# The Role of Plasticity on the Frictional Strength of Calcite Gouge with Increasing Normal Stress

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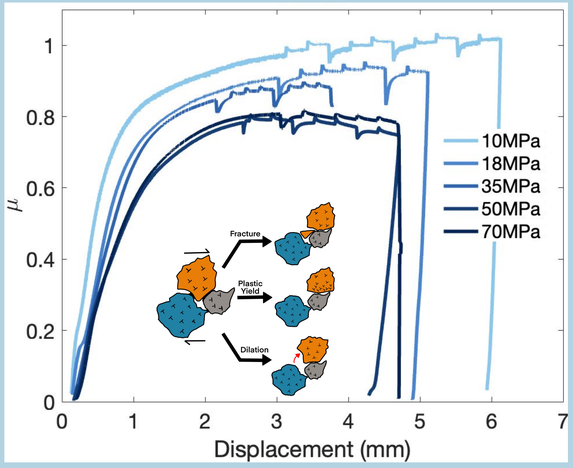
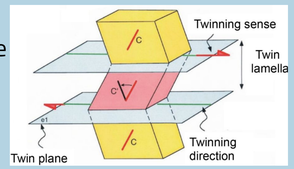
## Introduction

Calcite is a common crustal mineral present in fault zones. Experiments indicate that the friction of calcite gouge decreases with increasing normal stress.



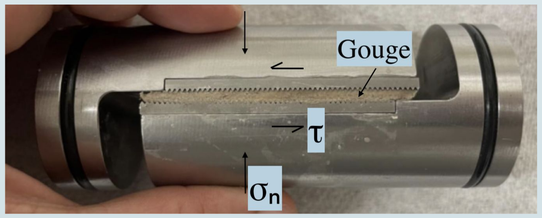

We hypothesize that this decrease is due to a change in partitioning of deformation mechanisms (dilation vs. intragranular plastic deformation vs. fracturing). To analyze the role of plastic deformation, we quantify twin density which is known to be a function of stress and strain in rocks (Rowe and Rutter, 1990; Rybacki, 2013). In addition, we quantify twin orientation to better understand the role of shear on twin formation.




Lacombe et al. (2021)

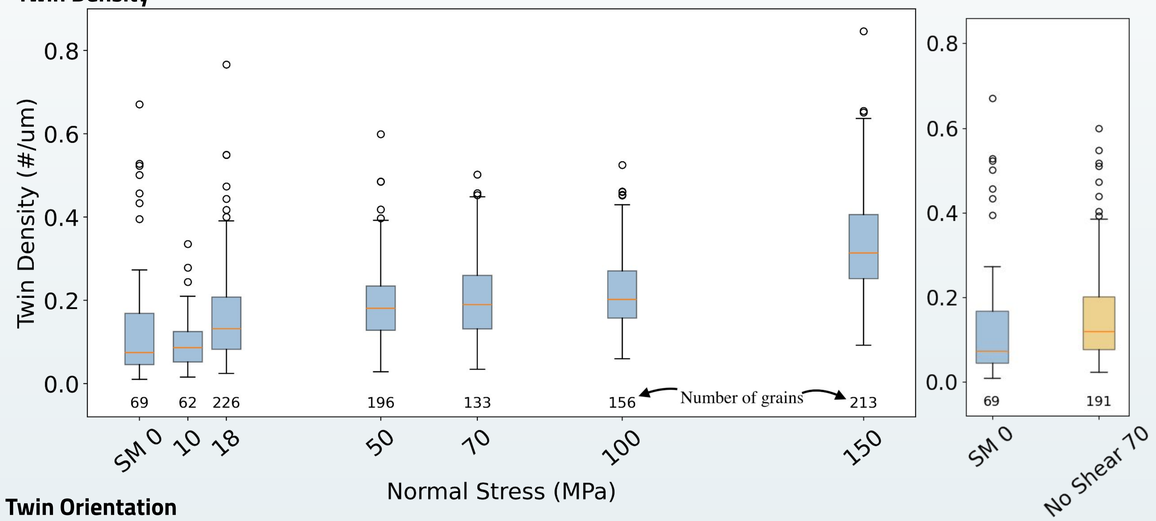
## Friction Experiment Details

- L-block direct shear in a triaxial apparatus at room temperature.
  - Normal stress = 10–150 MPa
  - Displacement rate = 0.1–3.0 μm/s
- Non-sheared samples: pressurized at 70 MPa




## Twin Density and Orientation Scales with Normal Stress

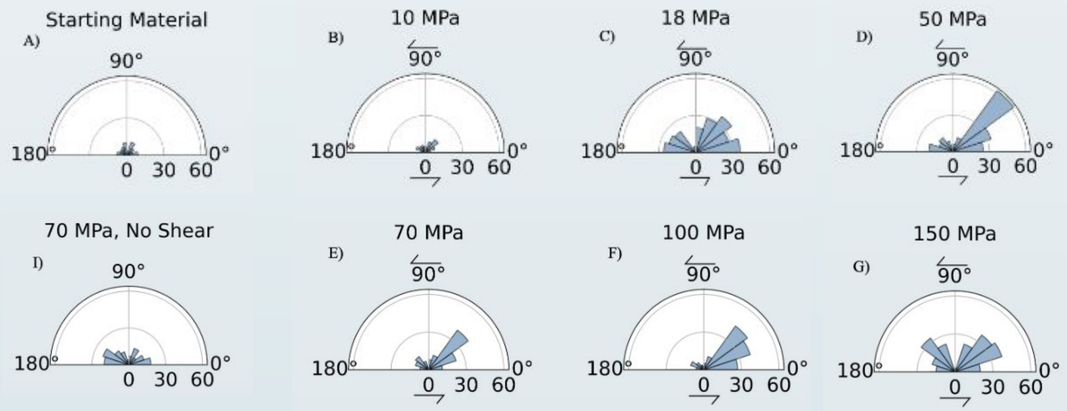
**Twin Density**




**Twin Orientation**

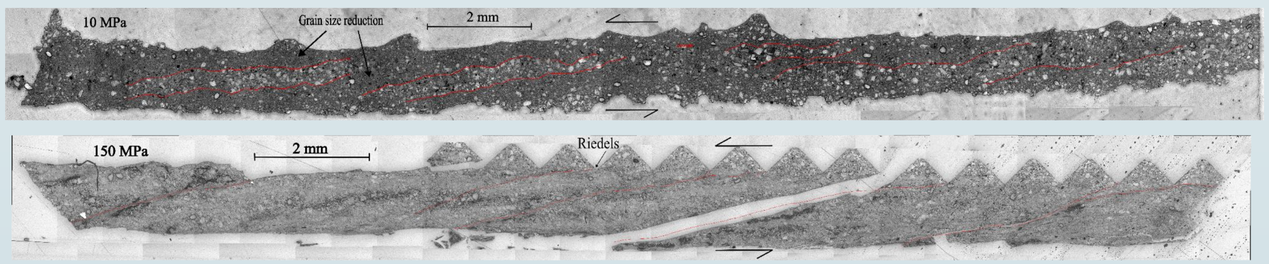
Non-Sheared Samples: scattered orientations

Sheared Samples: twins show alignment with $\sigma_1$



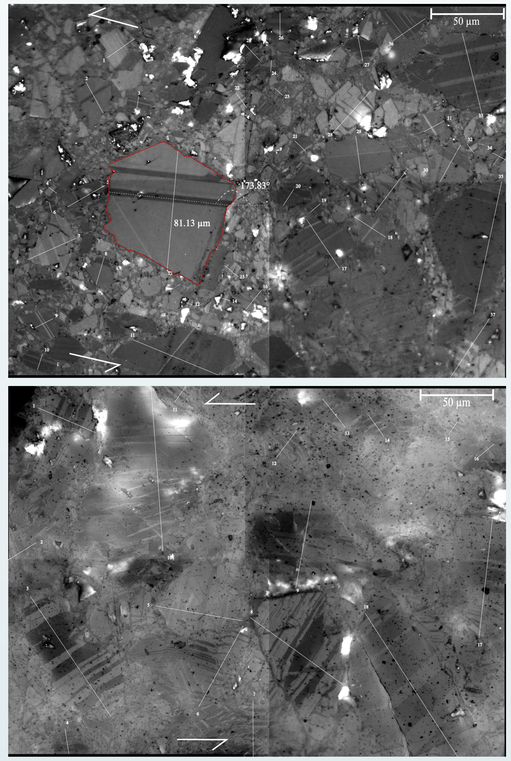

Two orientation peaks indicate complex twin development

**Full Sample Images -** Bright field reflected light




## Data Collection Methodology

- 10 photomicrographs per sample using bright field reflected light.




18 MPa (top) and 50 MPa (bottom): Grains with twins marked and labeled for data collection.

## Interpretation and Conclusion

- Number of grains with twins increases with increasing normal stress.
- Shear promotes the formation and alignment of twins, and the absence of shear results in dispersed orientations and lower twin densities.
  → **Twins accommodate frictional deformation!**
- Plastic deformation is accommodating more shear deformation at higher stresses

**Broader Significance**

Quantifying how plasticity contributes to frictional strength in gouge provides a basis for scaling laboratory friction experiments to natural fault behavior.

**Future Work**

Separate the roles of twinning, grain size reduction, and other mechanics in accommodating stress by evaluating how modified twin density affects gouge friction.