Fabric Induced Weakness of Tectonic Faults

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1. Problem

Mature fault zones such as the San Andreas in California appear to be weaker than predicted by theory and experiment. One explanation involves the presence of weak minerals, such as talc and other phyllosilicates. However, talc is only a minor constituent of most major fault zones and thus the question arises: how much of a weak mineral is needed to satisfy weak fault models?
Existing studies of homogeneous synthetic fault gouge indicate that >30% of the weak phase is necessary to weaken faults. Here, we describe friction experiments showing that weakening of fault zones composed of quartz and talc can be accomplished by as little as 4 wt% talc, provided that the talc forms a fabric and interconnected layer. Such fabrics have long been recognized in exhumed fault zones, and thus our observations may provide a common explanation for weakness of mature faults. Our work shows that bulk fault rock composition is a poor indicator of fault strength and stability and that details of the fault zone fabric play a critical role in determining the frictional strength and stability of tectonic faults.

2. Methods

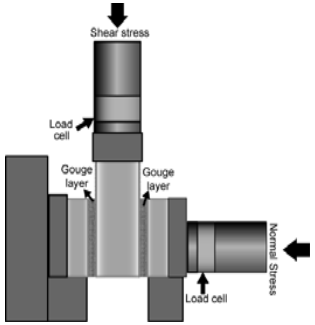


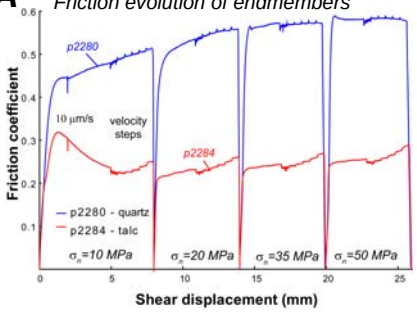
Figure 1: Schematic of experimental configuration

- Double-direct shear configuration in biaxial loading frame.
- Normal stress 10-20-35-50 MPa.
- Sliding velocity 1-1000 μm/s.
- Displacement up to 35 mm.
- Artificial gouges of quartz sand with interlayers of talc.
- Initial gouge thickness of 5 - 9 mm.

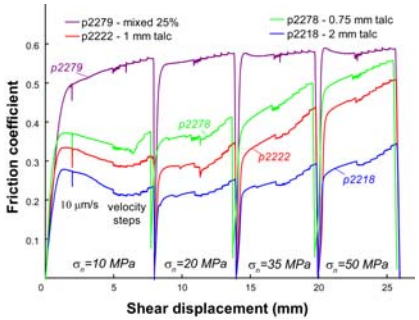

Figure 2: Photo of talc interlayer before deformation

3. Results

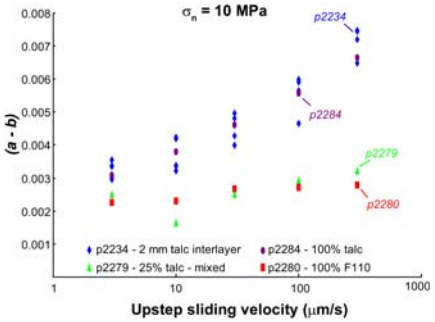
A *Friction evolution of endmembers*



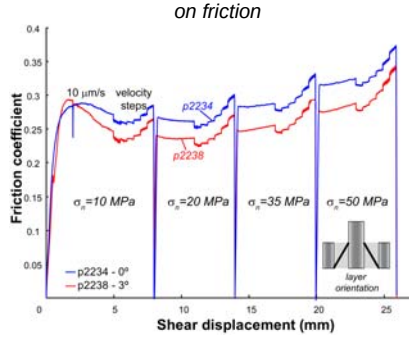
B *Friction evolution of talc mixture & talc interlayers*



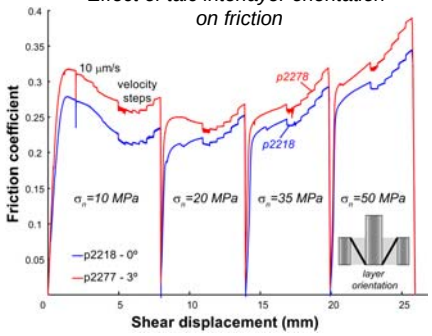
C *Effect of talc interlayer on stability (a-b) > 0 => stable sliding*



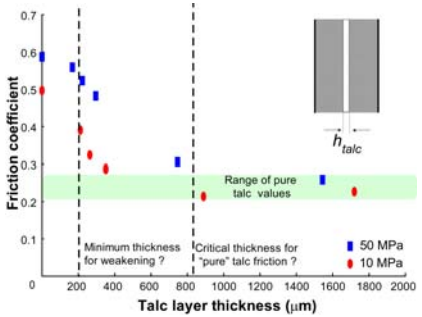
D *Effect of talc interlayer orientation on friction*



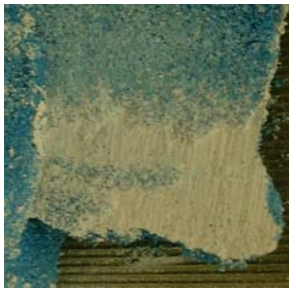
E *Effect of talc interlayer orientation on friction*



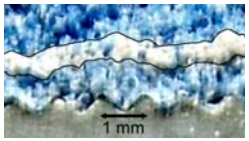
F *Effect of talc inter-layer thickness on friction*



4. Observations


Shear-parallel striations on talc interlayer (sliding surface)

Post-shear interlayer of talc showing undulations and evidence of buckling



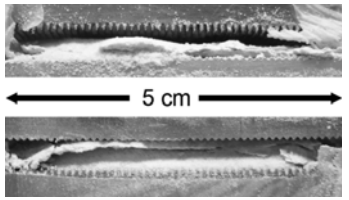


Photo of post-shear assembly. Sand was incohesive, talc layer cohesive

5. Conclusion

Only small amounts of talc are needed to weaken fault gouges, as long as the talc forms a through-going, interconnected layer.