COMPLEX INTERACTION BETWEEN BRITTLE AND DUCTILE RHEOLOGIES IN SLOW LABORATORY EARTHQUAKES

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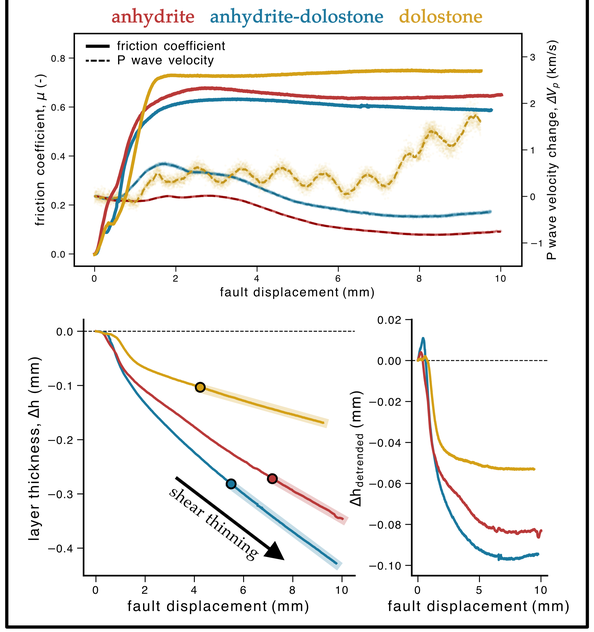
Motivation

Two of the largest and most destructive earthquakes that struck Italy in the last 30 years – Colfiorito Mw 6.0, 1997, and Norcia Mw 6.5, 2016 – nucleated within the Triassic Evaporites, composed of **anhydrite** and **dolostone**, in the Northern Apennines' crust. Field geology studies of exhumed fault zones within the Triassic Evaporites document faults hosted in anhydrite, dolostone, and, most commonly, mixed anhydrite-dolostone lithologies, with dolostone preferentially concentrated within the principal slip zones. **The respective roles of anhydrite and dolostone in governing fault slip behavior remain poorly constrained**. We integrate friction experiments on borehole samples with active acoustic surveys and microstructural analyses to disentangle the role of anhydrite and dolostone in controlling the frictional rheology of the seismogenic layer of Northern Apennines.

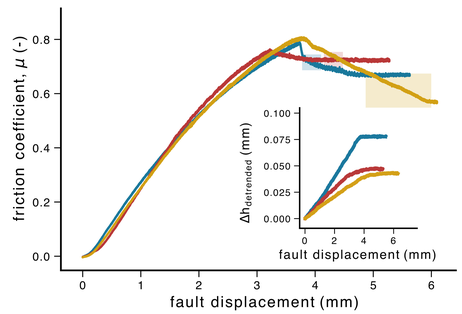


De Paola et al. (2008), Collettini et al. (2022)

Fabric development



Fault reactivation

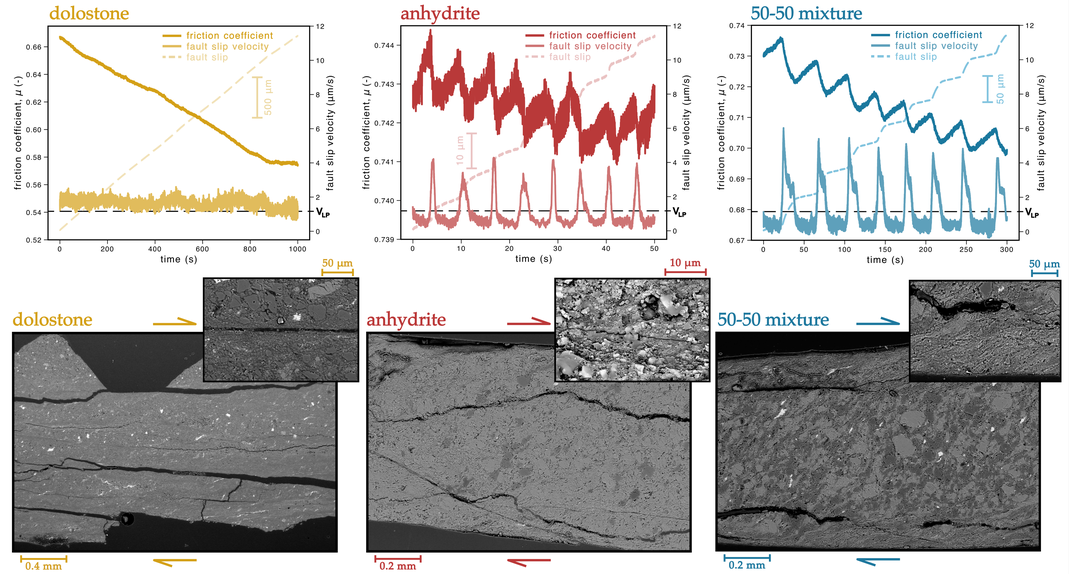


dolostone: stable sliding, strain-weakening

anhydrite: small slow slip events, slight strain-weakening

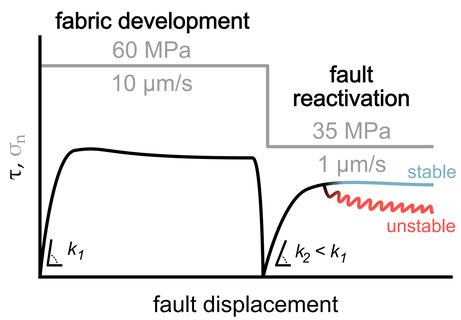
50-50 mixture: larger slow slip events, strain-weakening

The addition of dolostone to already slow-slipping anhydrite faults promotes the development of larger laboratory earthquakes. Fault slip velocity function transitions from symmetric to asymmetric (e.g., *Scuderi et al., 2020*; *Pozzi et al., 2022*). Microstructural observations reveal that anhydrite-dolostone faults feature significant strain localization along dolostone-rich thick Boundary shear bands containing pervasive S-C foliation. In the middle, we observe a thicker, coarser, weakly-foliated gouge layer composed by mixed anhydrite-dolostone particles.



Methods

Double-direct shear experiments following the experimental procedure of *Pozzi et al. (2022)*.



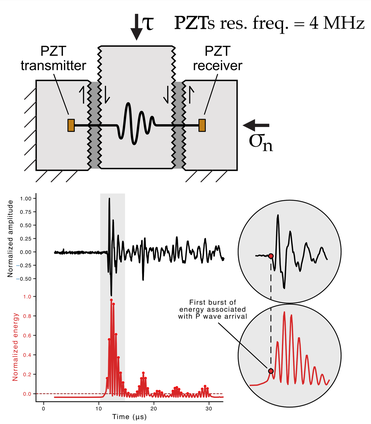
"BRAVA2" rock deformation apparatus
@Sapienza Rock Mechanics and Earthquake Physics Lab

3 fault gouges from borehole rocks:
100% anhydrite
50-50% anhydrite-dolostone
100% dolostone

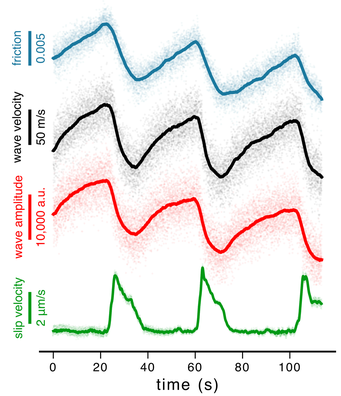
Initial grain size < 63 μm

100% ambient humity

Active acoustic surveys during:
shear fabric development
fault reactivation



Frictional rheology from acoustic waves



P wave velocity – and amplitude – growth reduces even if the shear stress increases linearly with time and there is **no slip on the fault**, suggesting the motion of structures that do not accommodate deformation along the vertical shear direction. The fault gouge does not behave as rheologically homogeneous medium but is rather composed by **brittle and ductile rheologies with non-linear interaction**. Ongoing full waveform inversion (FWI) analysis will help understaing which structures are responsible for wave velocity – and amplitude – reduction during the preseismic stage.

To look deeper into fault gouge deformation via ultrasonic wave analysis, see the following oral presentations:

- **Mauro** et al., *Fluid-assisted frictional healing revealed by ultrasonic waves*, 07 May, 17:20–17:30 (CEST) Room 2.21

- **De Solda** et al., *Seismic imaging in the laboratory: Reframing fault stability using elastic-wave observables*, 07 May, 12:15–12:25 Room G2