On the Nature of Fault Slip: From the Field to the Lab

F.X. Passelègue[1]

Michelle Almakari[2], Pierre Dublanchet[2], Fabian Barras[3], Marie Violay[1]

[1] Laboratoire Expérimental de Mécanique des roches, EPFL, Lausanne

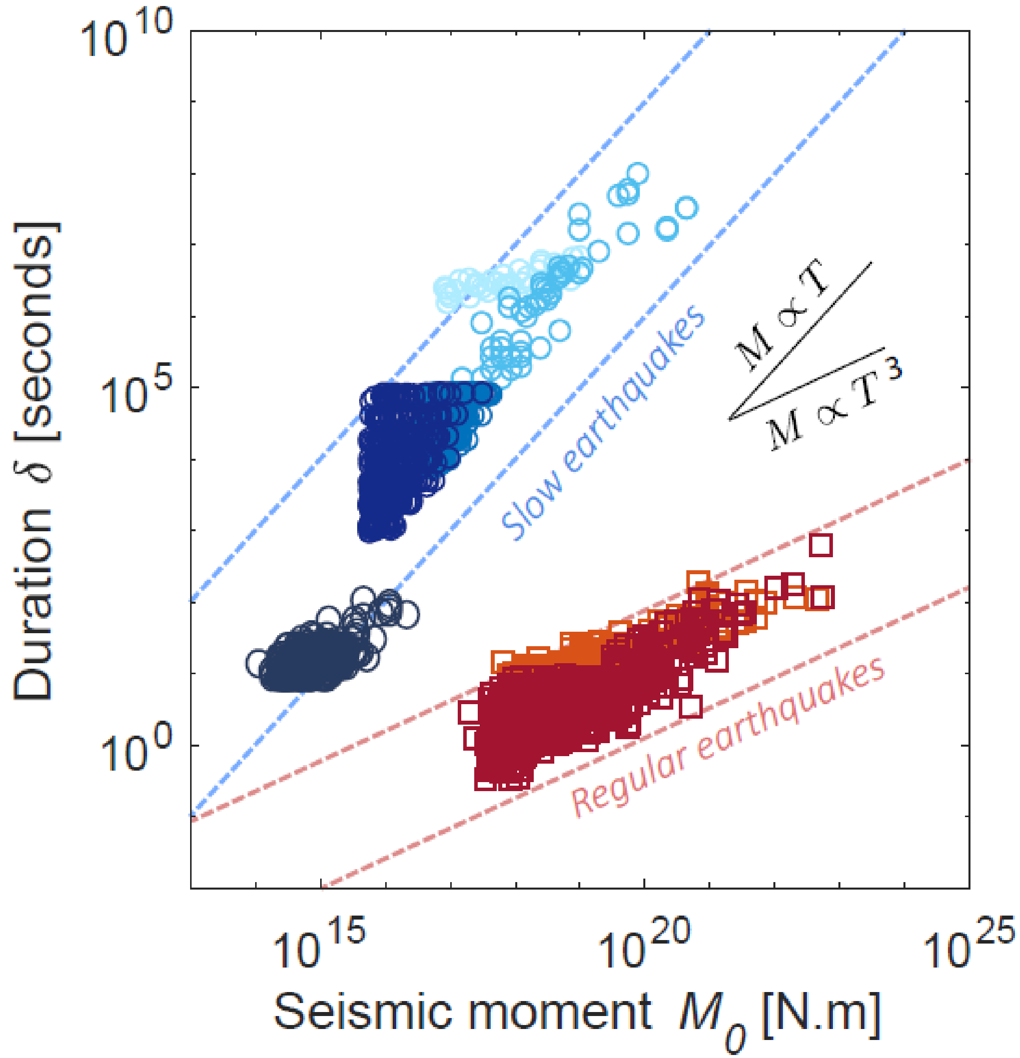
[2] MINES ParisTECH, Centre de Géosciences, Fontainebleau

[3] The Njord Centre for Studies of the Physics of the Earth, Oslo, Norway

Acknowledgments: Federica Paglialunga, Mateo Acosta, Alexandre Schubnel, Harsha Bhat Raul Madariaga, Soumaya Latour…

Various types of seismic ruptures

Passelègue et al., submitted



Scaling relations

$$M_0 \propto \Delta\sigma\, L^3$$

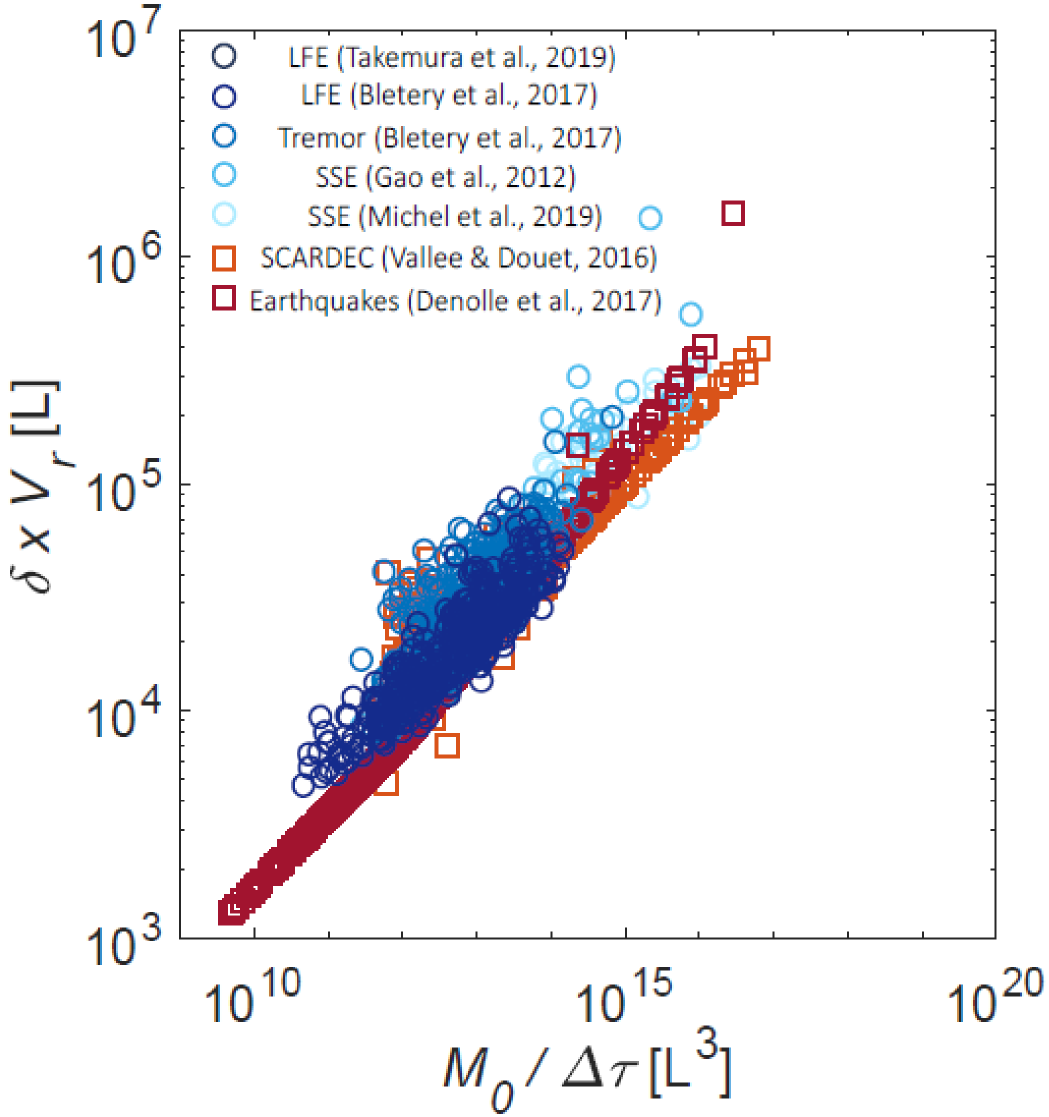
$$M_0 \propto \mu\, D\, L^2$$

$$\Delta\sigma \propto \mu \frac{D}{L}$$

$$\delta \propto L / V_r$$

Various types of seismic ruptures

Passelègue et al., submitted



Scaling relations

$$M_0 \propto \Delta\sigma\, L^3$$

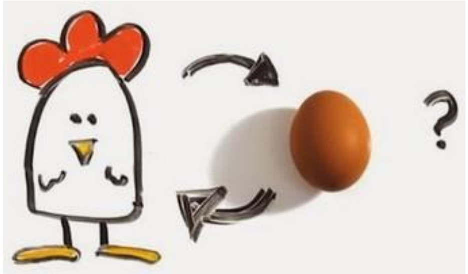
$$M_0 \propto \mu\, D\, L^2$$

$$\Delta\sigma \propto \mu \frac{D}{L}$$

$$\delta \propto L / V_r$$

Same physic

$$V_r \propto \Delta\sigma$$

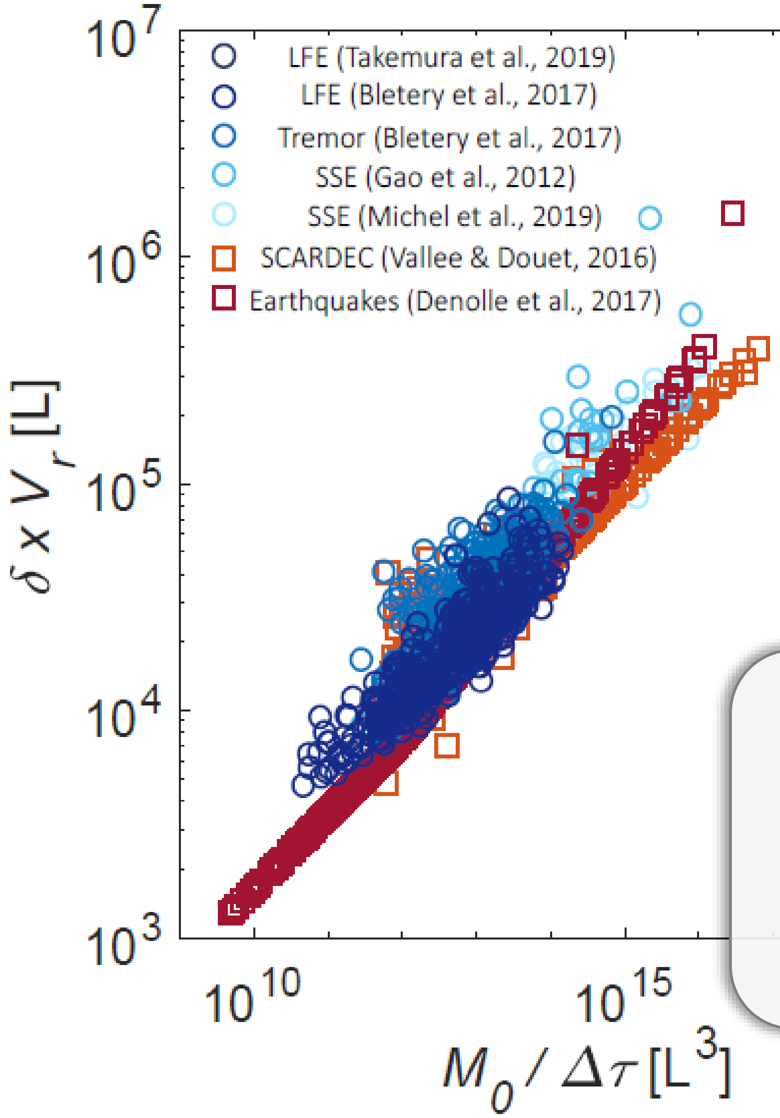


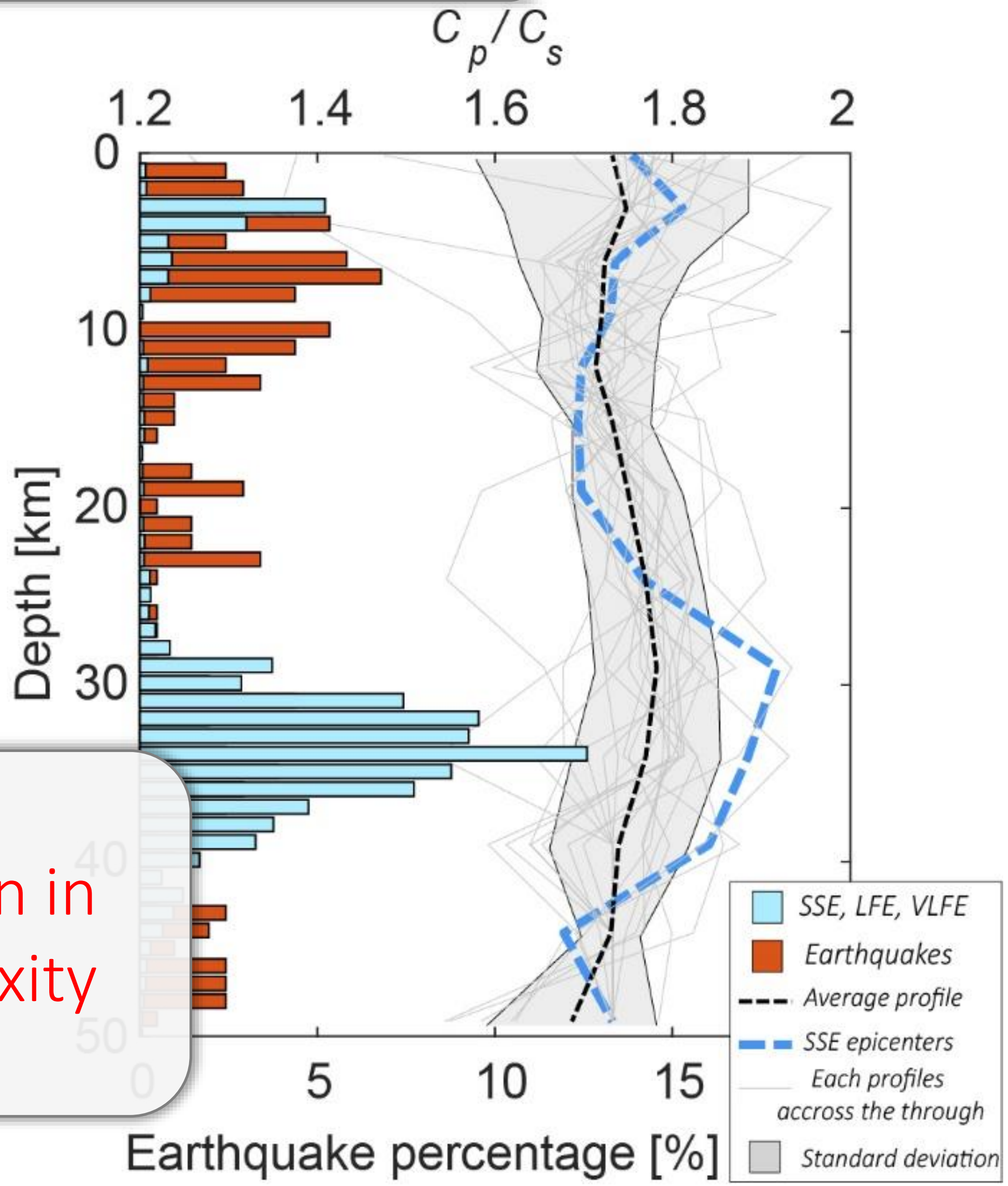
Ph.D. of F. Paglialunga

Work in progress

Various types of seismic ruptures

Passelègue et al., submitted





Organisation in this complexity

Which parameter(s) control(s) the nature of seismicity?

Something that:

- changes spacially along faults

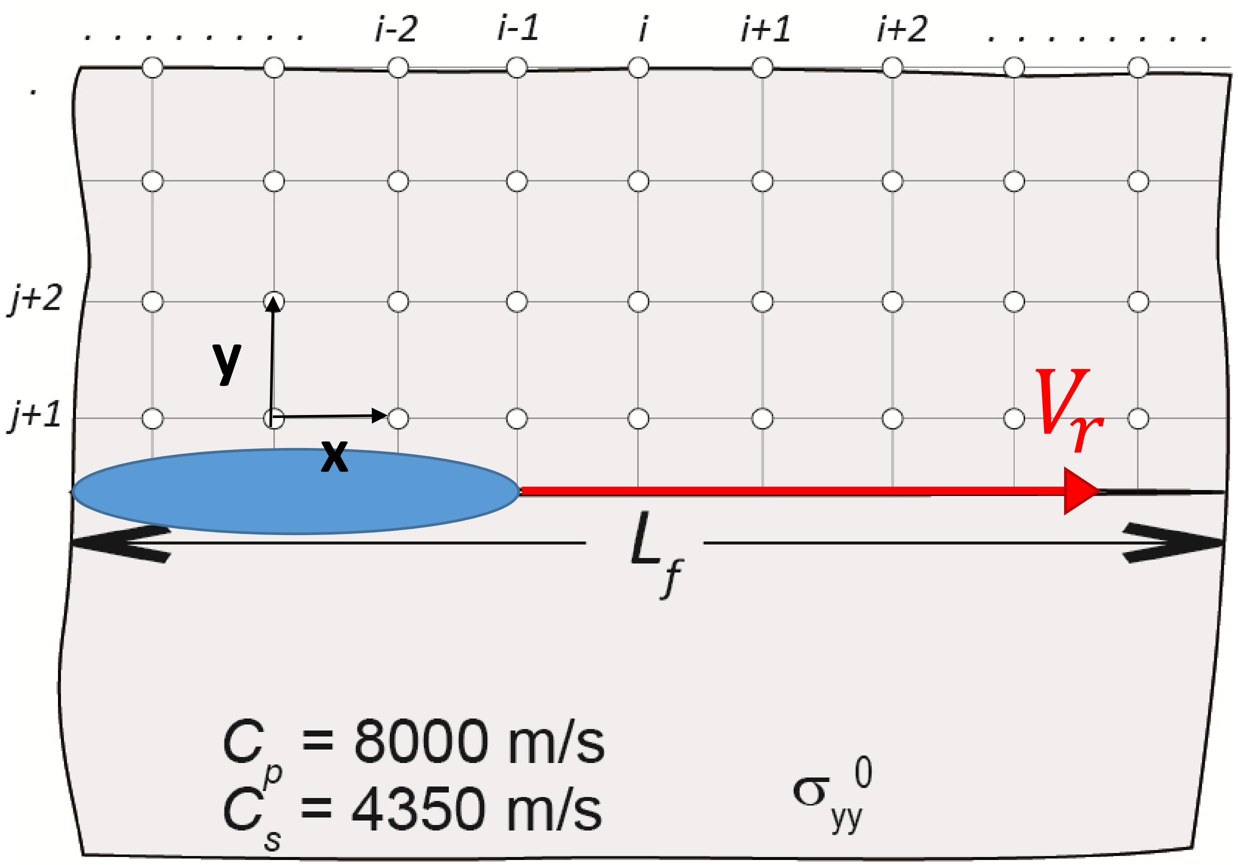
Fault jogs can present both slow and fast ruptures

- Is variable with time

A same asperity can break seismically and aseismically

- Dominates at shallow depth or close to BDT, affected by fluid pressure

Reproduce earthquakes in the laboratory: controlled conditions!



Measurement of stress along the fault

Regular triaxial experiments

$$\sigma_{xy}(i,j) \ \& \ \sigma_{yy}(i,j) = constant$$

Here

$$\sigma_{xy}^0(i,j) = constant \quad \sigma_{yy}^{eff}(i,j)$$ vary spacially

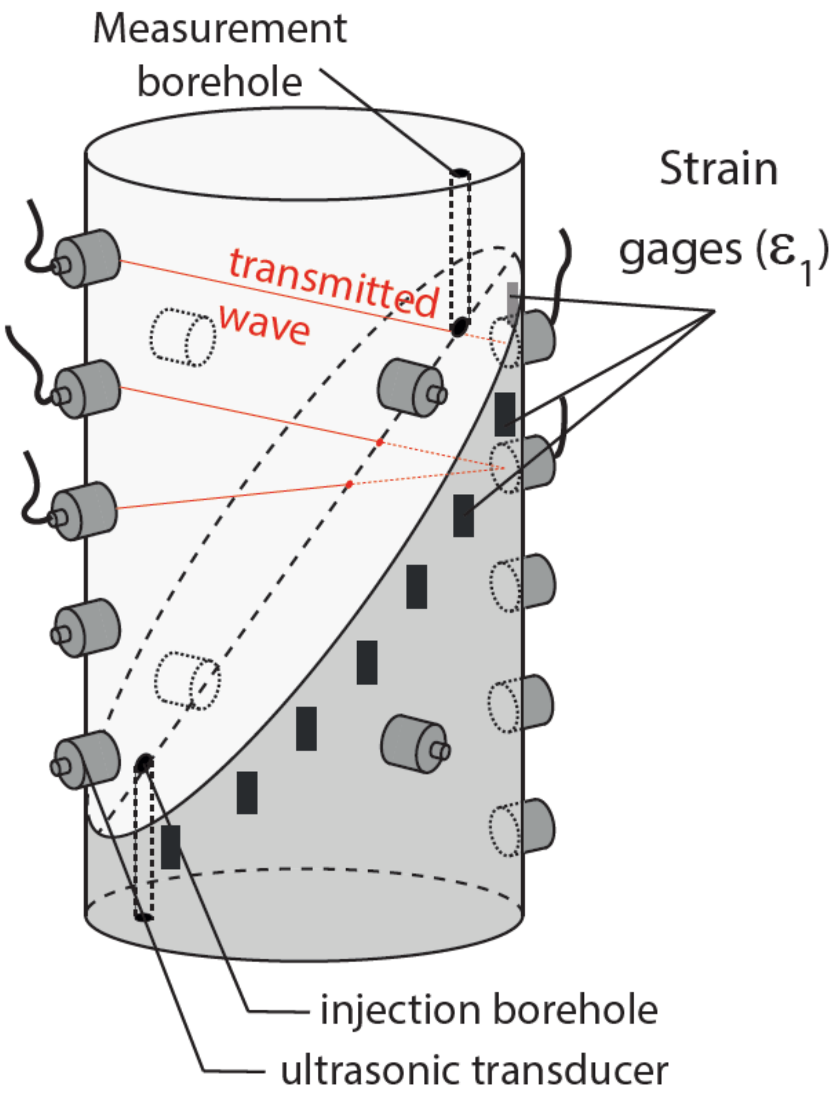
Fluid injection at the edge of the fault

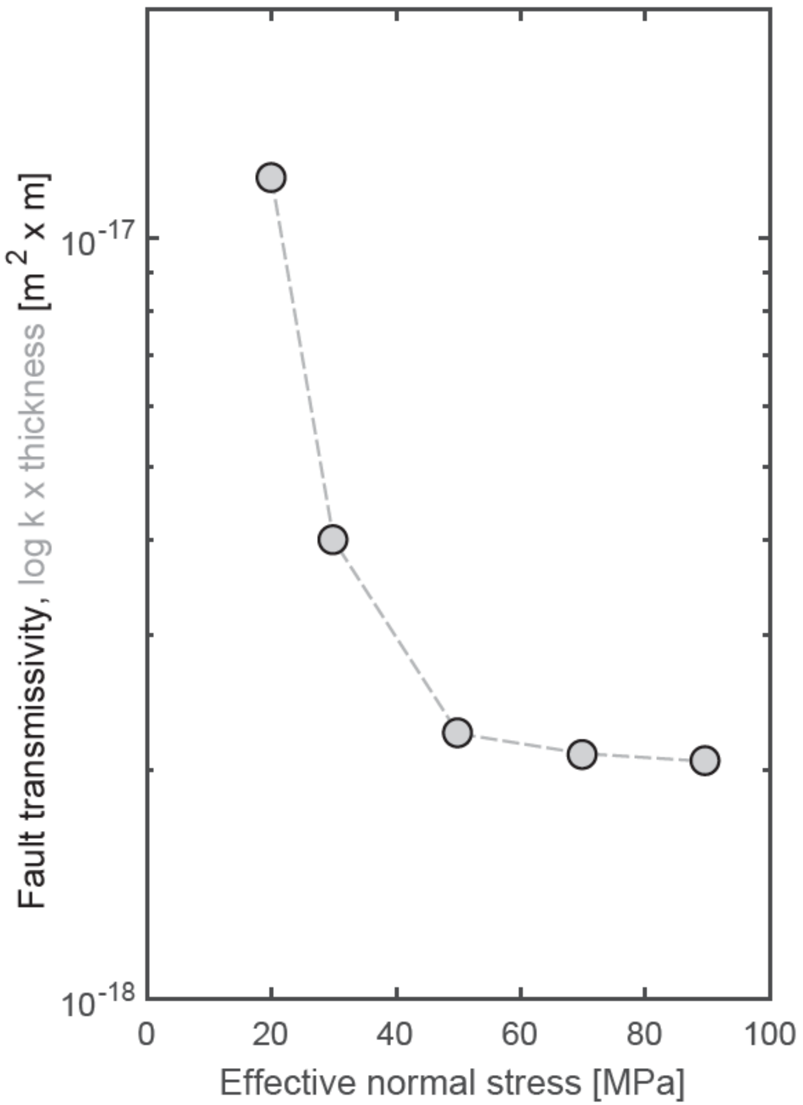
Low fault permeability, no bulk diffusion

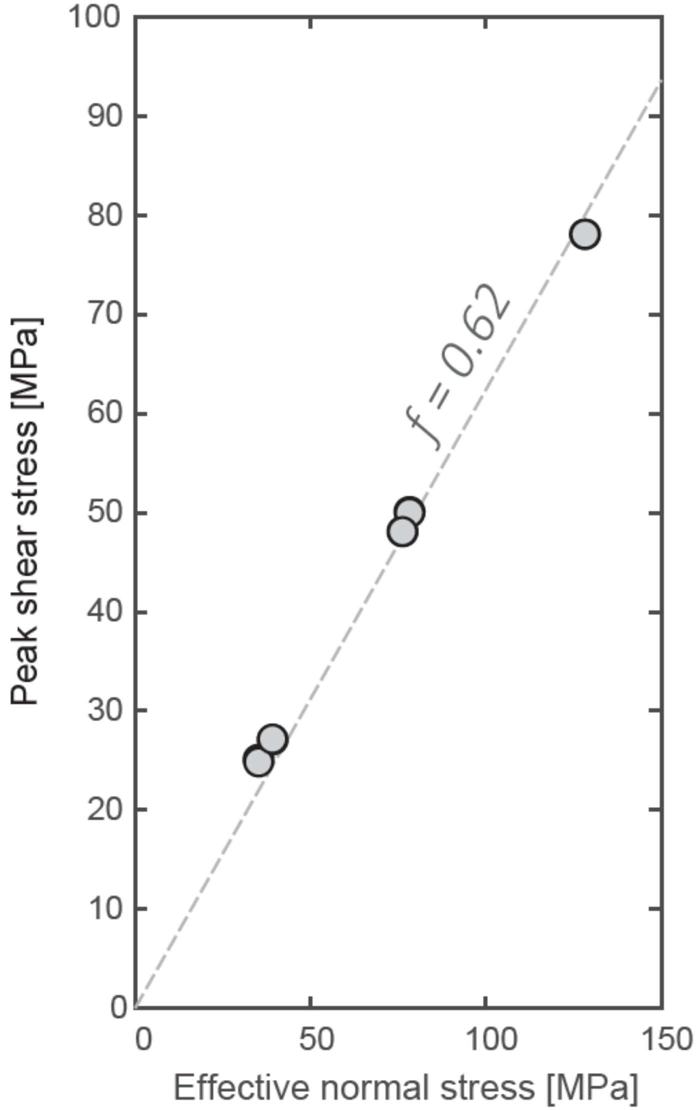
Inversion of the fluid pressure

(Almakari et al, in prep)

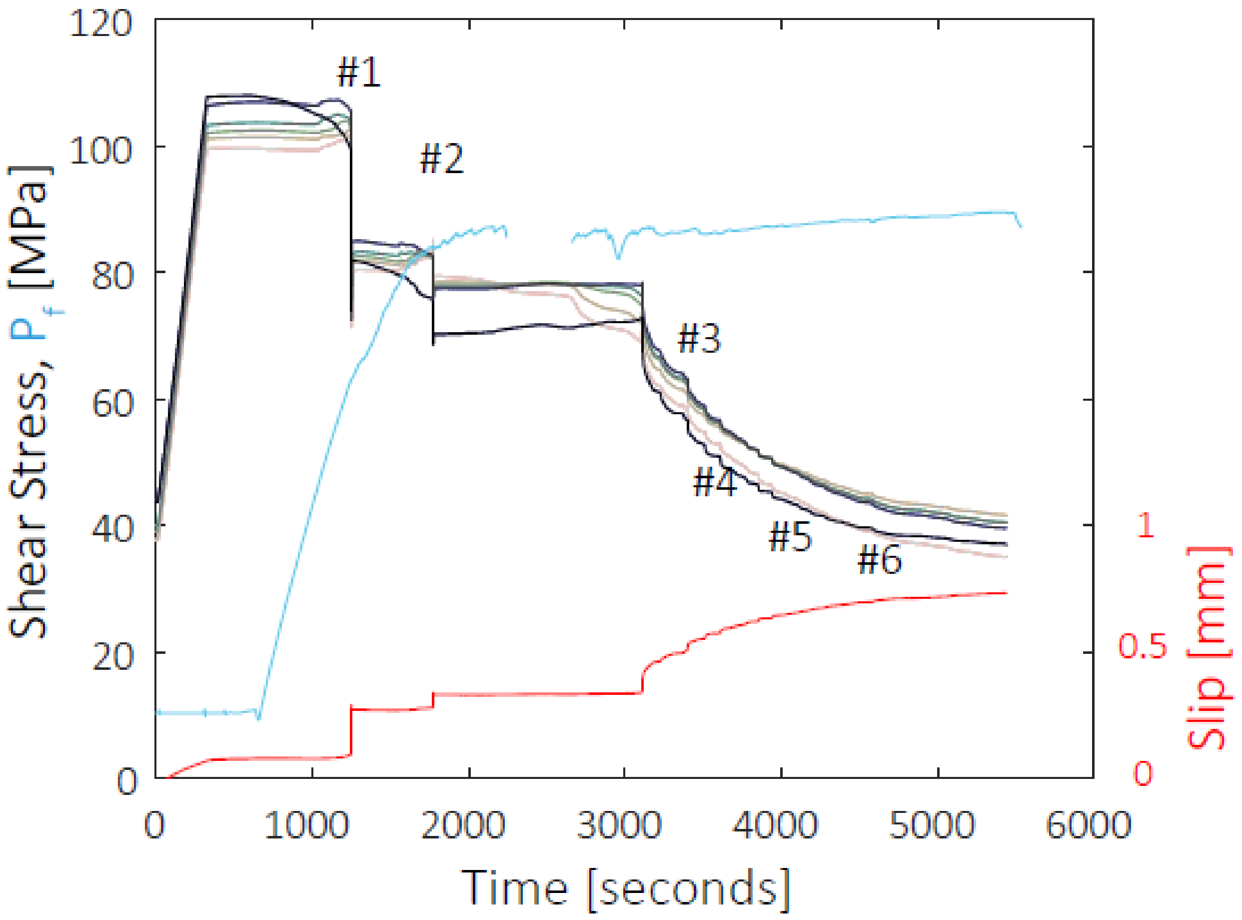
Reproduce earthquakes in the laboratory: controlled conditions!



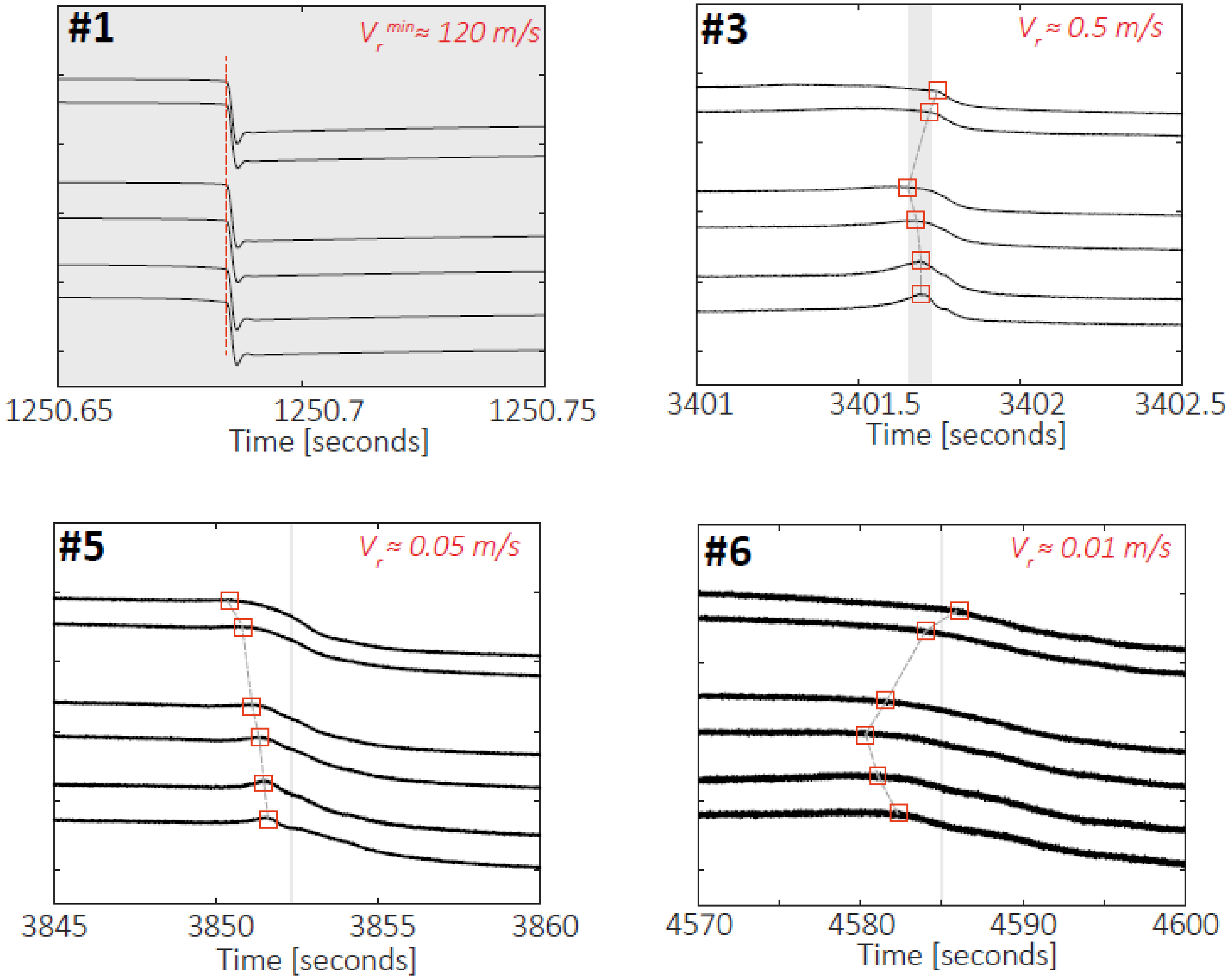




Experimental results: From fast to transient slow slip events

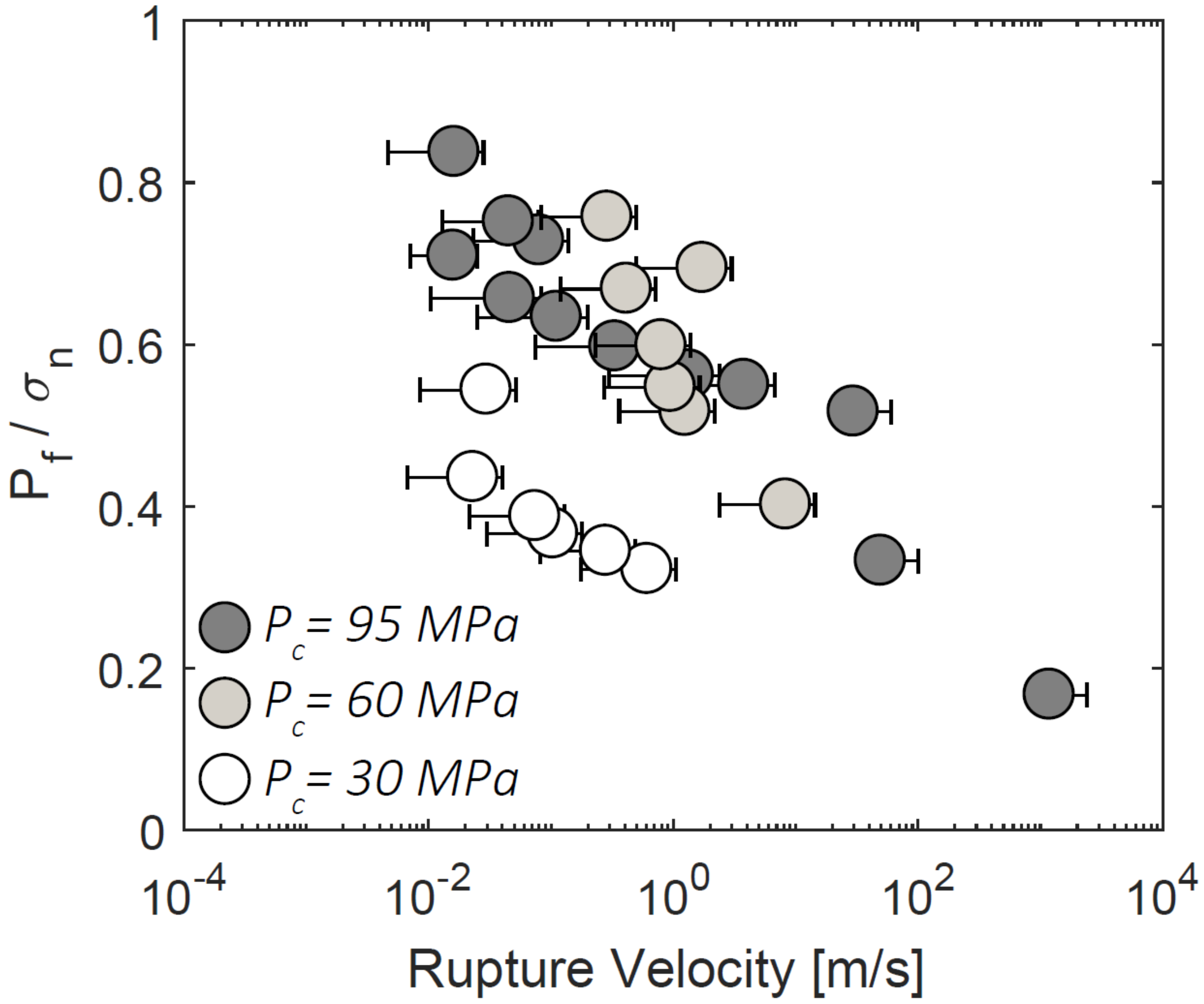


Slip rate and stress drop decrease with decreasing τ_0



***Rupture speed also**: transition from fast to slow rupture*

What about the control of the rupture speed?



$V_r \searrow Pf \propto L_c?$

$L_c < L_f$

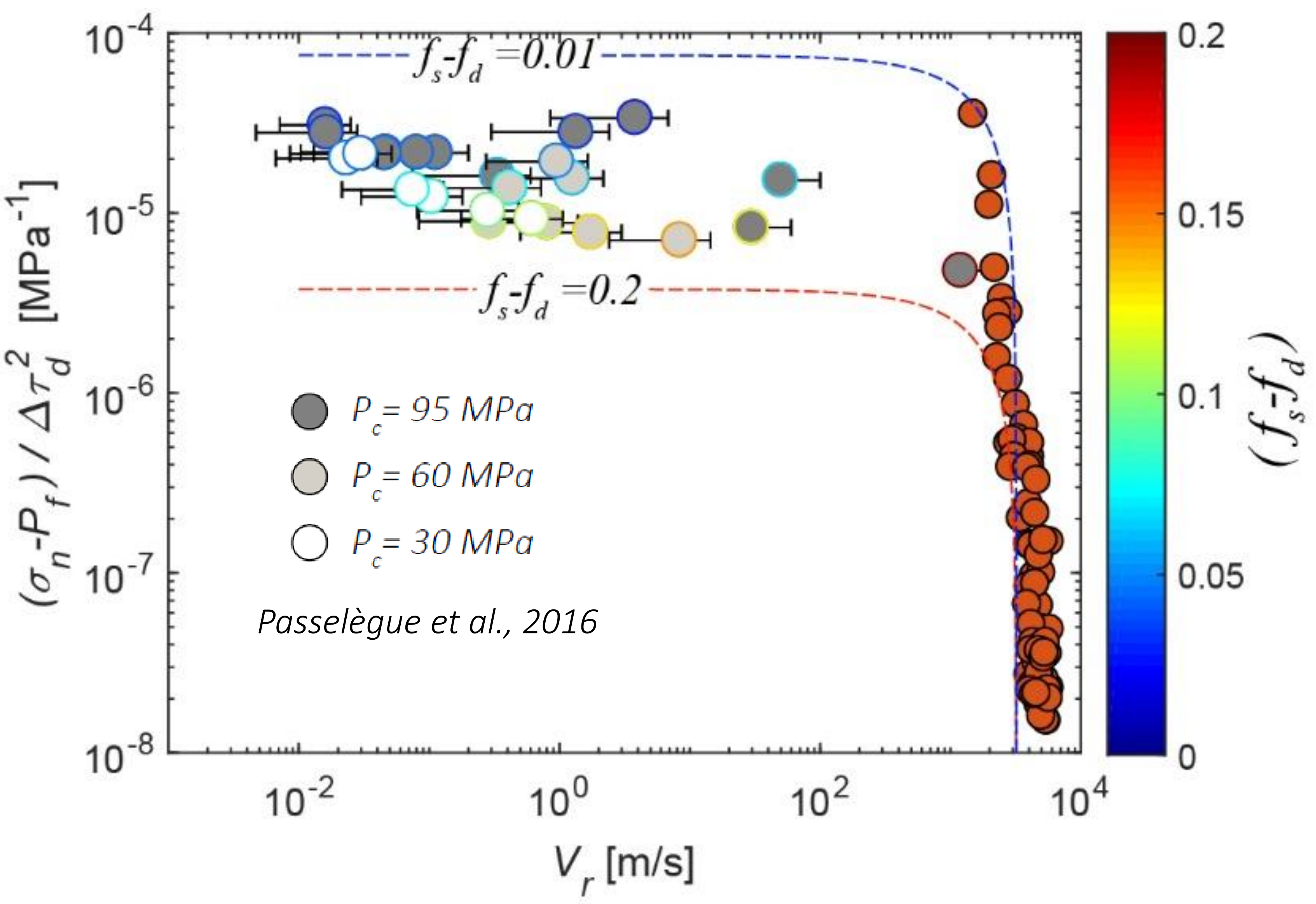
From LEFM *(Freund, 1990)*

$$V_r = C_R\left(1 - \frac{G_c}{\Gamma}\right)$$

⇕

$$V_r = C_R\left(1 - \frac{(\overline{\sigma_n} - \overline{P_f})}{(\tau_0 - \tau_r)^2}\frac{\Omega E^*}{\pi l/2}\right)$$

What about the control of the rupture speed?



$V_r \searrow Pf$

$V_r \nearrow \Delta\tau^d$

Passelègue et al., 2016

Initial stress τ_0 & Energies are keys!

On going work and perspectives

Ph.D. of Federica Paglialunga

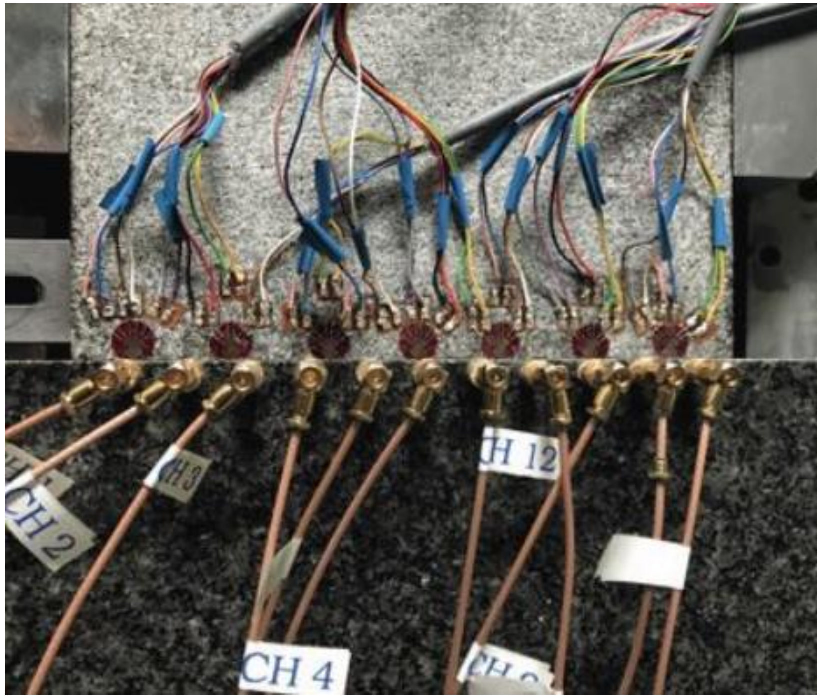
She is closing the energy budget in the lab: Eg, Eh, Er

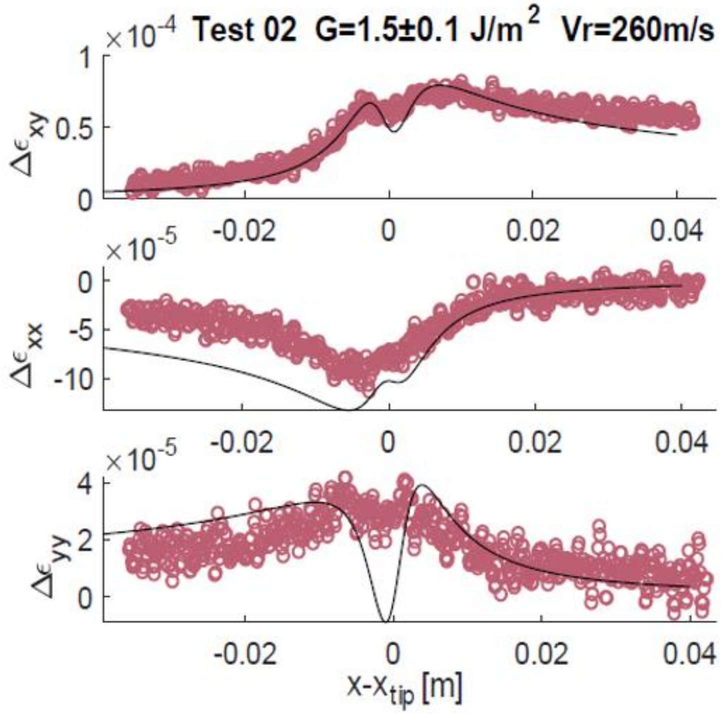
She compare the estimates of E_G (LEFM, Sismo, Stress-slip)

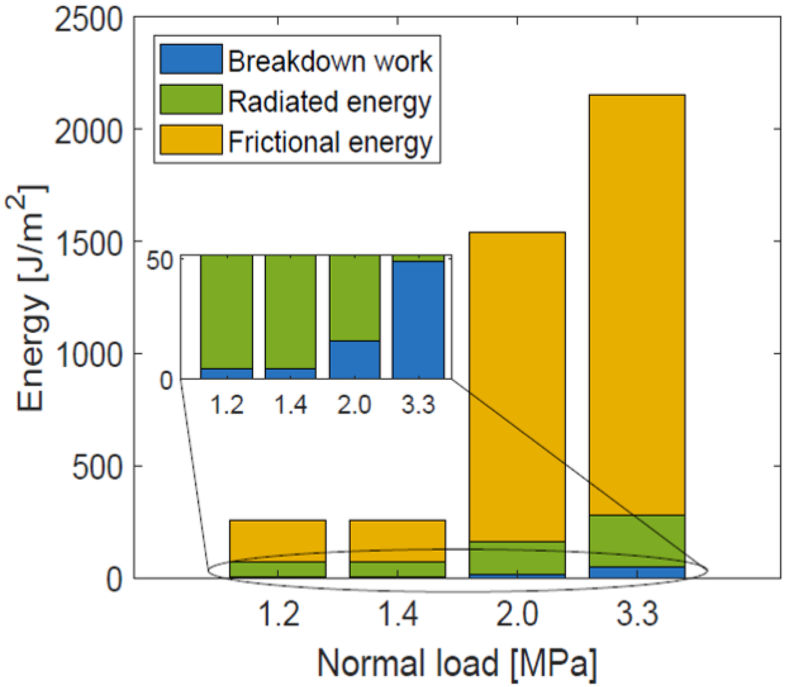
Study deceleration and rupture arrest (control on τ_0)

Wednesday

TS2.5/EMRP1.12







Conclusions and Take home message

Rupture speed, i.e. nature of the seismicity,

depends of

the **stress acting along the fault** ahead of the rupture tip, **the energy available**

- Explain slow rupture phenomena at shallow depth and in fluid over-pressurized area
- What about rupture length? Also predictable from LEFM!
- Low stress level inhibits radiation damping terms → V_r remains slow *(Barras et al., 2019)*

Small rupture of high stressed patches trigger slow rupture front?