Fault healing plays a key role in creating the spectrum of tectonic faulting styles from seismic to aseismic slip

EGU General Assembly 2020

EGU2020-2761
EGU General Assembly 2020

Chris Marone

Dipartimento di Scienze della Terra
La Sapienza Universita` di Roma, Italia
and
The Pennsylvania State University, Rock Mechanics lab, Geosciences,
University Park, PA, USA

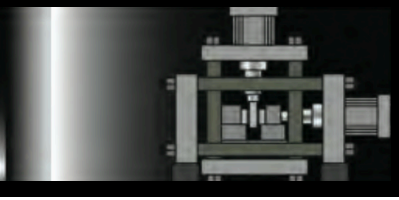
5 May 2020

US NSF, DOE, LANL

INGV,Roma

European Research Council
Seventh Framework Programme
"Ideas" Starting Grant
GLASS: 259256

PENN STATE ROCK AND SEDIMENT MECHANICS LABORATORY

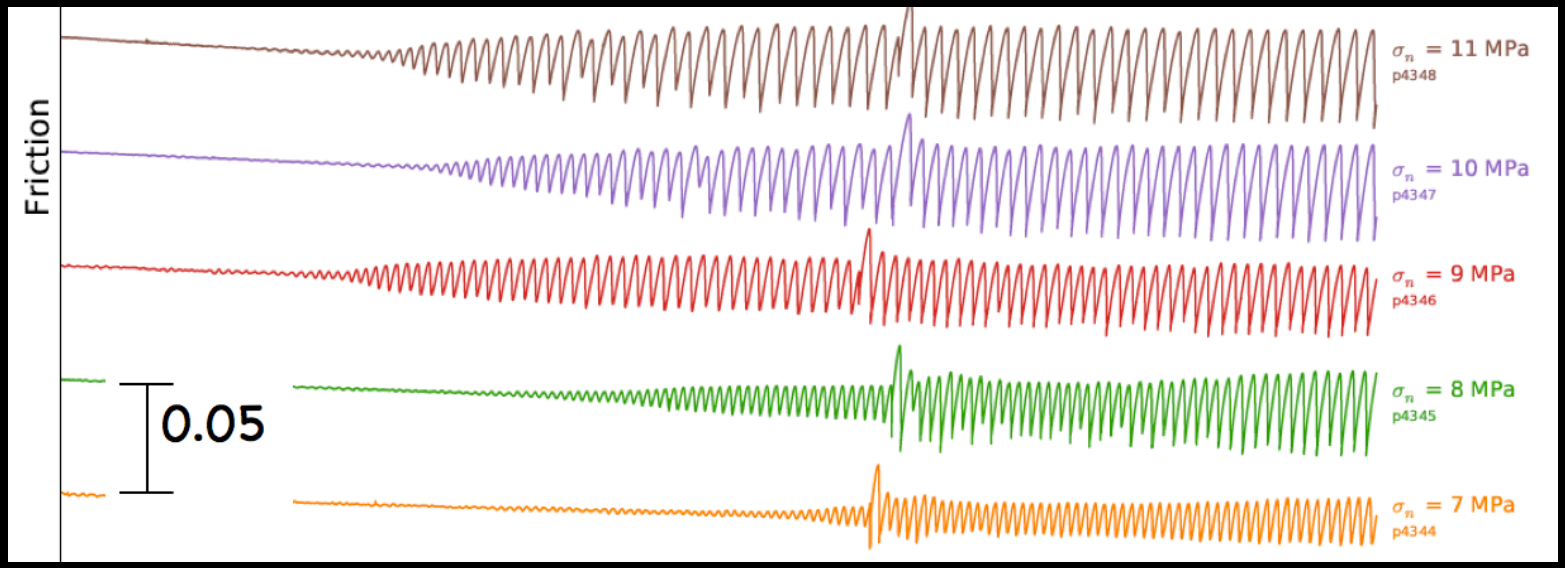


SAPIENZA UNIVERSITÀ DI ROMA

Fault healing plays a key role in creating the spectrum of tectonic faulting styles from seismic to aseismic slip

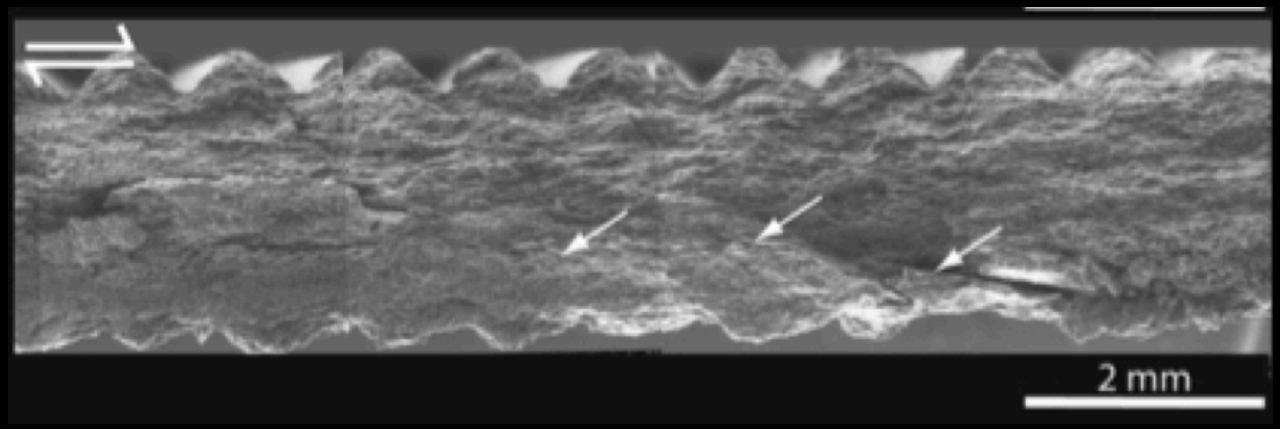
One Key Point

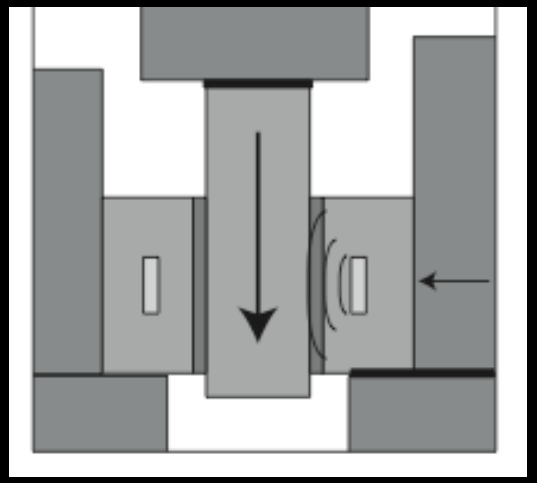
When faults creep quasi-continuously (for example because the healing rate is near zero) the potential energy drop during an instability is (near) zero.



Fault healing plays a key role in creating the spectrum of tectonic faulting styles from seismic to aseismic slip

- Lab work showing the complete spectrum of slip behaviors – A new opportunity to investigate the mechanics of slow slip
- Mechanisms: Why are they slow?
    - Rate dependence of the critical rheologic weakening rate

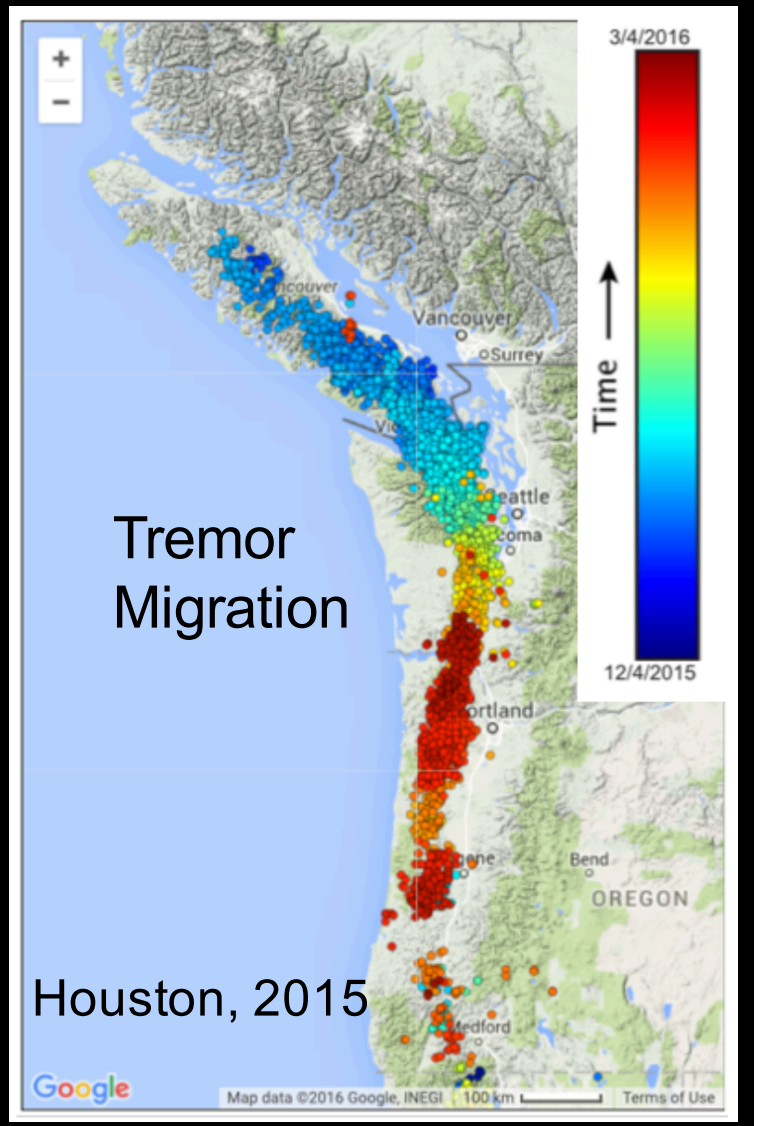




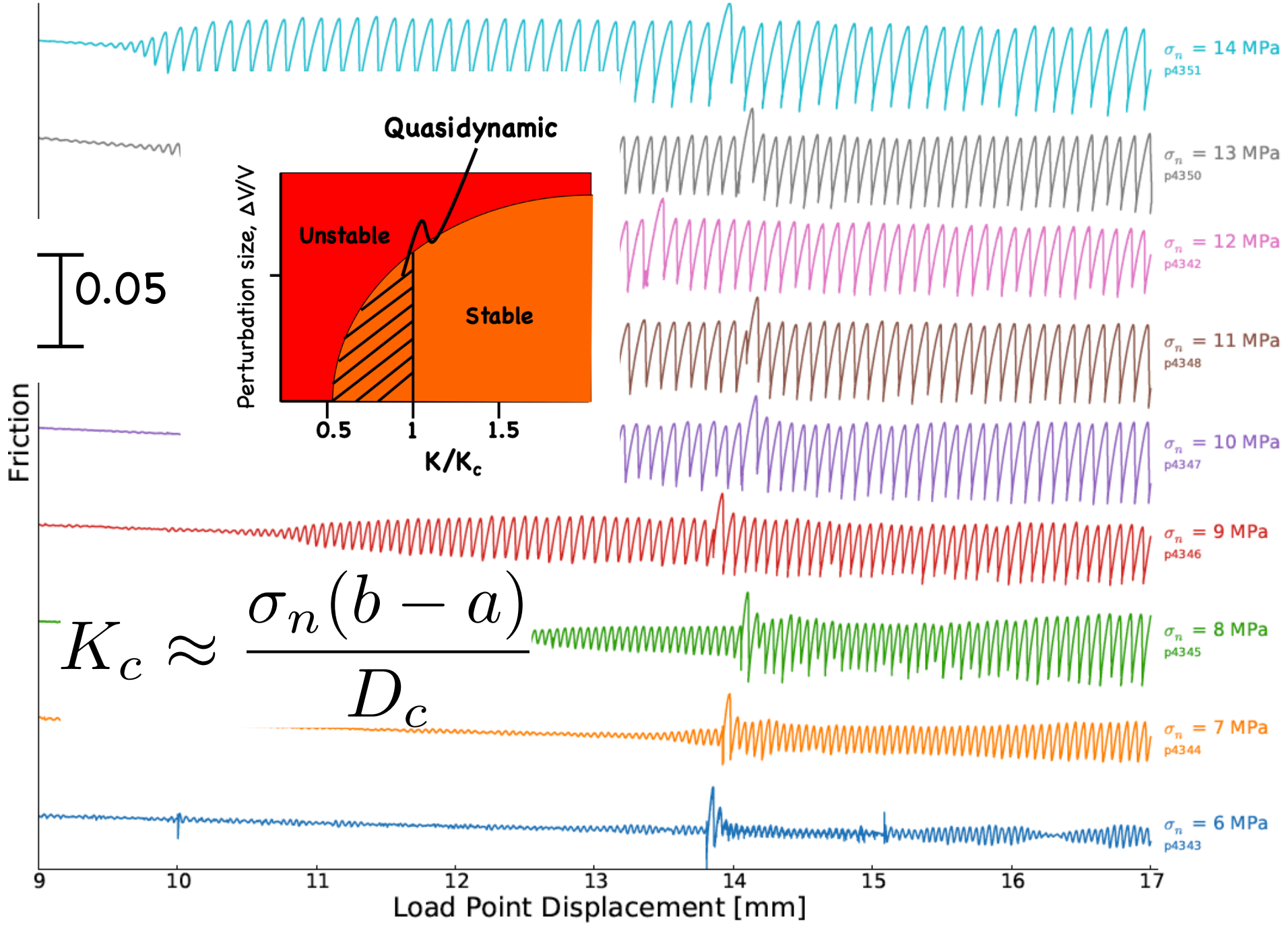
The spectrum of fault slip behaviors

- Ordinary earthquakes
- Tsunamigenic earthquakes
- Tectonic Tremor
- Episodic tremor and slip (ETS)
- Low frequency earthquakes
- Very low frequency earthquakes
- Long term slow slip events
- Slow precursors
- Aseismic slip

Slow Earthquakes

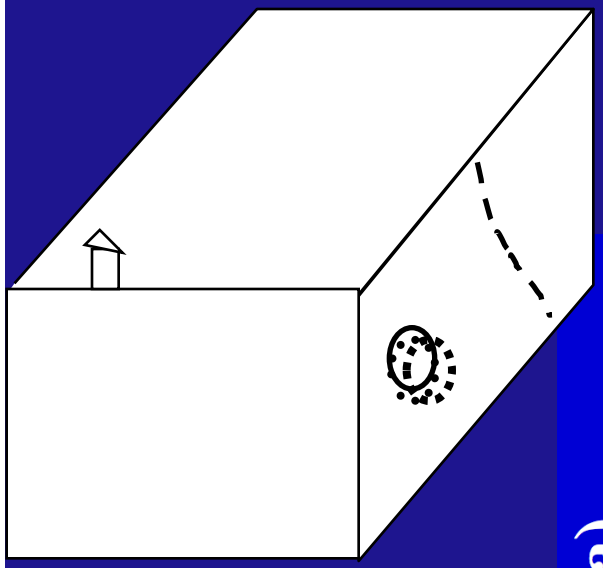


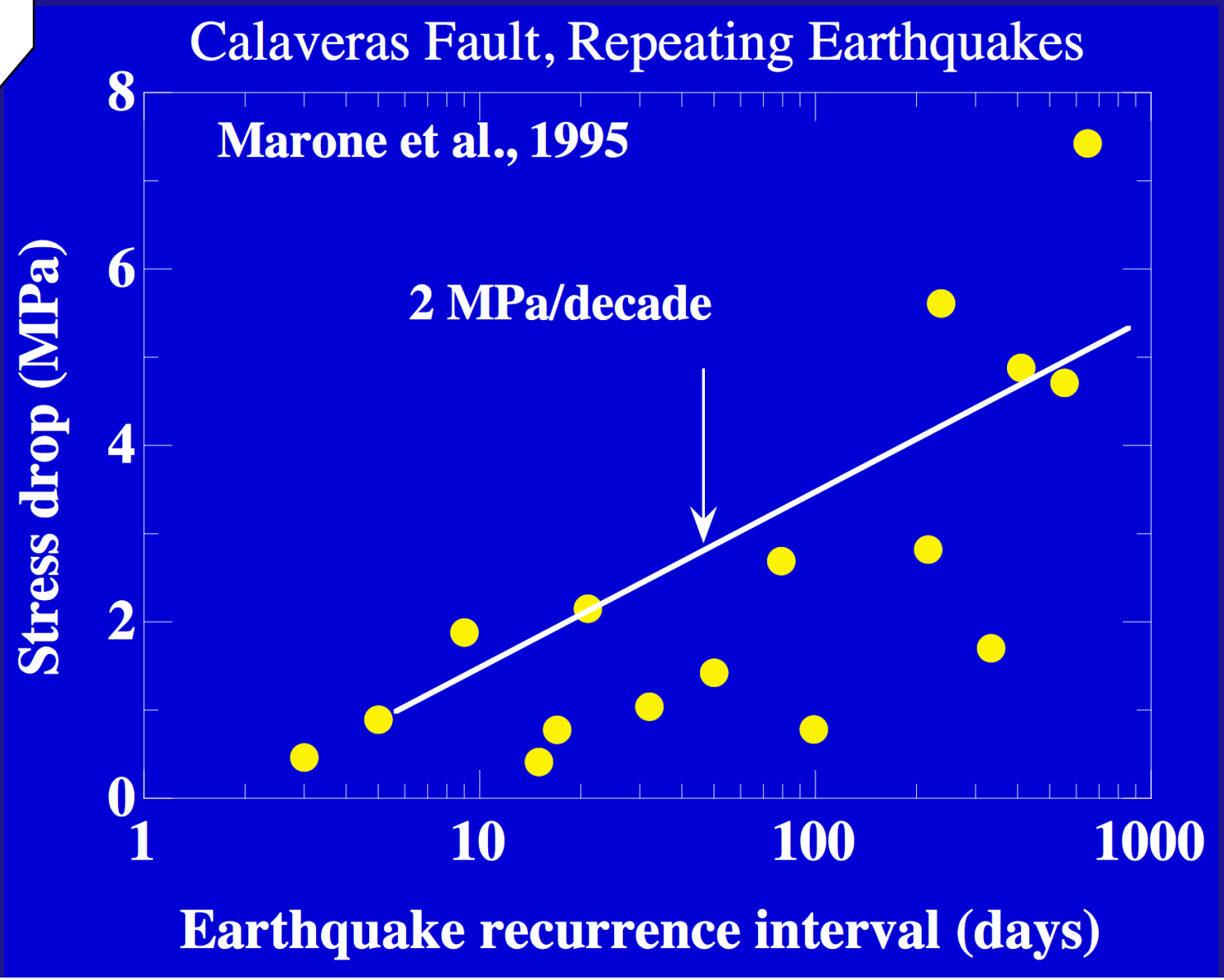
The spectrum of fault slip behaviors



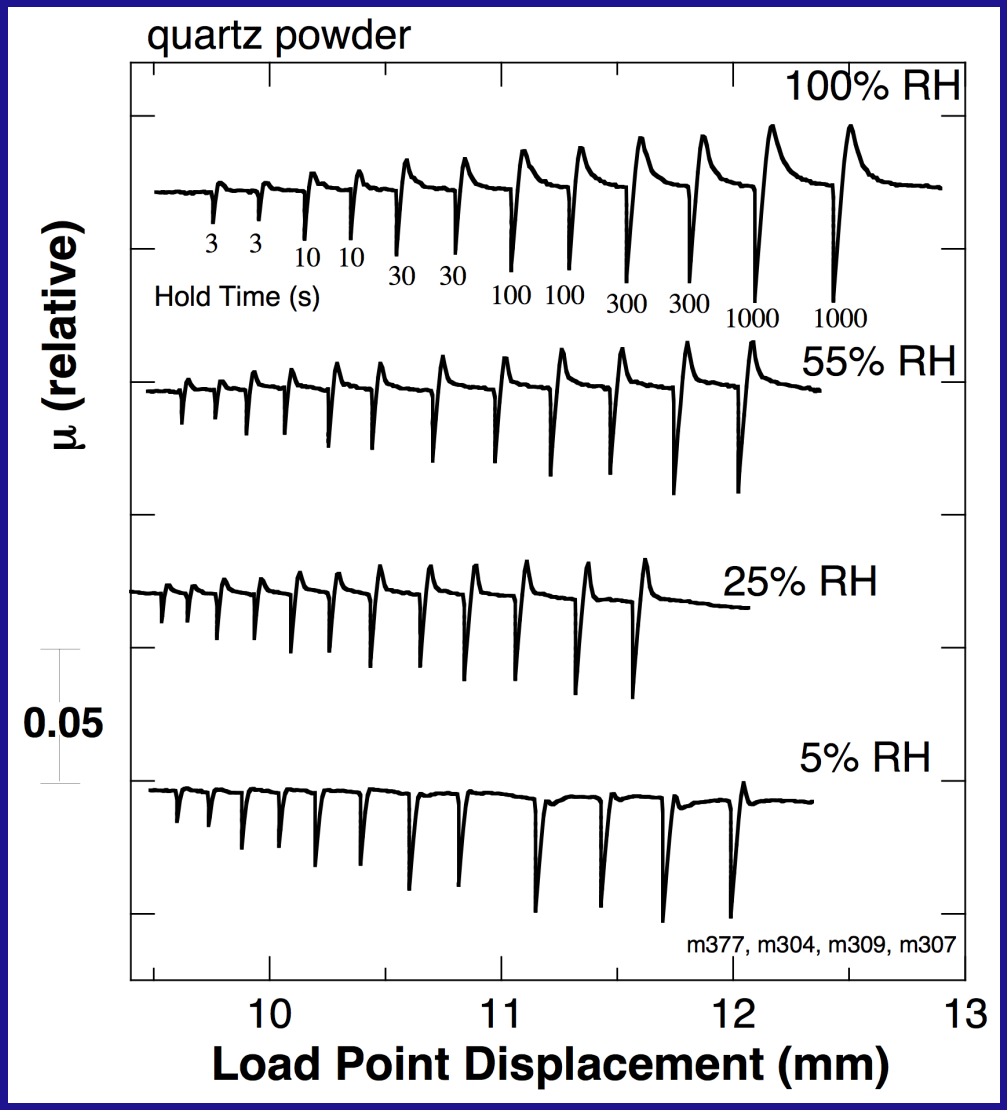
$$K_c \approx \frac{\sigma_n (b-a)}{D_c}$$

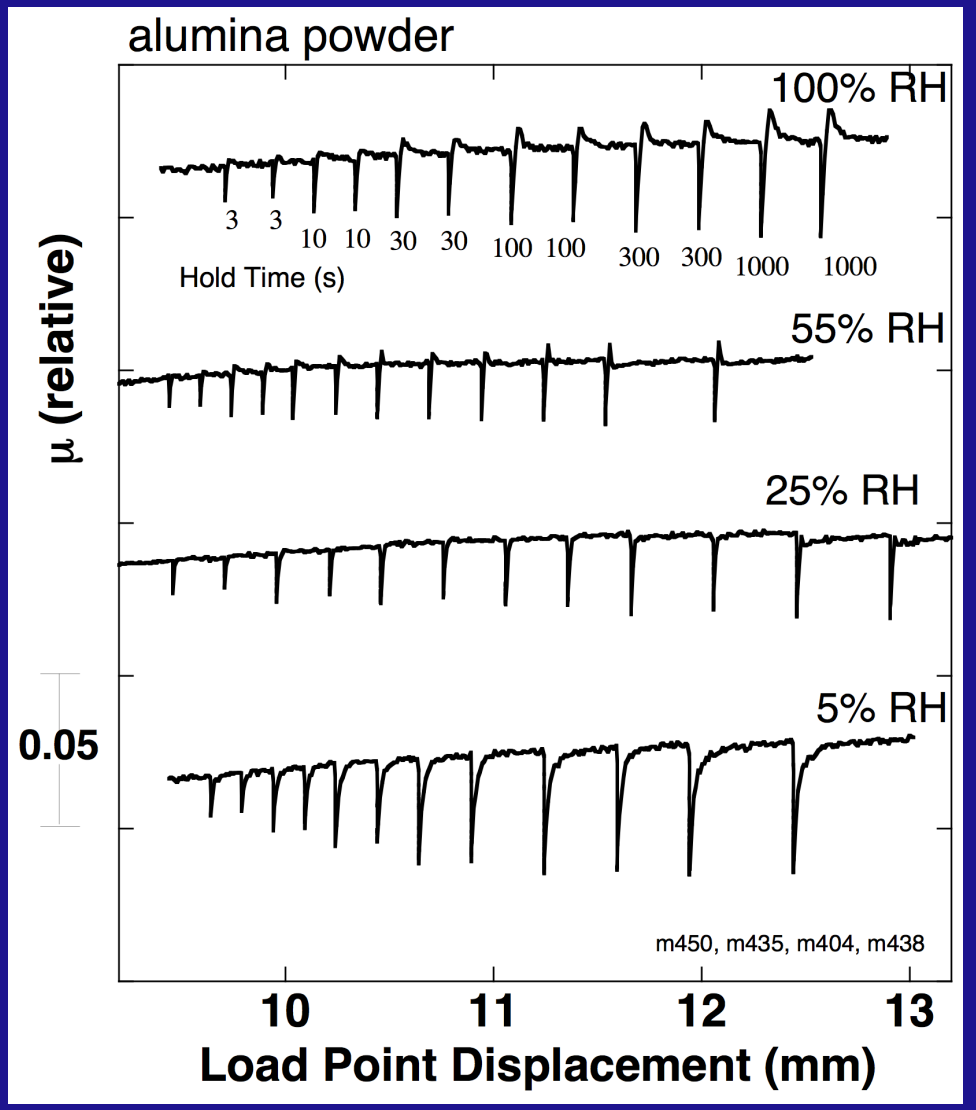
Fault Healing





Chemically-Assisted Frictional Aging; Creep at Adhesive Contact Junctions

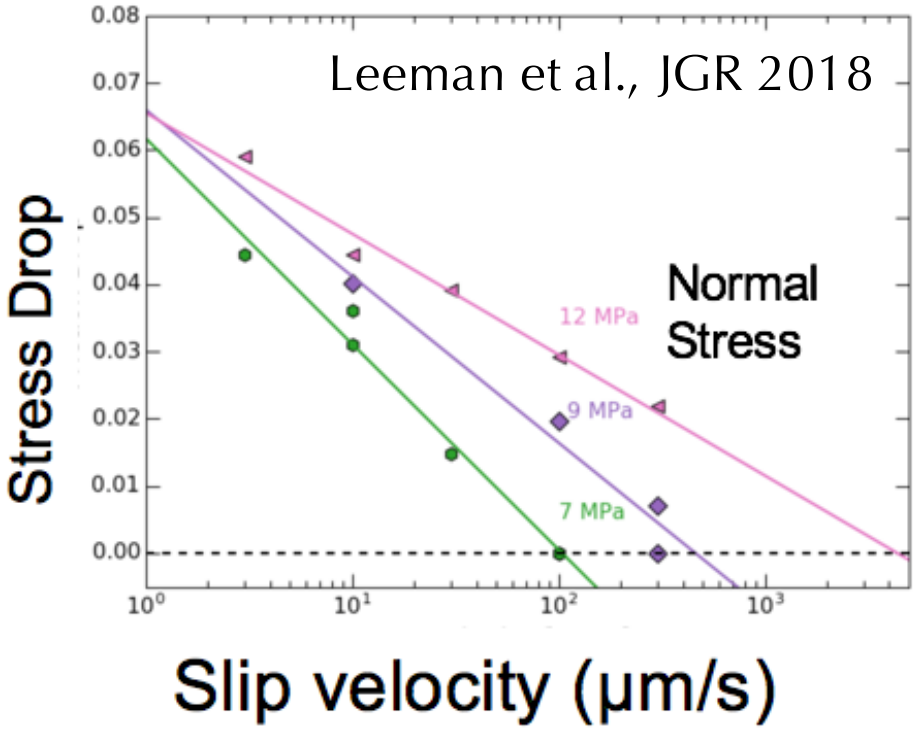


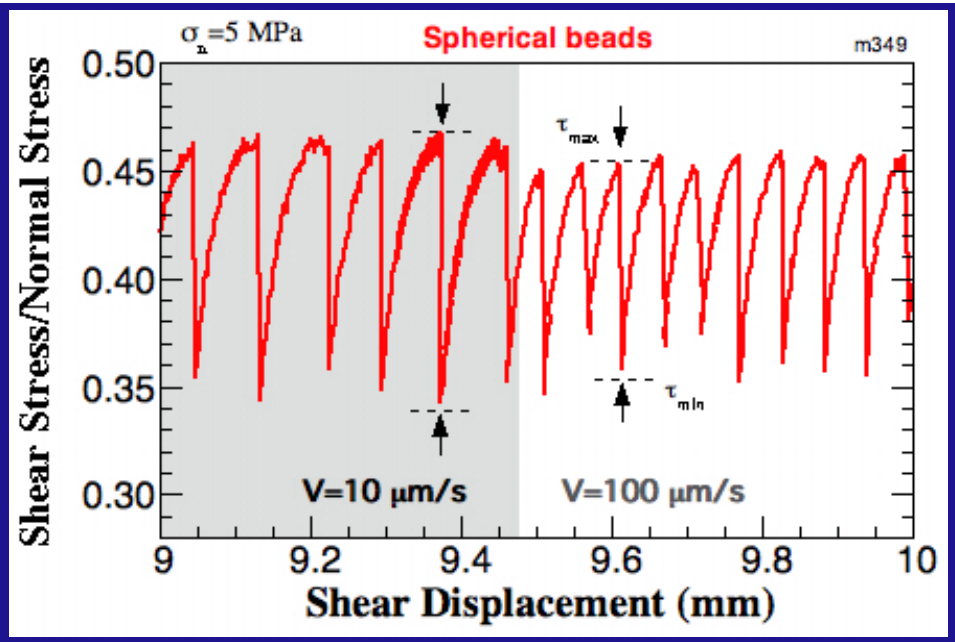


In-situ Particle Comminution; Production of Fresh Surface Area

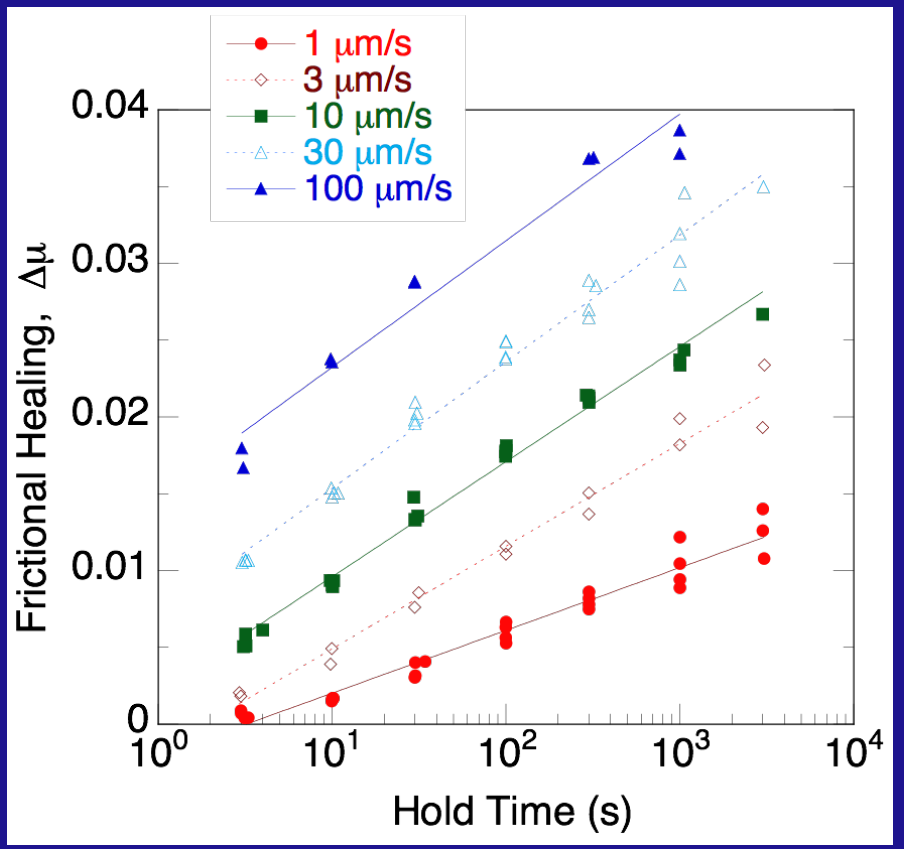
Frye and Marone, Jour. Geophys. Res. 2002

Contact aging and slip stability depends on slip velocity



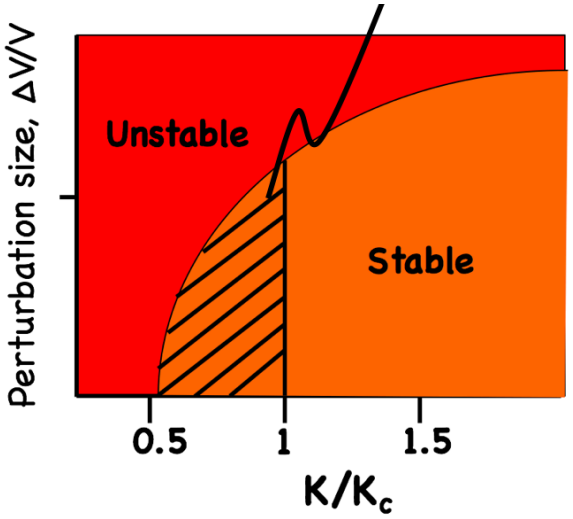


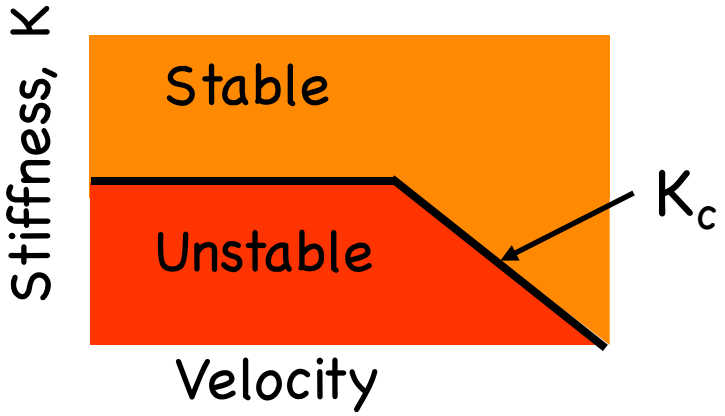
Mair, Frye and Marone, JGR 2002

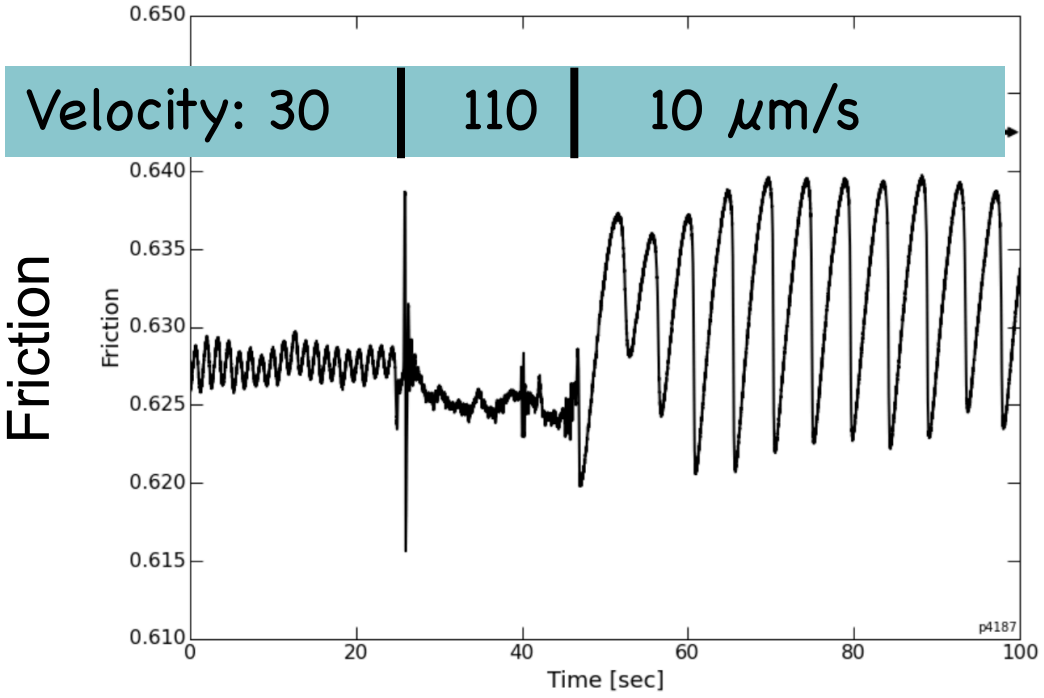


Marone, 1998, *Nature*

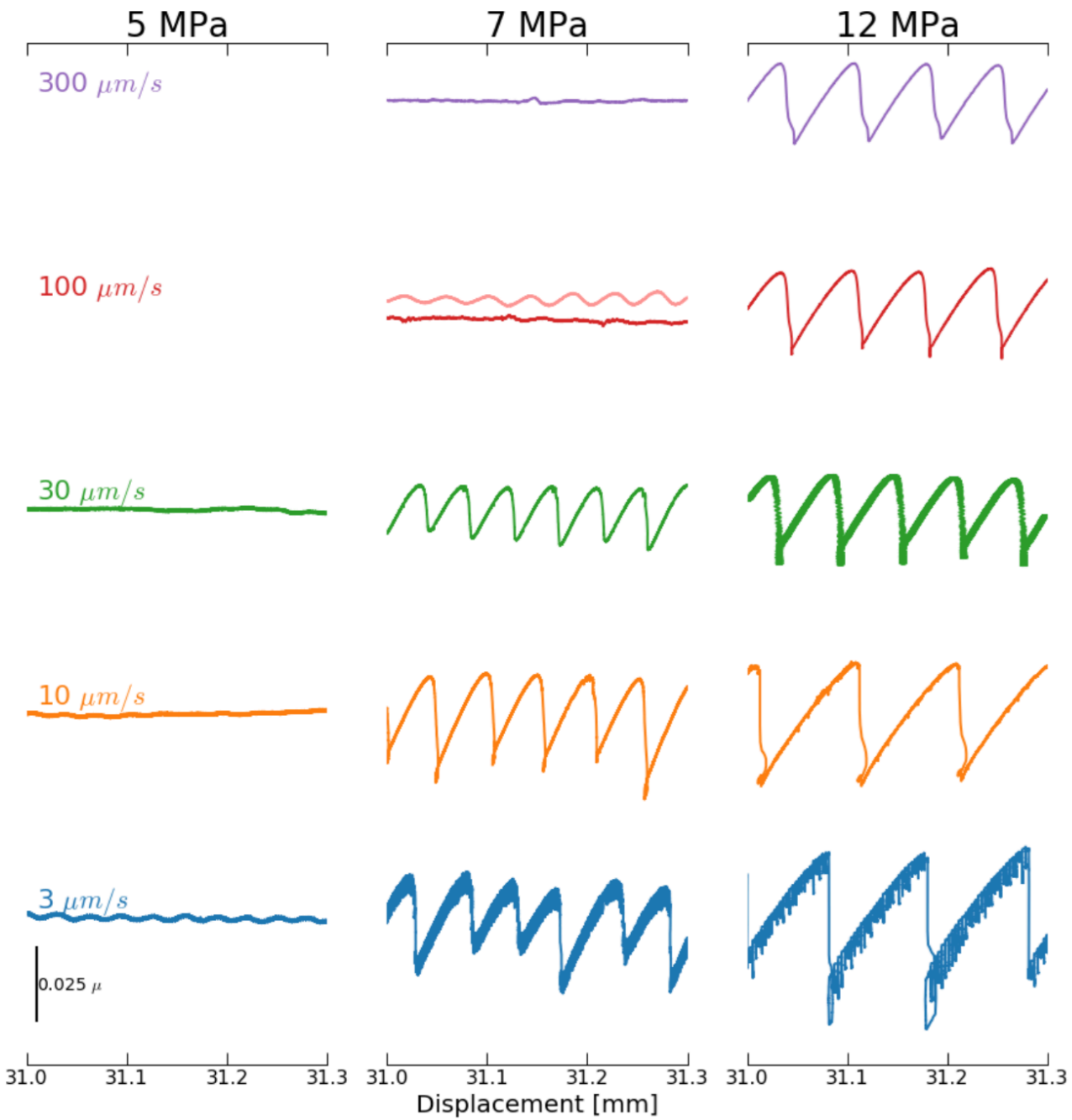
Quasi-dynamic because $K_c(V, \gamma)$



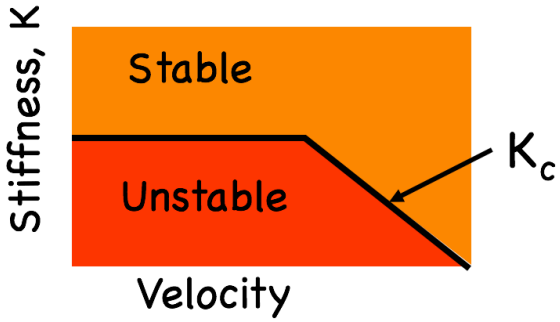




Leeman, Marone & Saffer *JGR*, 2018



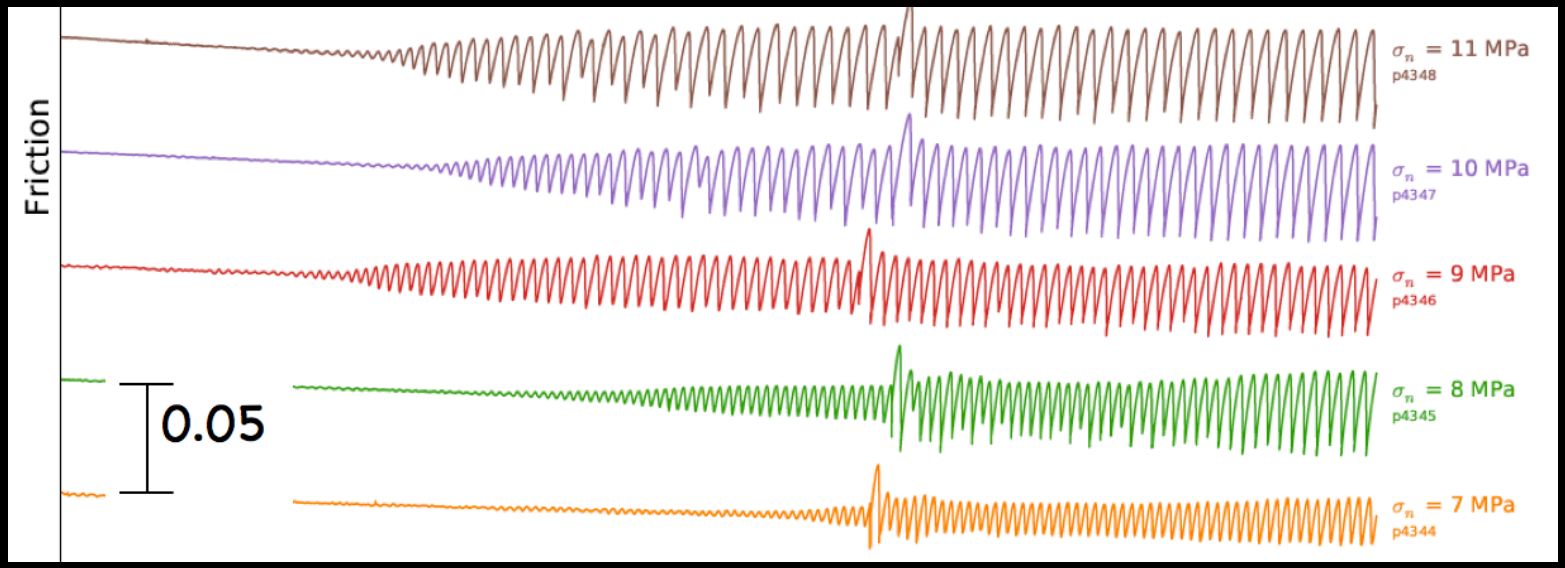
K_c is a function of slip velocity



Leeman, Marone & Saffer JGR, 2018

Key Points

1. Lab experiments show the full spectrum of slip rates from fast, dynamic rupture to slow slip
2. This occurs for conditions near the friction stability boundary
3. Stick-slip stress drop is lower for slower events and decreases with slip event speed –the same as for tectonic faulting



The Mechanics of Slow Earthquakes

Mechanisms: *Why are they slow?*

A. Rate dependence of the critical rheologic weakening rate

B. Fracture mechanics: Energy release rate equals (frictional) weakening rate.

C. Stress drop is negligible because the dynamic force imbalance is near zero

D. At the stability boundary, the fault creeps quasi-continuously and therefore the healing rate is (near) zero, which means the potential energy drop during a potential instability is (near) zero.