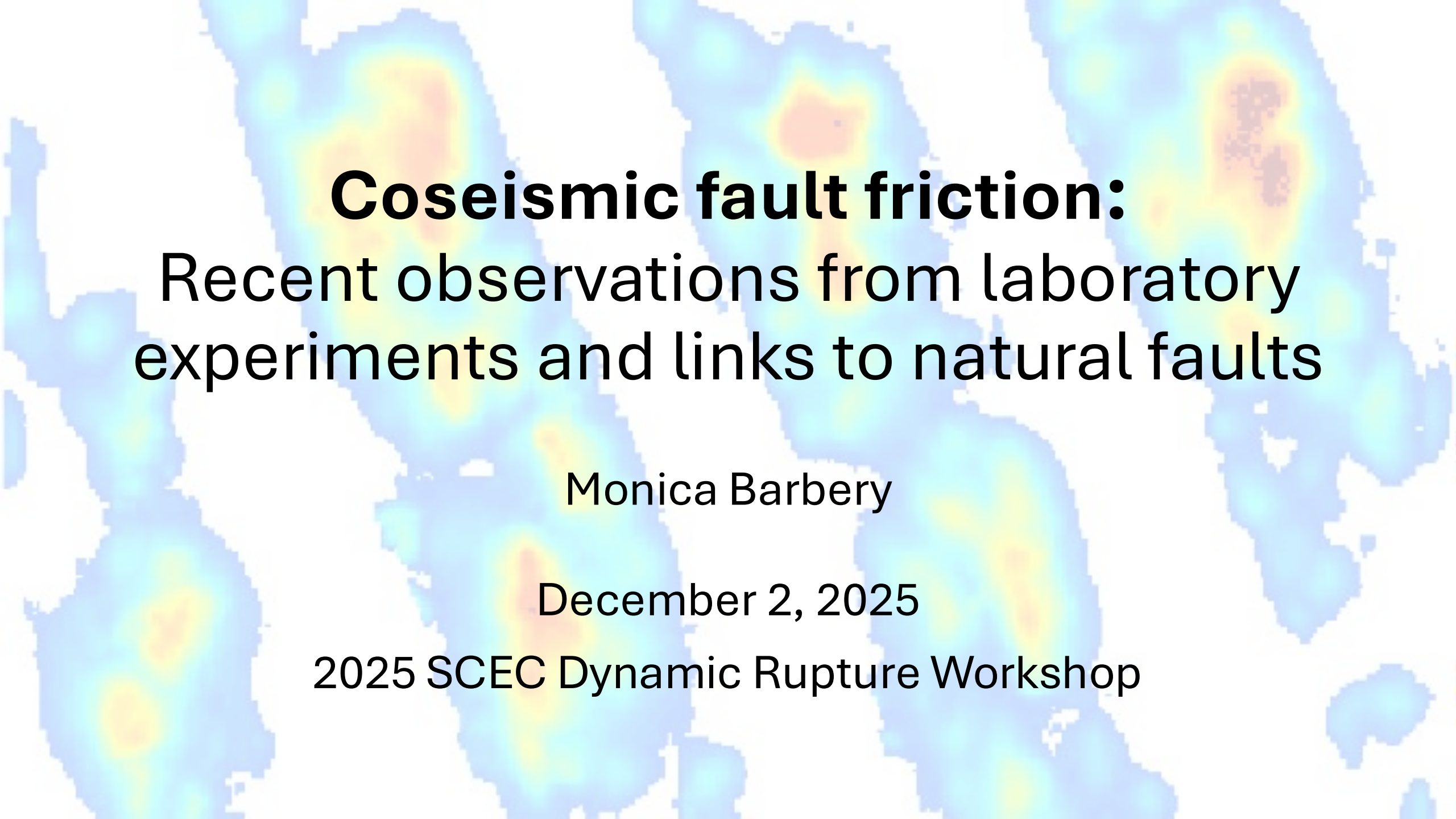




Coseismic fault friction:

Recent observations from laboratory experiments and links to natural faults

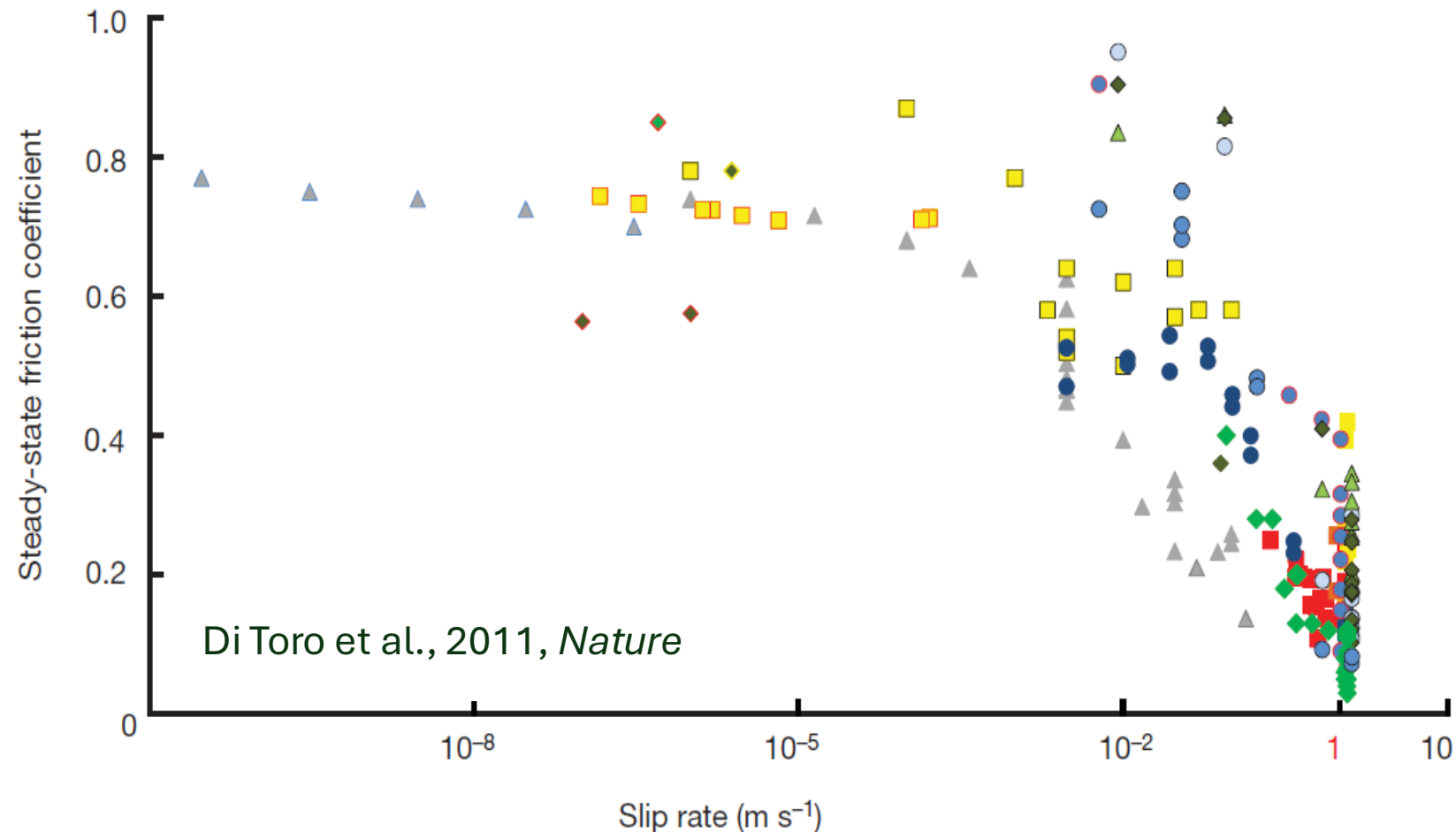
Monica Barbery

December 2, 2025

2025 SCEC Dynamic Rupture Workshop

A non-exhaustive list of proposed dynamic weakening mechanisms

- Thermal pressurization of pore fluids
- Flash heating of asperities
- Viscous flow
- Melt lubrication
- Mineral dehydration
- Mineral decarbonation
- Silica gel lubrication
- Nanoparticle lubrication
- Elastohydrodynamic lubrication



Thermal Pressurization



Flash Heating



Viscous Flow



Melt Lubrication

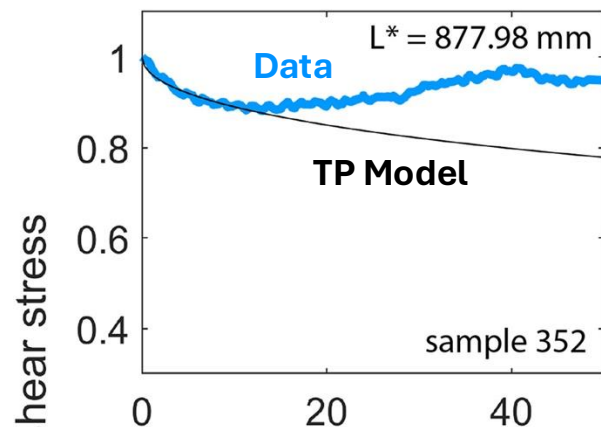


Links to Natural Faults

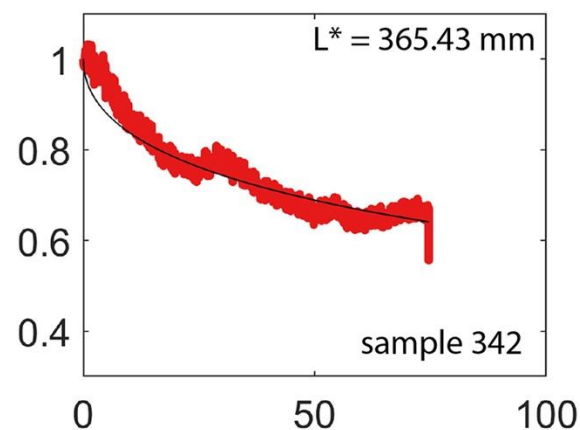
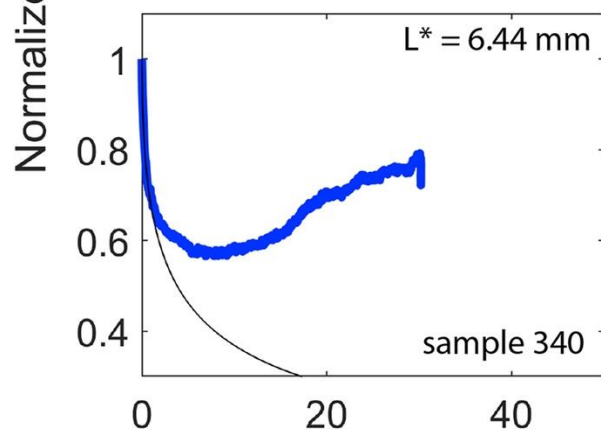
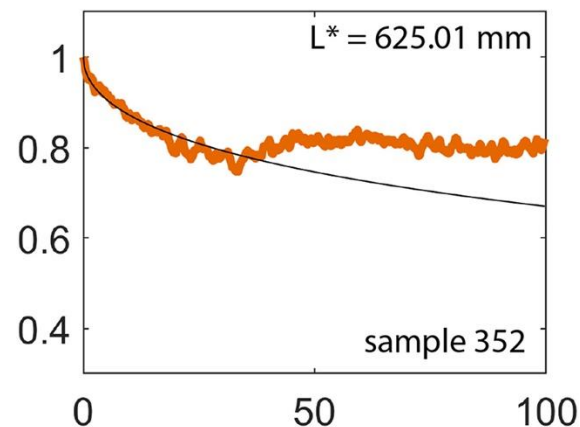


Experiments on diabase

Low Displacement Faults



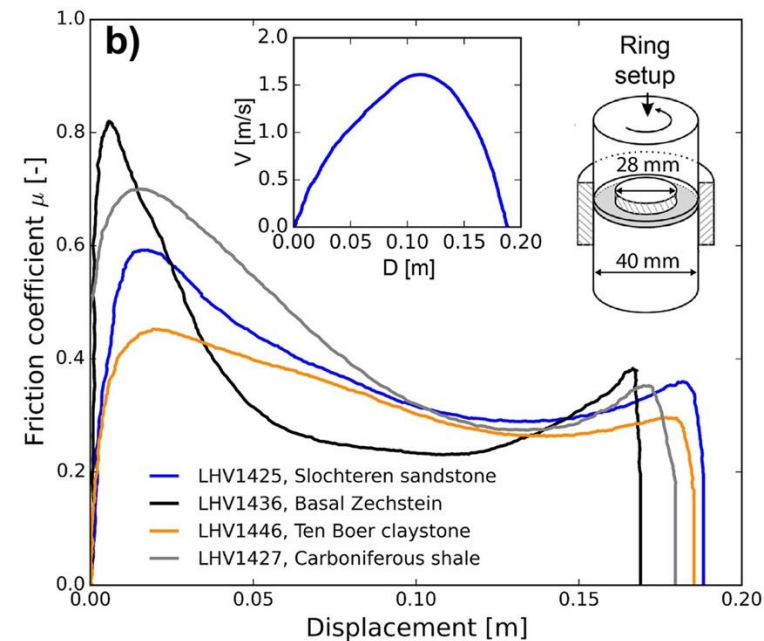
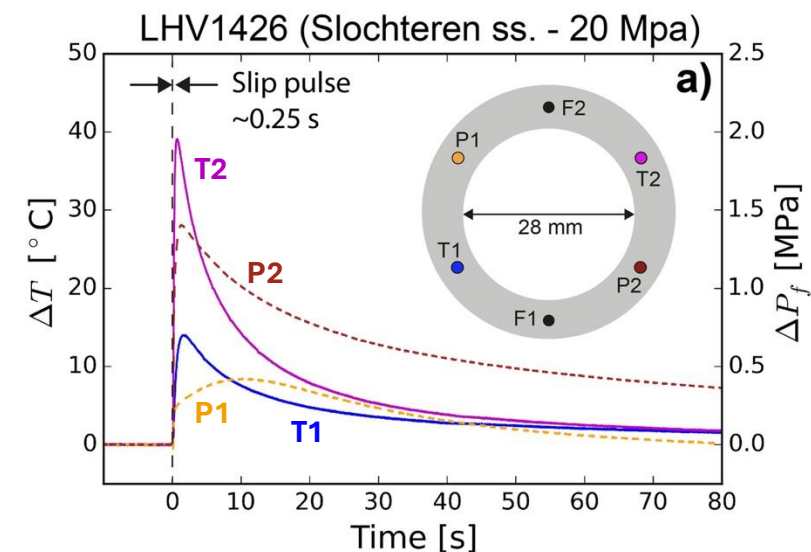
High Displacement Faults



Displacement [mm]

Badt et al., 2020, *JGR*

Experiments on sandstone

Hunfeld et al.,
2021, *GRL*

Thermal Pressurization



Flash Heating



Viscous Flow



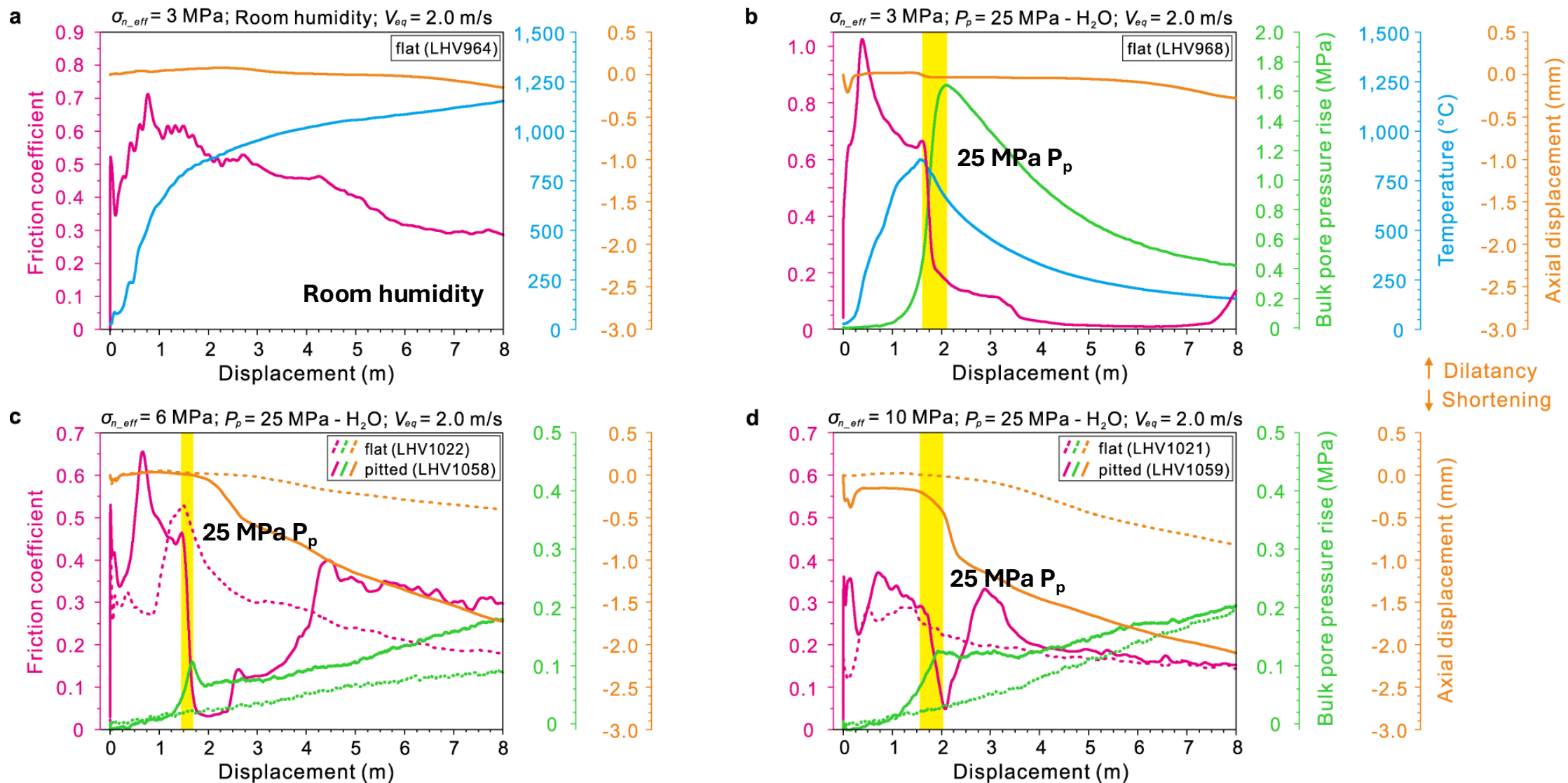
Melt Lubrication



Links to Natural Faults



Experiments on diabase



Thermal Pressurization



Flash Heating



Viscous Flow



Melt Lubrication



Links to Natural Faults



Experiments on diabase

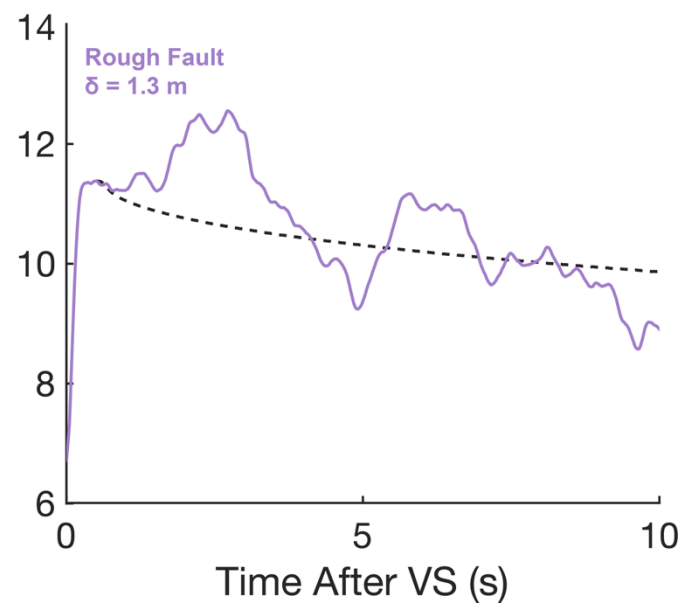
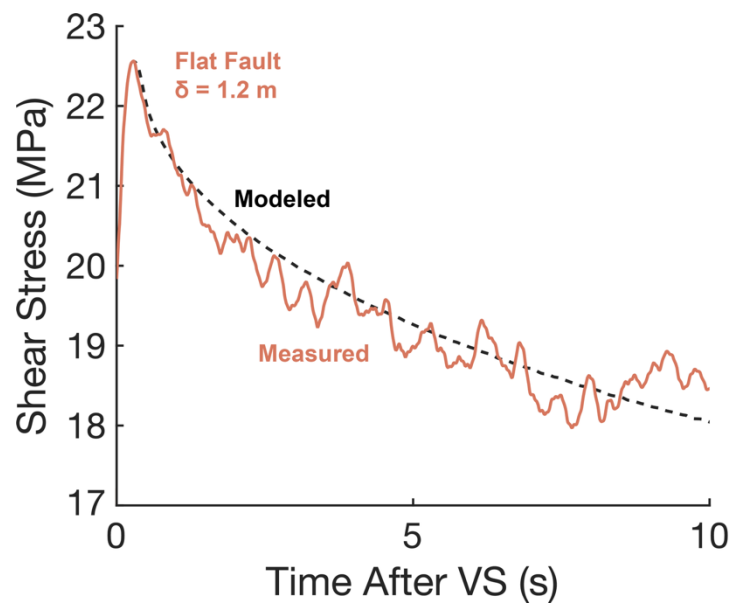
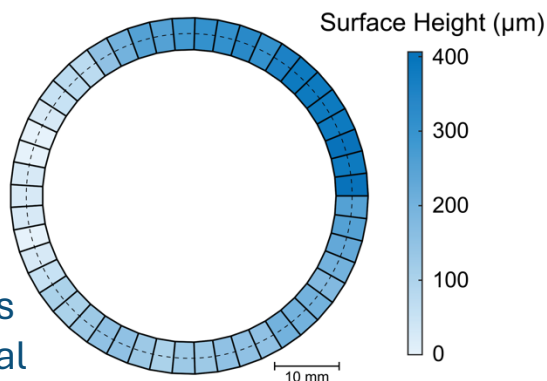
Flat & rough faults

45 MPa σ_n

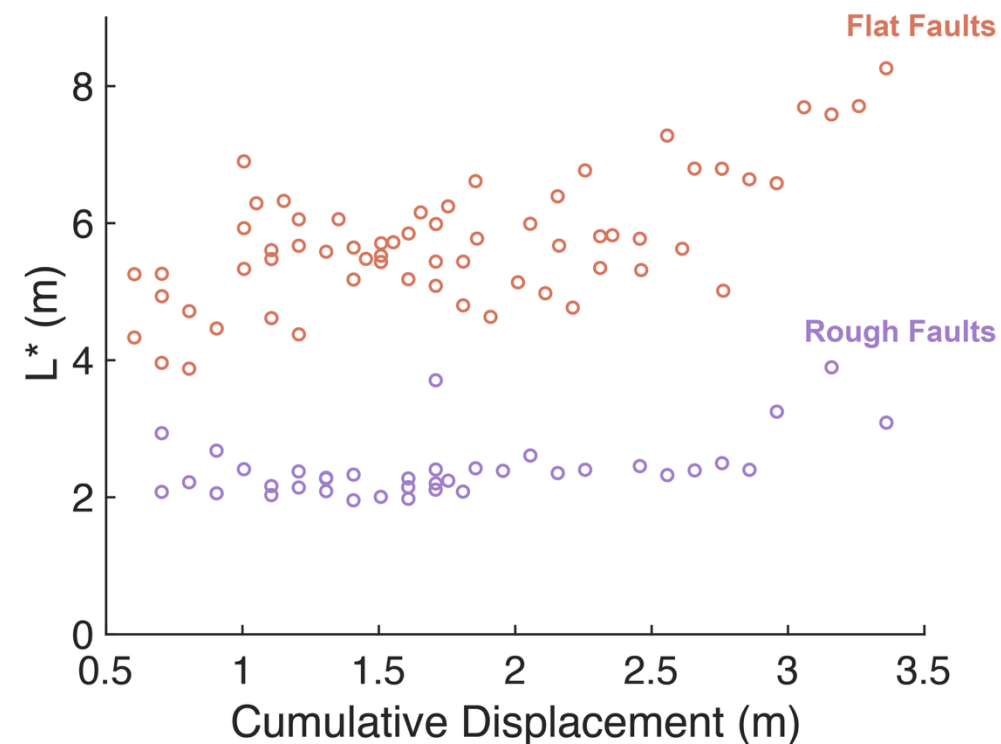
25 MPa P_p

10 mm/s

Roughness mimics
lower end of natural
fault roughness



Barbery and Tullis, in prep



Poster **MR23B-0051**
at AGU25 (12/16)

Thermal Pressurization

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Flash Heating

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Viscous Flow

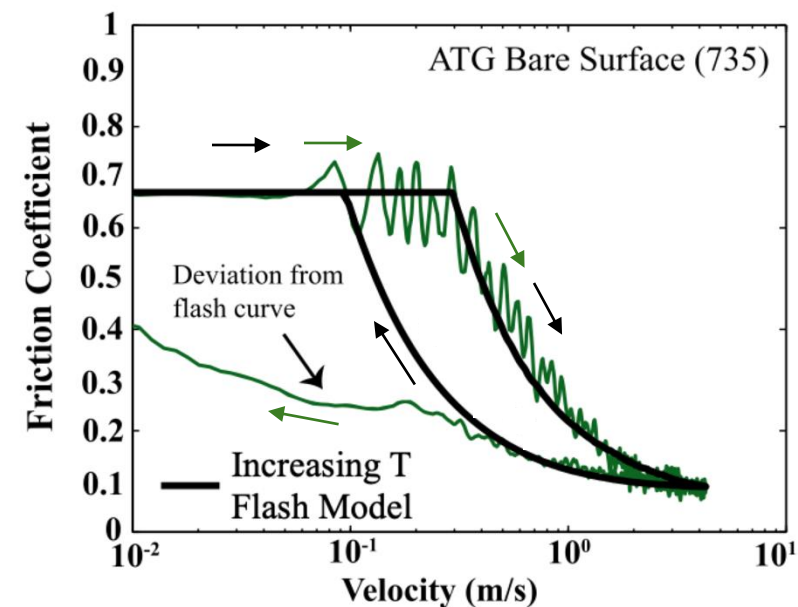
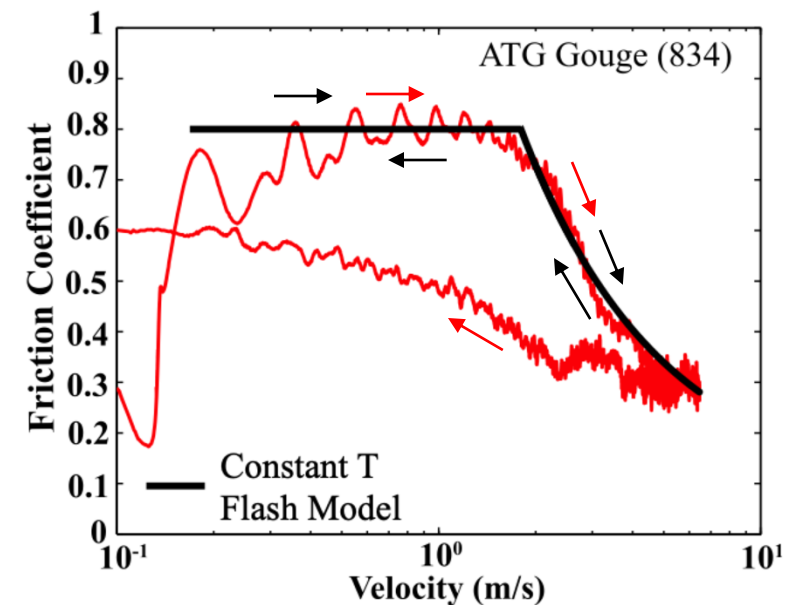
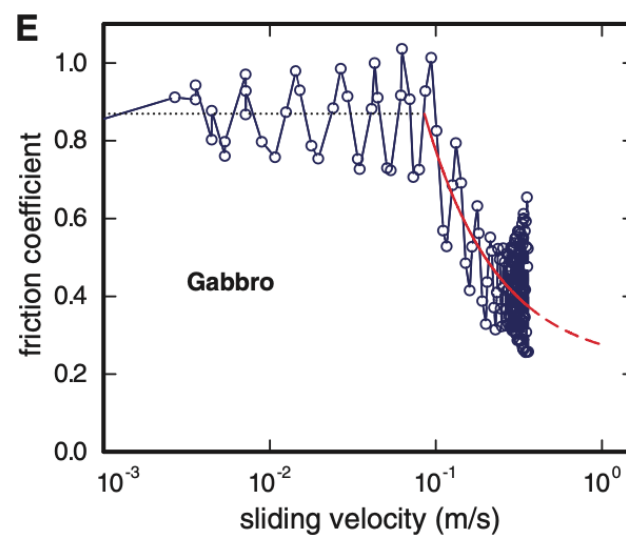
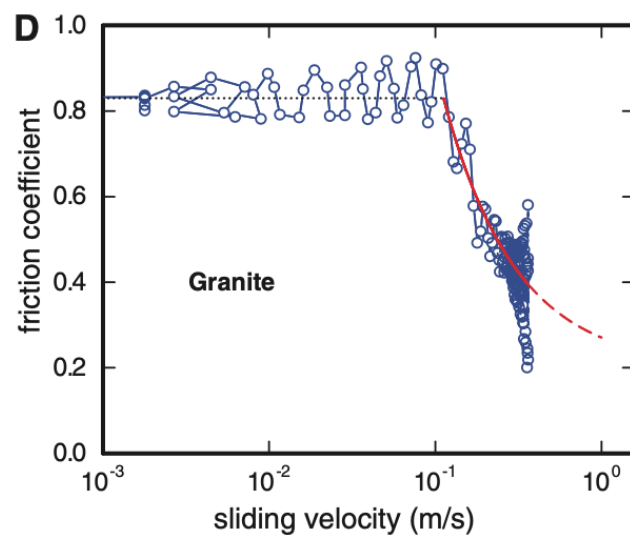
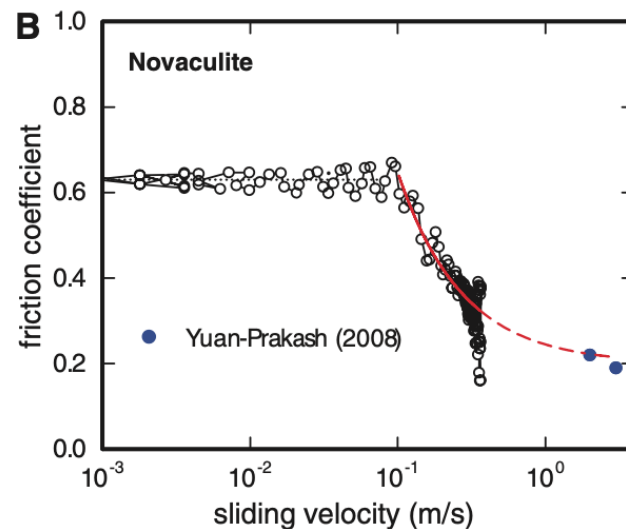
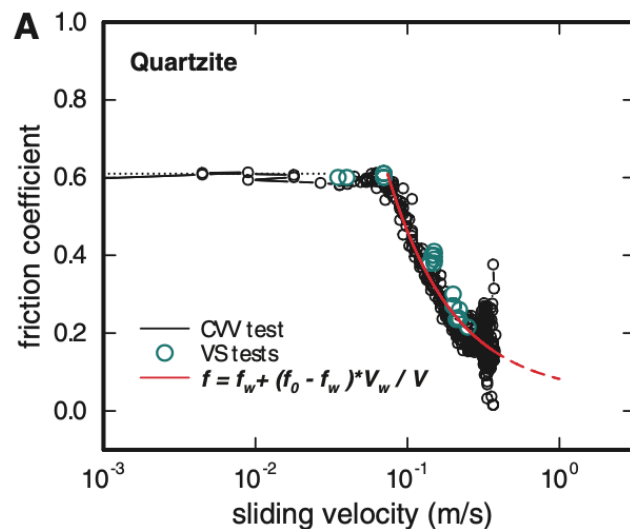
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Melt Lubrication

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Links to Natural Faults

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Goldsby and Tullis, 2011, *Science*Proctor et al., 2014, *JGR*

Thermal Pressurization



Flash Heating



Viscous Flow



Melt Lubrication



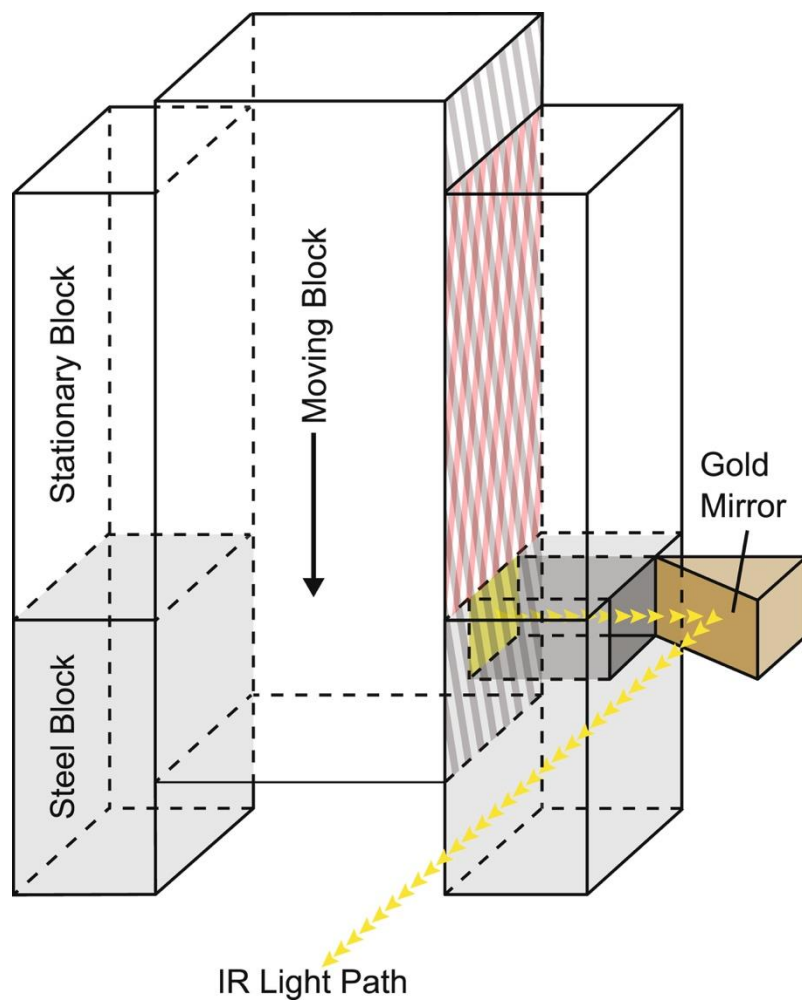
Links to Natural Faults



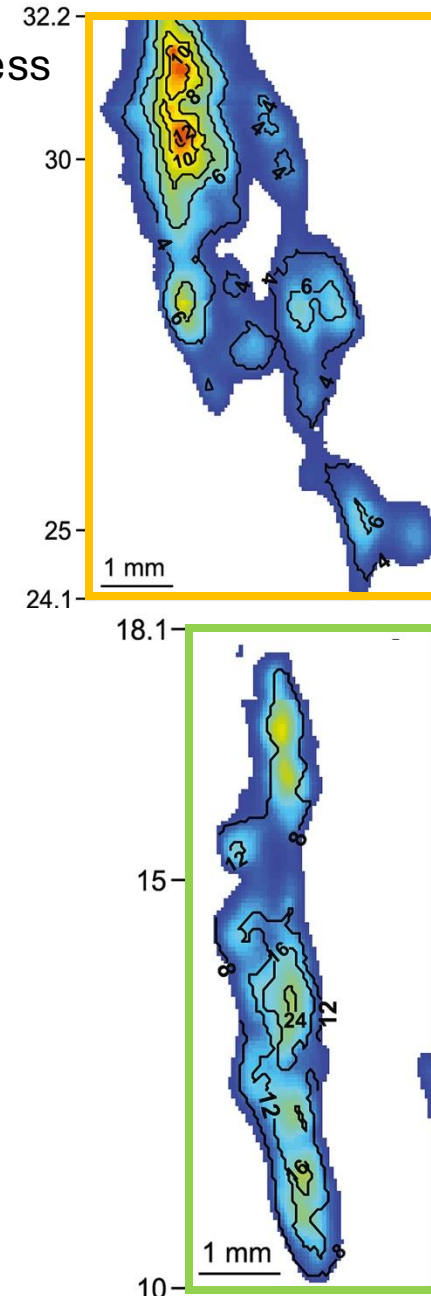
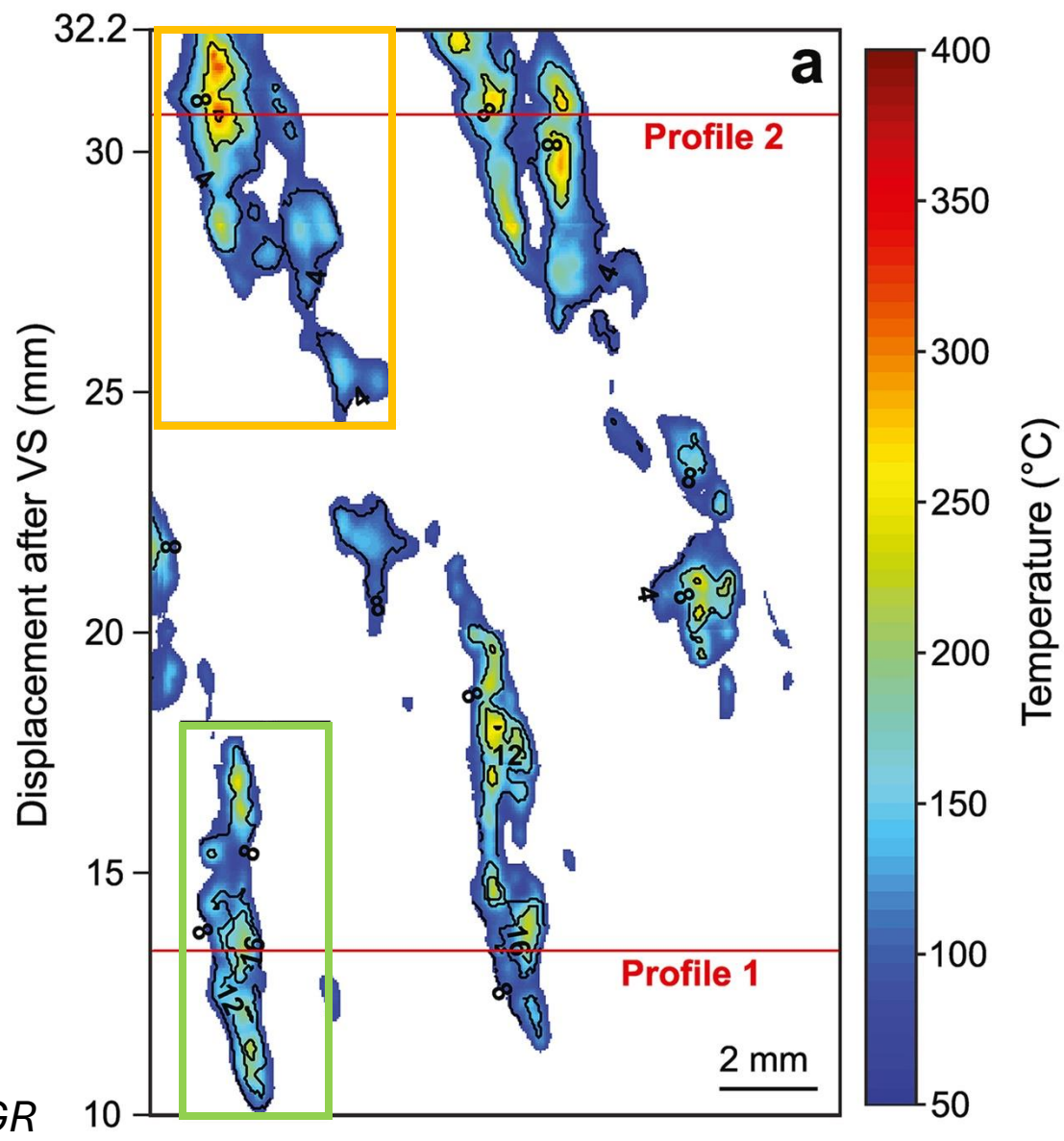
Experiments on granite

8 MPa normal stress

0.3-0.9 m/s

Barbery et al., 2021, *JGR*

surface temperatures → non-uniform local normal stress



Thermal Pressurization

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Flash Heating

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Viscous Flow

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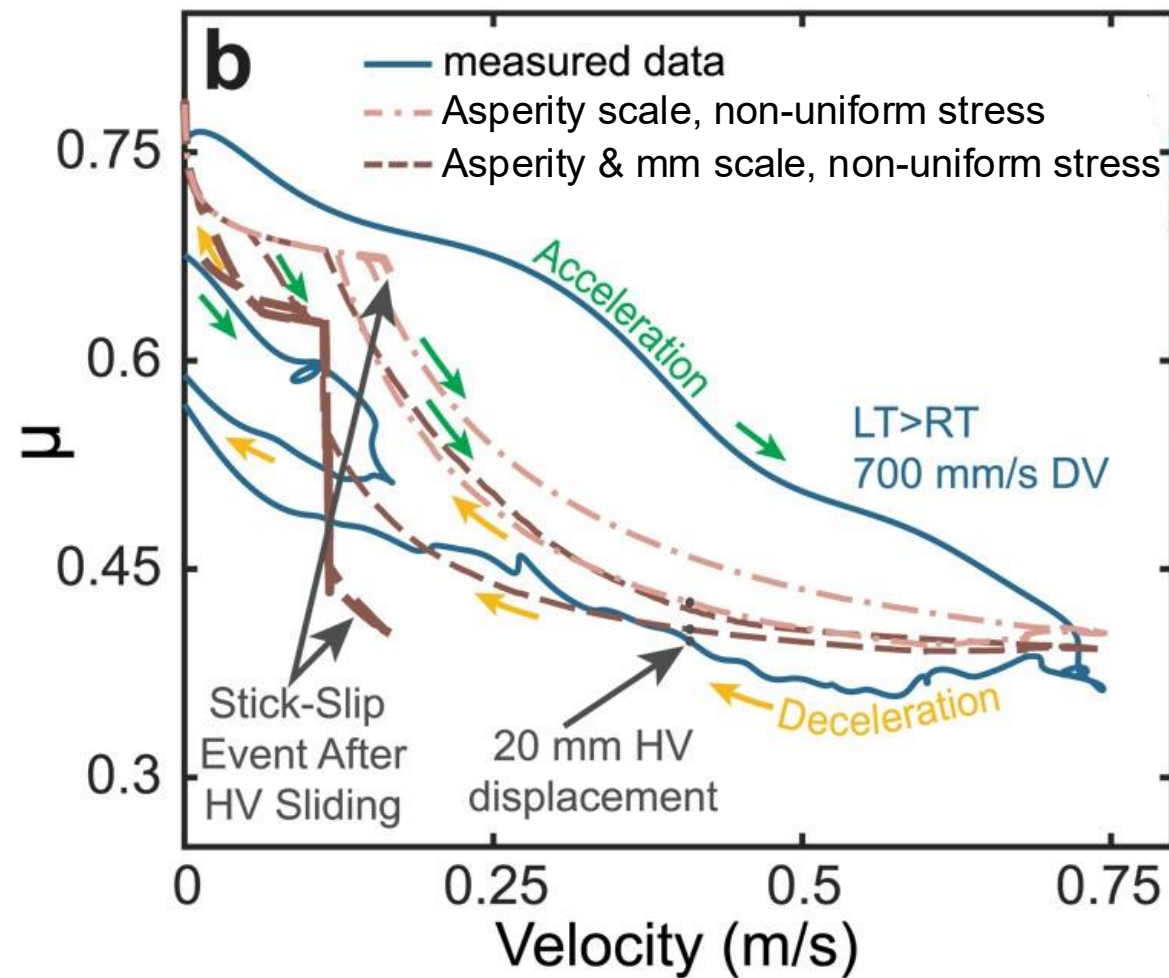
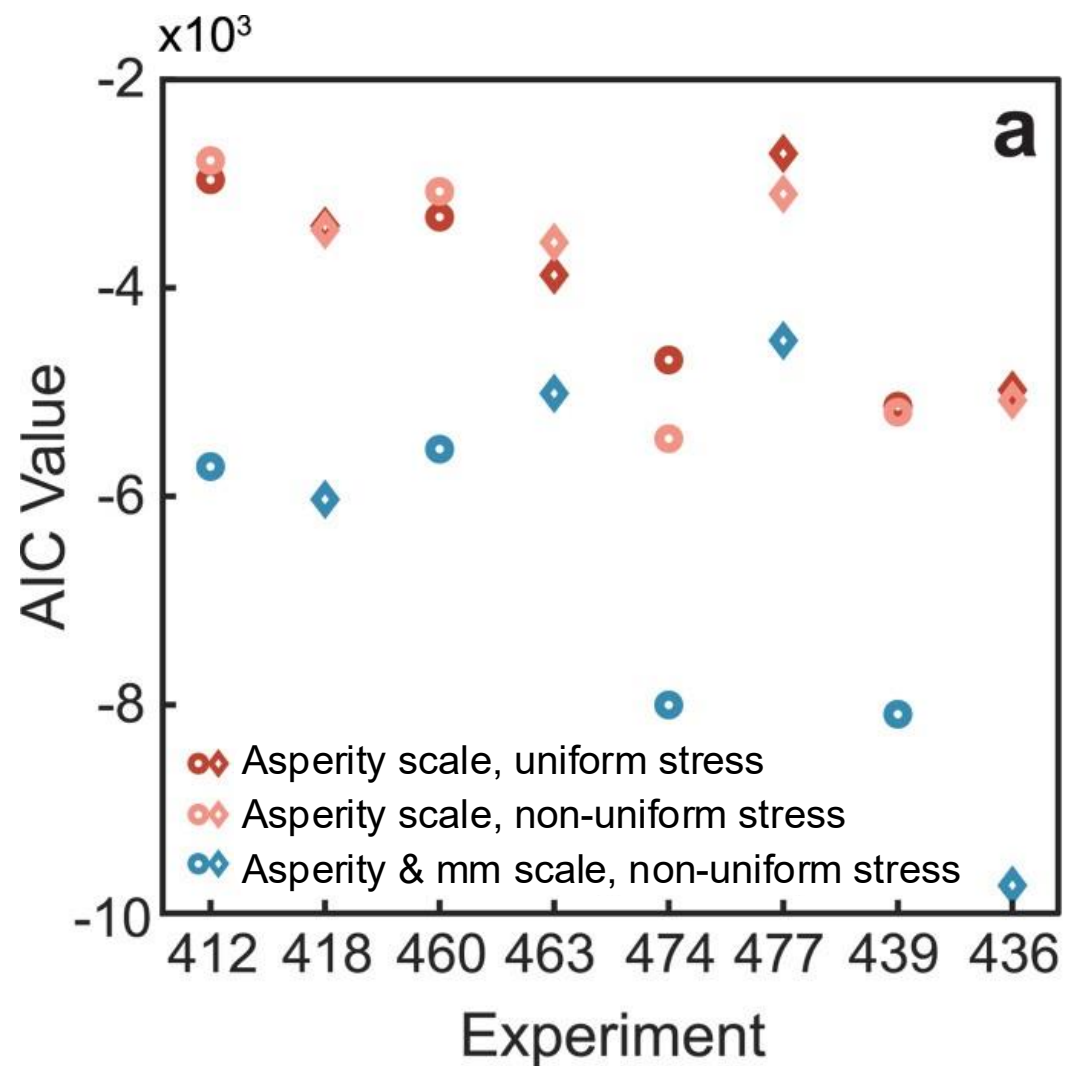
Melt Lubrication

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Links to Natural Faults

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Three flash heating models analyzed:



Thermal Pressurization



Flash Heating



Viscous Flow



Melt Lubrication



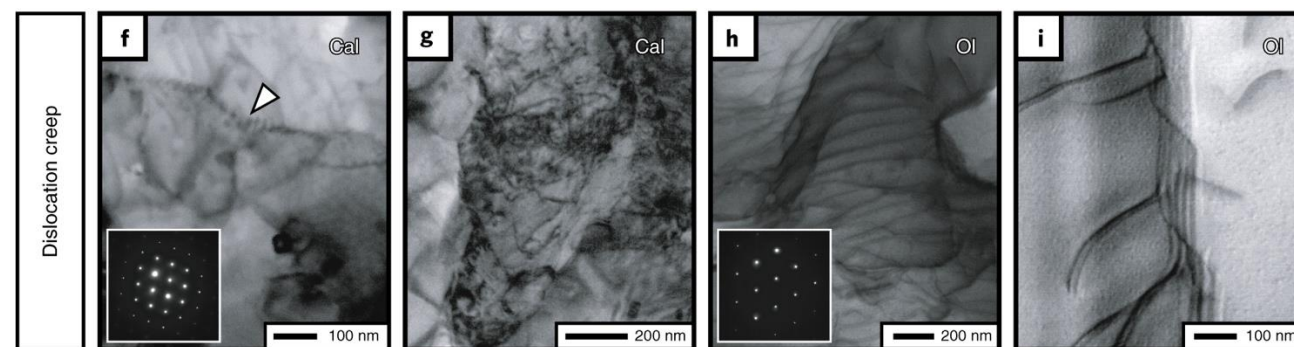
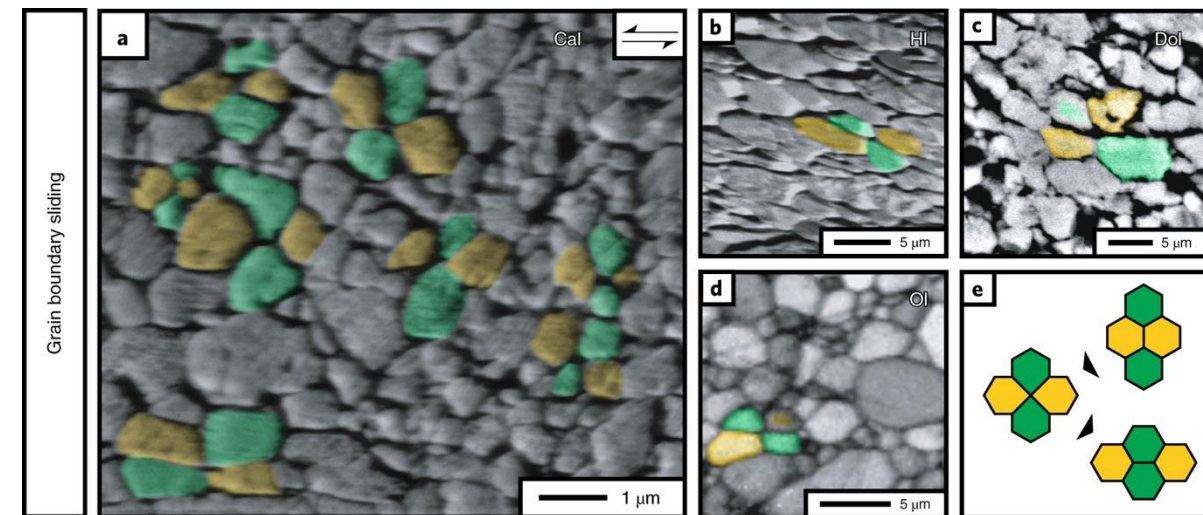
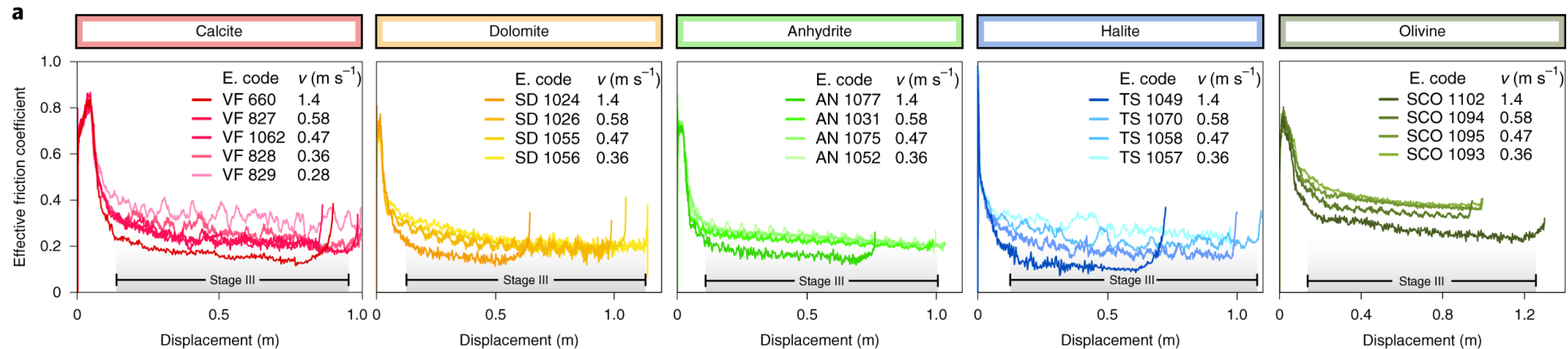
Links to Natural Faults



Experiments on anhydrous rock-forming minerals

20-25 MPa normal stress

0.28-1.4 m/s



Thermal Pressurization



Flash Heating



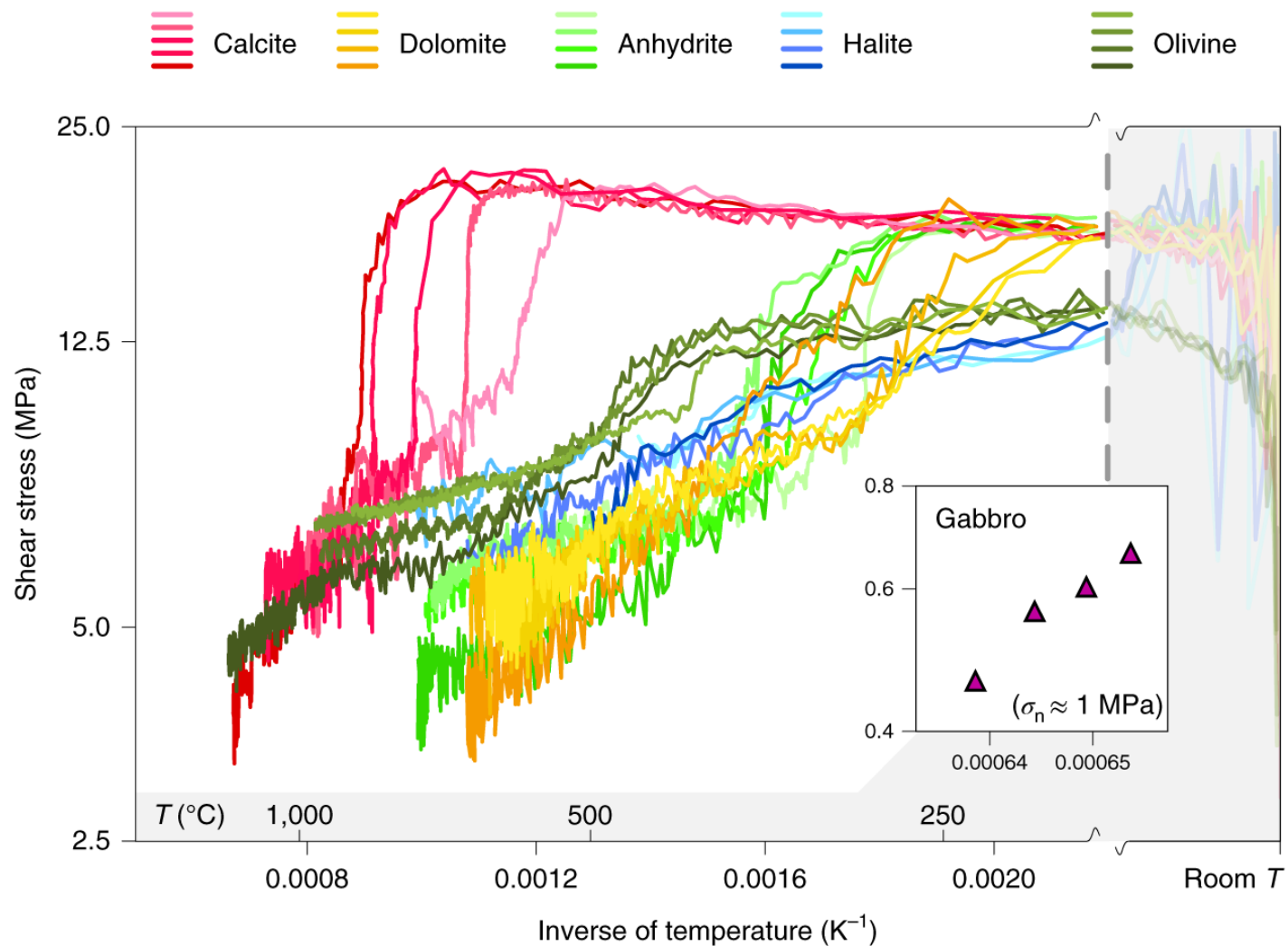
Viscous Flow



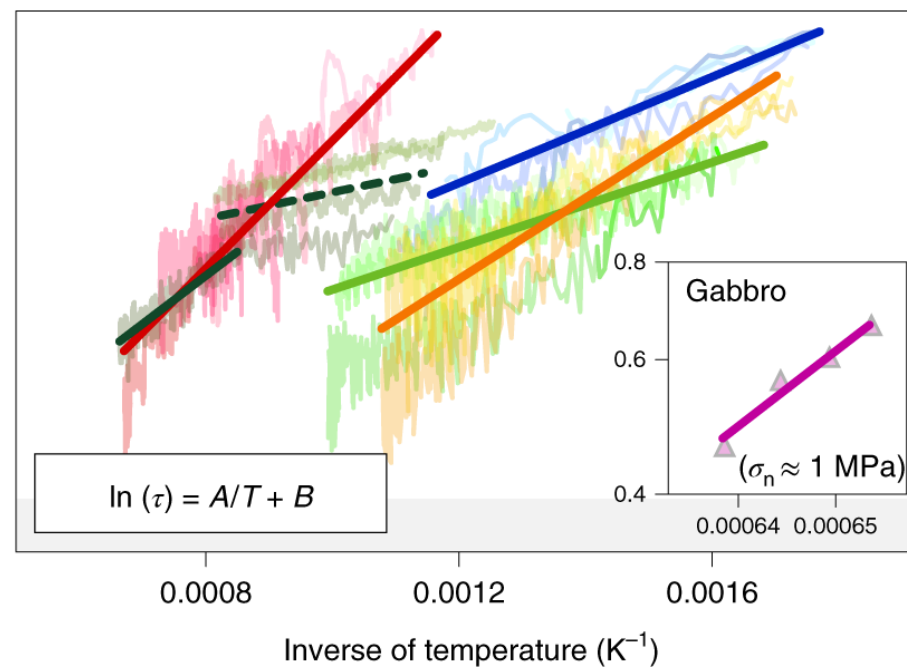
Melt Lubrication



Links to Natural Faults



Best fit	Calcite	$\ln(\tau) = 1950.804/T + 0.110$
	Dolomite	$\ln(\tau) = 1238.735/T + 0.151$
	Anhydrite	$\ln(\tau) = 648.712/T + 0.957$
	Halite	$\ln(\tau) = 815.215/T + 0.951$
	Olivine 1 (average)	$\ln(\tau) = 400.117/T + 1.590$
	Olivine 2 (1.4 m s^{-1})	$\ln(\tau) = 1472.210/T + 0.570$
	Gabbro	$\ln(\tau) = 22459.330/T - 15.090$



Thermal Pressurization

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Flash Heating

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Viscous Flow

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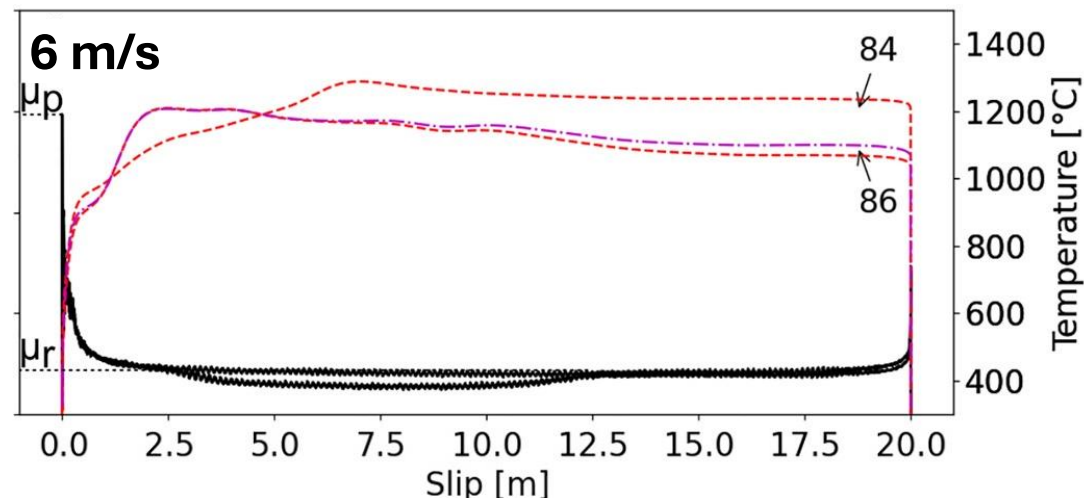
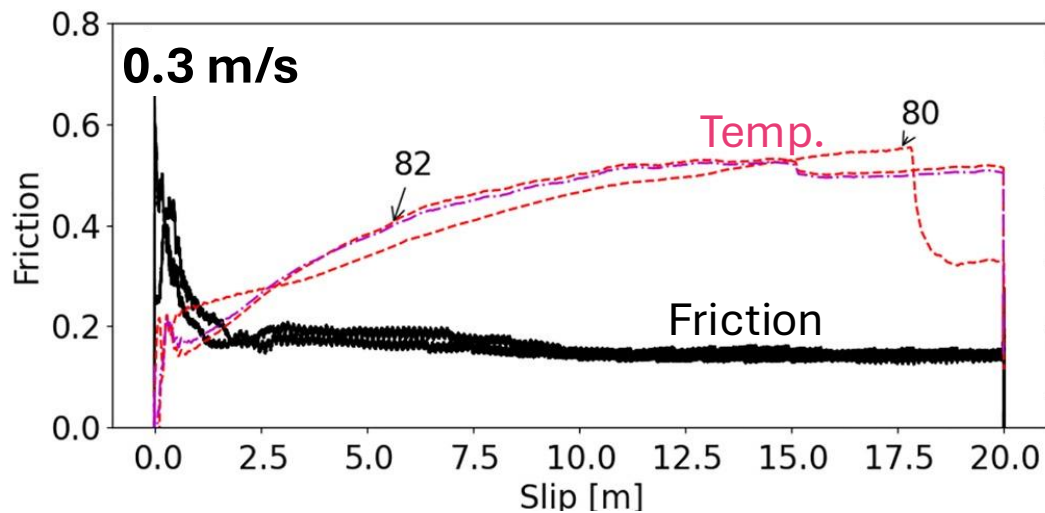
Melt Lubrication

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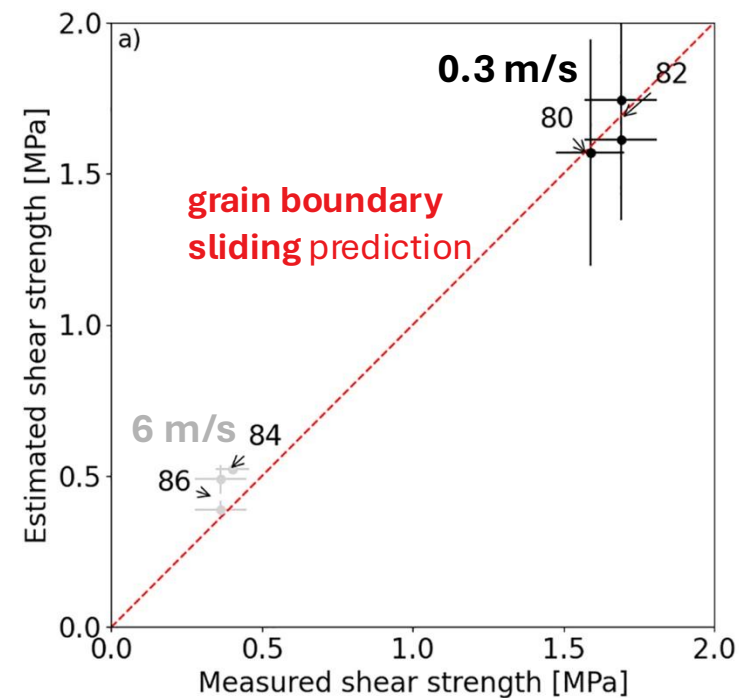
Links to Natural Faults

○○○

Experiments on marble



Optical fiber
to measure
temperature



Aretusini et al.,
2021, *GRL*

Thermal Pressurization



Flash Heating



Viscous Flow



Melt Lubrication

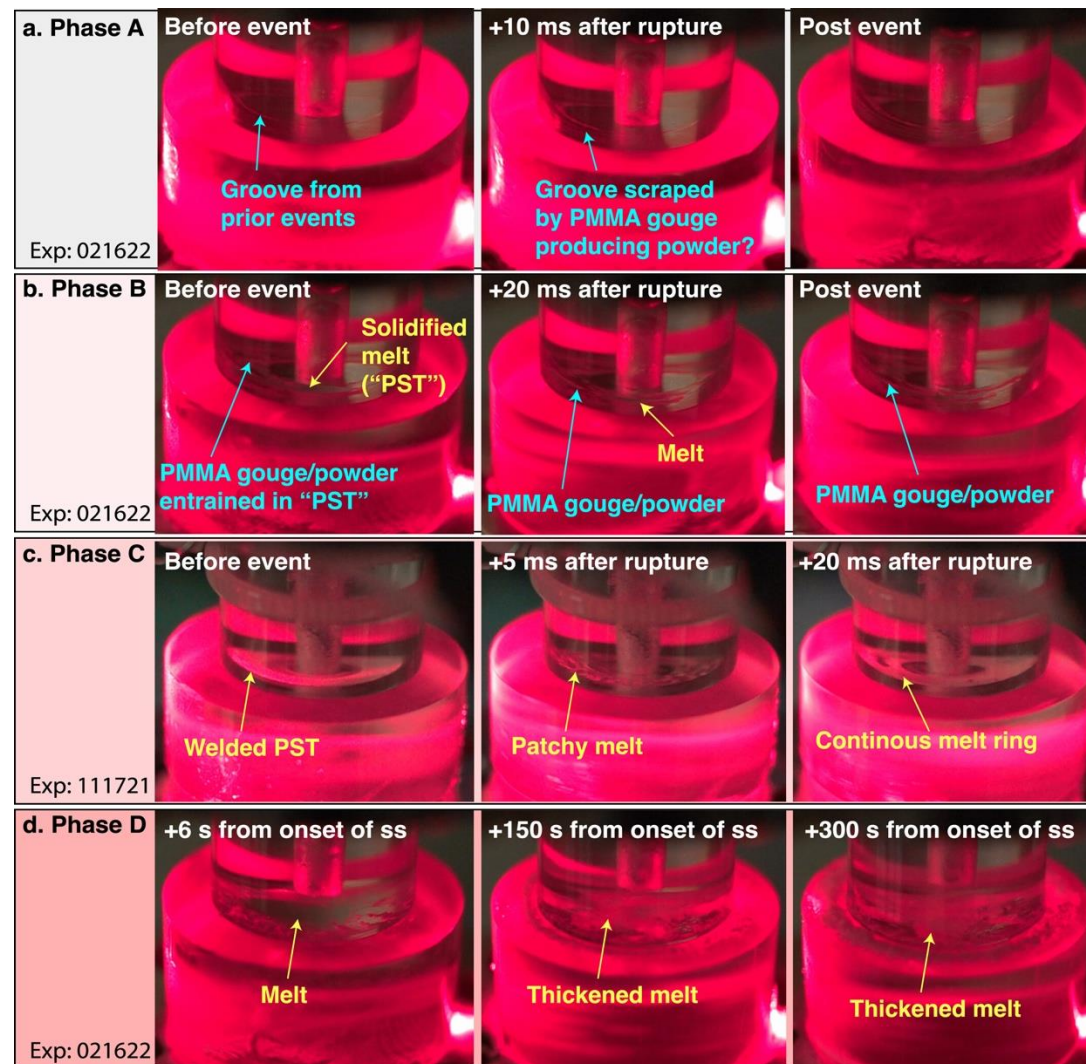
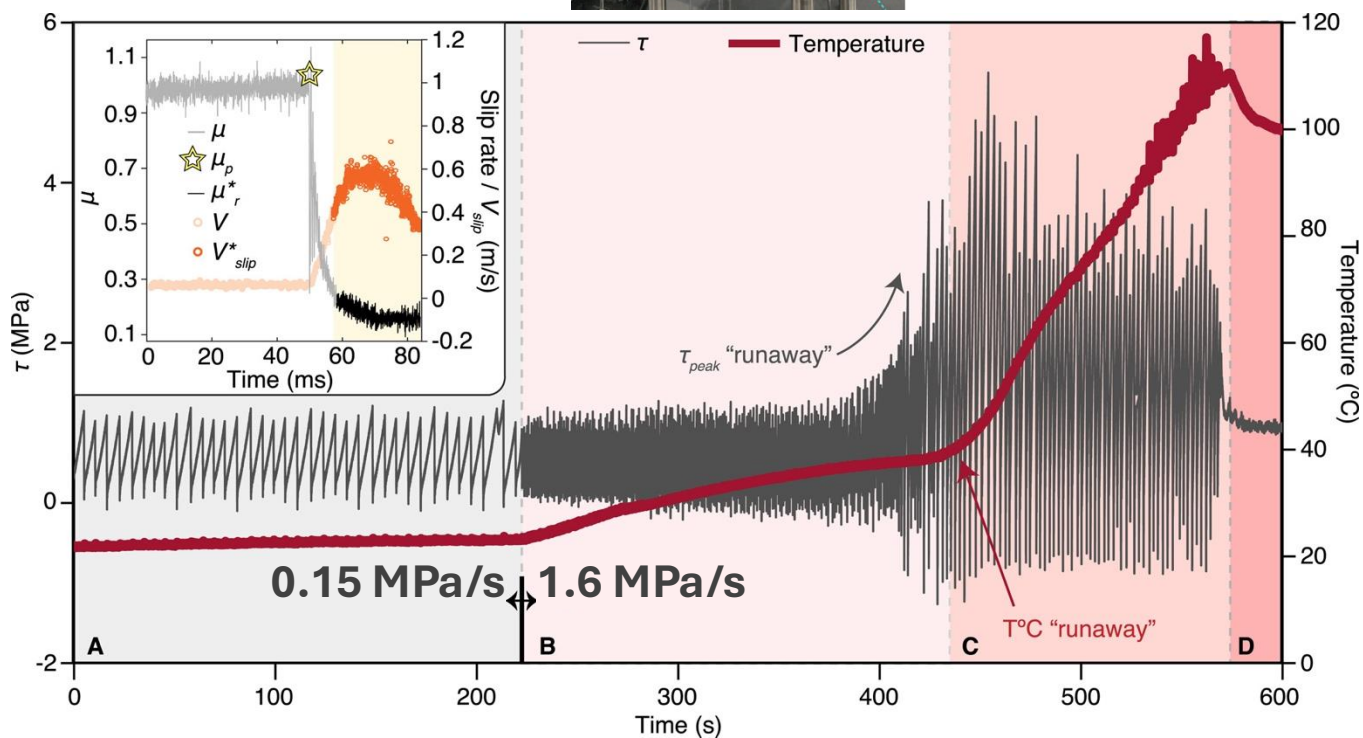
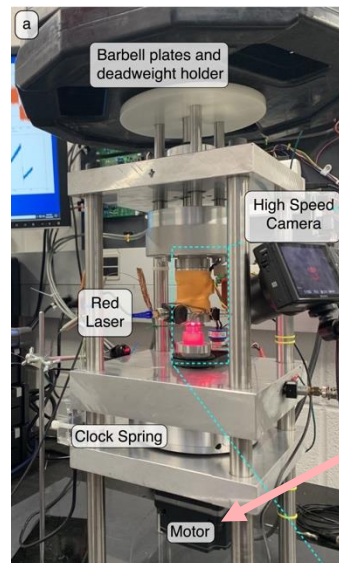


Links to Natural Faults



Experiments on PMMA

Increasing σ_n
from 3.5 MPa



Conrad et al., 2023, *JGR*

Thermal Pressurization



Flash Heating



Viscous Flow



Melt Lubrication



Links to Natural Faults

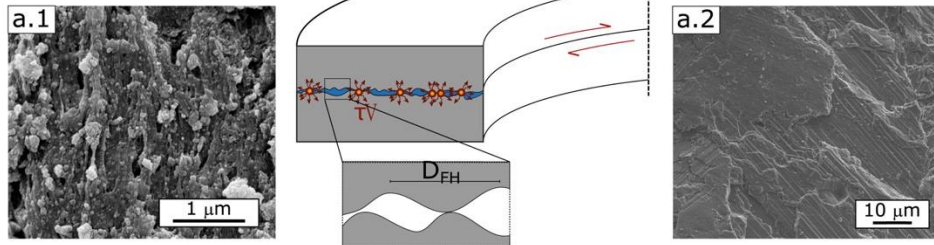


Model combining **asperity scale weakening** with **bulk weakening**

Compilation of 100+ rotary shear experiments (basalt, gabbro, calcite, marble, granite)

σ_n 5–40 MPa, V 0.1–6.5 m/s, P_p 0–15 MPa

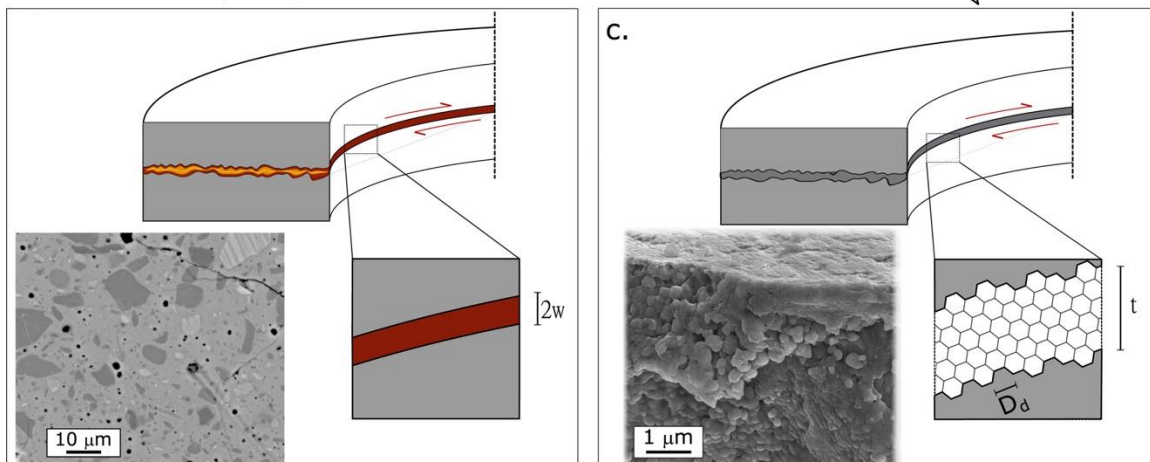
asperity scale weakening



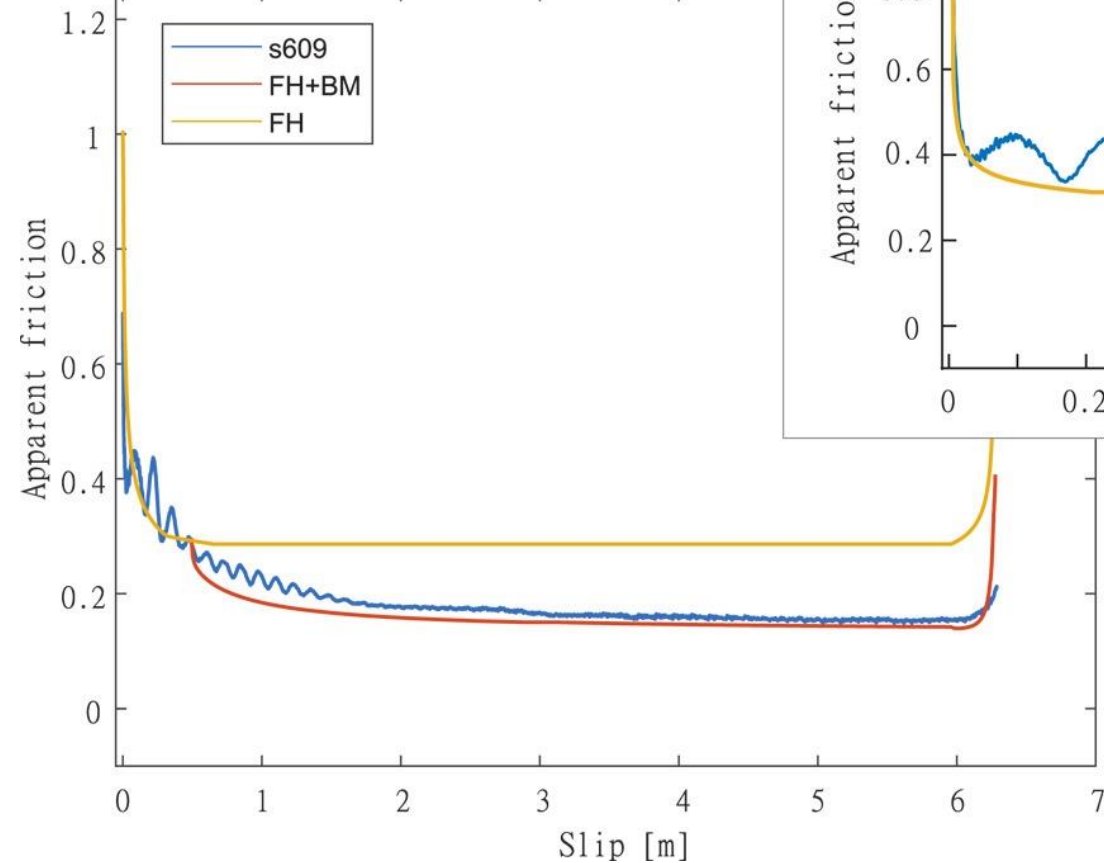
Silicate rich rock

Calcitic rock

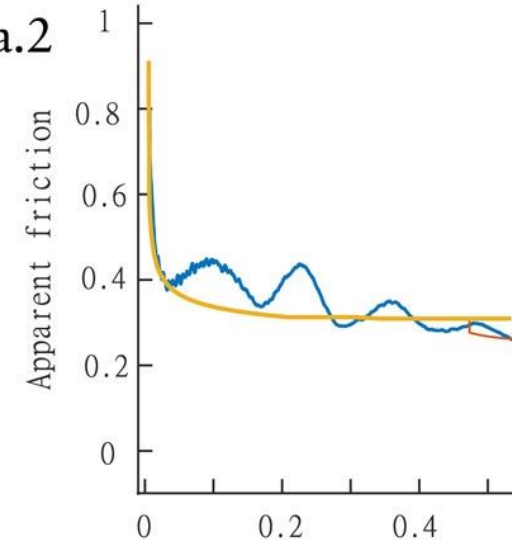
bulk weakening



a.1 s609 gabbro



a.2



Cornelio et al., 2022, *JGR*

Thermal Pressurization

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Flash Heating

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Viscous Flow

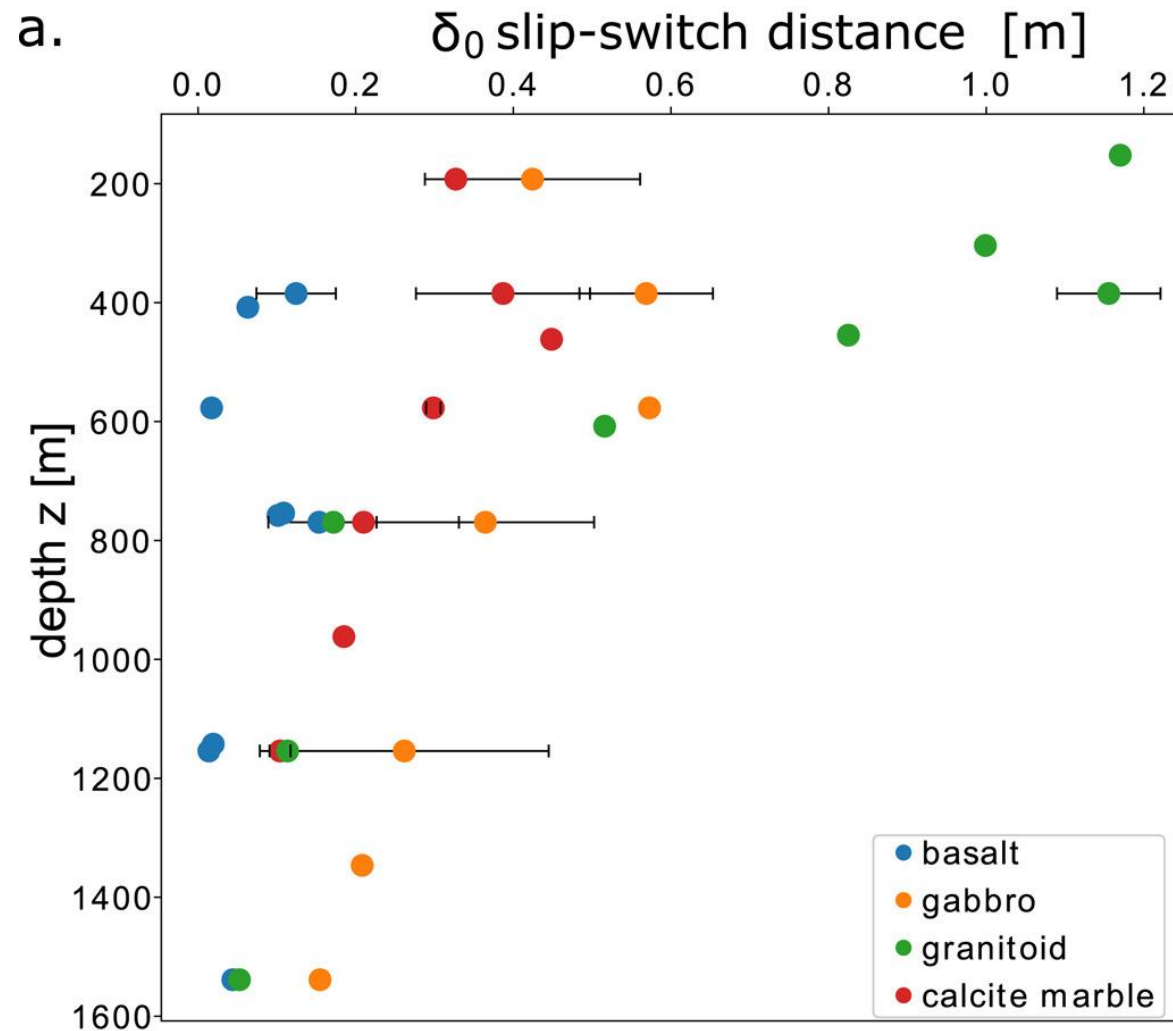
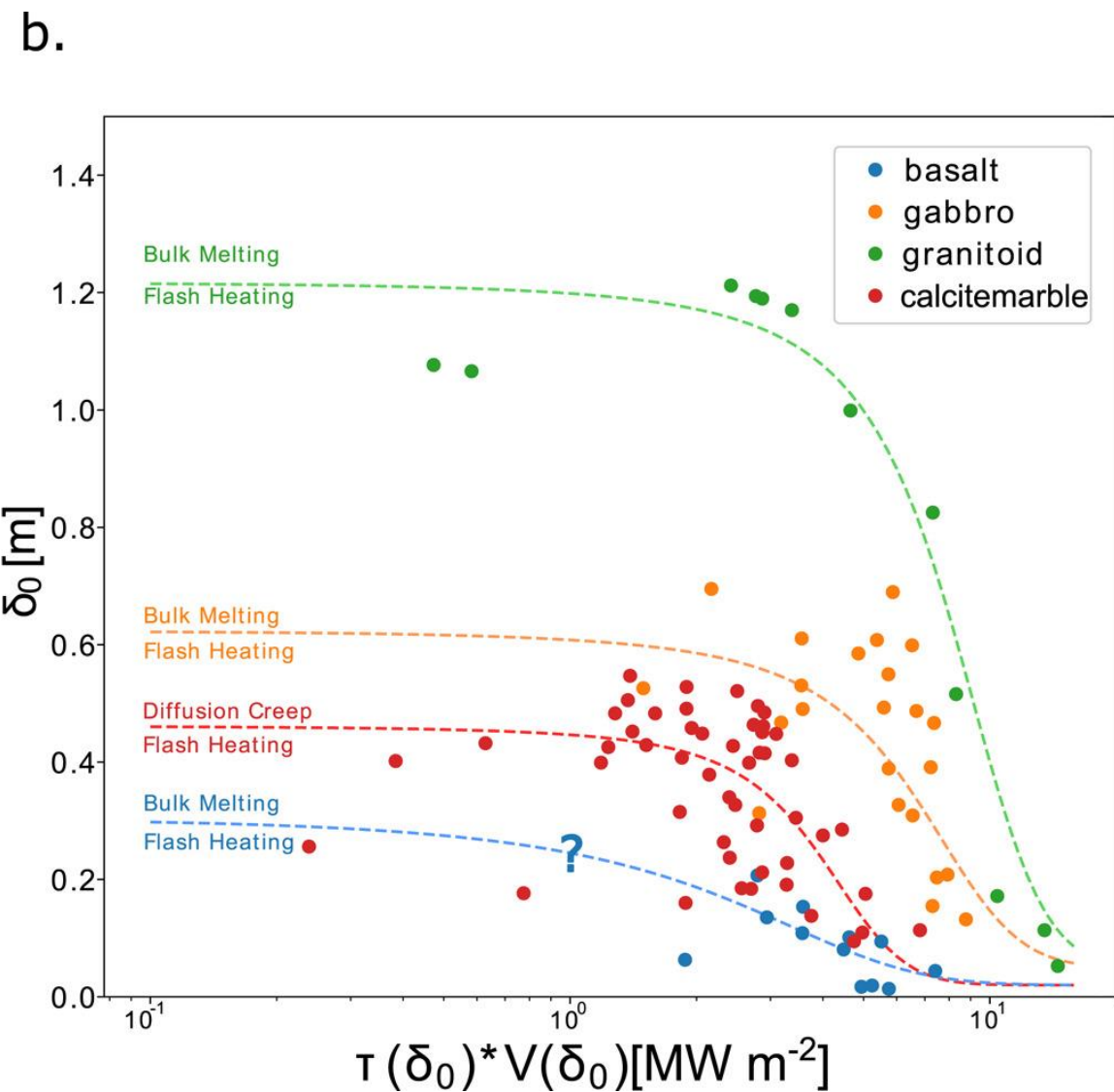
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Melt Lubrication

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Links to Natural Faults

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Cornelio et al., 2022, *JGR*

Thermal Pressurization

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Flash Heating

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Viscous Flow

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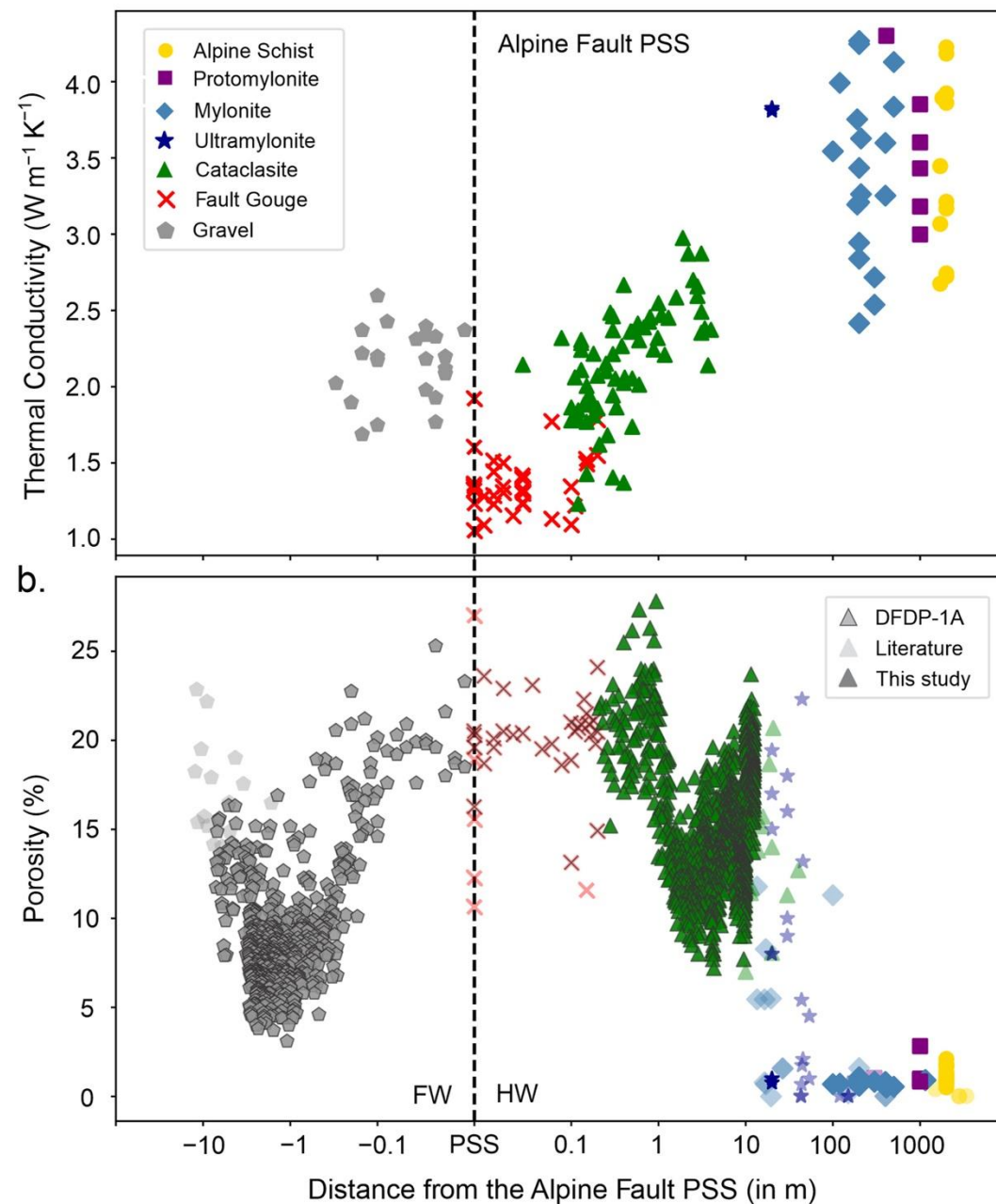
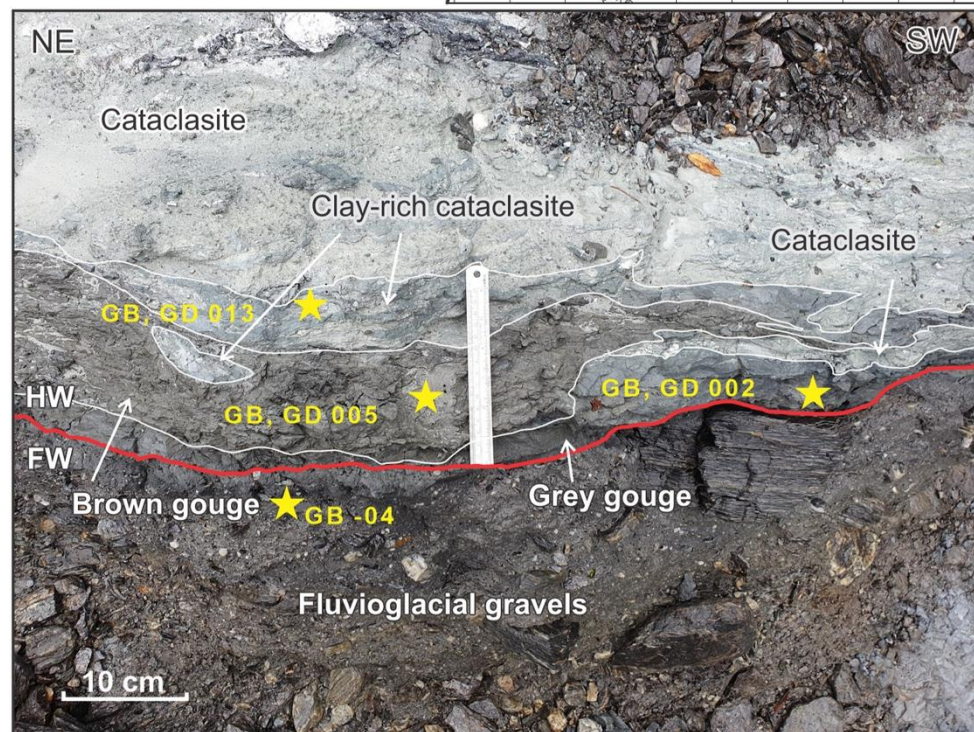
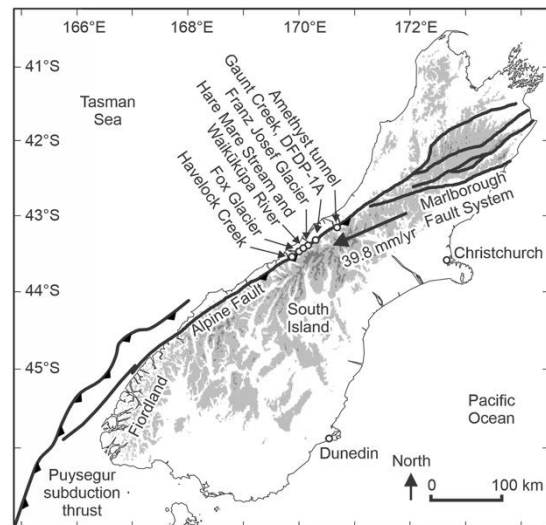
Melt Lubrication

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Links to Natural Faults

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Alpine Fault



Thermal Pressurization

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Flash Heating

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Viscous Flow

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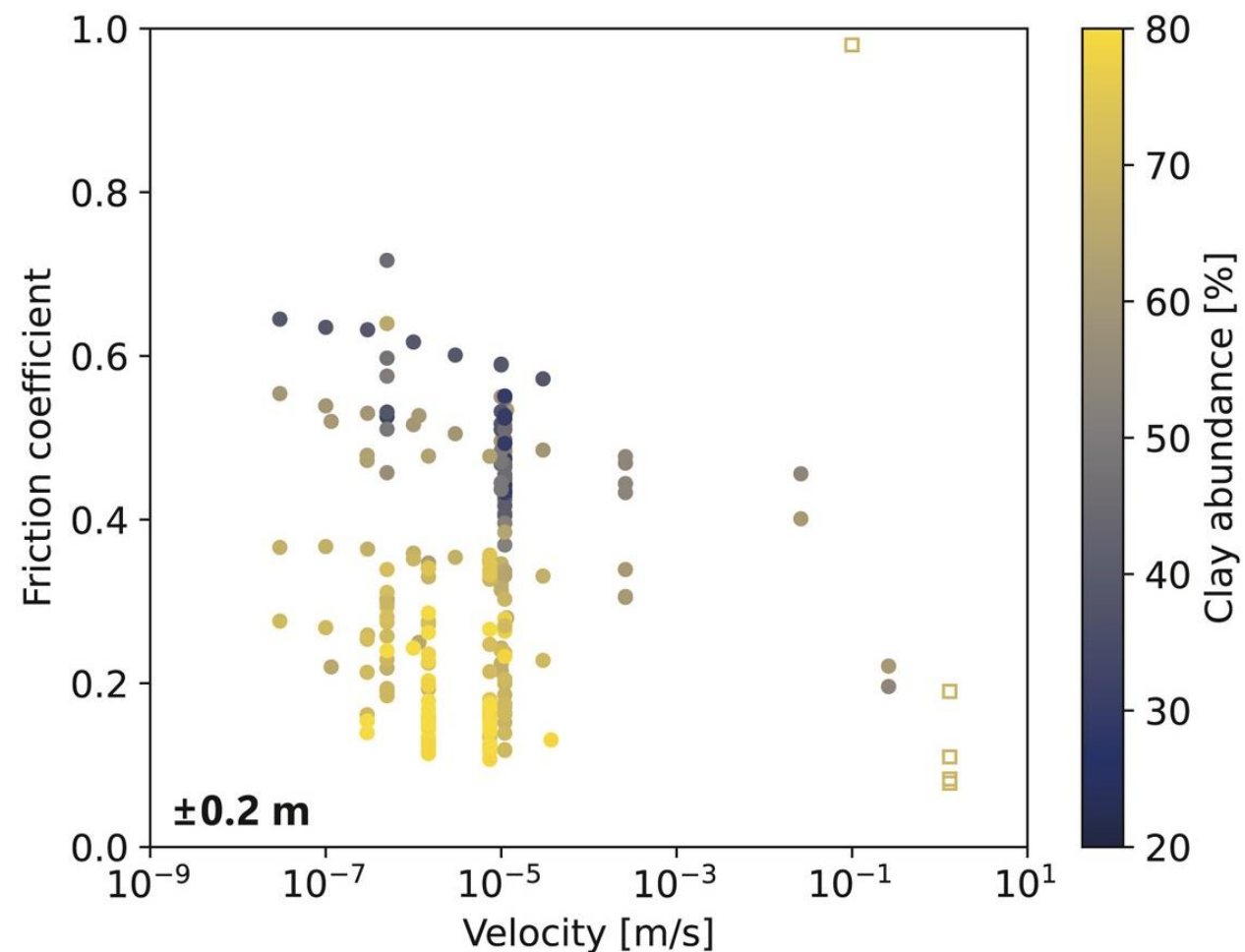
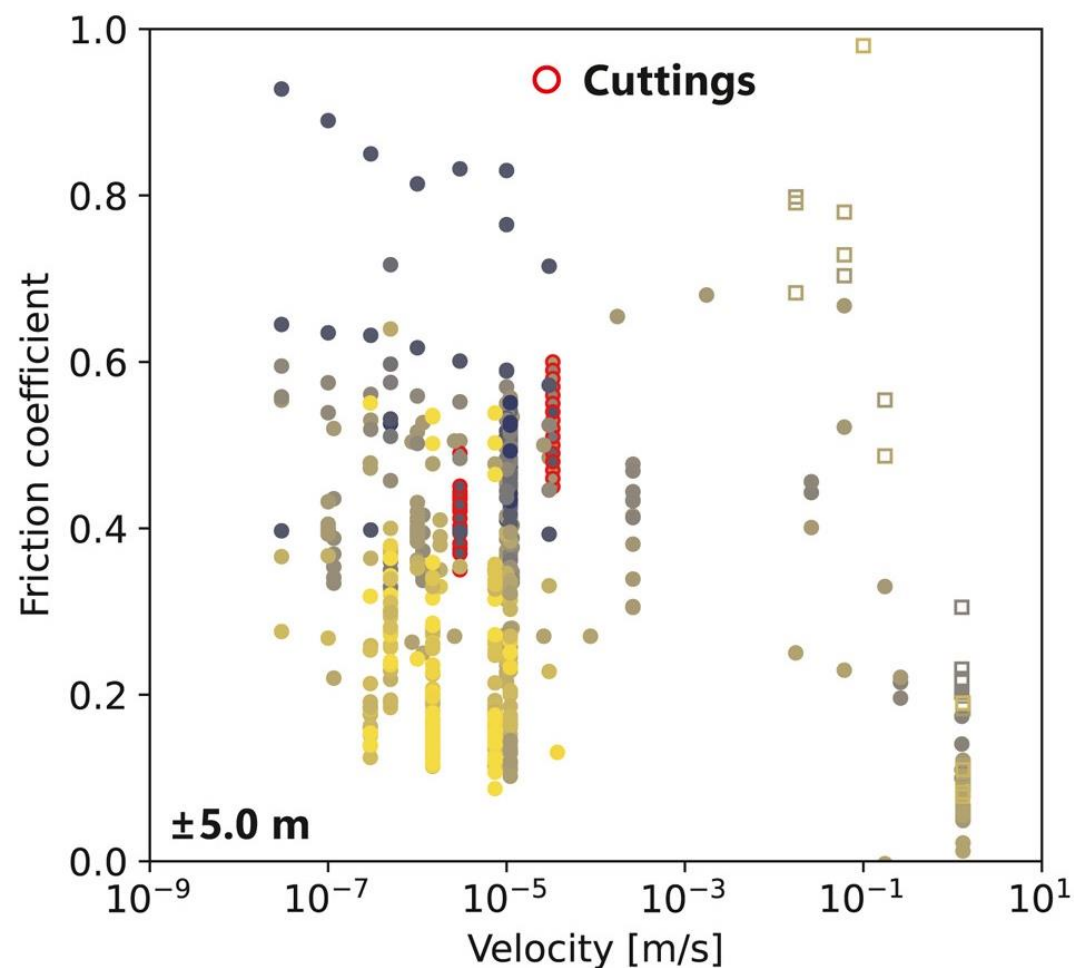
Melt Lubrication

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Links to Natural Faults

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Compilation of low and high velocity friction experiments
on samples from the **Nankai Trough**



Thermal Pressurization



Flash Heating



Viscous Flow



Melt Lubrication

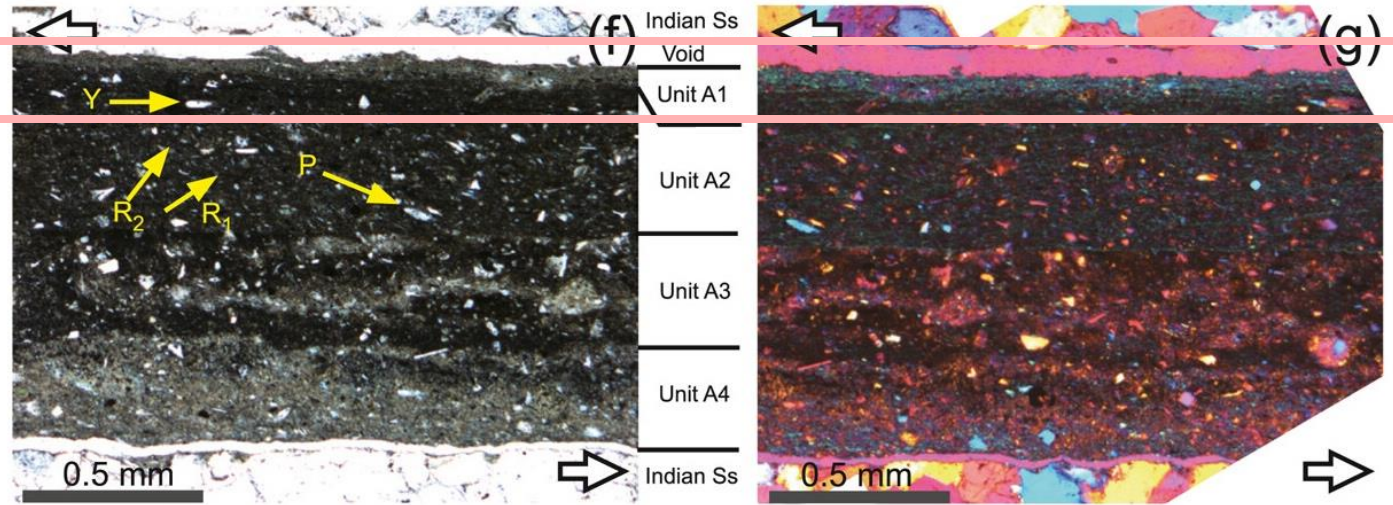


Links to Natural Faults

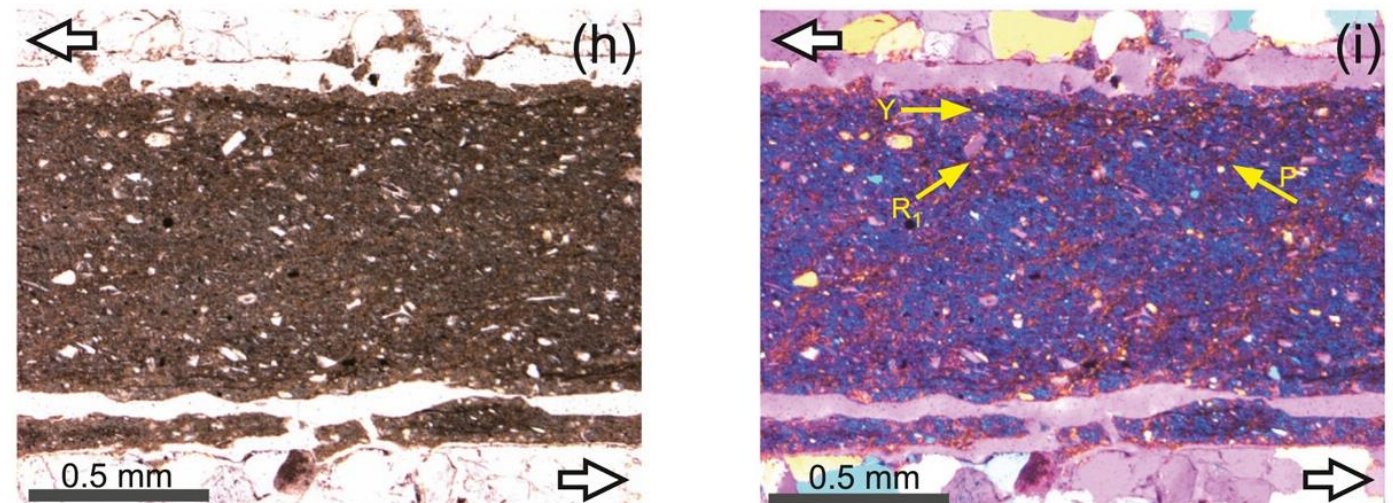


Samples from experiments with constant **total shear strain**

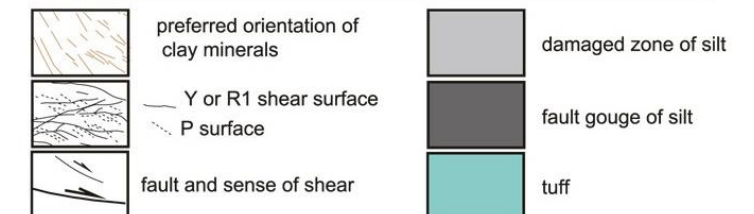
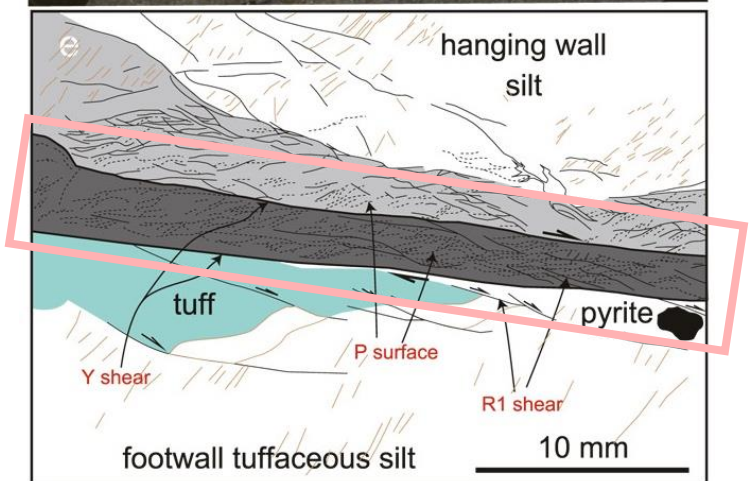
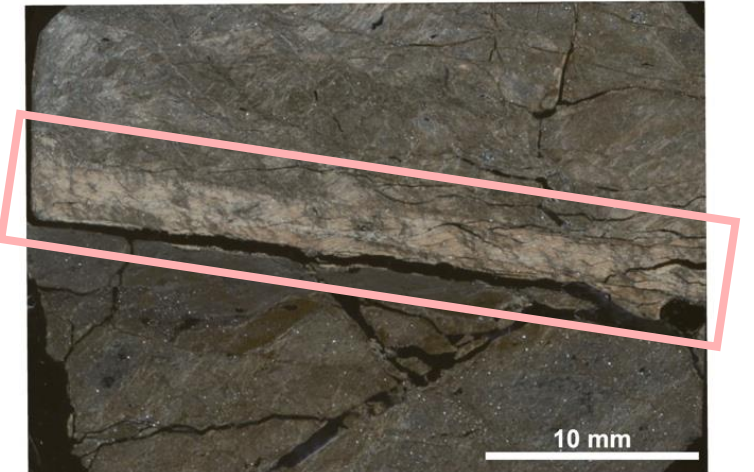
High V



Low V



Core sample from Nankai Trough



The background of the slide is a large-scale astronomical image of a galaxy cluster. It features several bright, elongated galaxy groups. Overlaid on this is a color-coded density map, where blue represents lower density and yellow/red represents higher density, highlighting the most concentrated regions of galaxies.

Thank you!