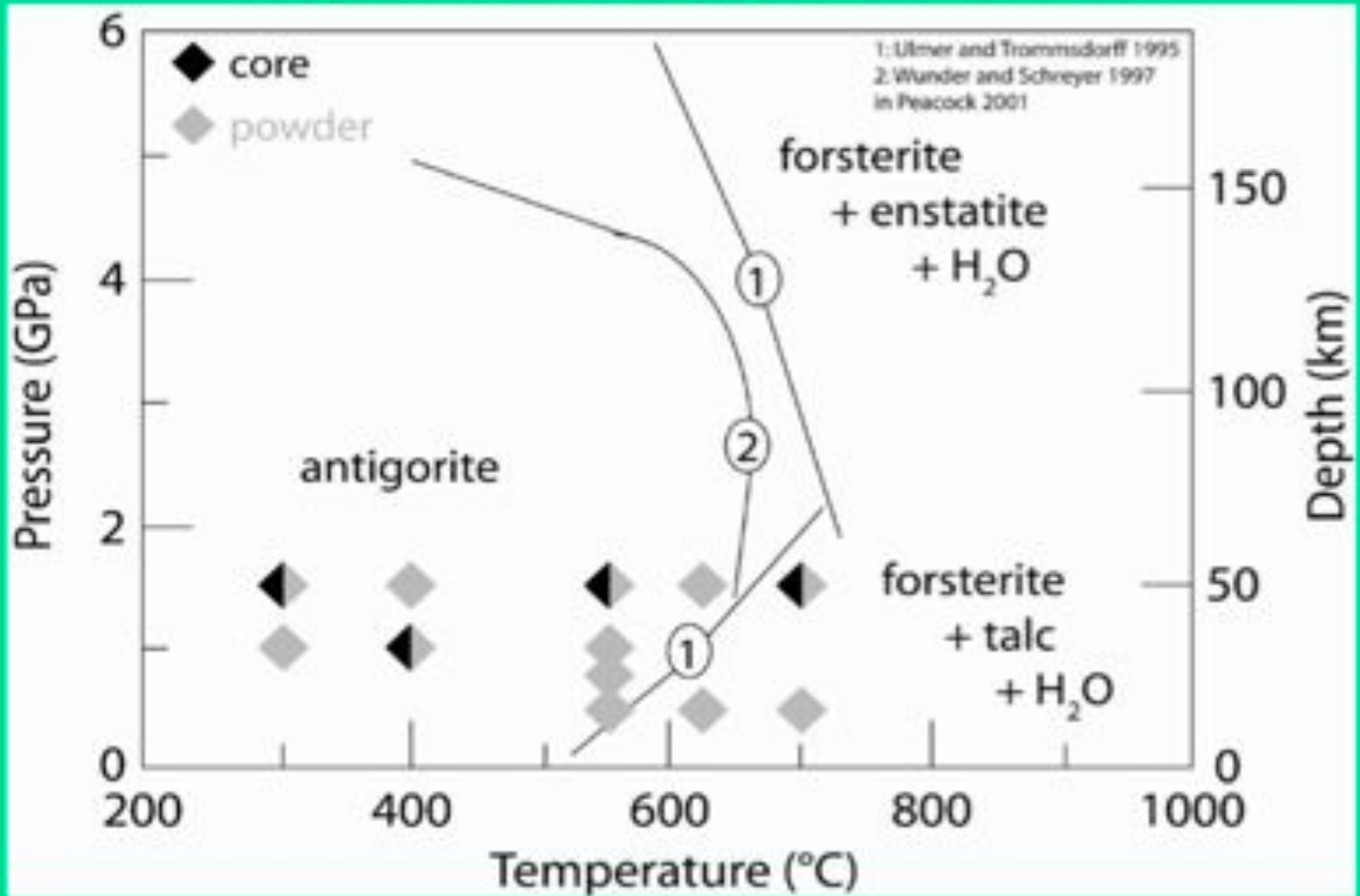
Raleigh and Paterson (1965)



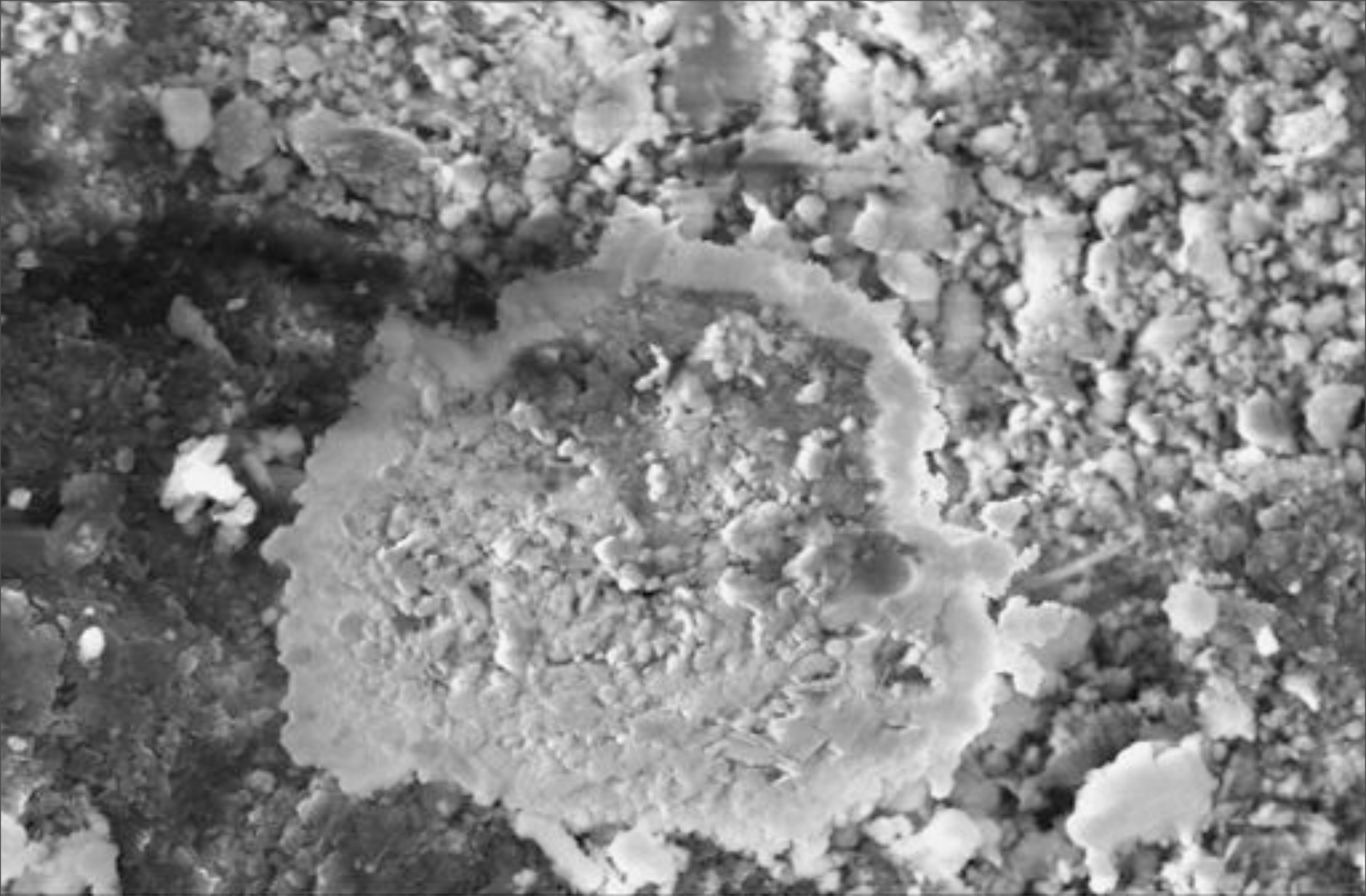
- lower confining P
- faster strain rate:
 $7 \times 10^{-4} \text{ s}^{-1}$
- very low strain



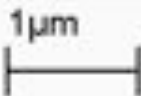
Experimental Conditions



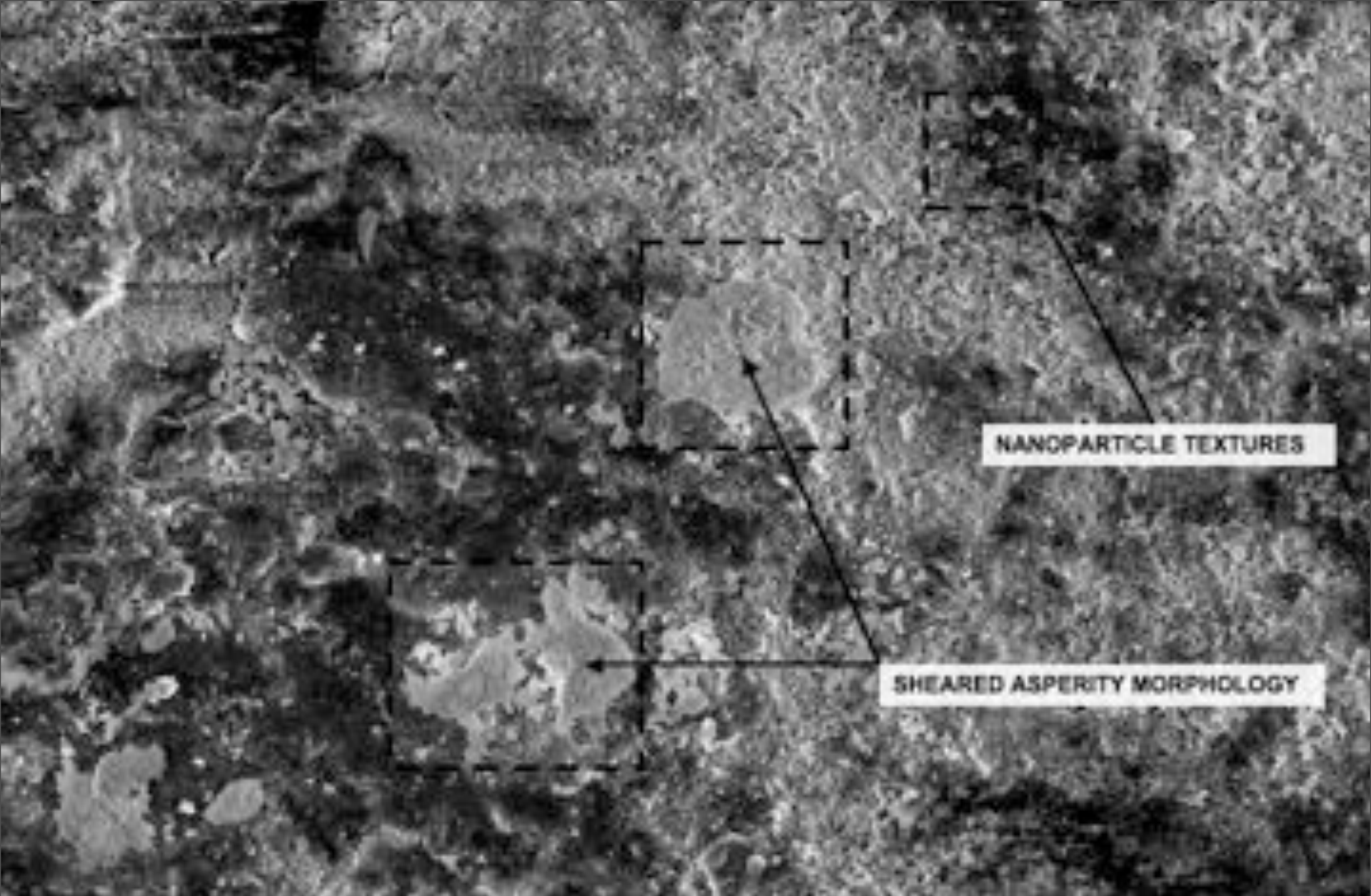
Chernak & Hirth, EPSL 2010



Mag = 18.05 K X



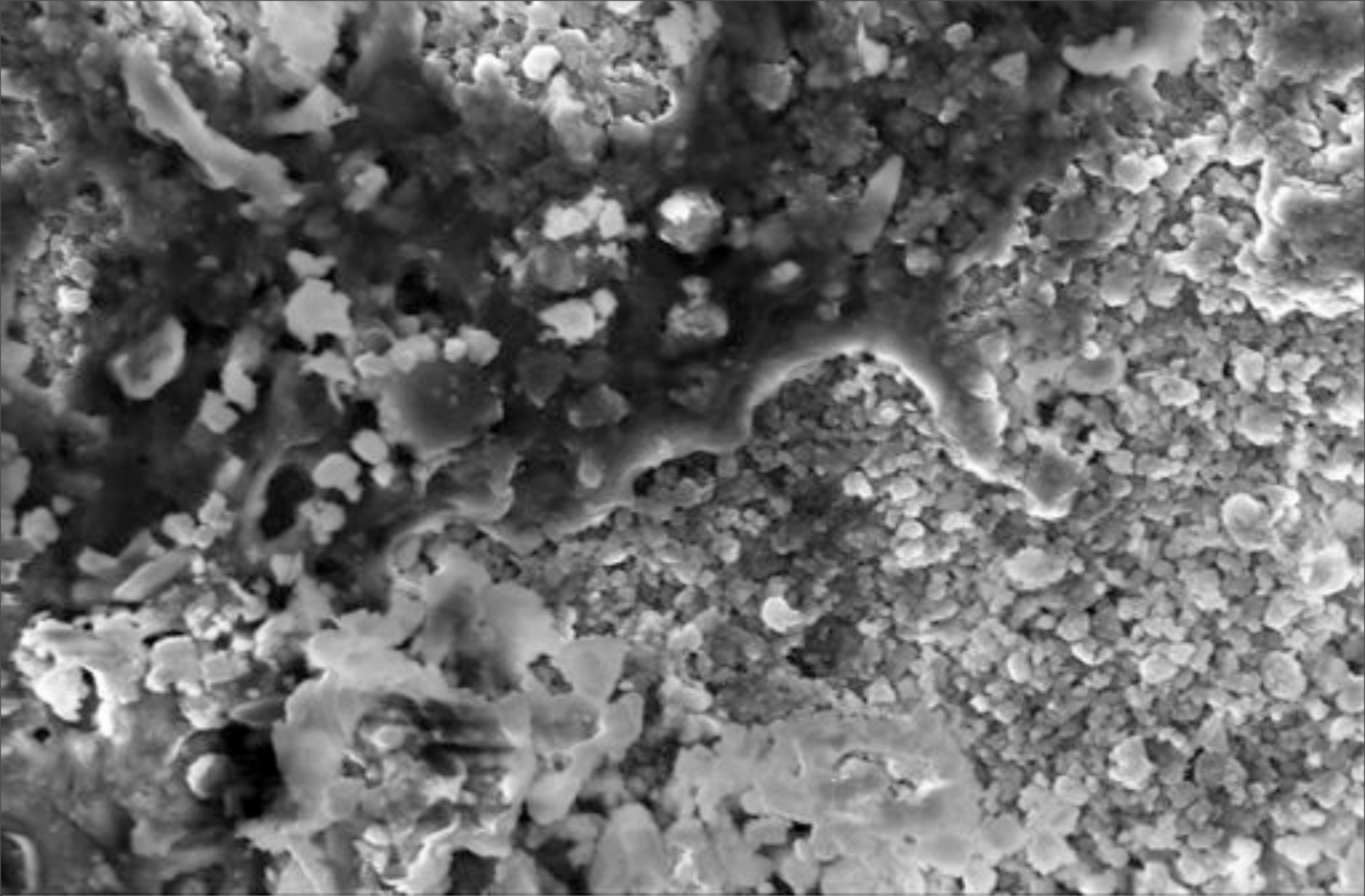
EHT = 8.00 kV
WD = 7 mm



NANOPARTICLE TEXTURES

SHEARED ASPERITY MORPHOLOGY

Mag = 4.04 K X 10µm EHT = 7.00 kV
WD = 7 mm



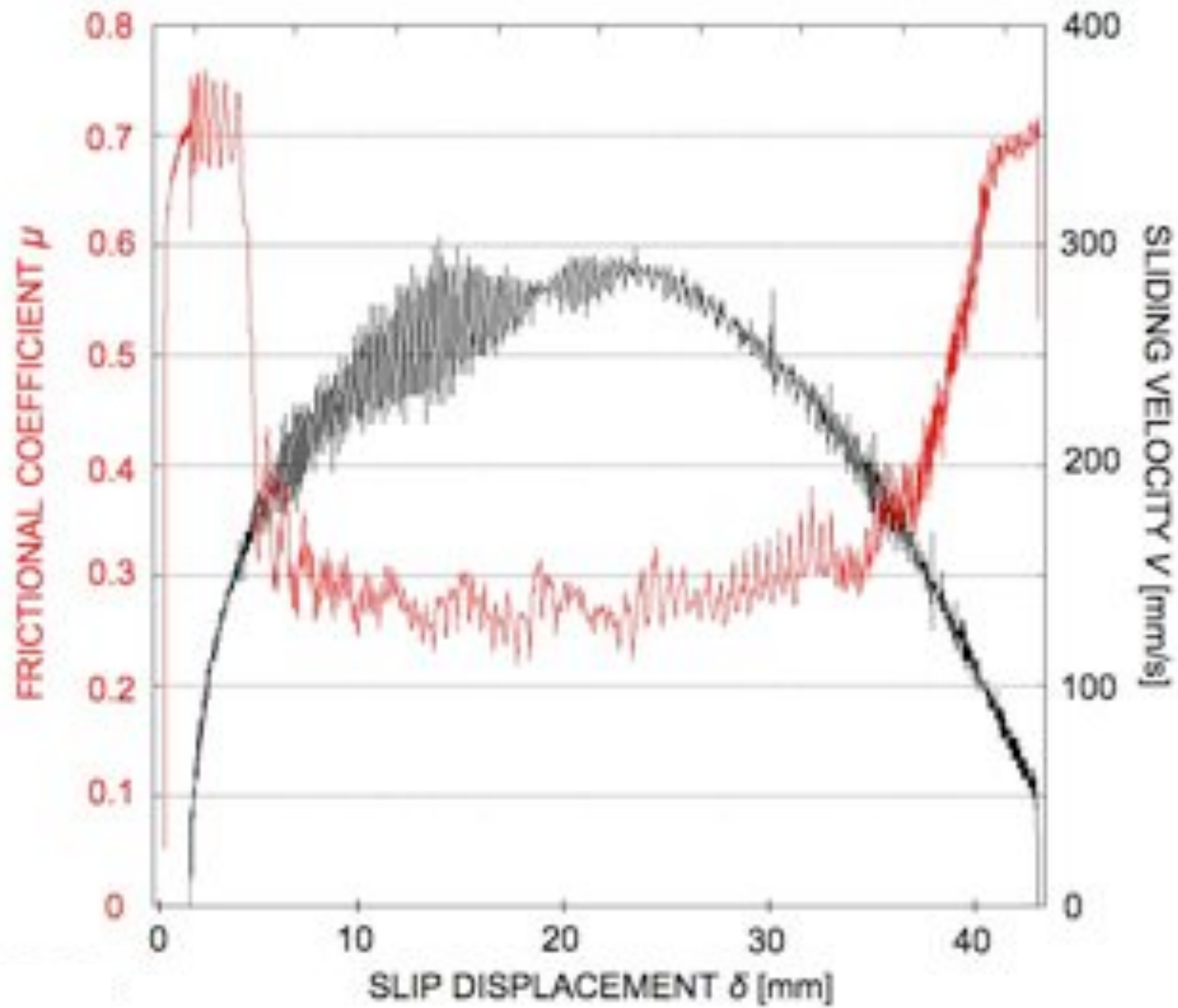
Mag = 25.00 K X

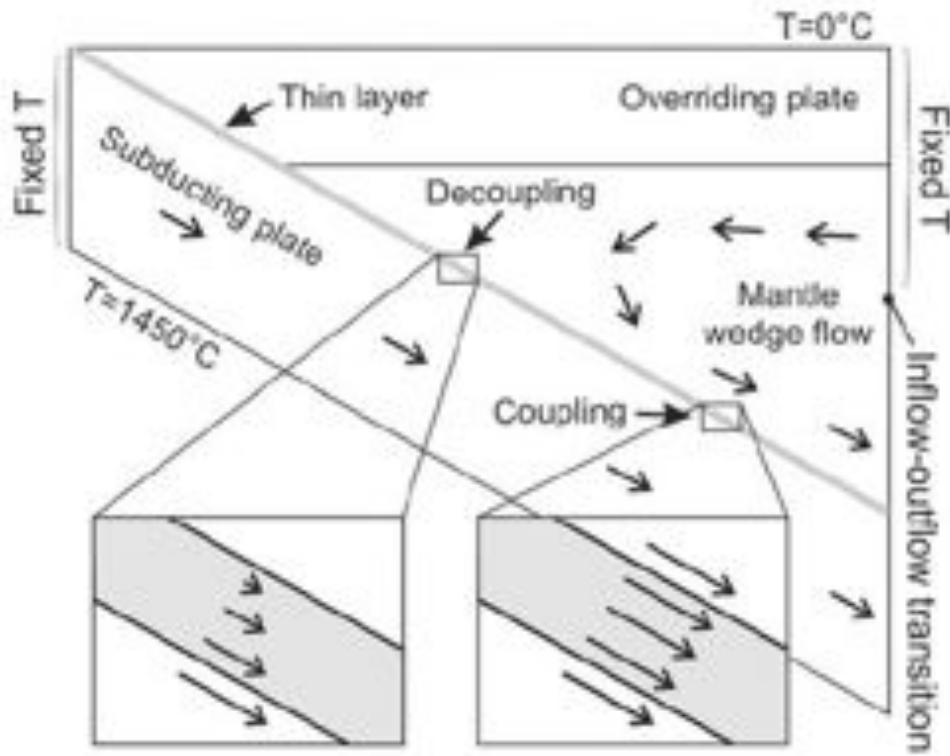
1 μ m



EHT = 5.00 kV

WD = 5 mm





Extrapolation using rate dependence observed for localized zone gives effective viscosity $\sim 10^{17}$ Pa s

Consistent with viscosity required for decoupling in models of Wada et al. (2008)

Wada et al. 2008