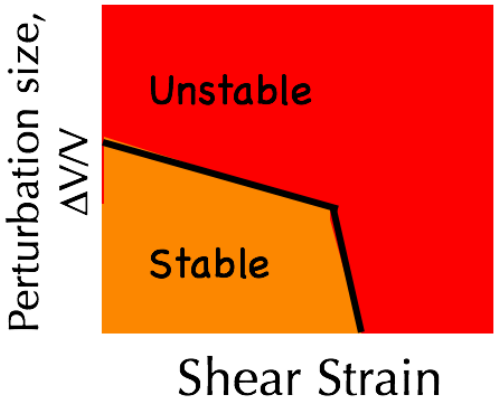
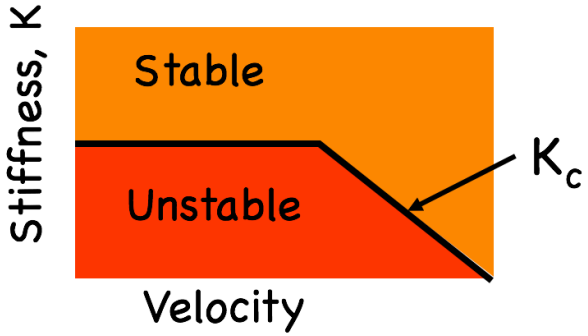
Mechanics of Earthquakes and Faulting

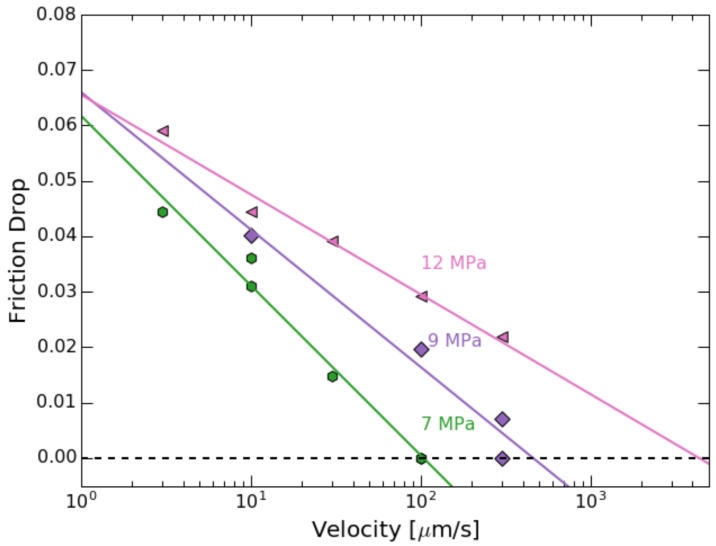
Lecture 17 , 30 Mar. 2021

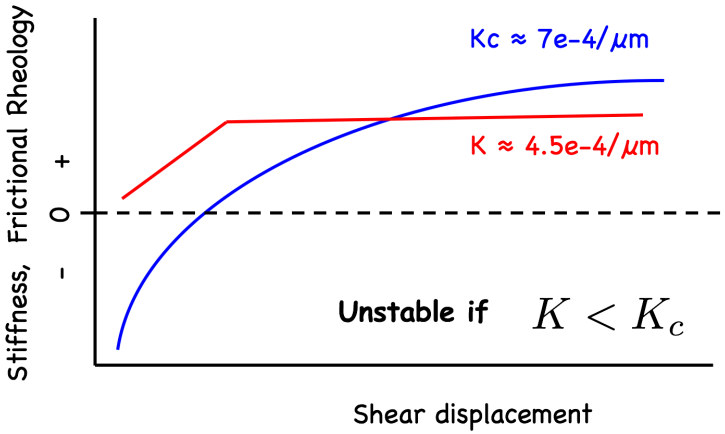
www.geosc.psu.edu/Courses/Geosc508

- Lab results show the full spectrum of fault slip rates in a manner consistent w/ RSF laws and expectations for frictional stability.
- Earthquake Nucleation Size based on RSF and concept of critical weakening rate Kc
- Source Parameters and Scaling Relations for Earthquakes
- Precursors to lab earthquakes

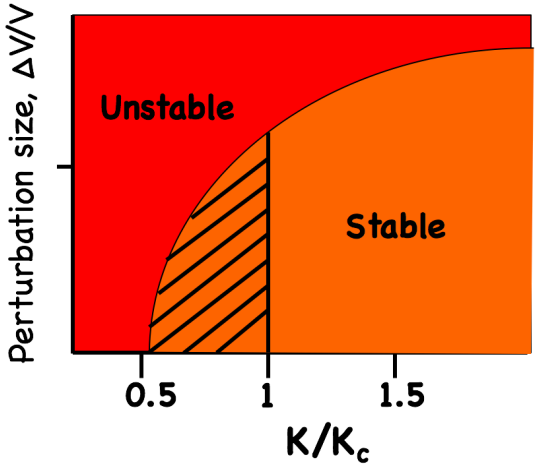


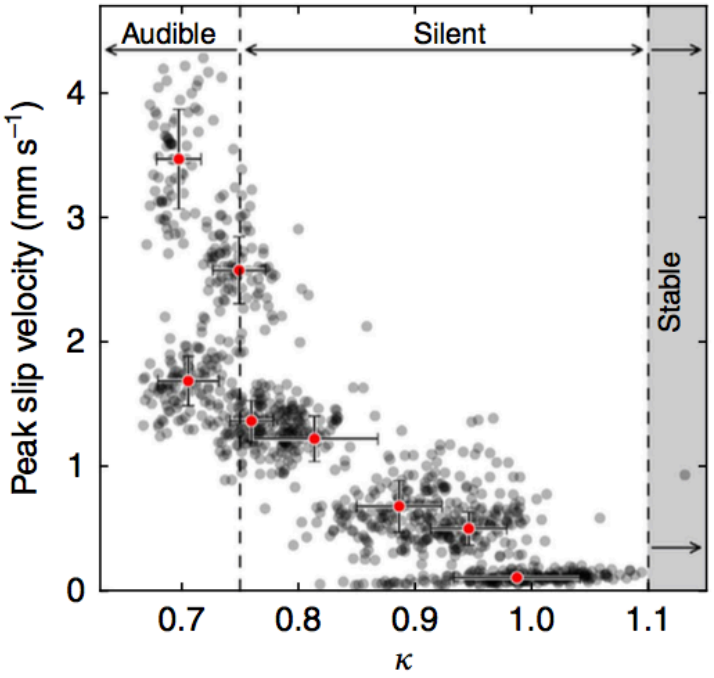






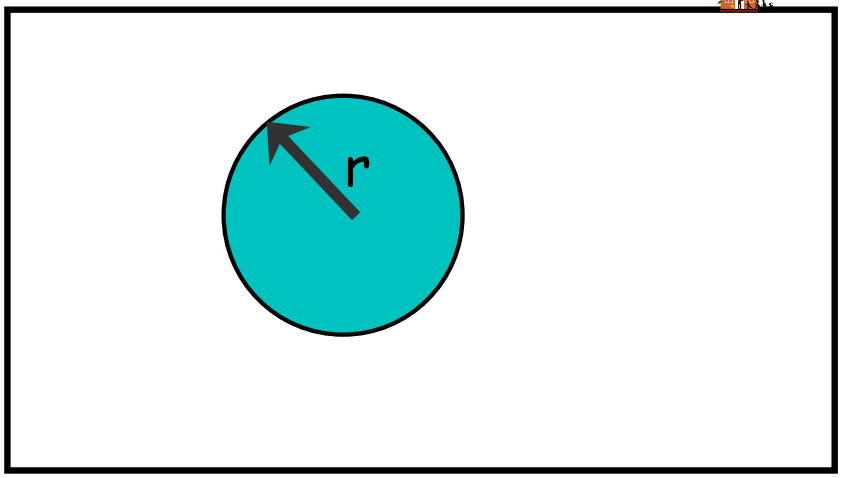
Summary of our recent lectures





Ordinary Earthquakes

Seismic waves are created by rapid acceleration at the rupture front

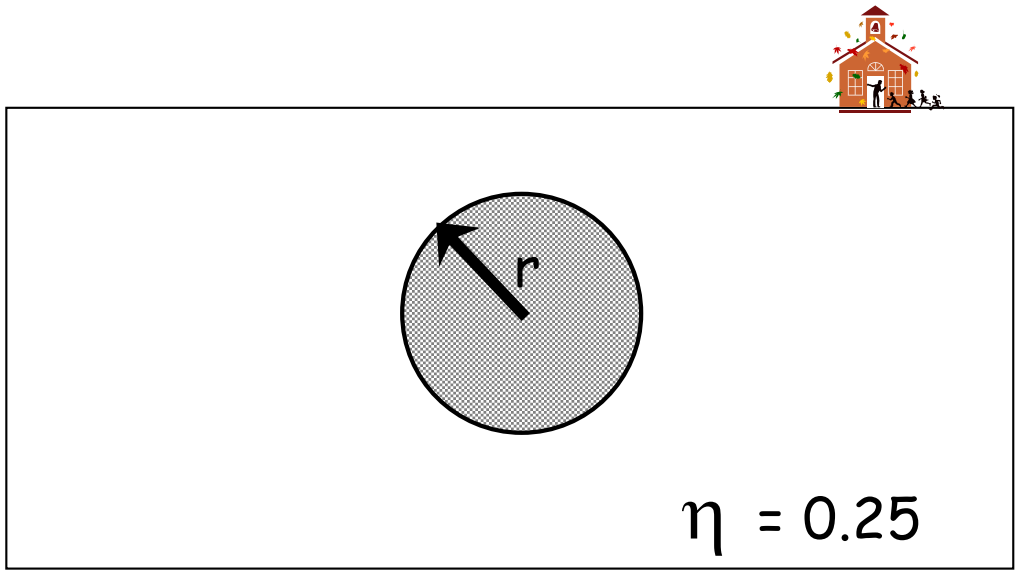


Ordinary (fast) Earthquakes

V_r is a few km/s

Images from the aftermath of the Anchorage earthquake

Earthquake Source Parameters and Scaling Relations



Dislocation model for fault slip and earthquake rupture

$$\Delta\sigma = \frac{7\pi}{16} G \frac{\bar{u}}{r}$$

$$M_o = G\bar{u}A$$

$$M_o = C\Delta\sigma r^3$$

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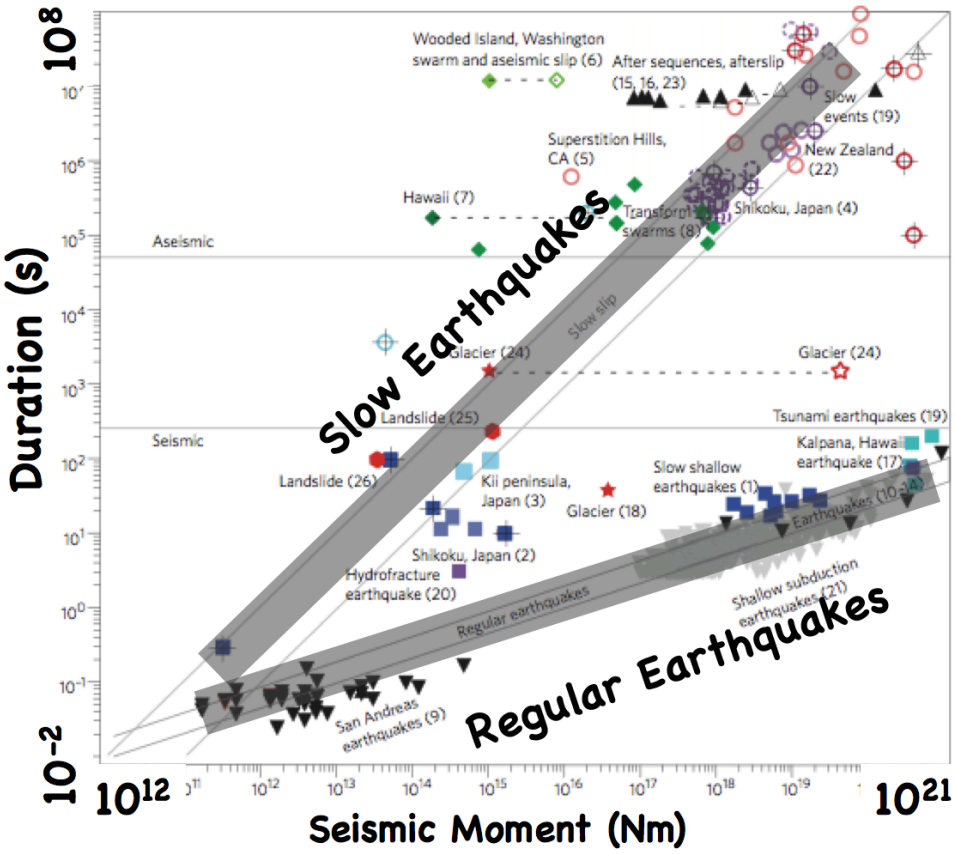


Ide et al., 2007; Peng and Gomberg, 2010

$$\Delta\sigma = \frac{7\pi}{16} G \frac{\bar{u}}{r}$$

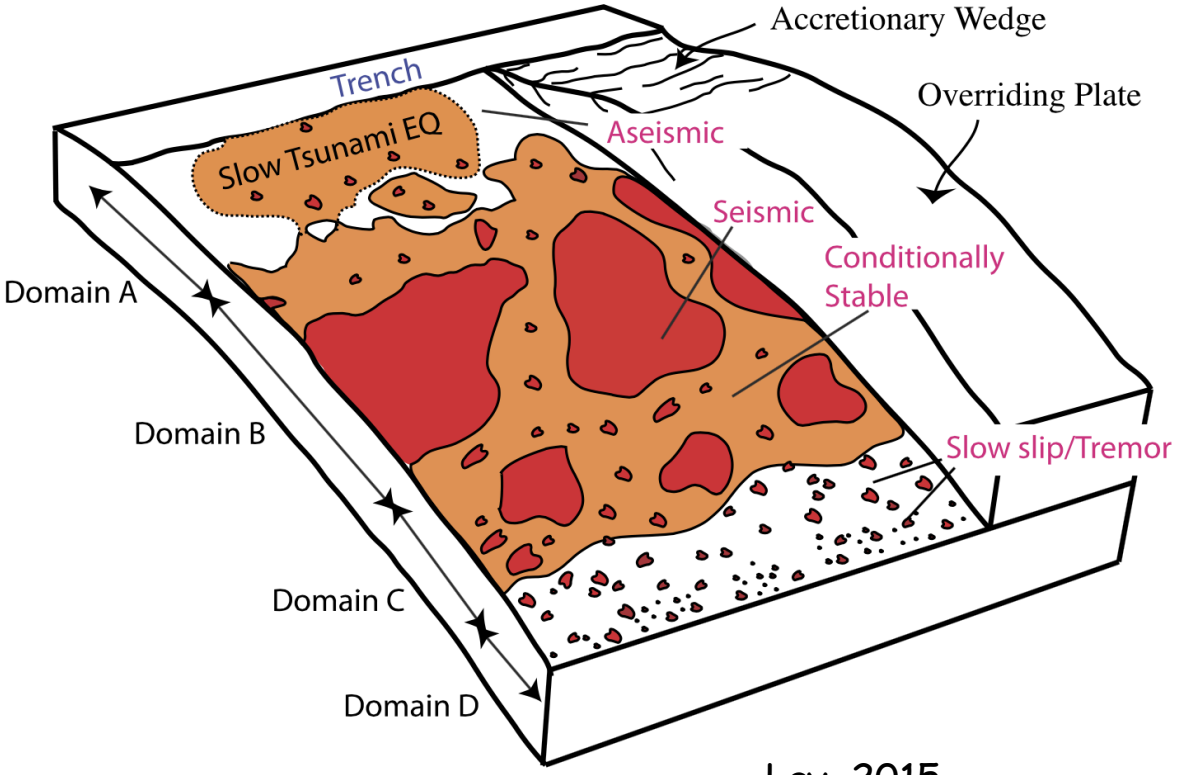
$$M_o = G\bar{u}A$$

$$M_o = C\Delta\sigma r^3$$

$$V_r = \frac{r}{T}$$

$$M_o = C\Delta\sigma V_r^3 T^3$$

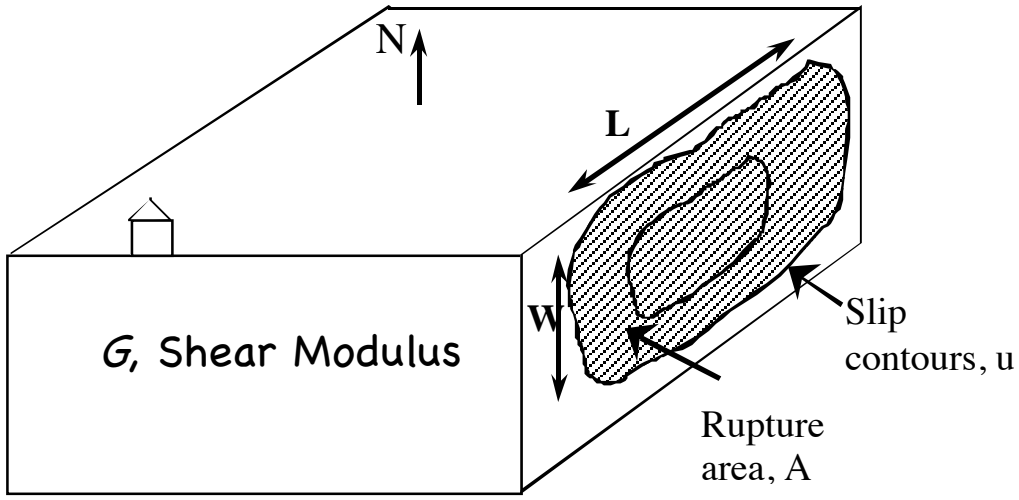
A. Where should slow earthquakes occur?
B. How could we get slow and fast slip on the same fault segment?



Lay, 2015

Lab guidance

Slow slip and complex behavior near the stability boundary, defined by: $K \approx K_c$

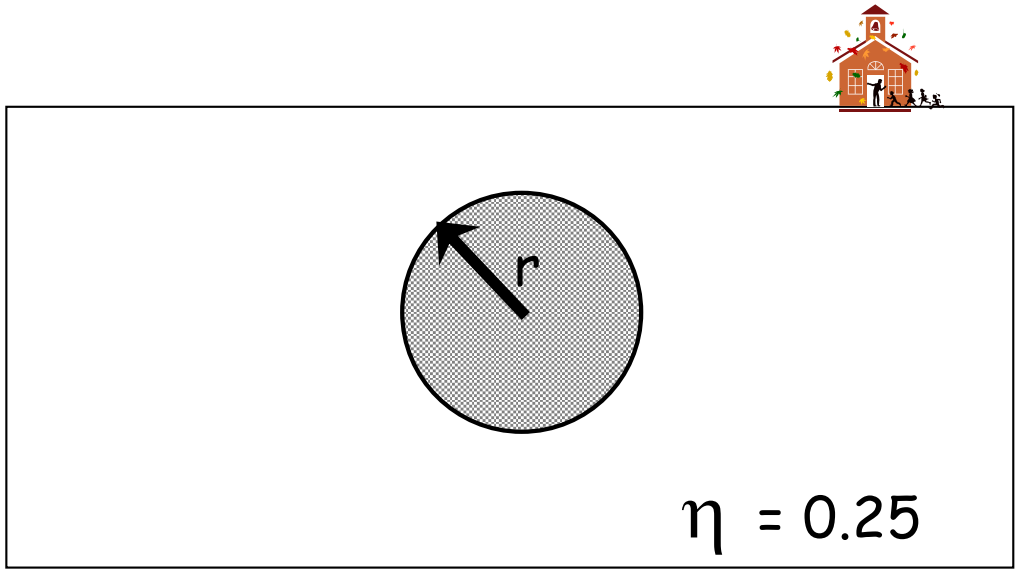


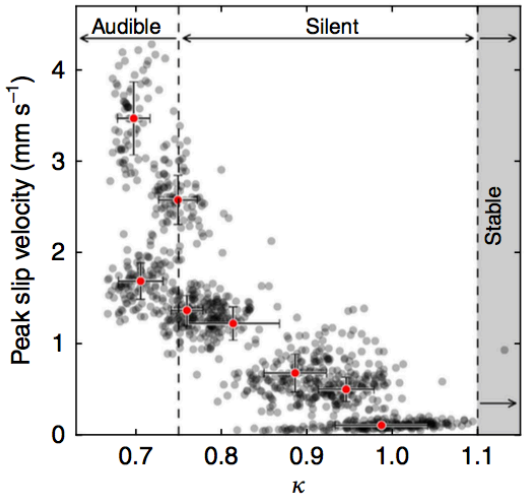
$$M_o = G\bar{u}A$$

1. Earthquake Nucleation occurs when the patch size exceeds *h**

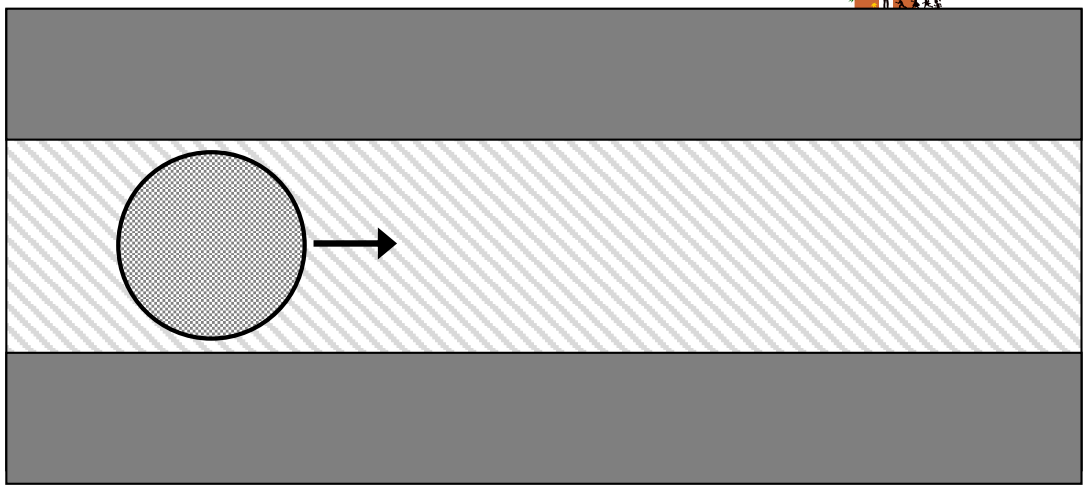
Slow Earthquakes occur when $\frac{K}{K_c} \approx 1.0$

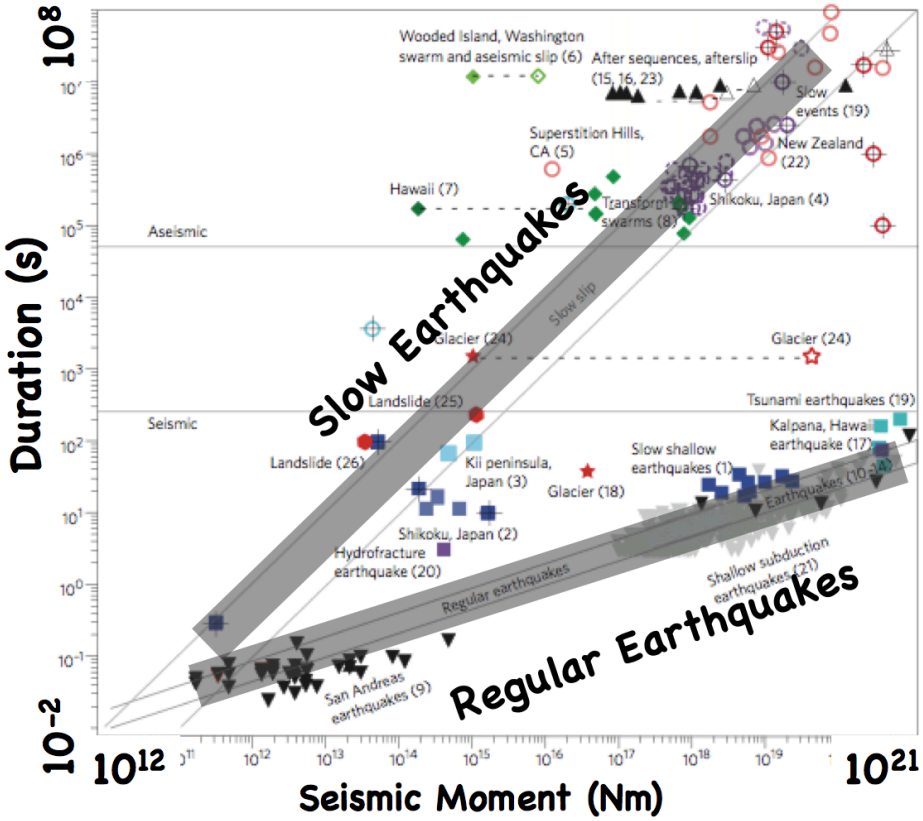
What if the rupture patch size were limited to that size?





$$h^* = \frac{GD_c}{\sigma_n(b-a)}$$



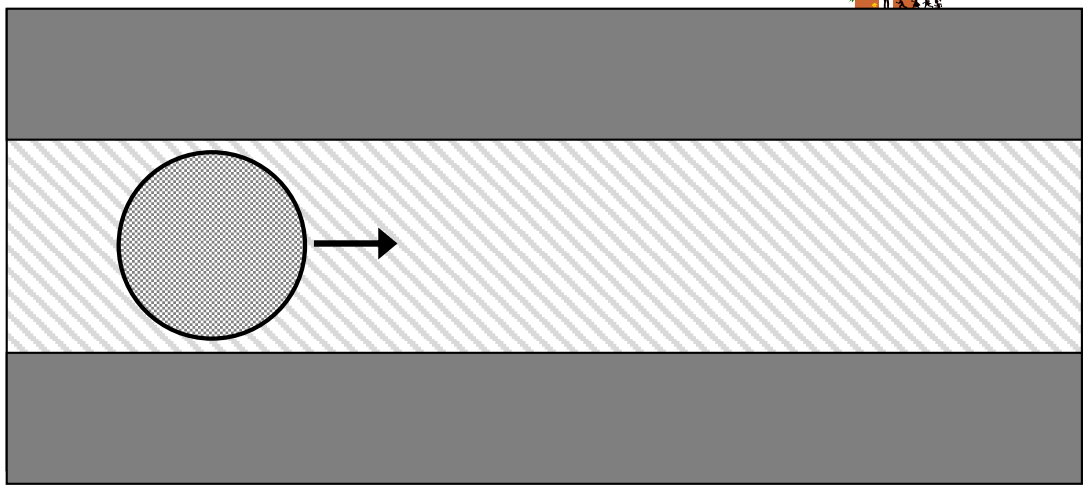


Slow slip when effective rupture patch size is limited by heterogeneity

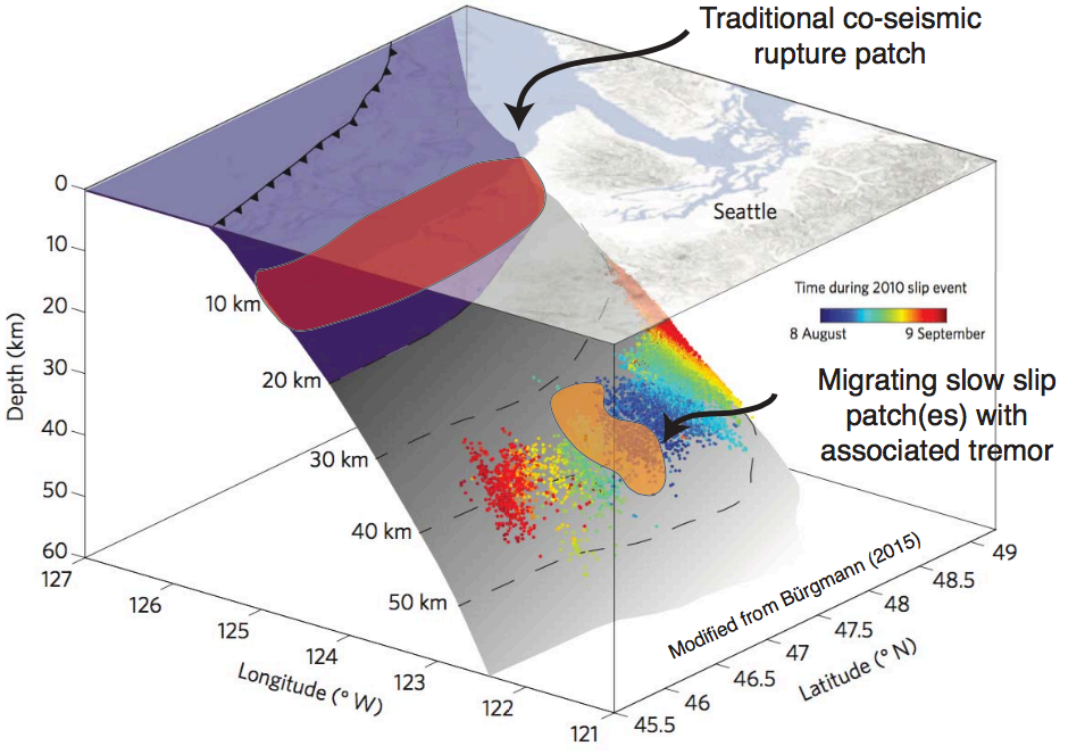
$$M_o^{patch} = G\bar{u}r^2$$

~~$$M_o = C\Delta\sigma r^3$$~~

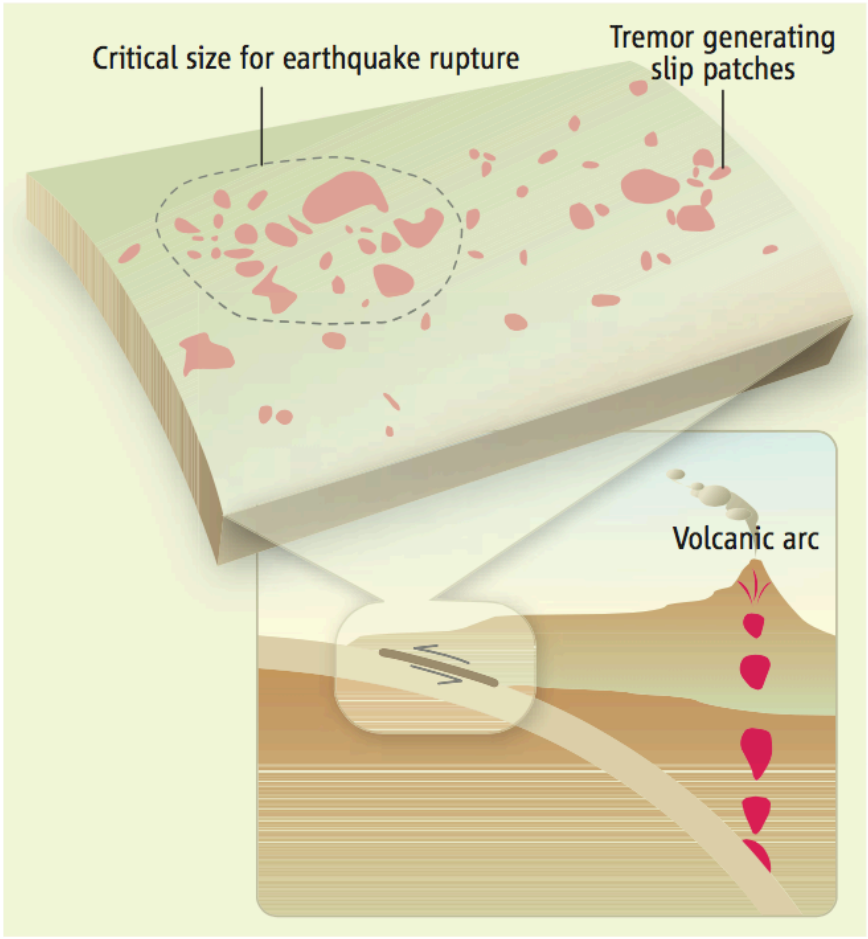
$$M_o \approx V_r T$$



Slow slip when effective rupture patch size is limited by heterogeneity



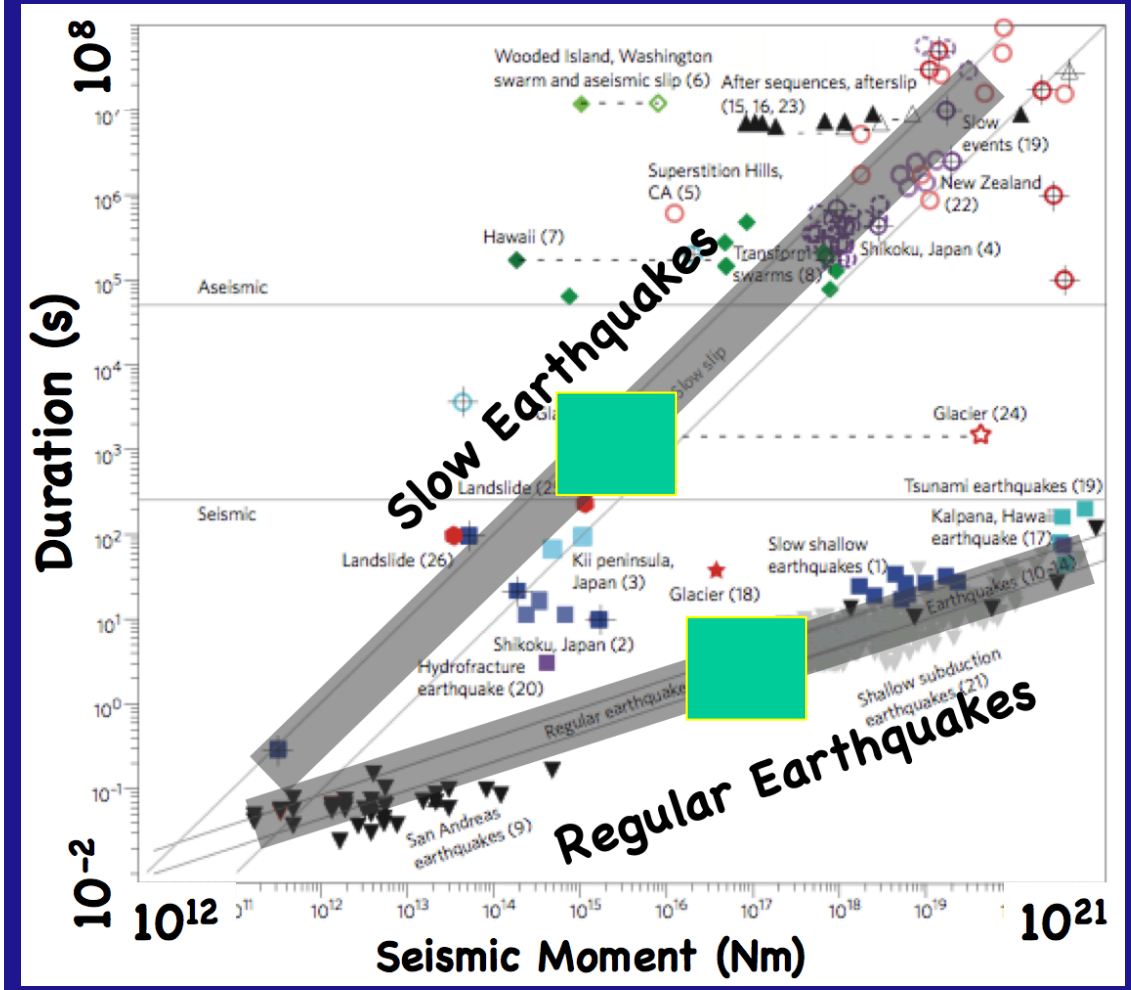
Bürgmann, 2015; Houston, 2015

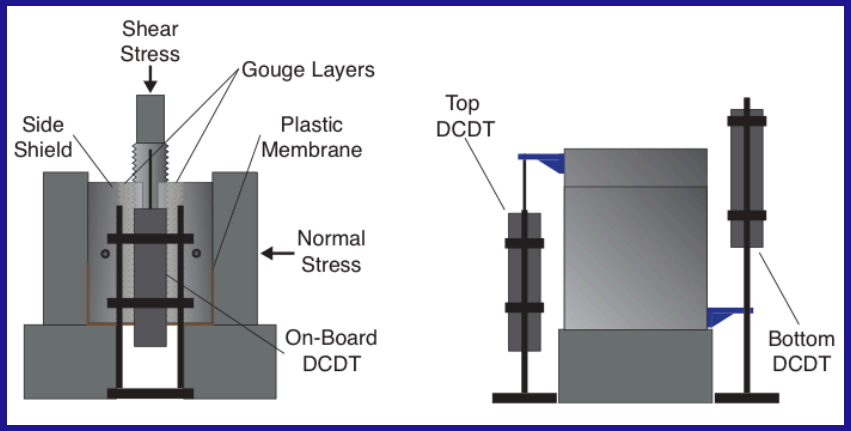


Richardson and Marone, 2008

Conclusion 1

Lab data show a continuous spectrum from fast to slow slip

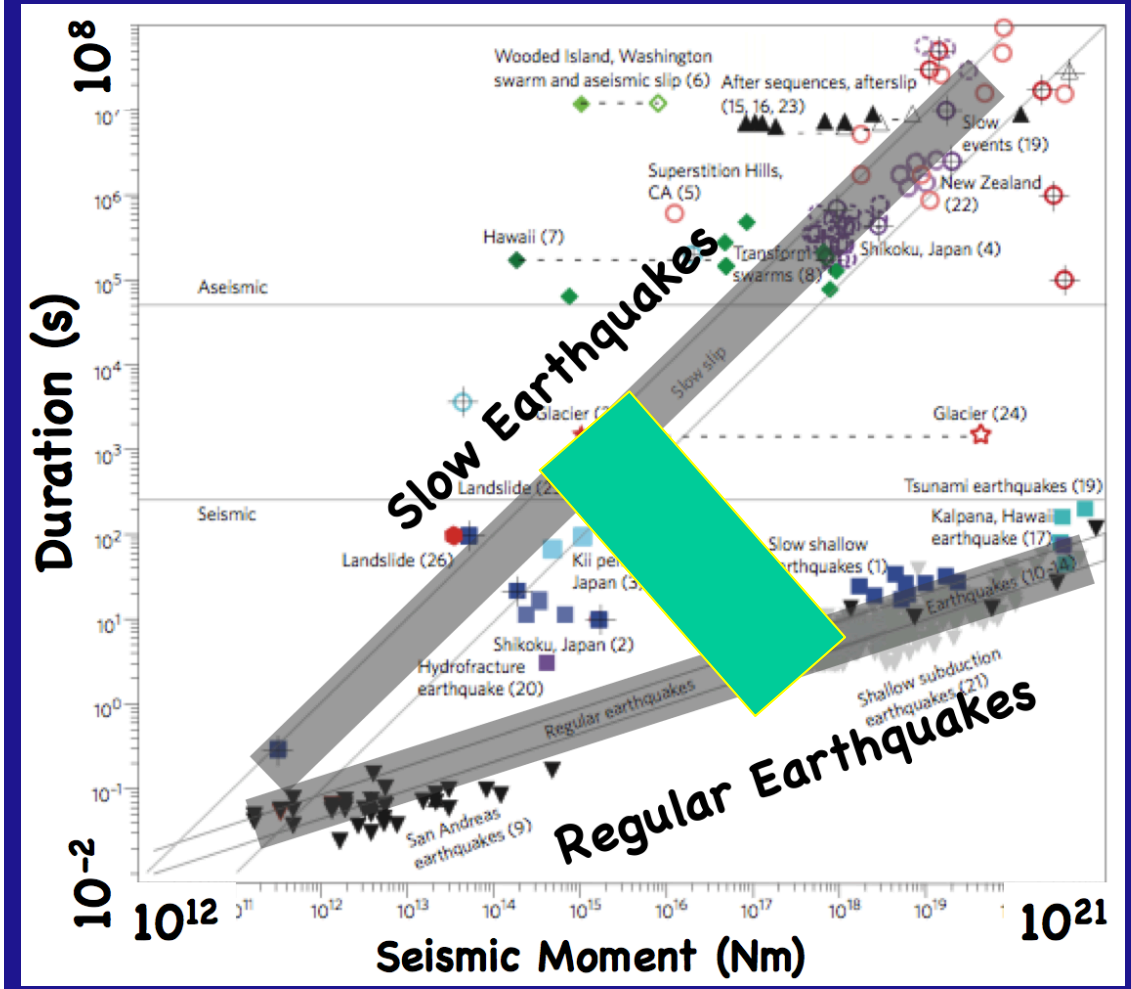


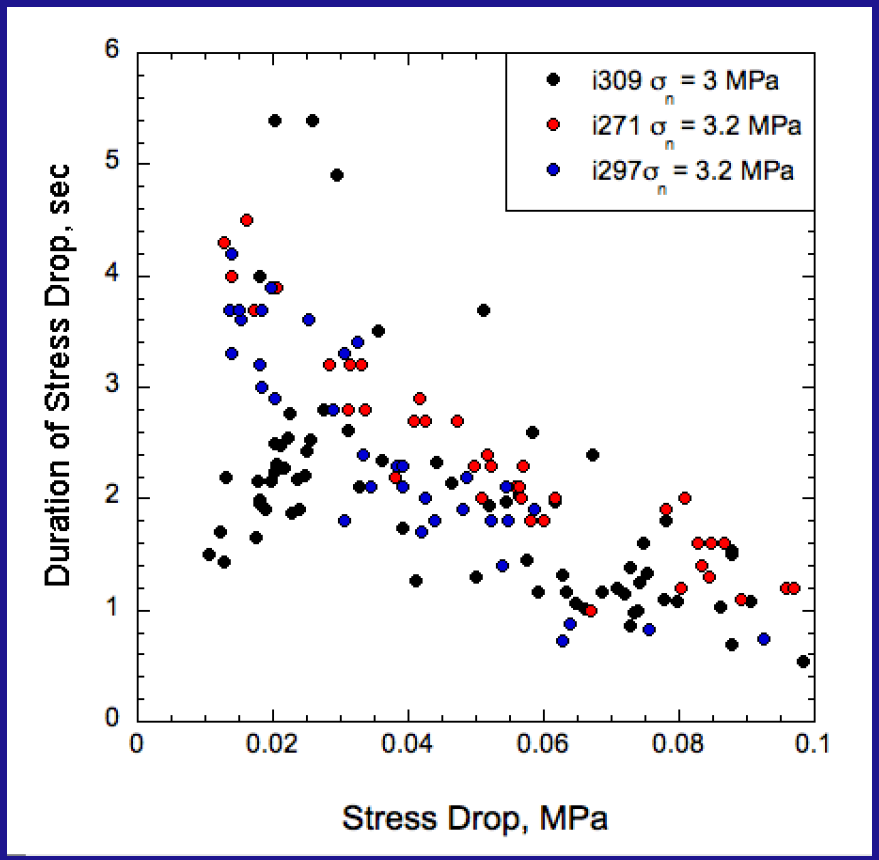


Ide et al., 2007; Peng and Gomberg, 2010

Conclusion 1

Lab data show a continuous spectrum from fast to slow slip





Ide et al., 2007; Peng and Gomberg, 2010

nature geoscience

LETTERS

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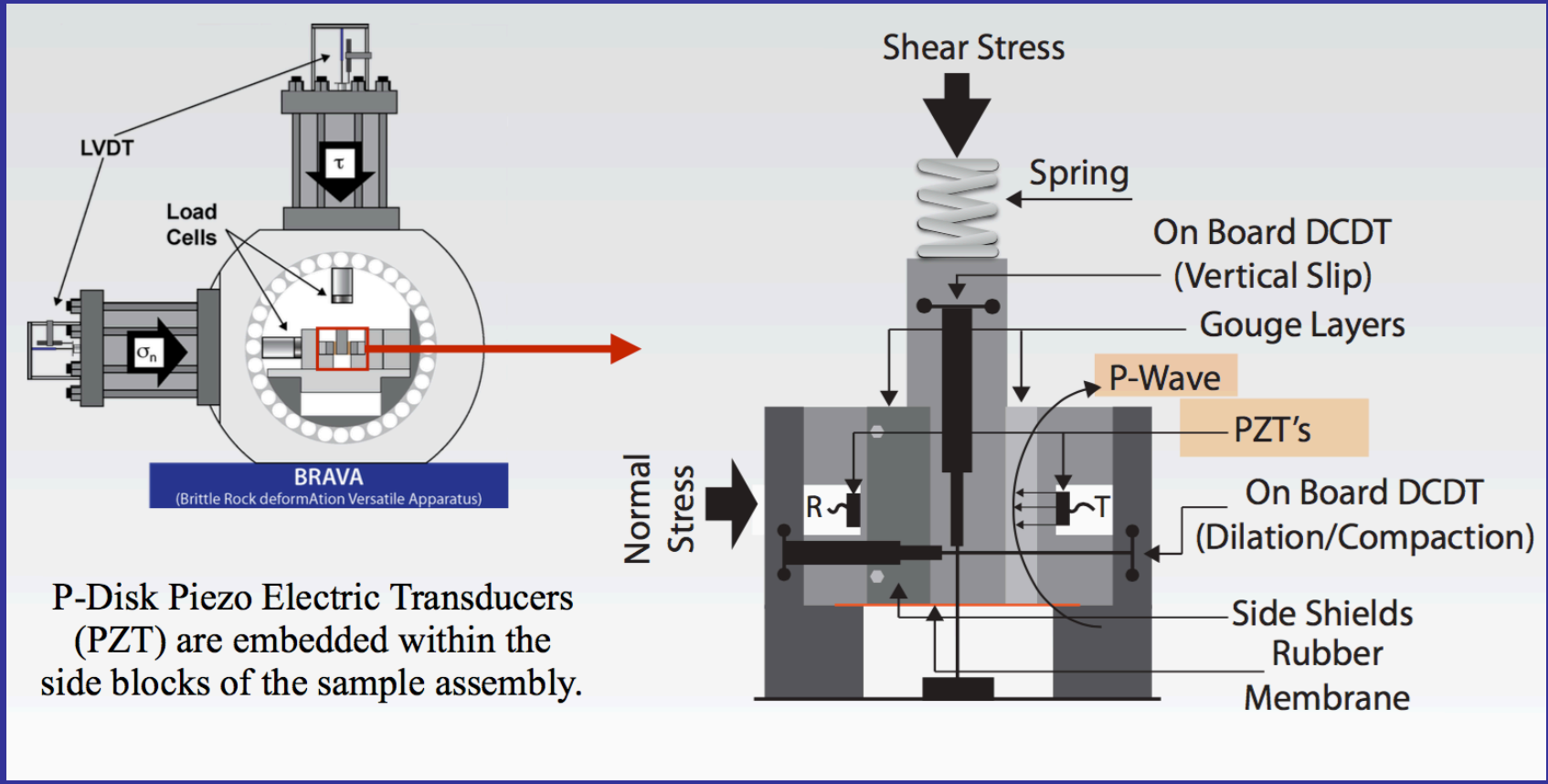
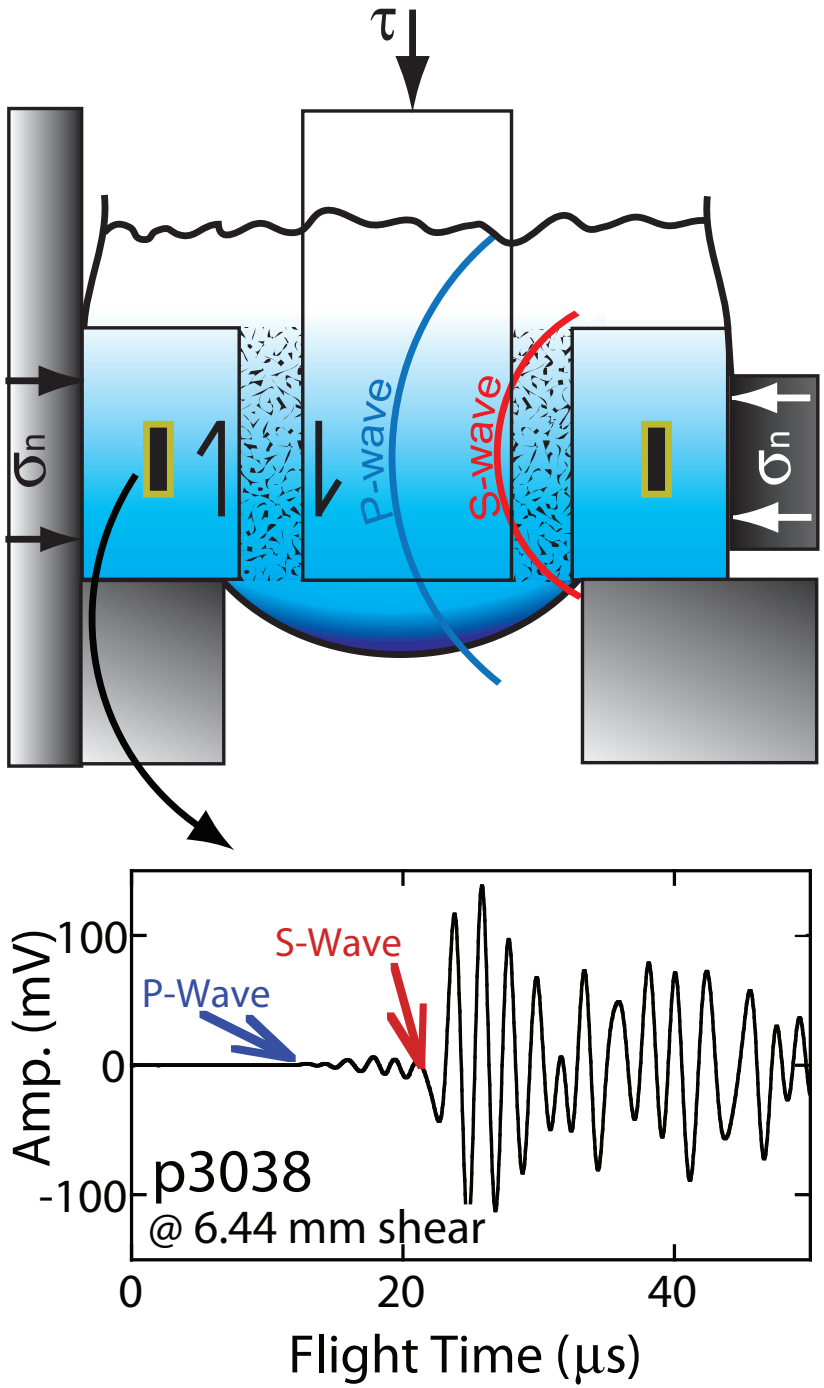
Precursory changes in seismic velocity for the spectrum of earthquake failure modes

M. M. Scuderi[1,2*], C. Marone[3], E. Tinti[2], G. Di Stefano[2] and C. Collettini[1,2]



P-Disk Piezo Electric Transducers (PZT) are embedded within the side blocks of the sample assembly.


τ
σn
σn
P-wave
S-wave
Amp. (mV)
100
0
-100
S-Wave
P-Wave
p3038
@ 6.44 mm shear
0
20
40
Flight Time (μs)