An analysis of the Dynamic Stress Drop for mining induced seismic events

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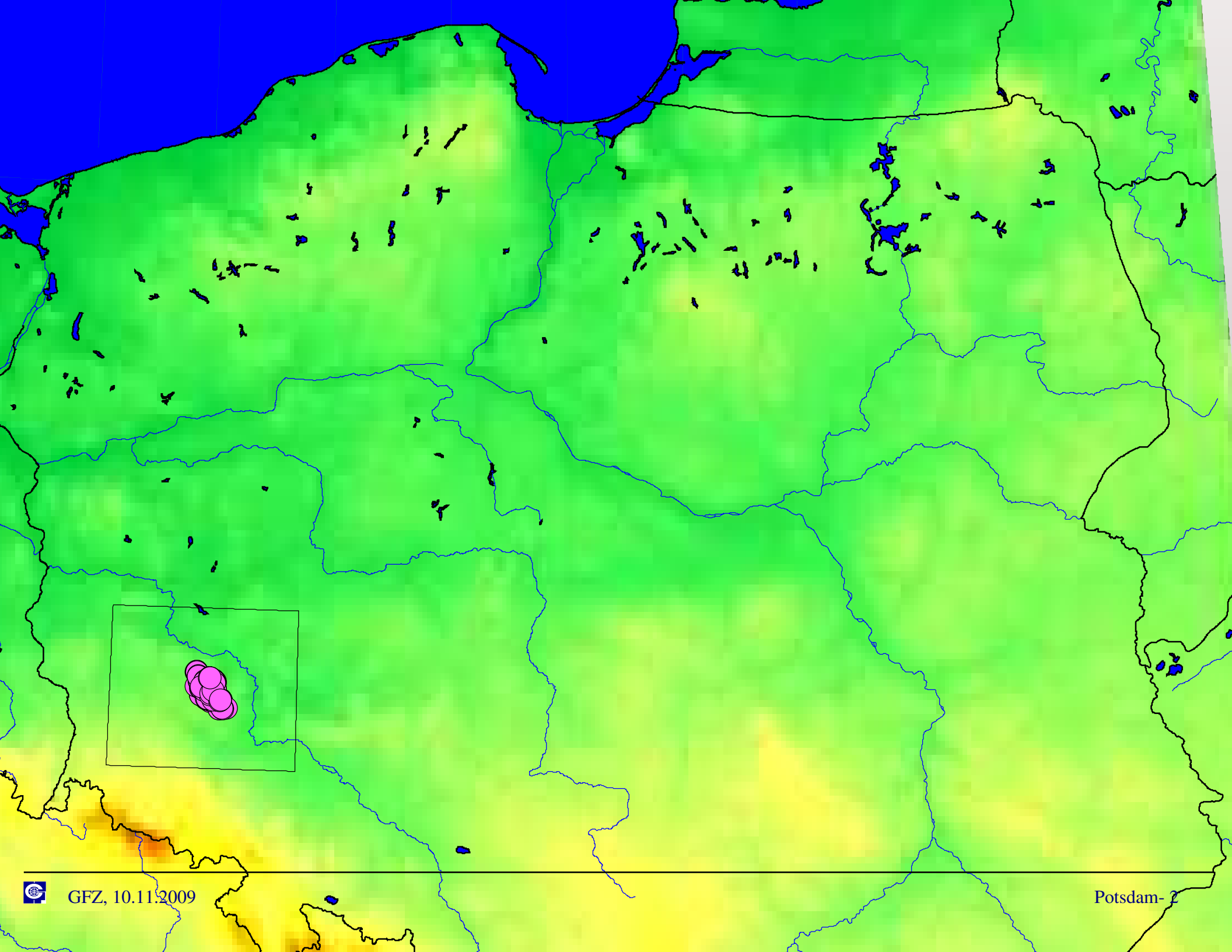
Plan of the talk

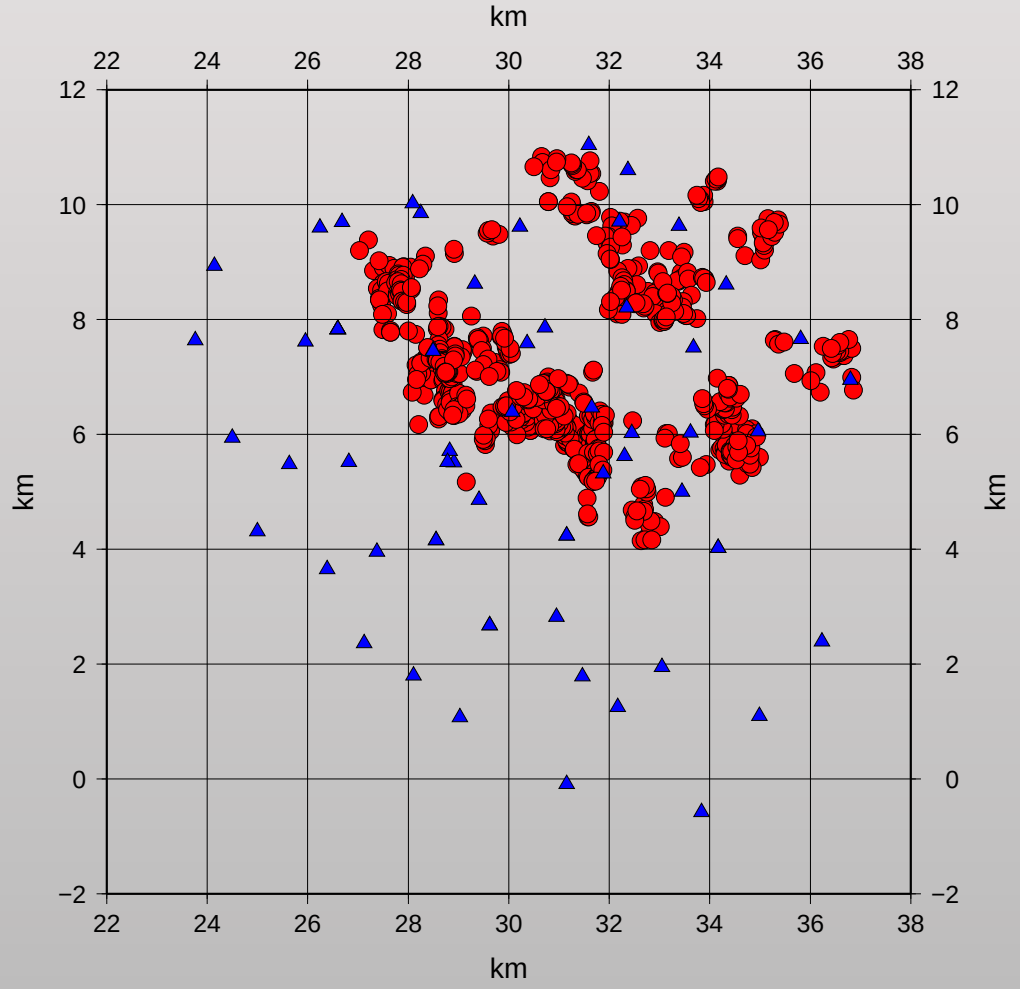
- Background review of the seismicity induced by mining in Poland
- Soure parameters from seismic spectra
- ***Rupture velocity and dynamic stress drop***



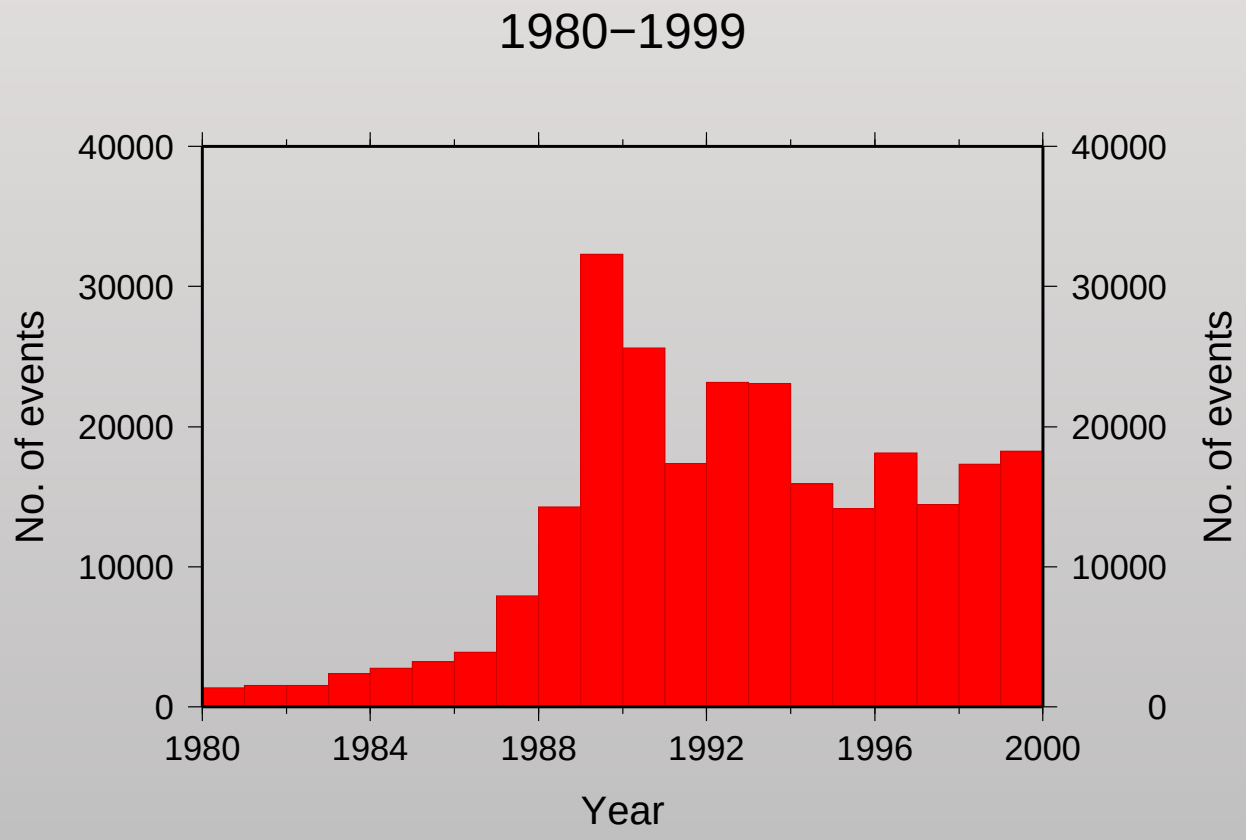
Mining technology (cd)

Mining technology (cd)

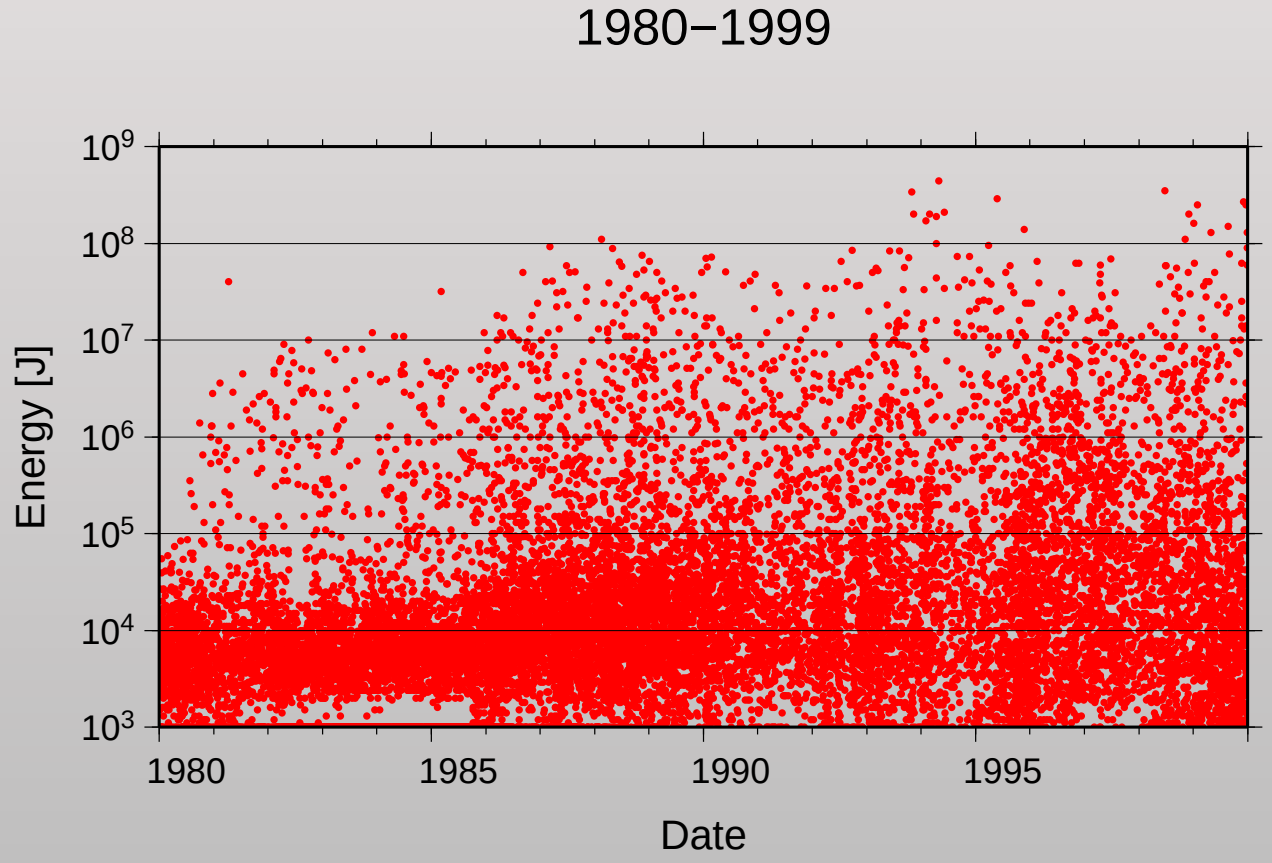
Polish copper mines



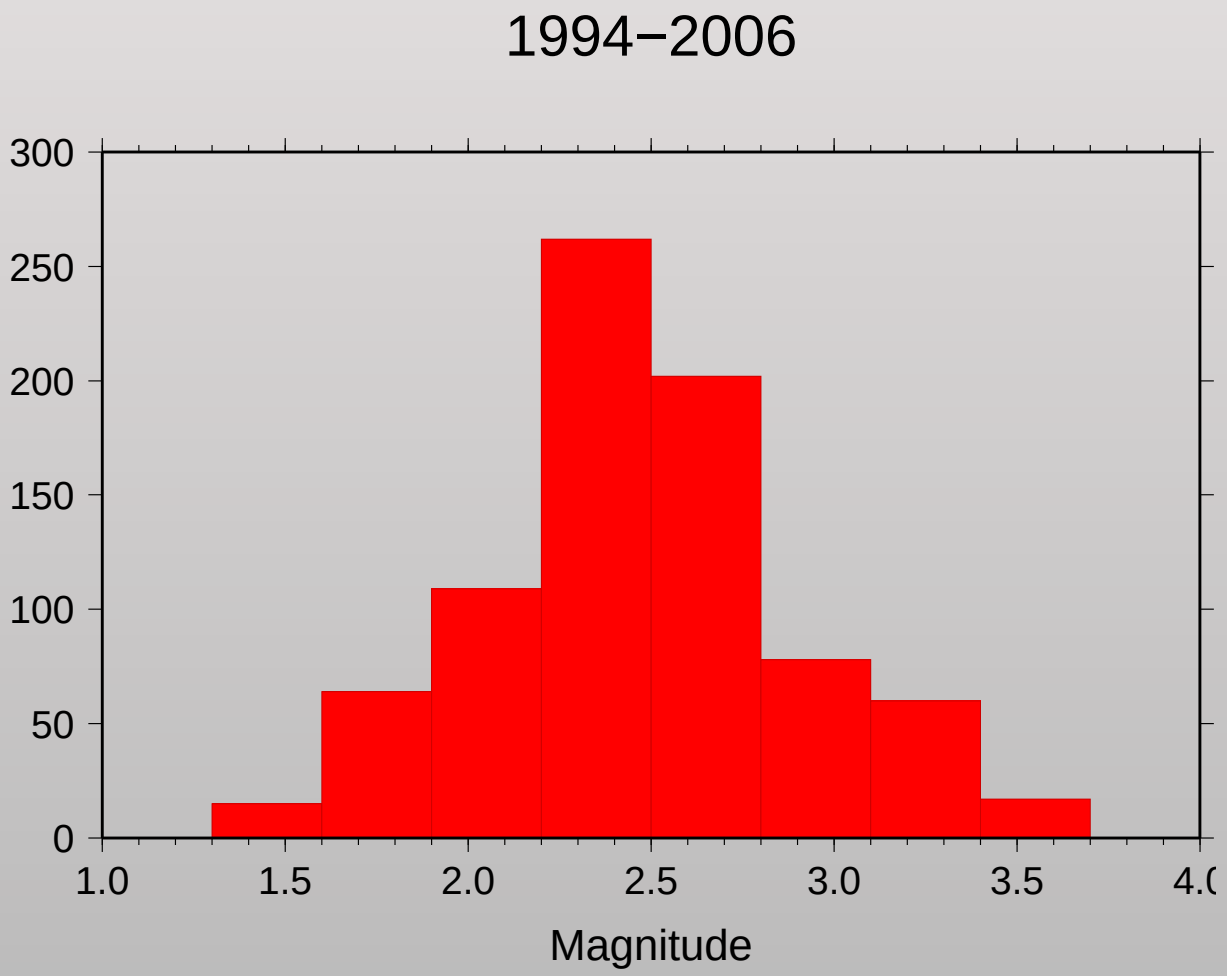
LGOM Seismicity



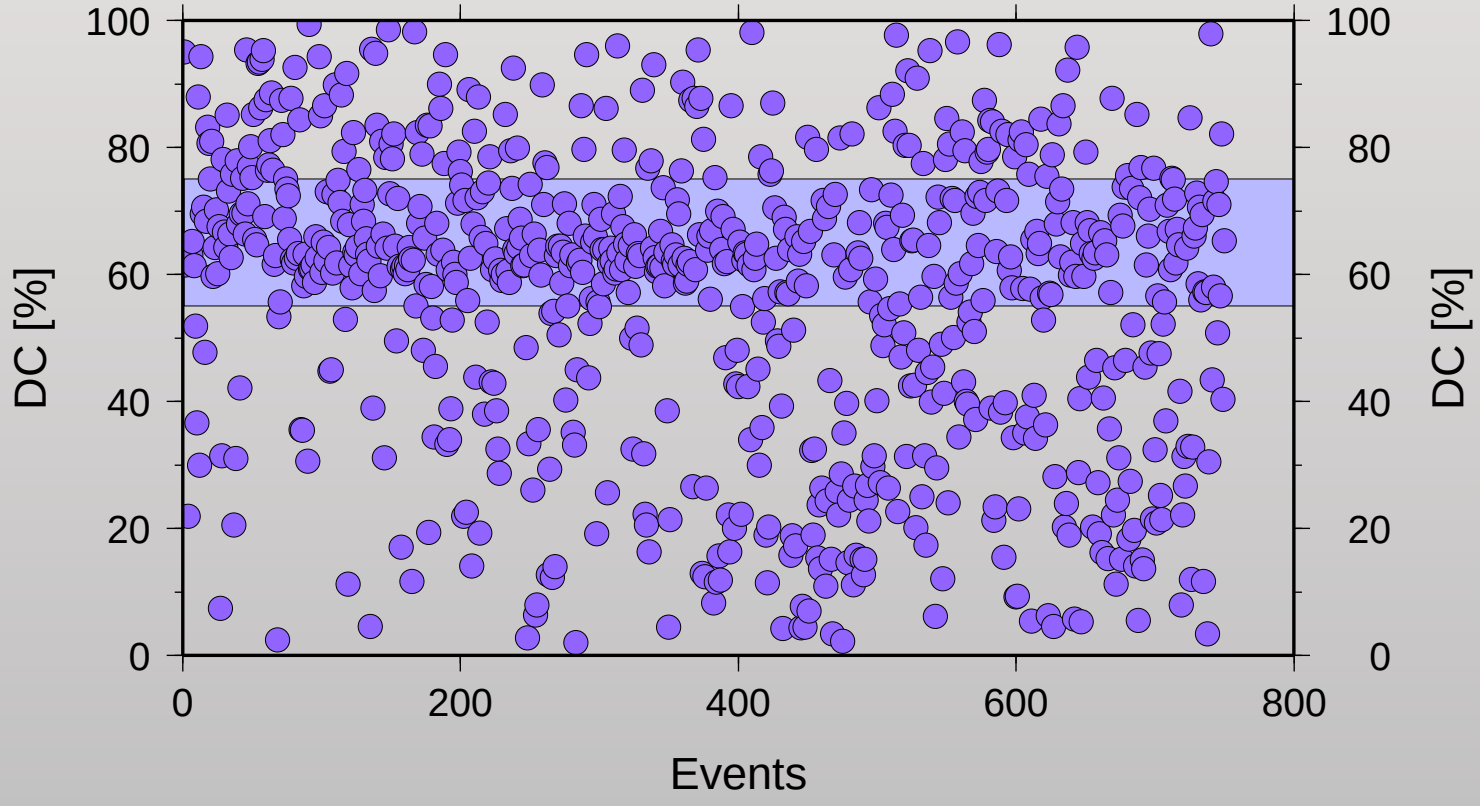
LGOM Seismicity



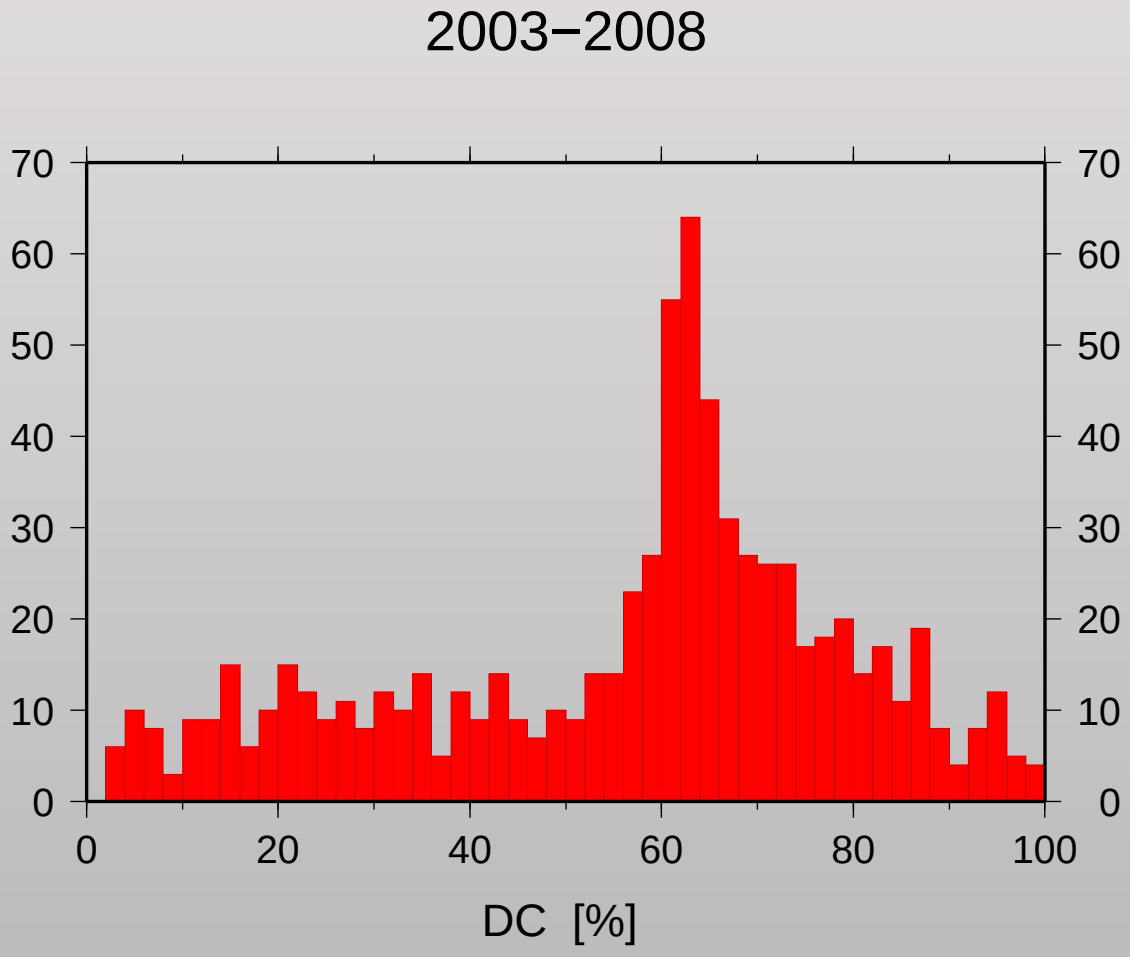
Analyzed data



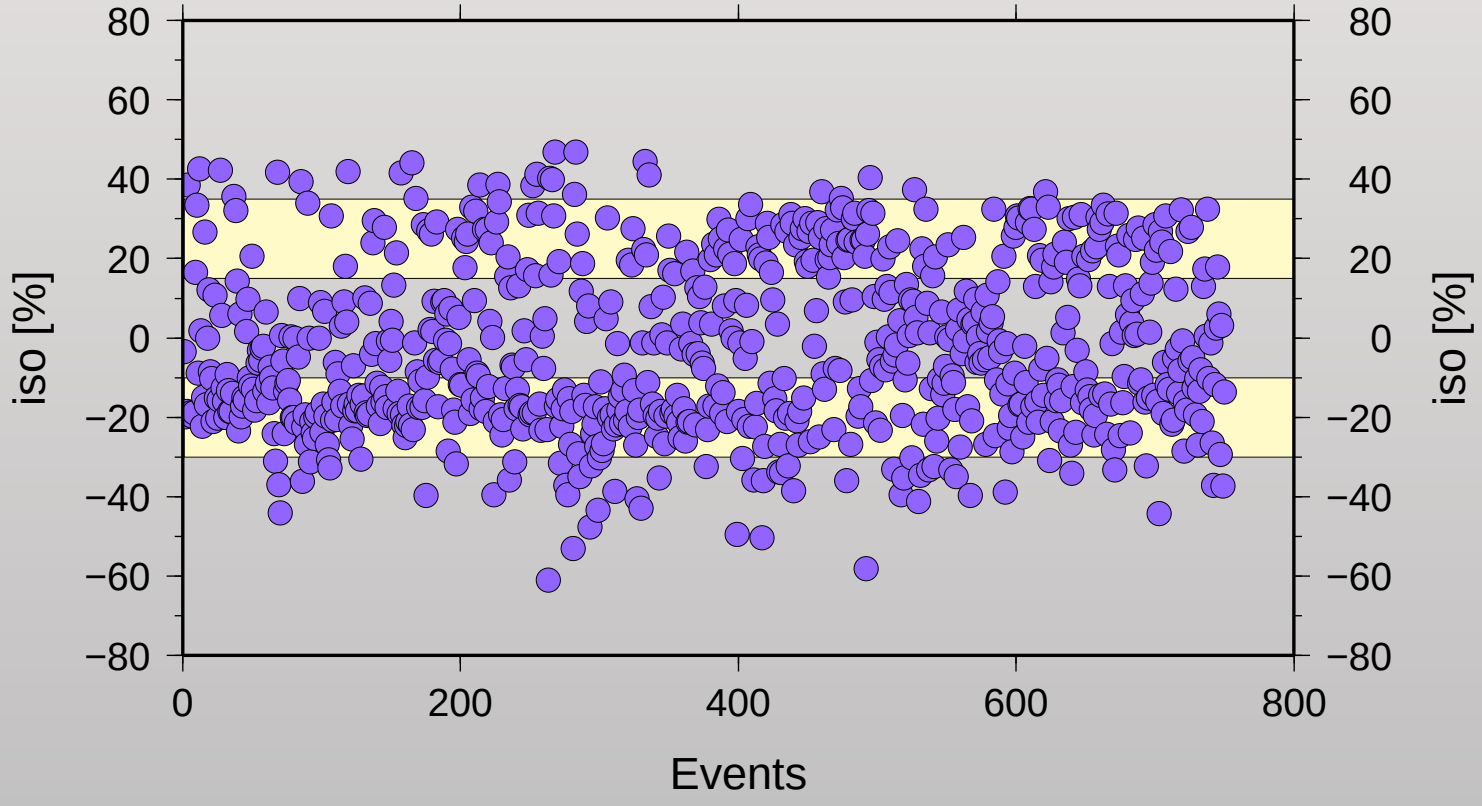
Moment Tensor



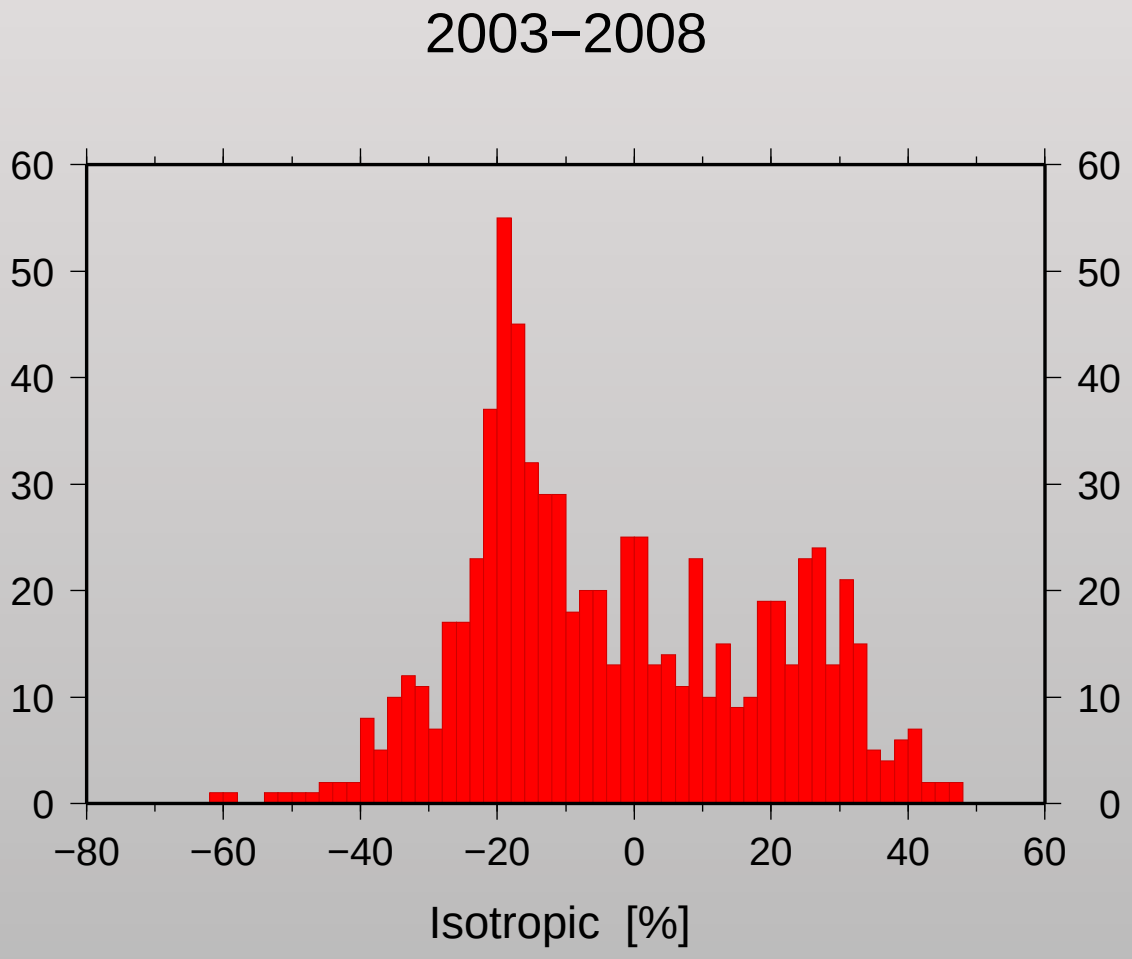
Moment Tensor



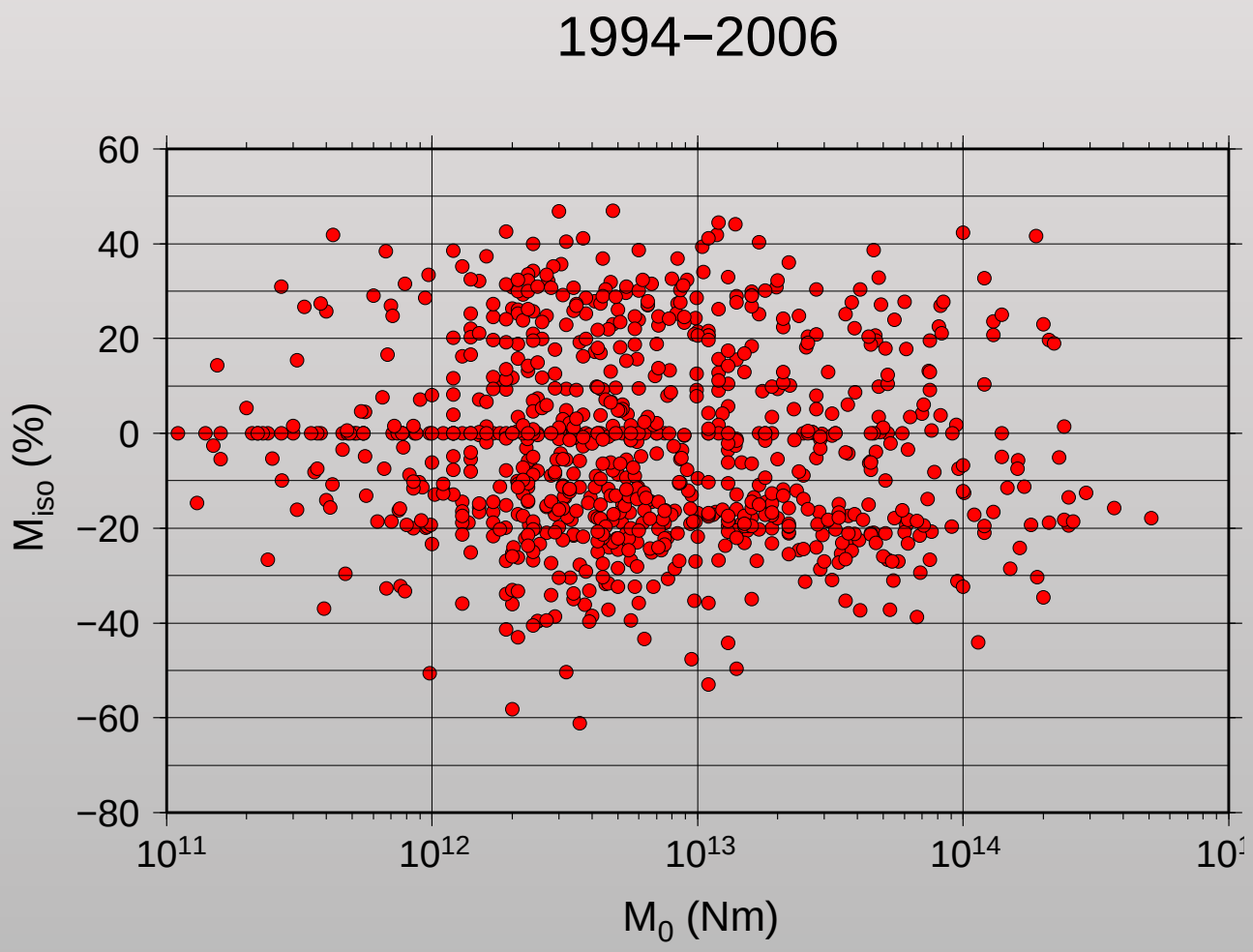
Moment Tensor



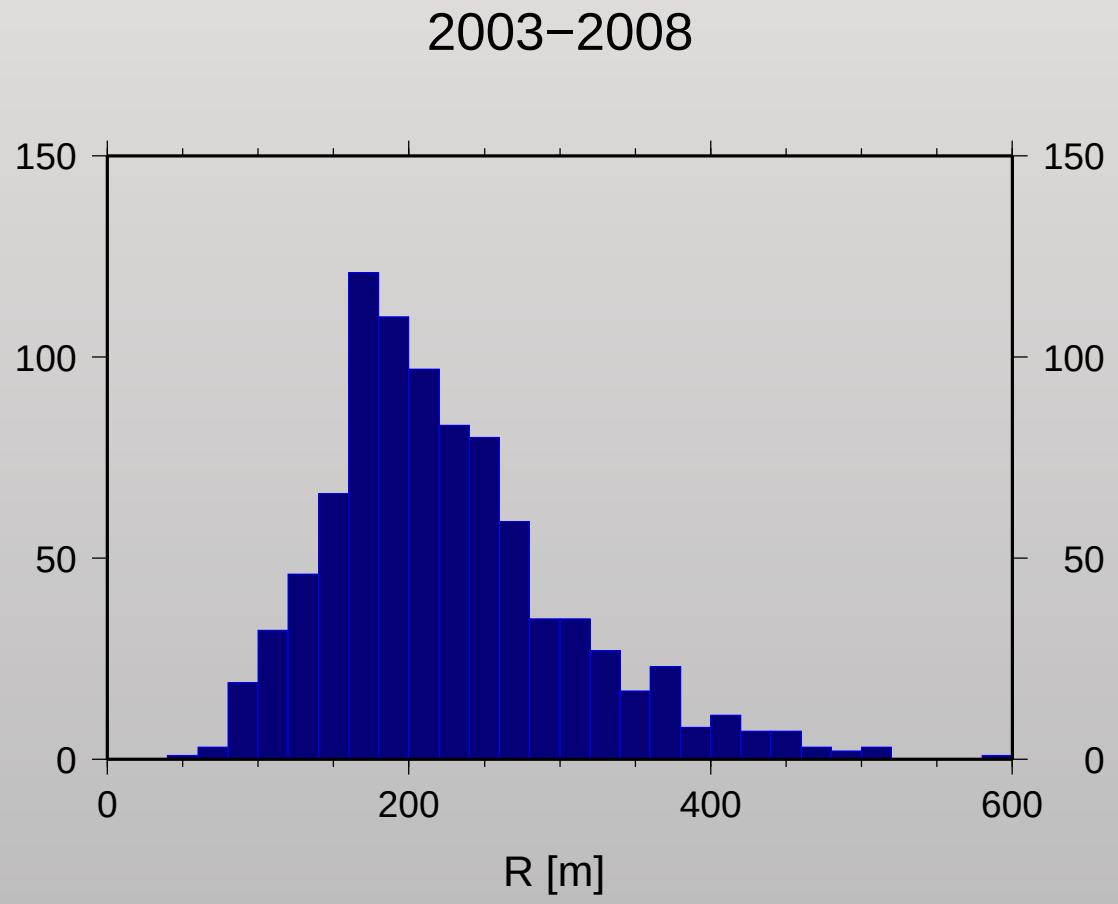
Moment Tensor



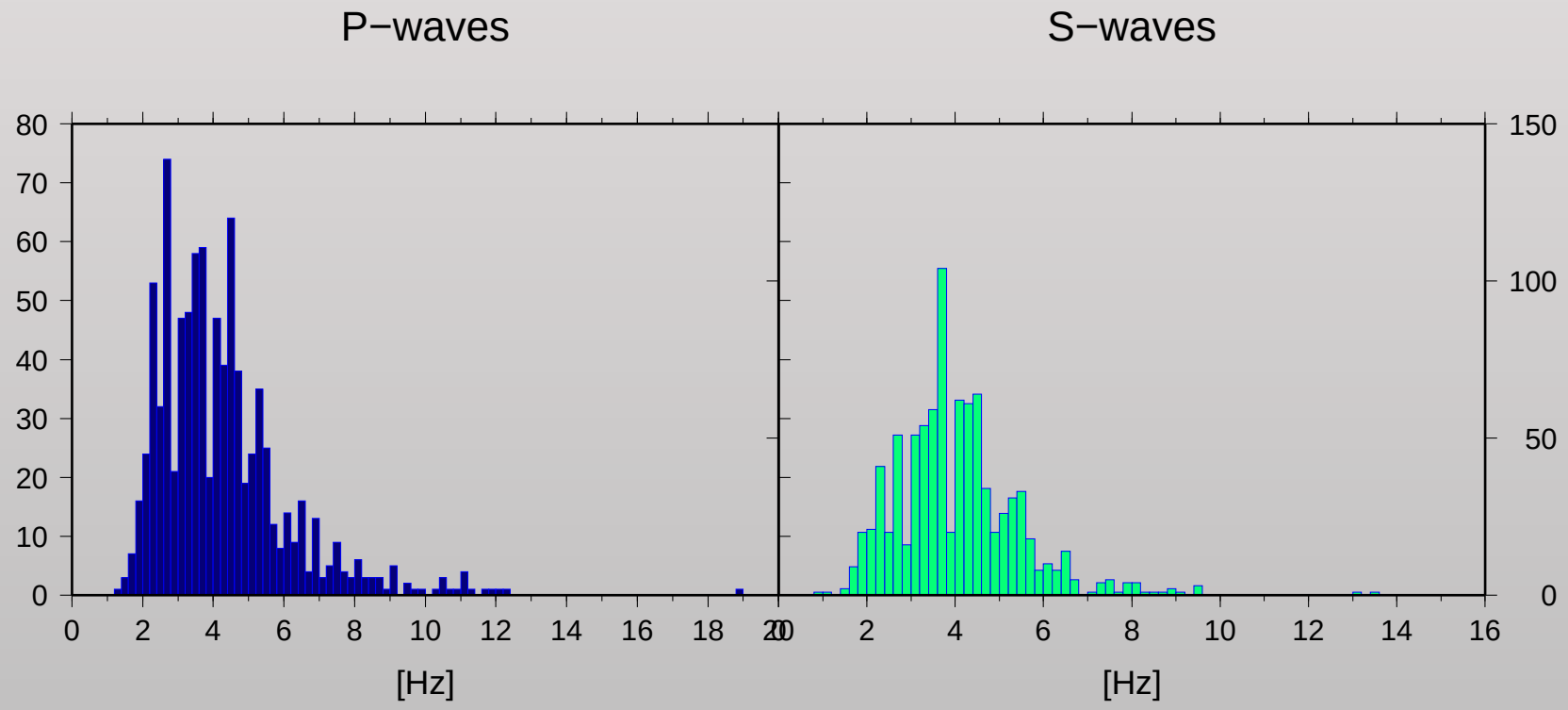
Moment Tensor



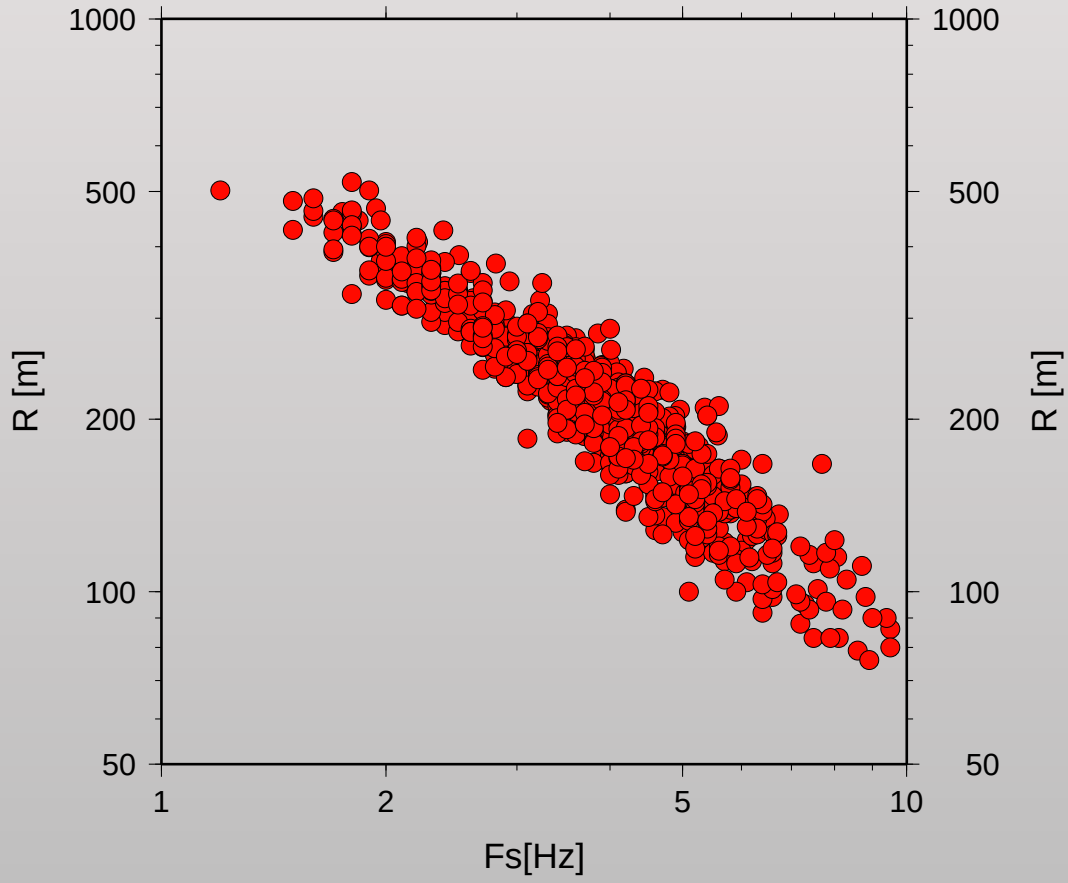
Spectral parameters



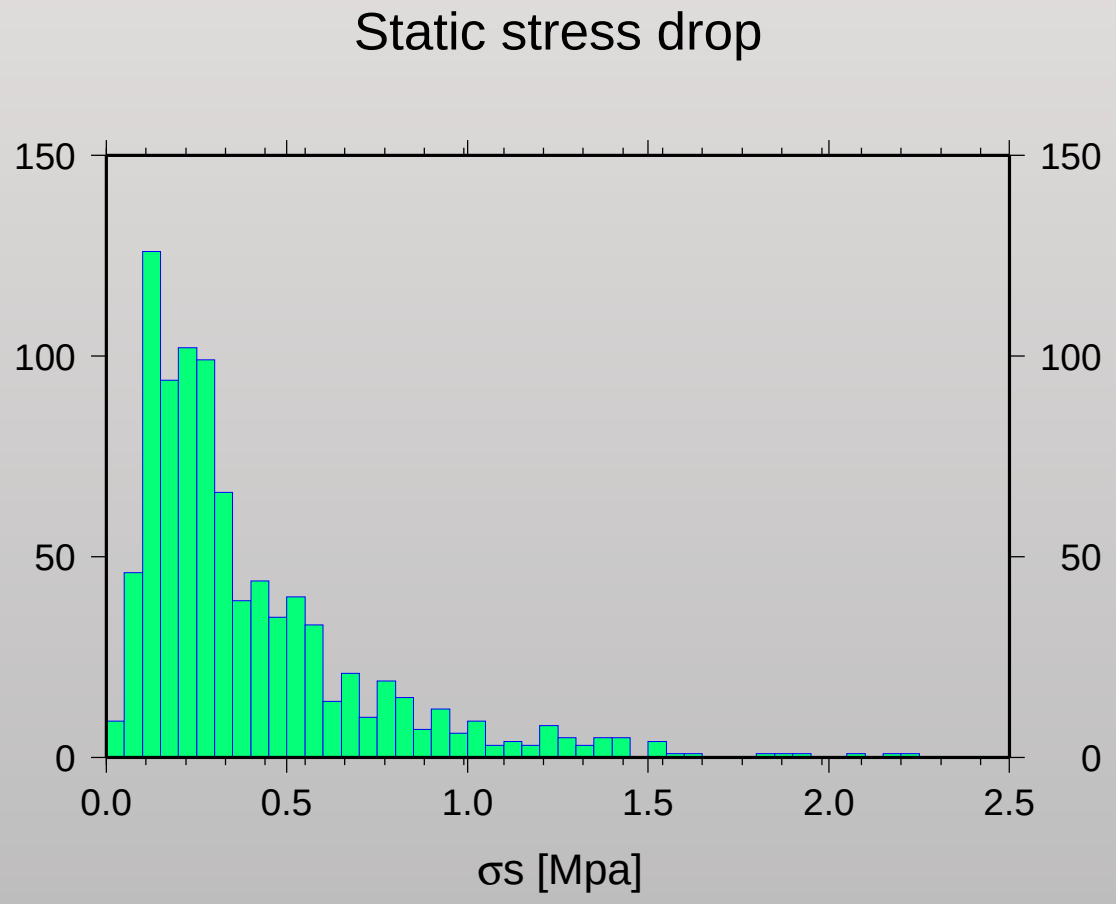
Spectral parameters



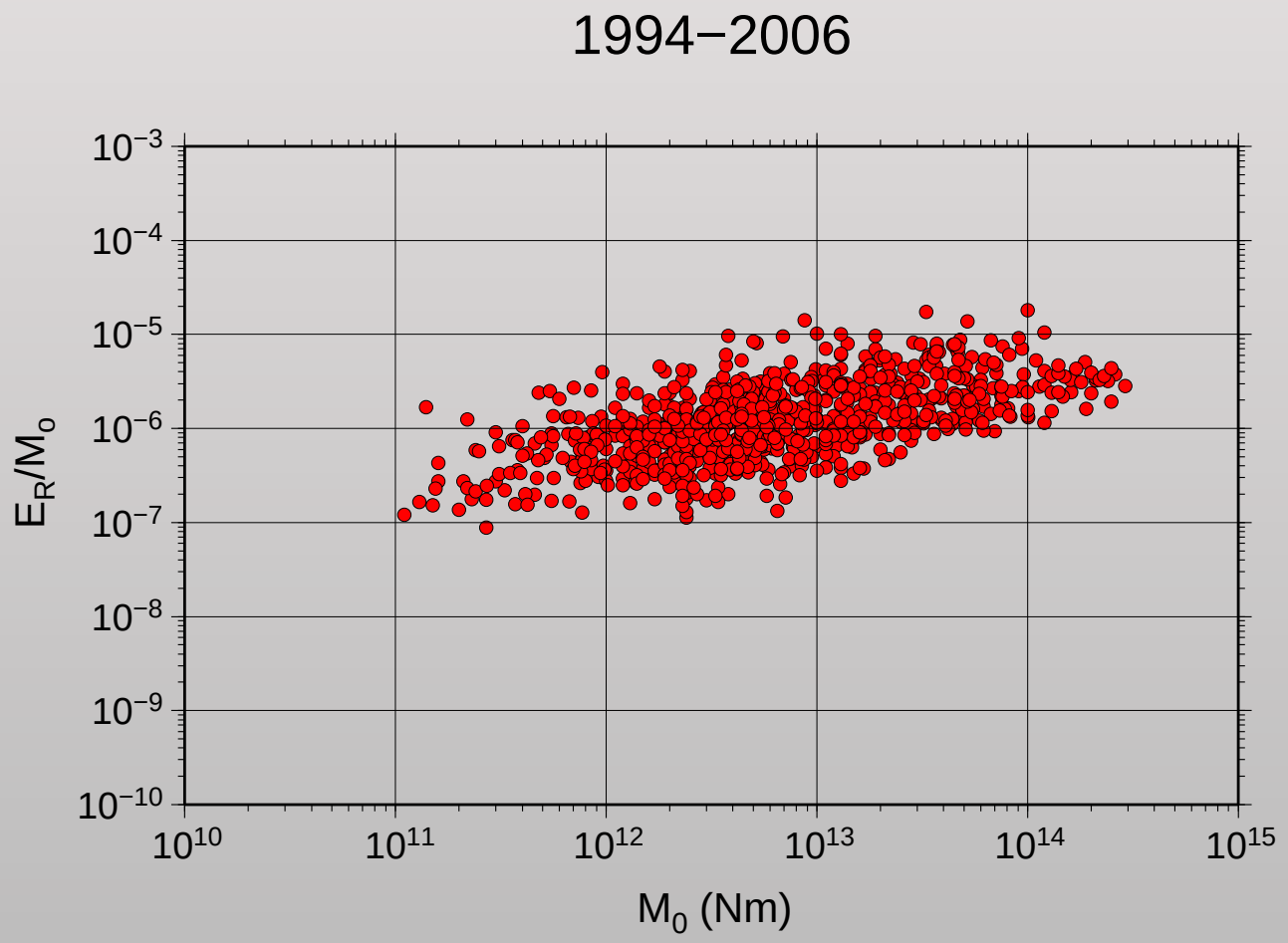
Spectral parameters



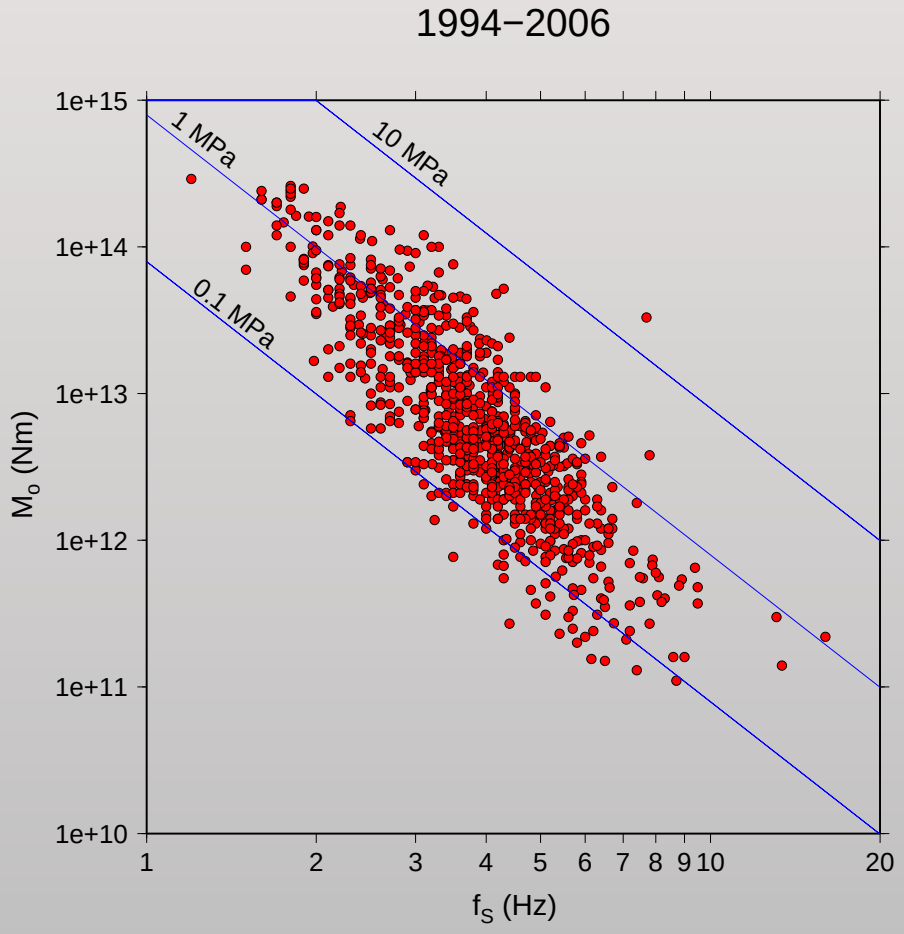
Spectral parameters



Spectral parameters

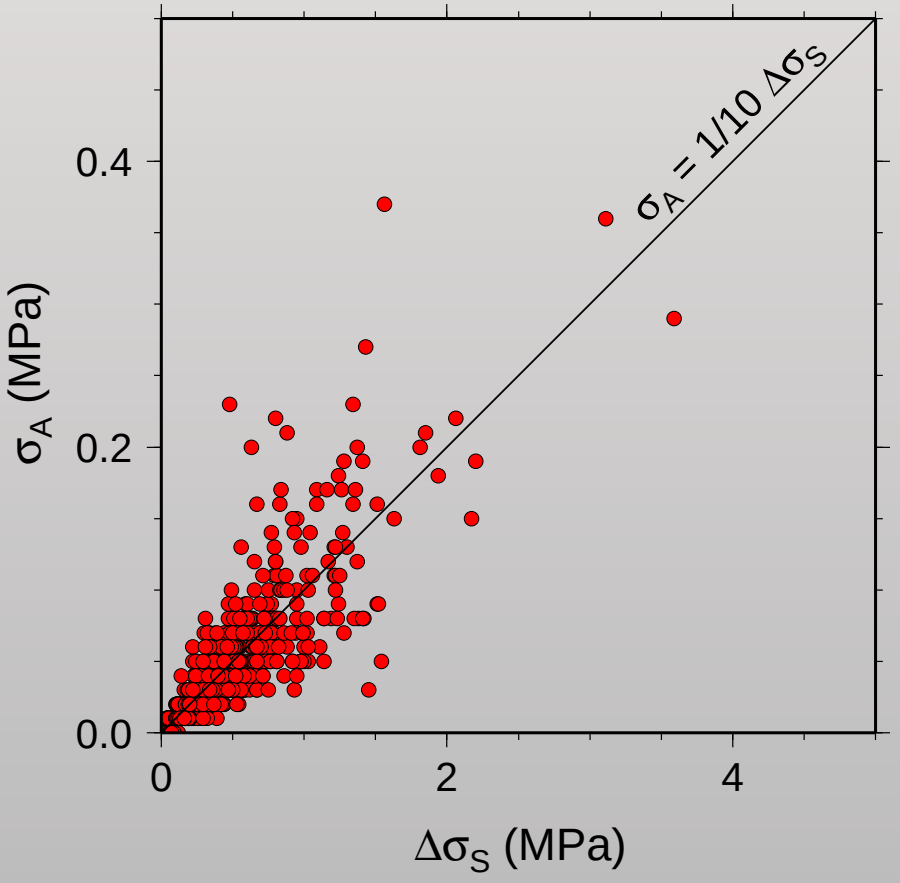


Spectral parameters



Spectral parameters

1994–2006



Stress drops - classical estimators

- Static (Brune) stress drop $[\sigma_0 - \sigma_1]$

$$\Delta\sigma_s = \frac{7}{16}\frac{M_0}{R^3}$$

- Apparent stress

$$\sigma_a = \frac{\mu E}{M_0}$$

$$\sigma_a \approx 1/10\ \Delta\sigma \quad \text{(Rudna copper mine)}$$

Stress drops - classical estimators

- Dynamic stress drop $[\sigma_0 - \sigma_d]$

$$\Delta\sigma_d = \frac{M_0}{4\pi v_r^3 I}\left(1-\xi^2\right)^2 \frac{\mathrm{d}S}{\mathrm{d}t}$$

$$I = \int_0^T S(t)\,\mathrm{d}t$$

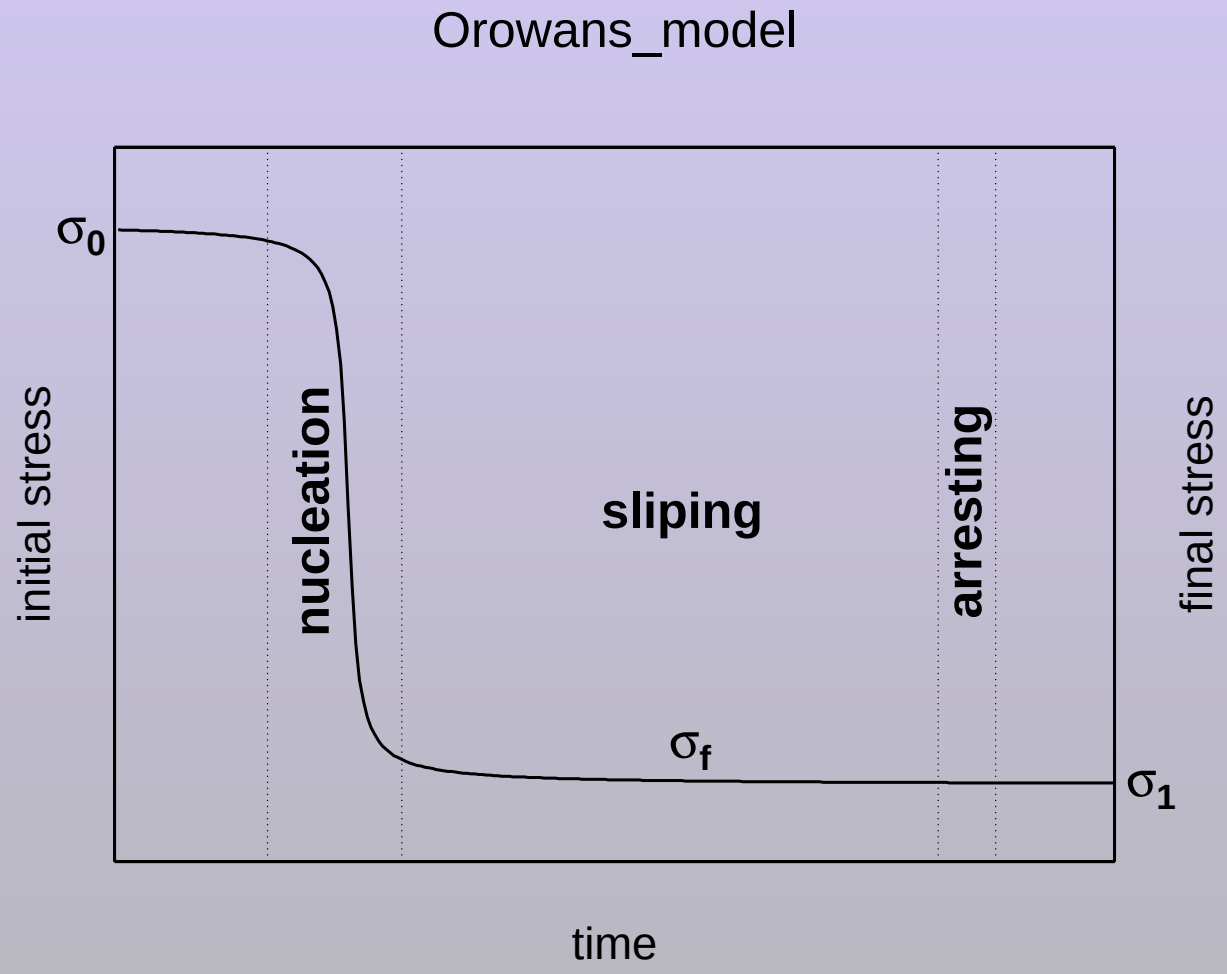
- Mo - seismic moment
- v_r - constant (assumption!) rupture velocity
- ξ - geometrical (directional) factor - assumed to be 0.75
- S - STF
- T - rupture duration time

Partial stress drop/overshooting

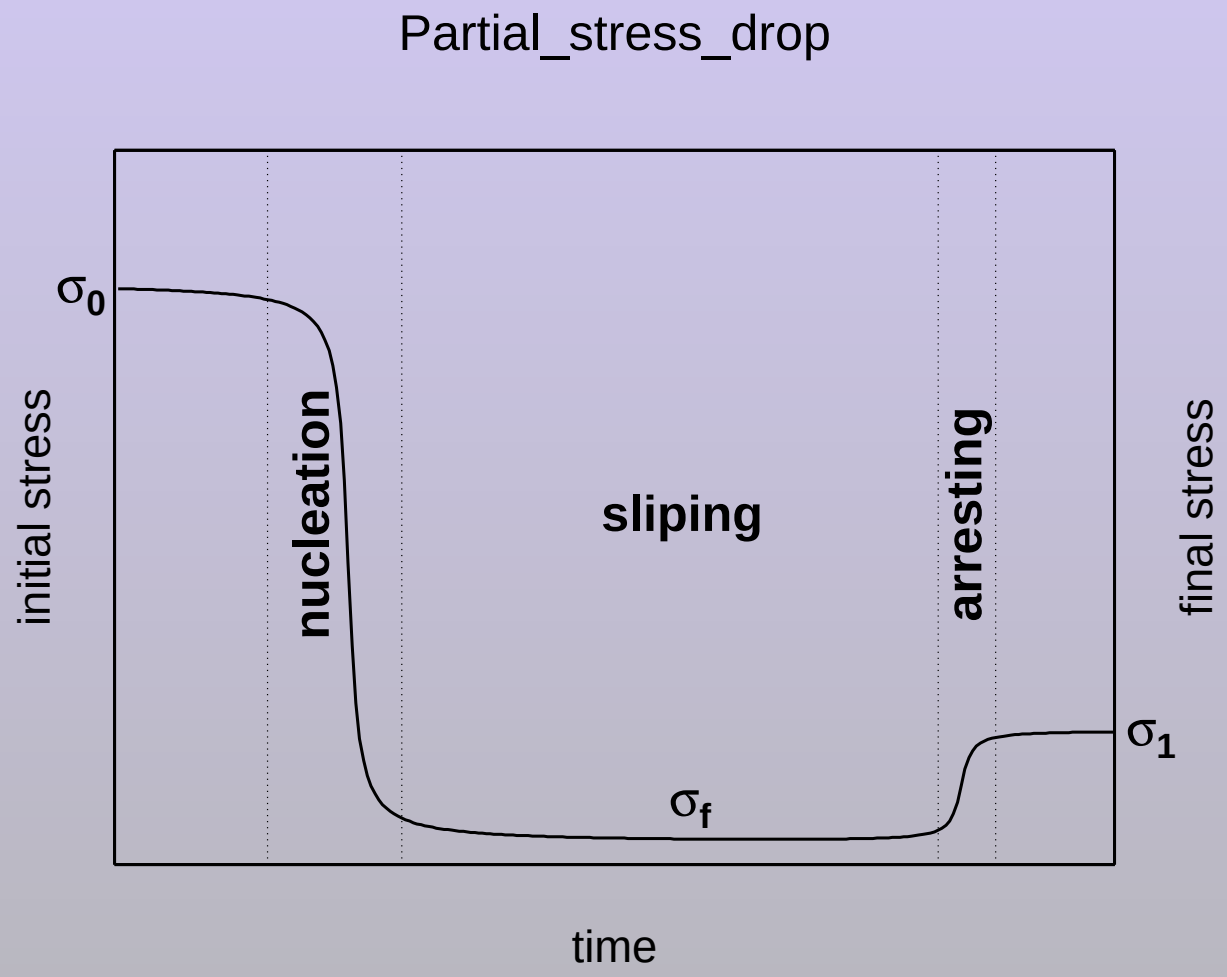
$$\gamma_d = \Delta\sigma_d/\Delta\sigma_s \approx \frac{\sigma_0 - \sigma_d}{\sigma_0 - \sigma_1}$$

$$\gamma_d \begin{cases} = 1 & \text{Orowan's model} \quad \sigma_d = \sigma_1 \\ > 1 & \text{partial stress drop} \quad \sigma_d < \sigma_1 \\ < 1 & \text{“overshooting”} \quad \sigma_d > \sigma_1 \end{cases}$$

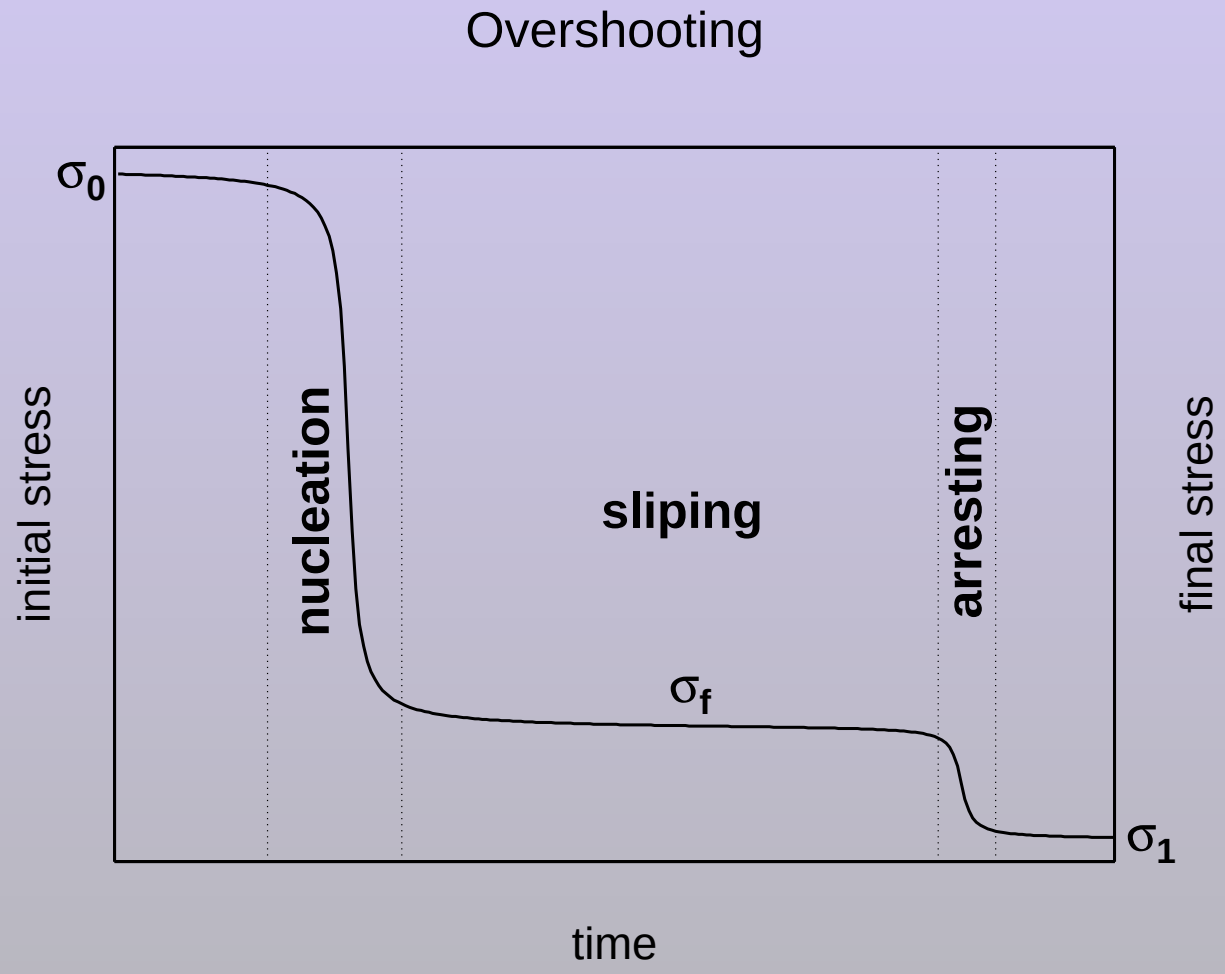
Partial stress drop/overshooting



Partial stress drop/overshooting

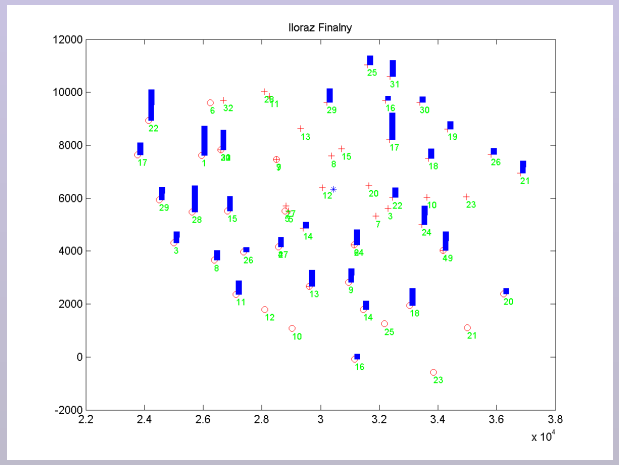


Partial stress drop/overshooting



Rupture velocity

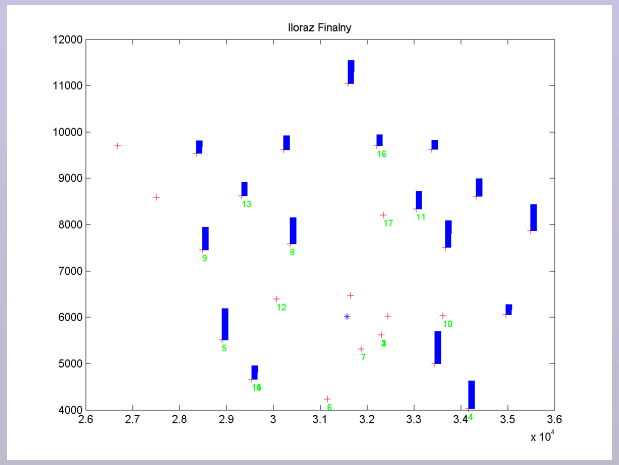
"circular type"



no visible directivity

$$V_r = 0.5 V_s$$

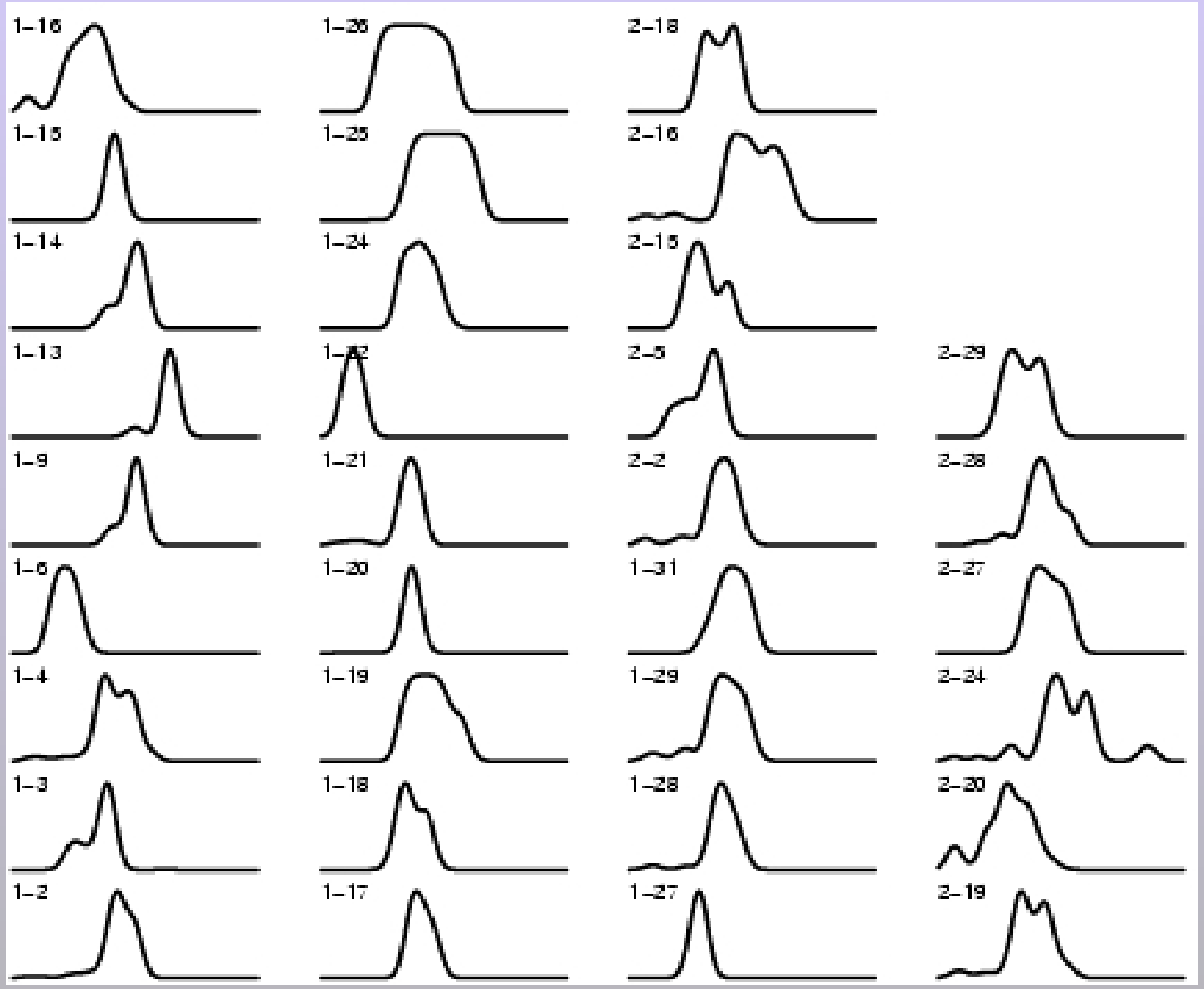
"unilateral type"



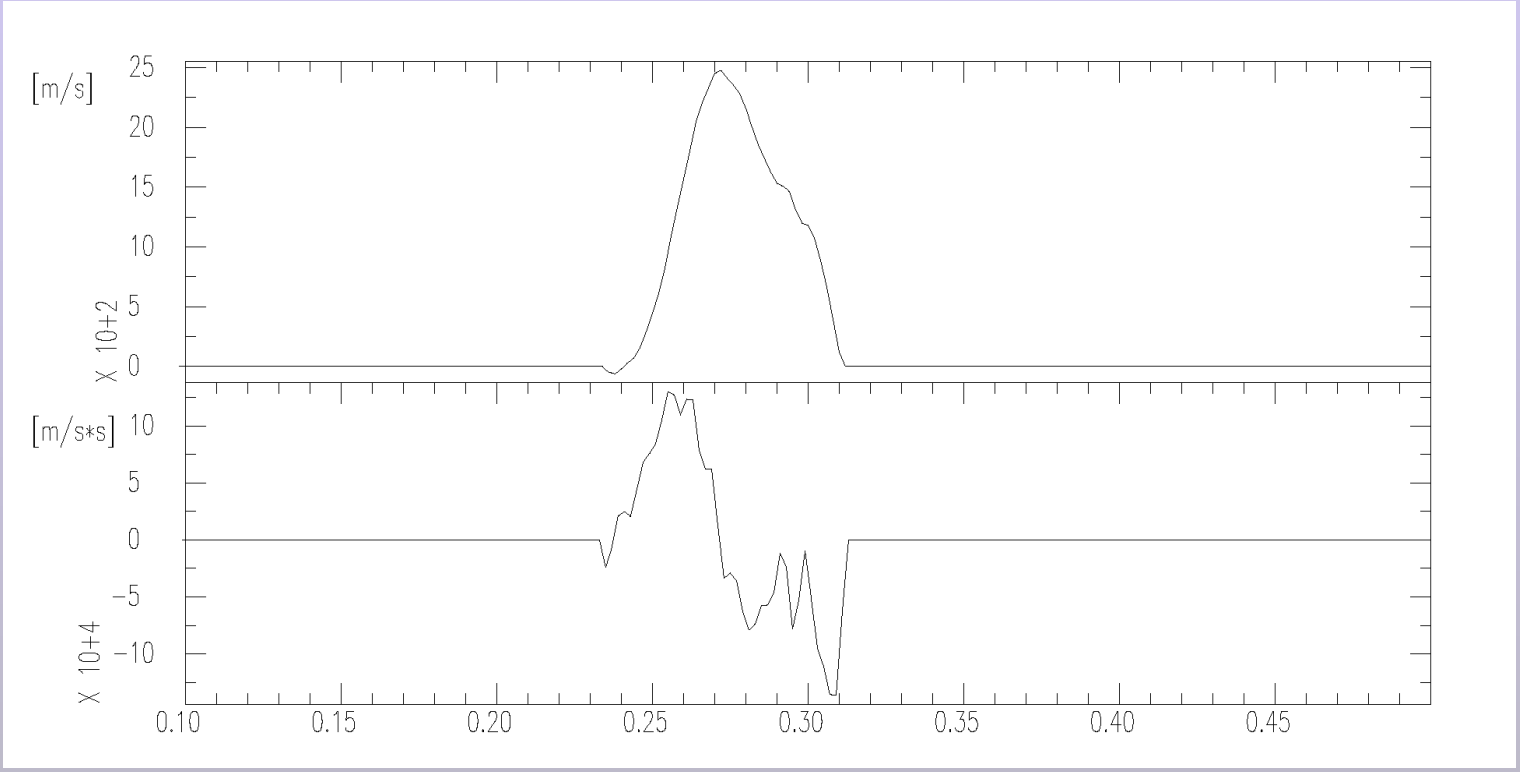
directivity of T distribution

$$T(\theta) = \frac{L}{V_r} - \frac{L}{V_P}\cos(\theta)$$

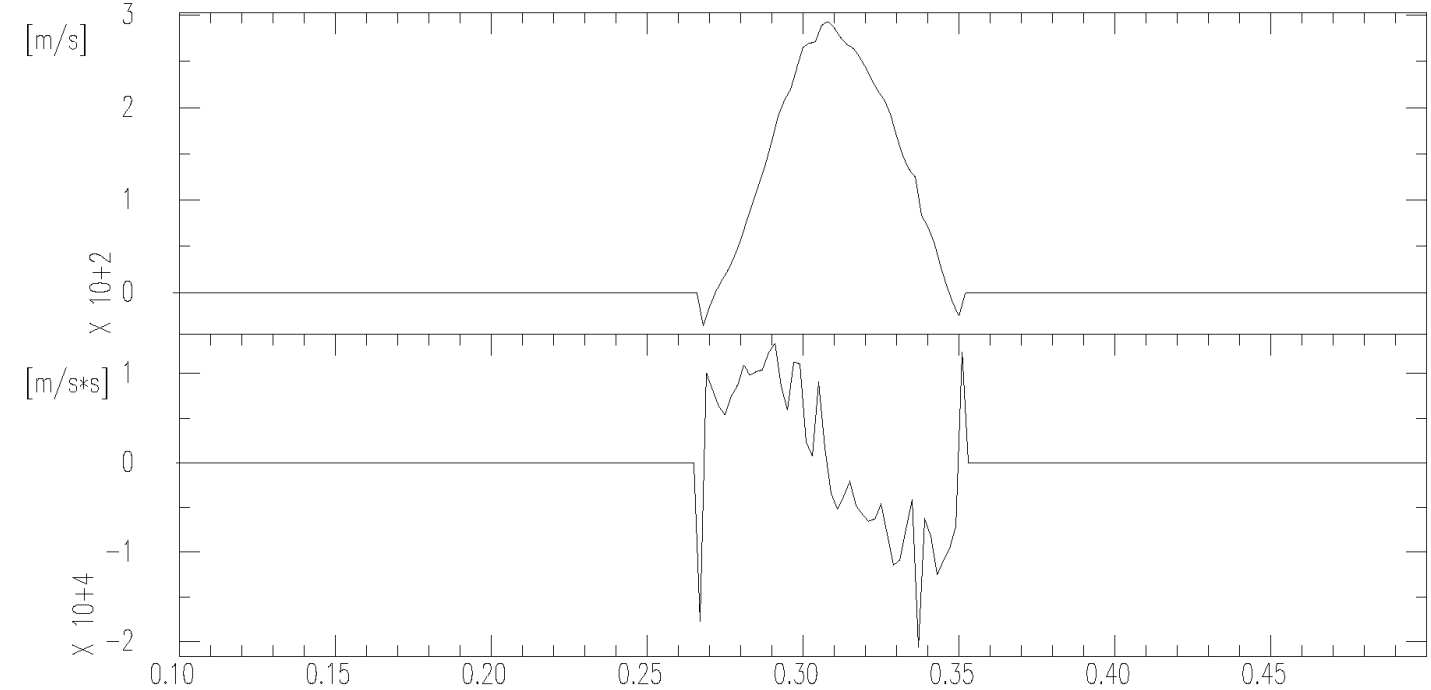
STF- spatial distribution



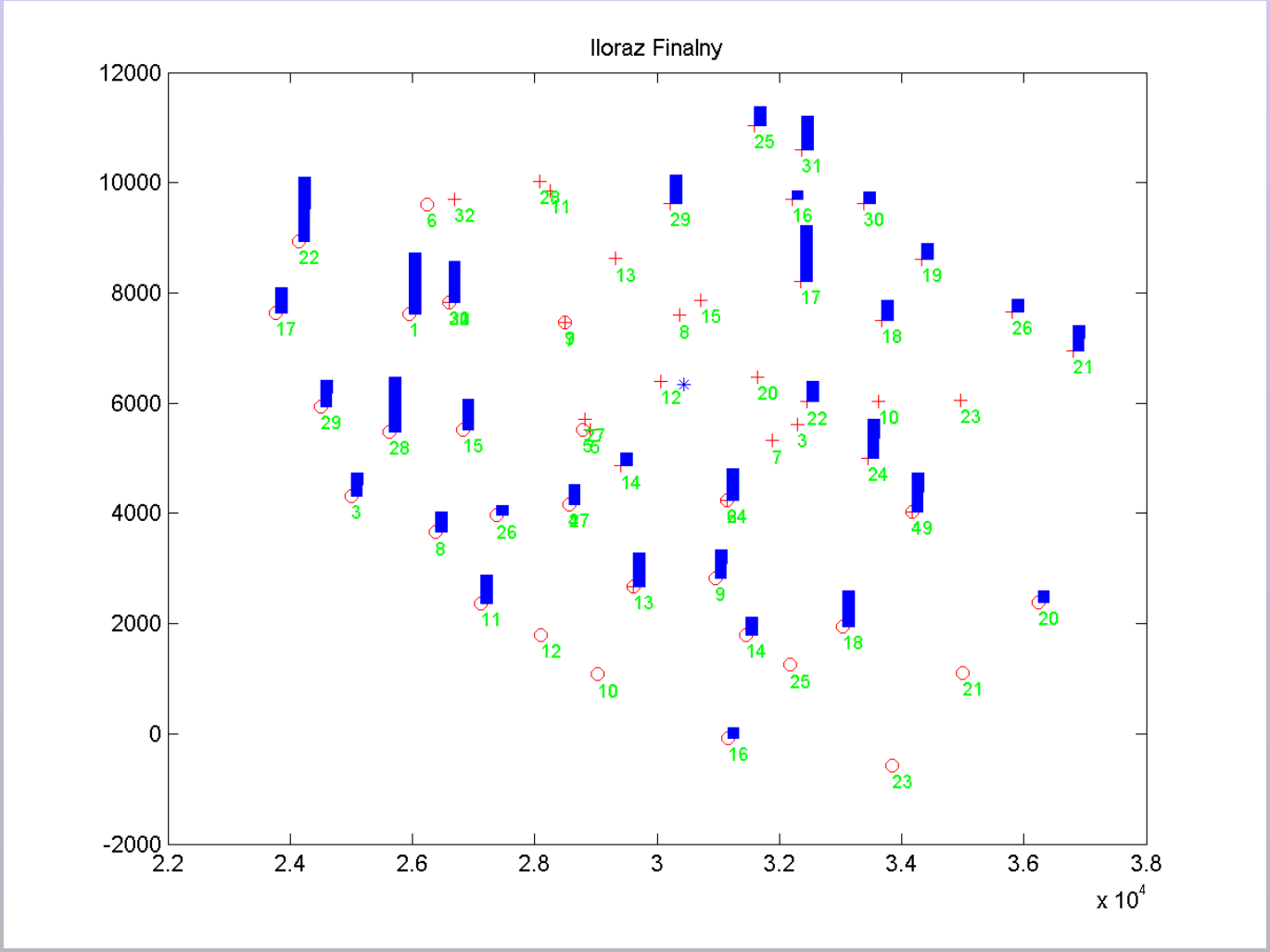
Source Time Function



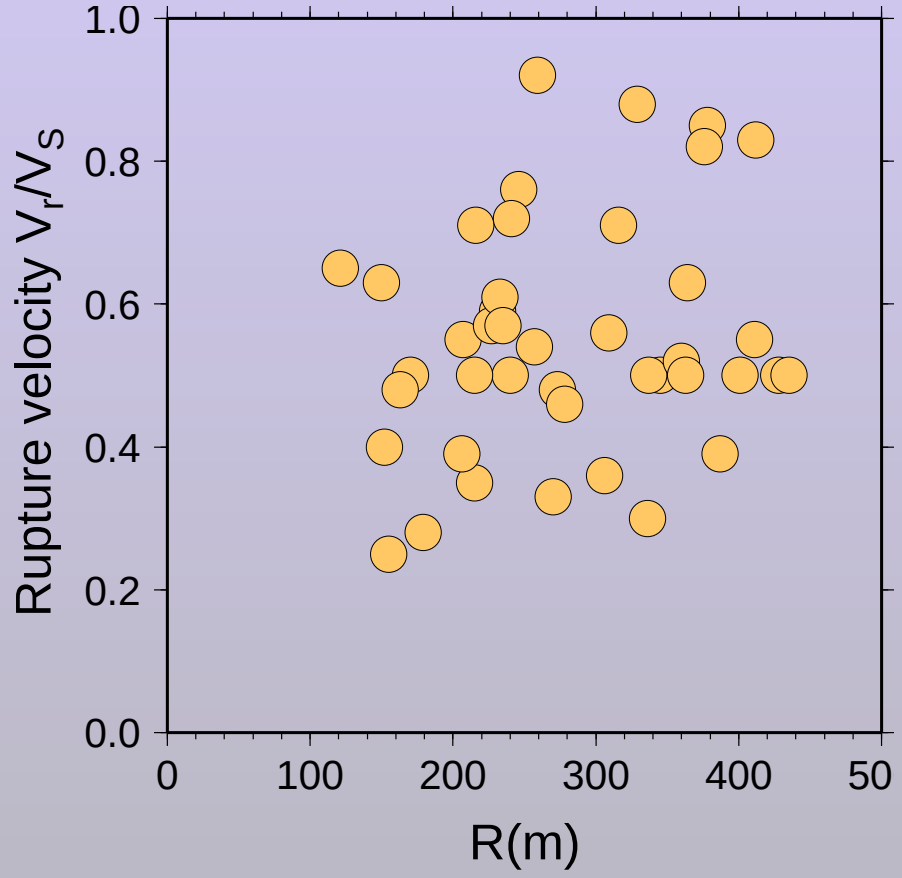
Source Time Function

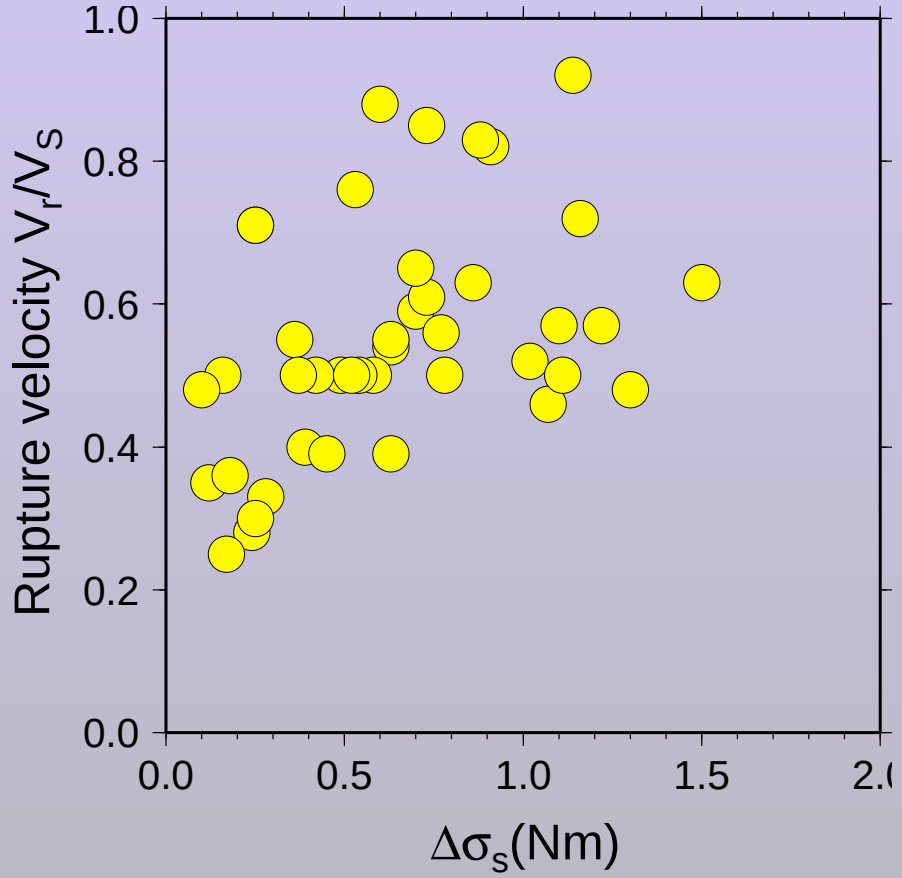


STW width - spatial distribution

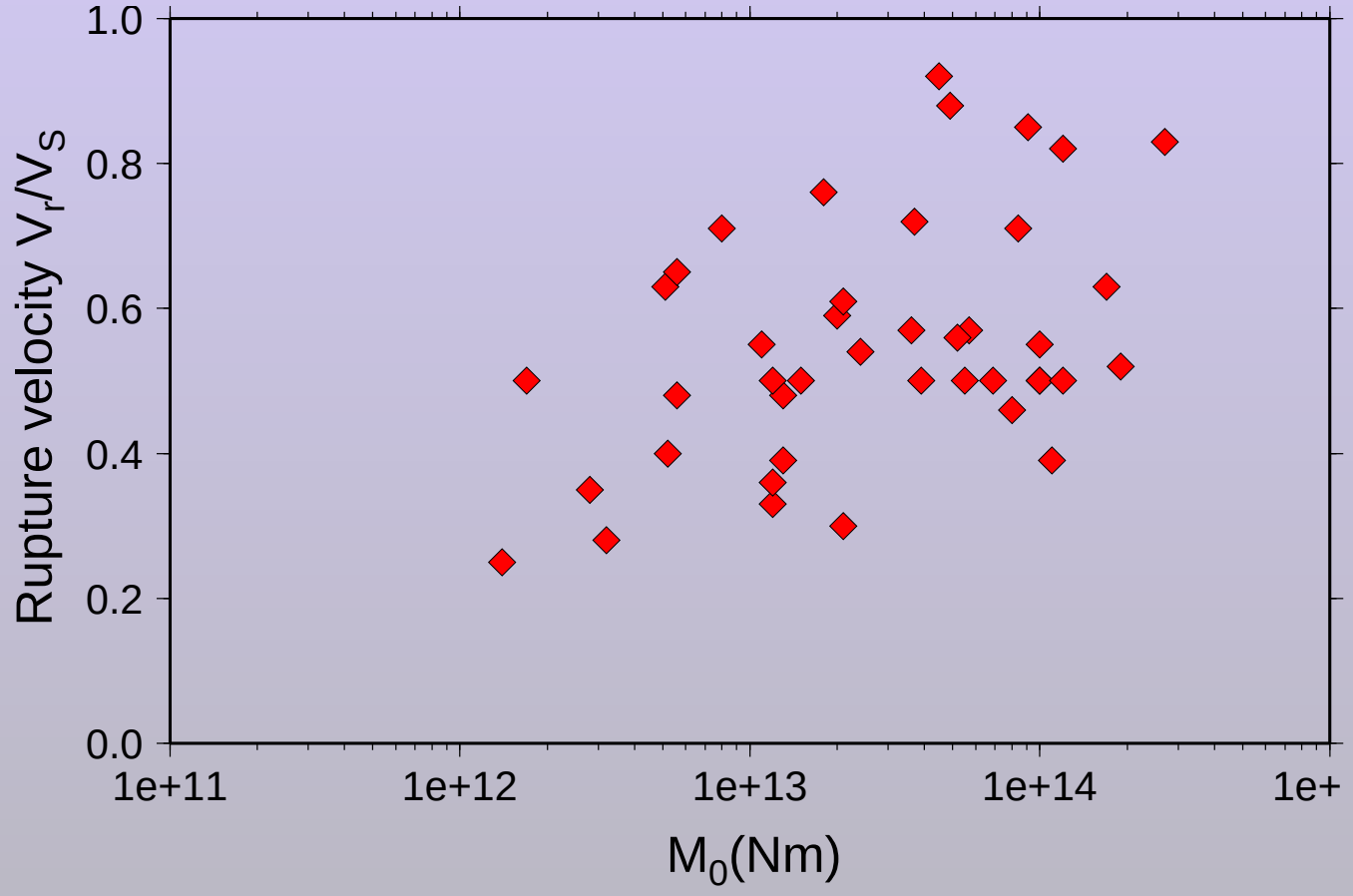


Rupture velocity

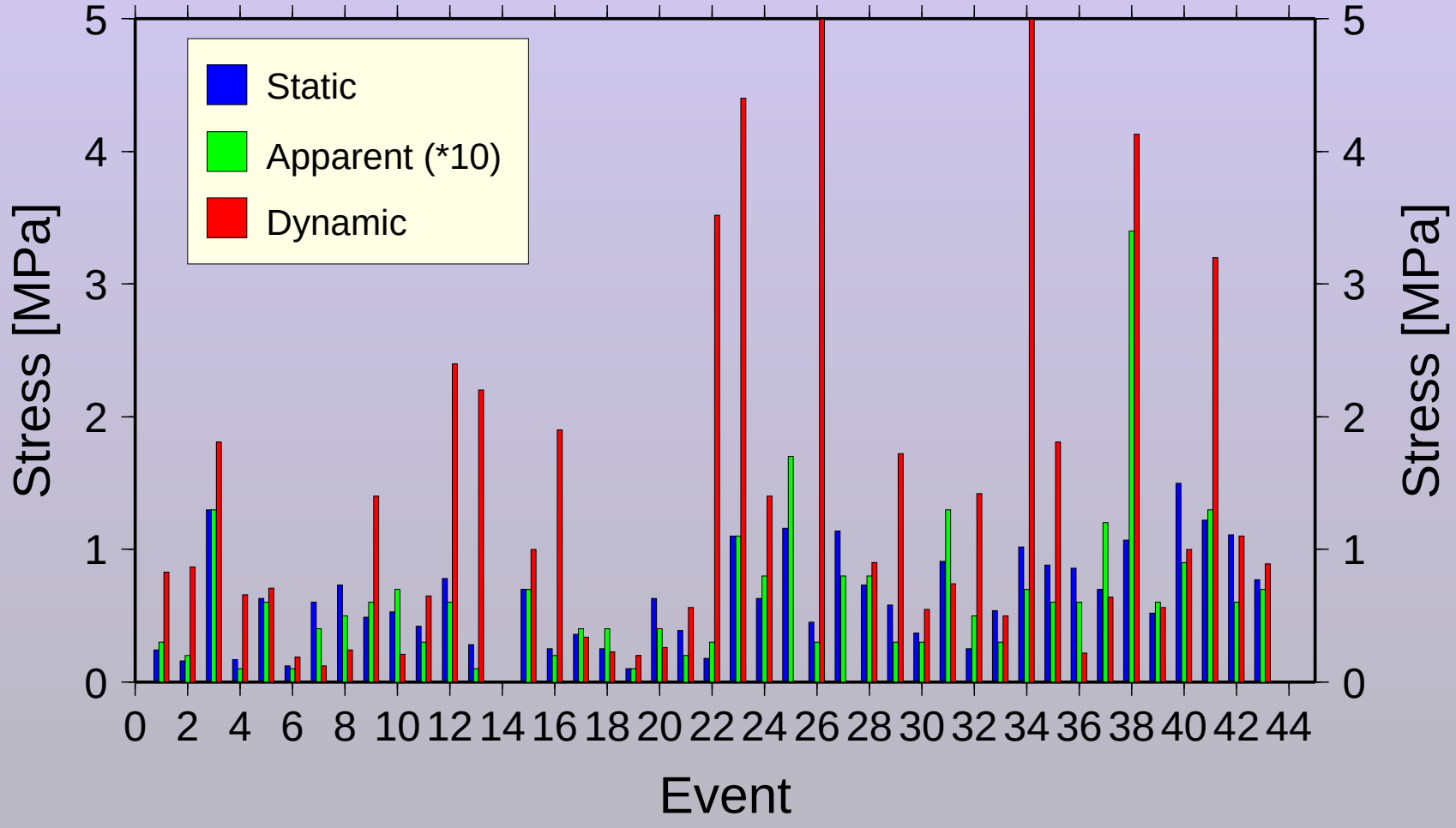




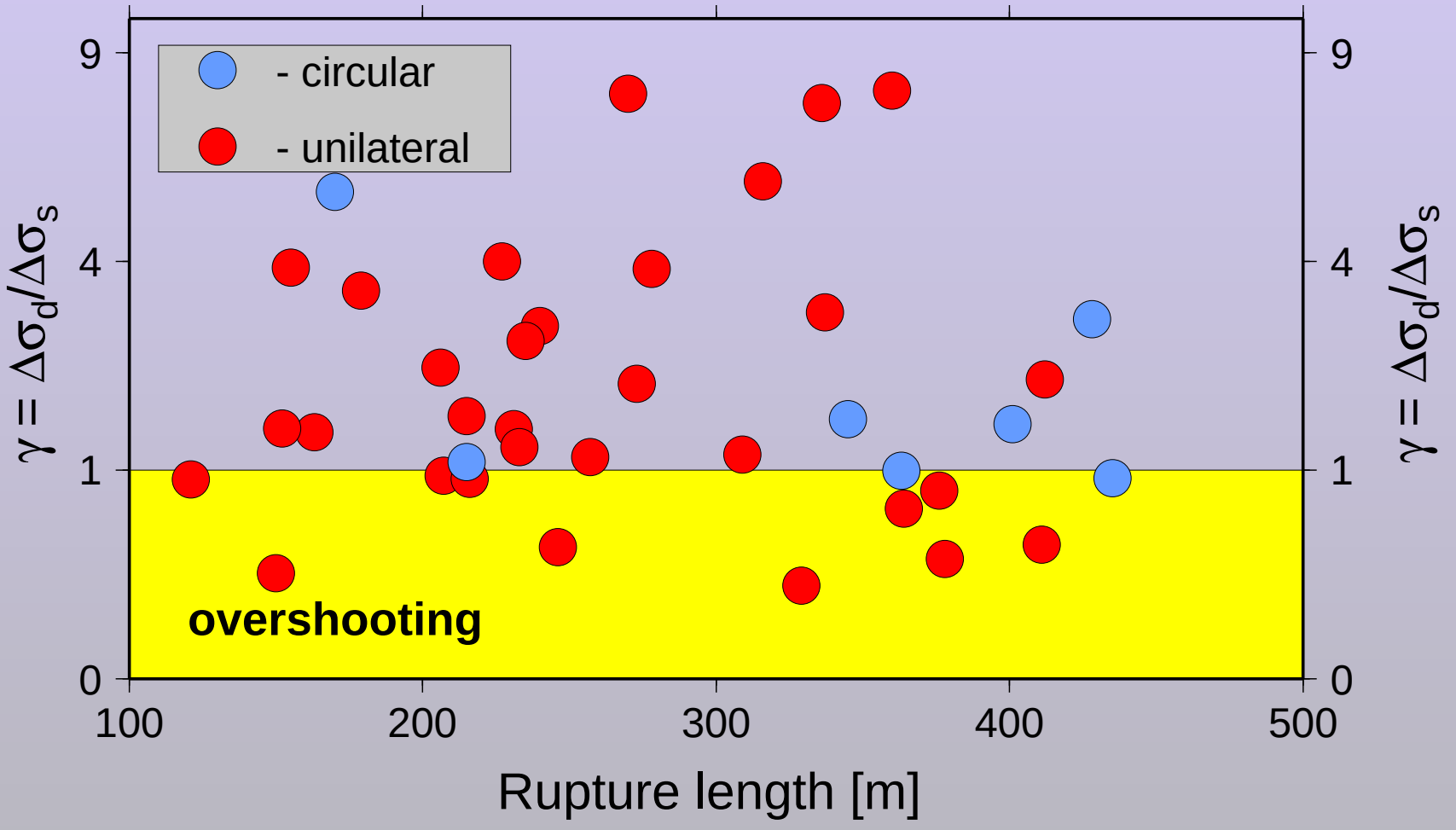
Rupture velocity



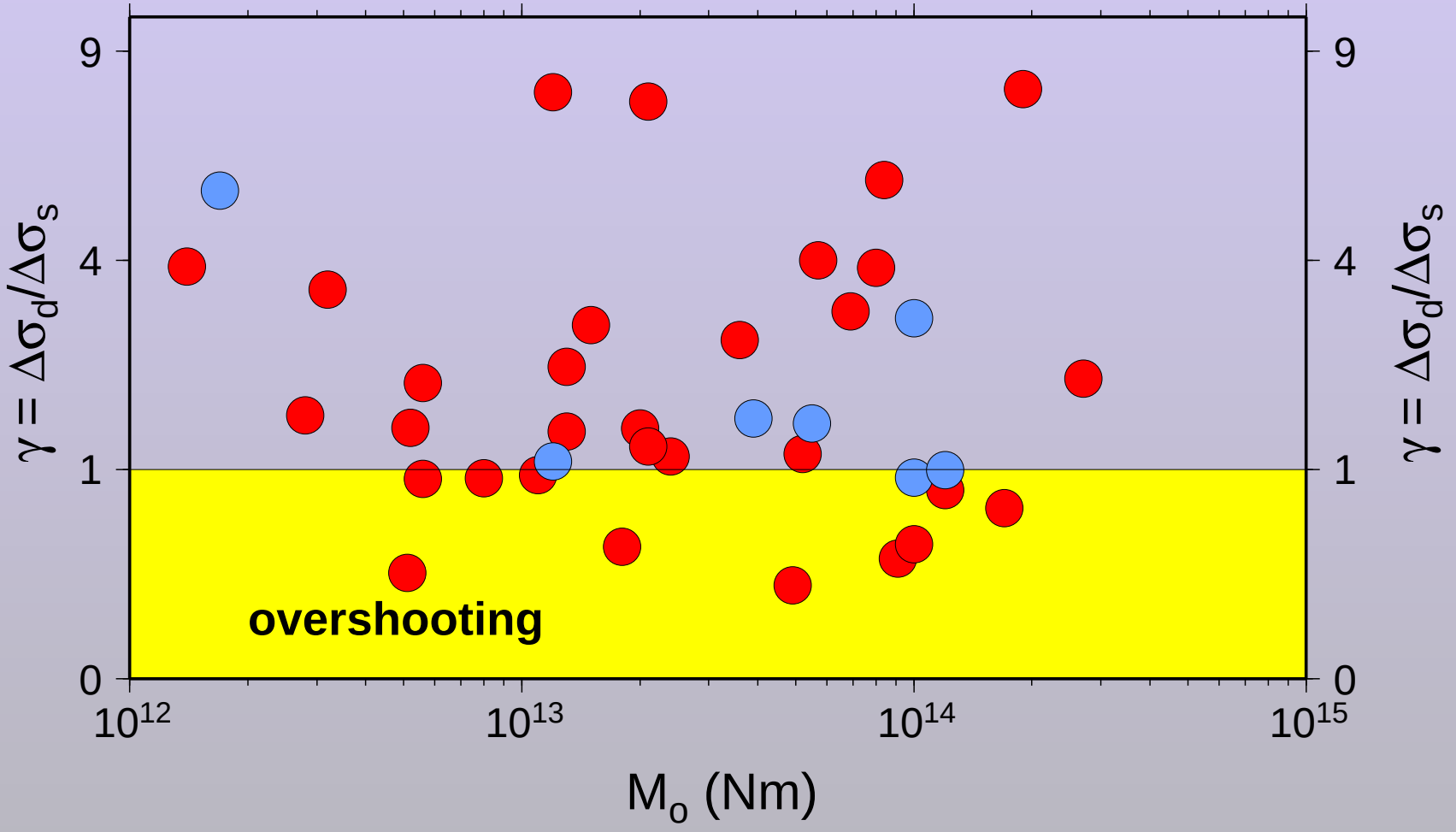
Stress estimates



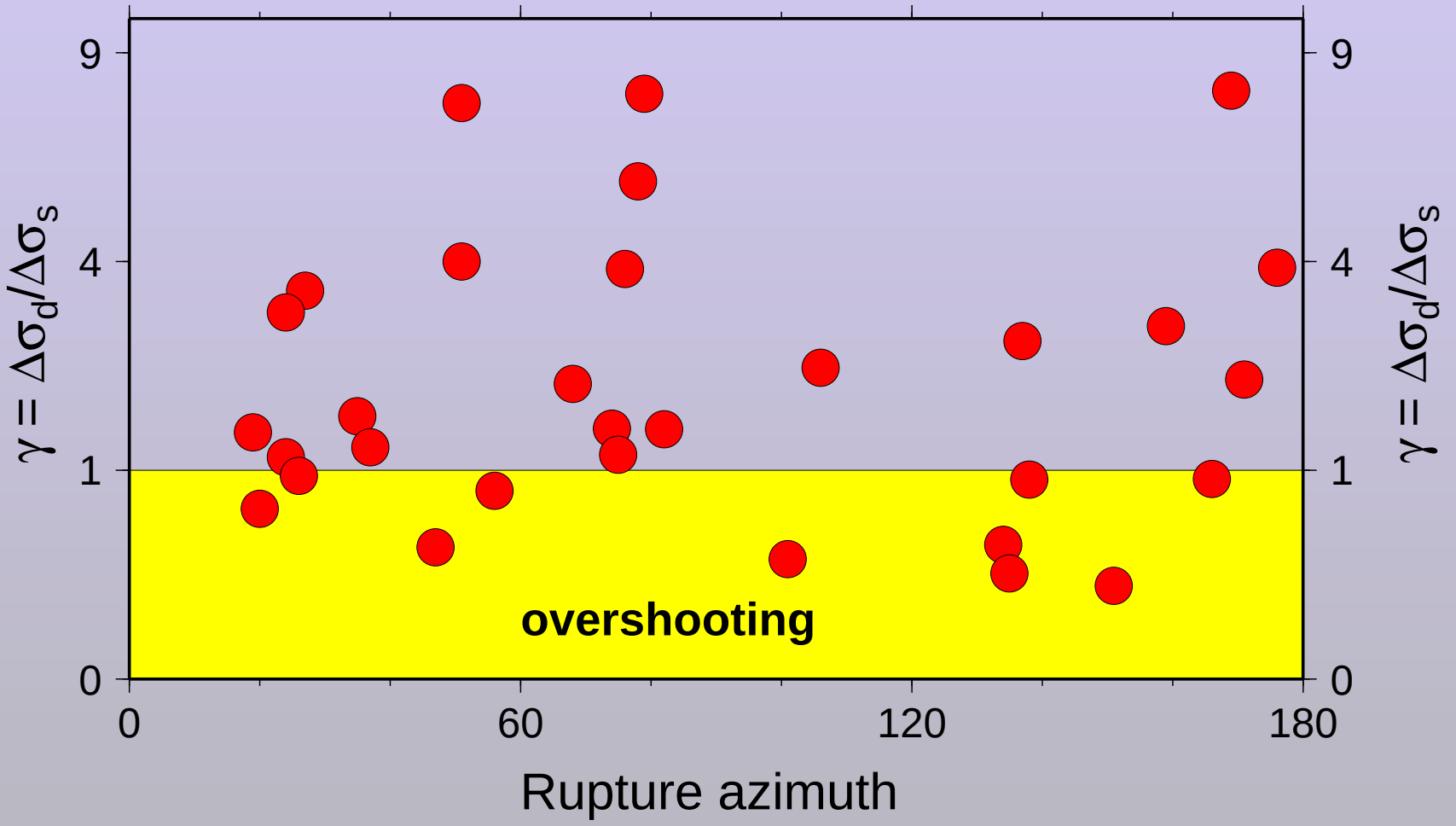
Correlations



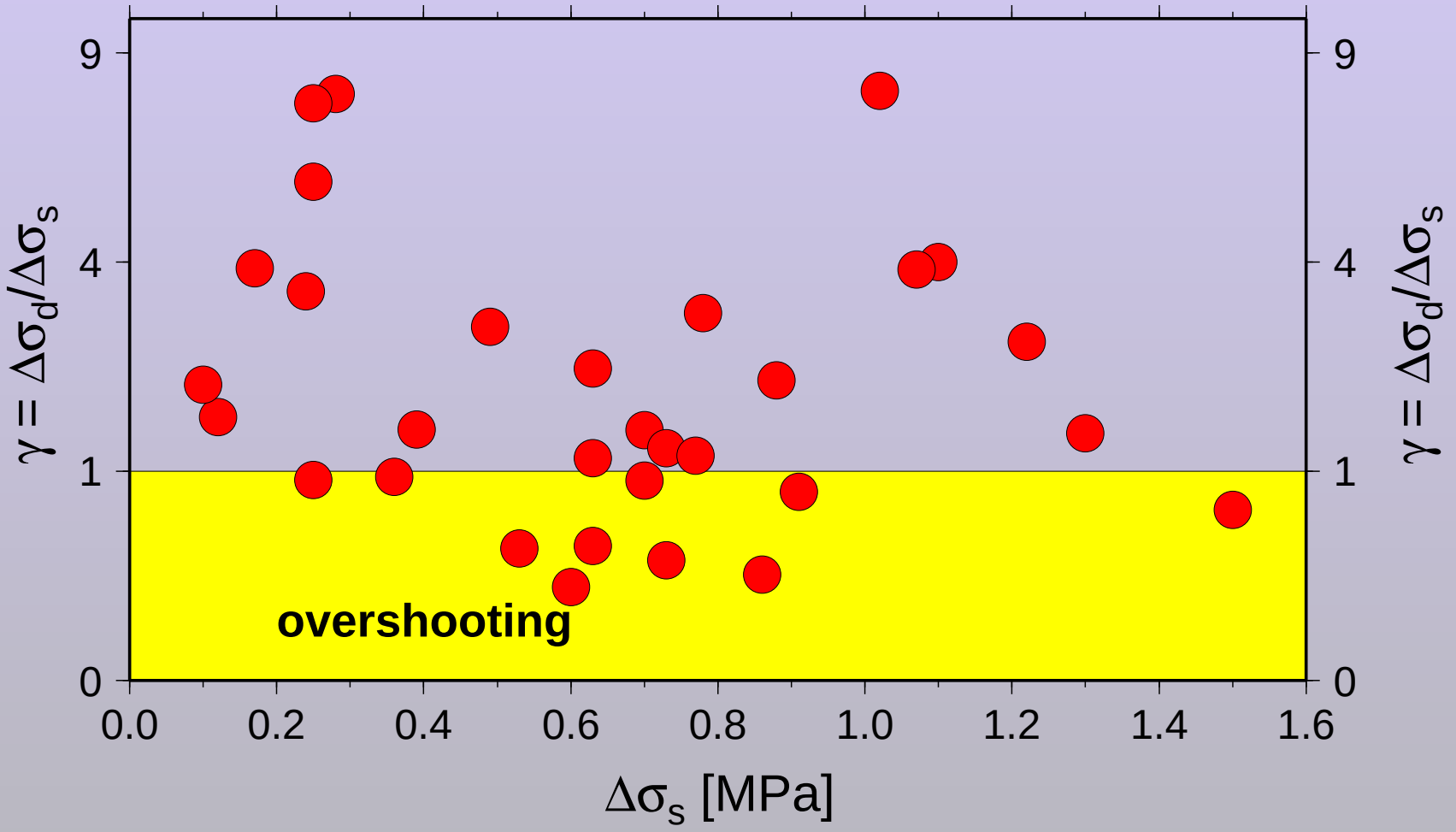
Correlations



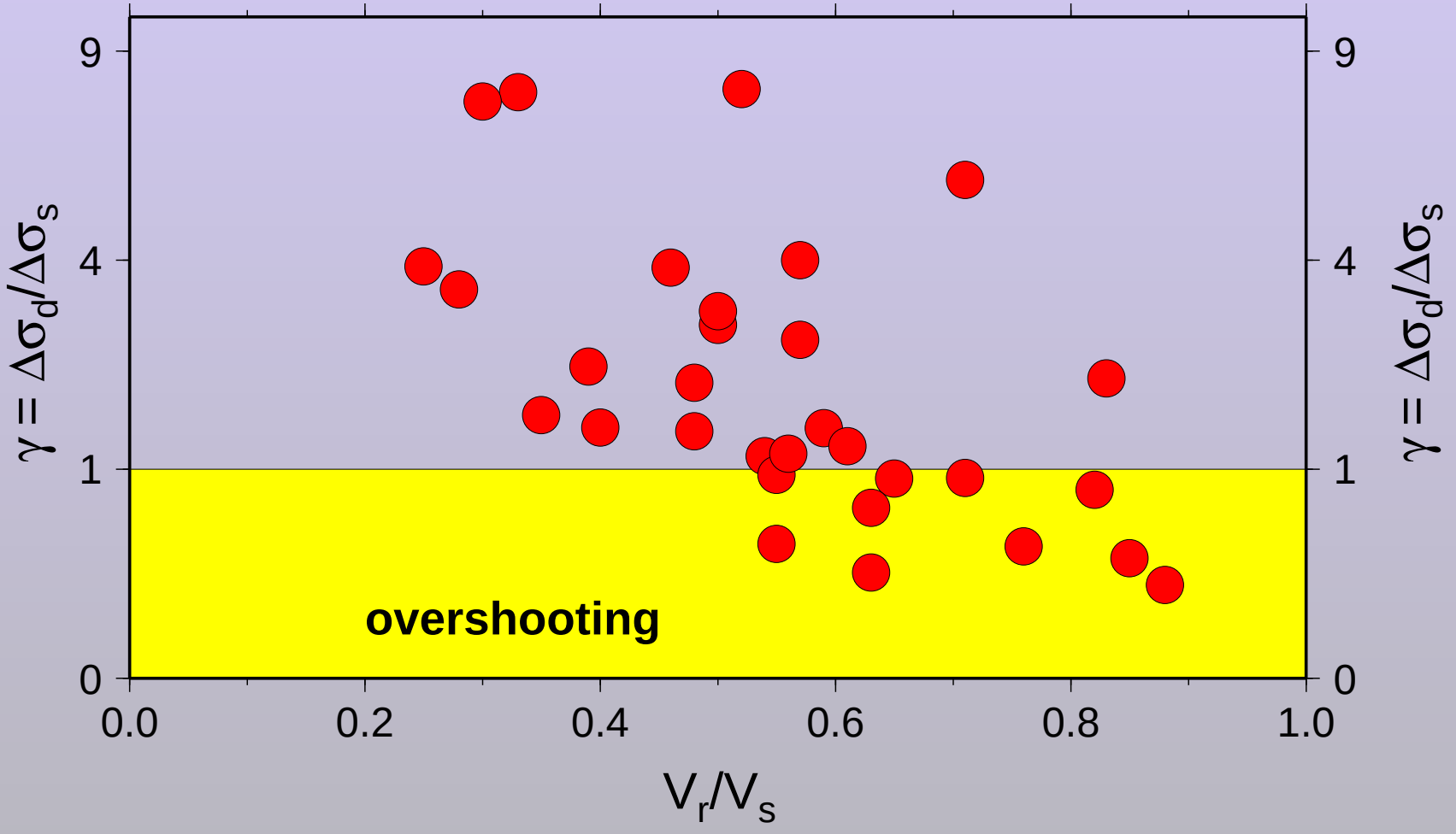
Correlations



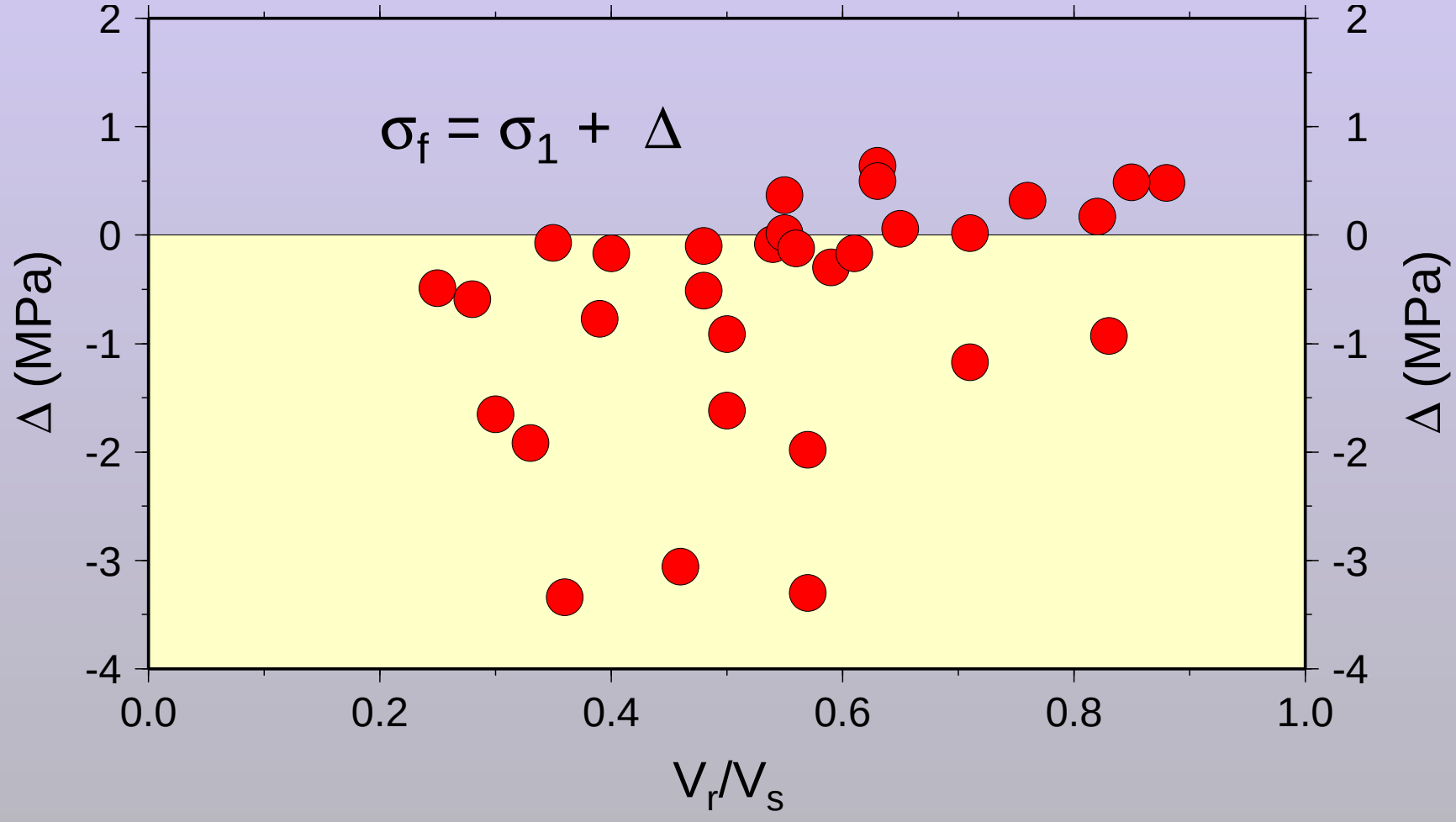
Correlations



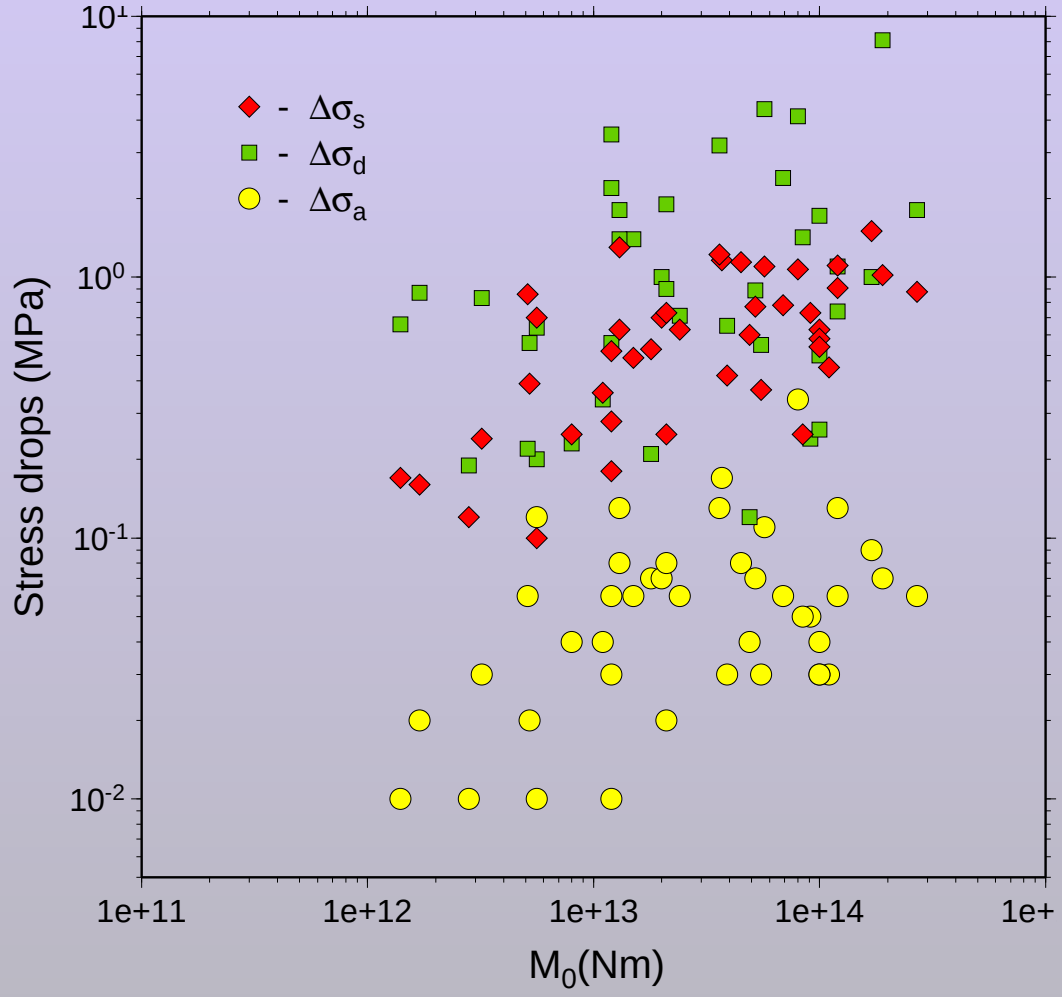
Velocity


9
4
1
0
0.0
0.2
0.4
0.6
0.8
1.0
$\gamma = \Delta\sigma_d/\Delta\sigma_s$
V_r/V_s
overshooting

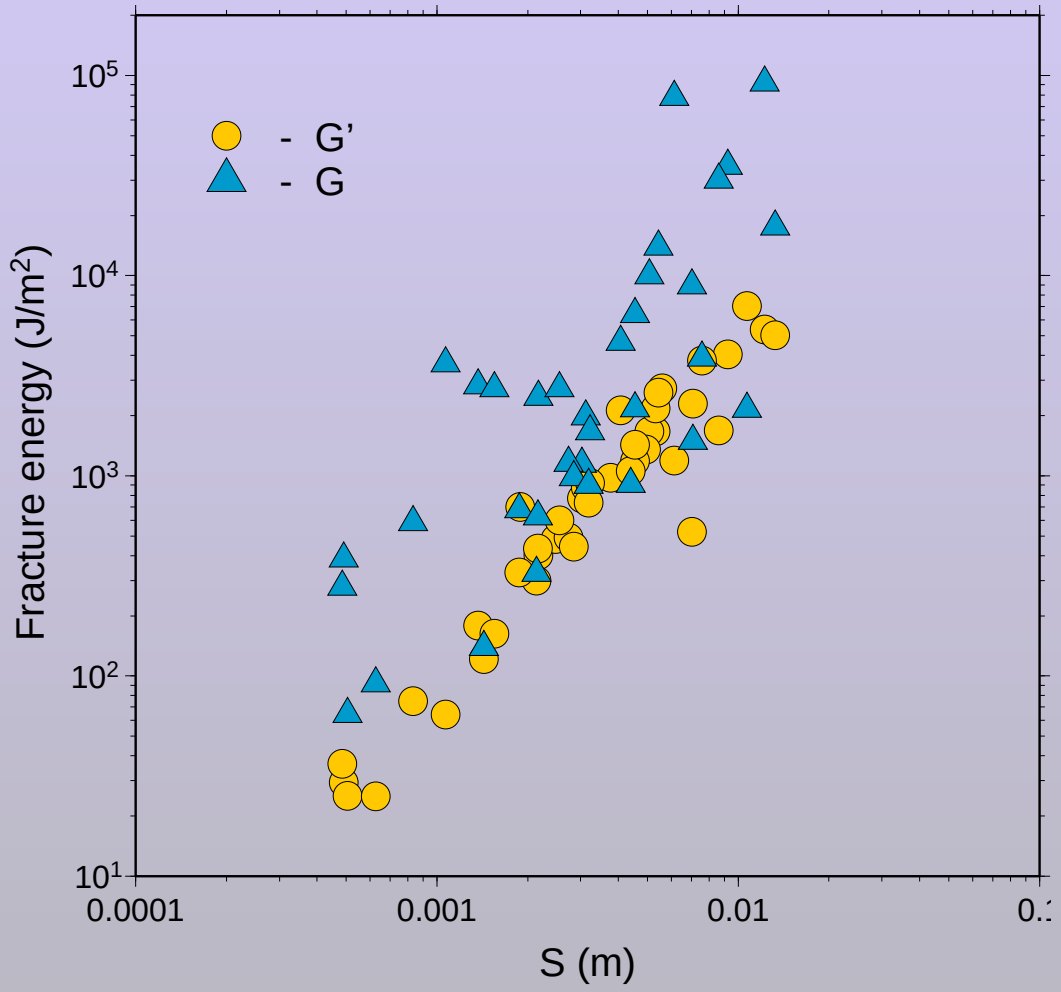
“Overshhoting” stress



Scaling stresses with M_0



Fracture energy



Source size: Madariaga, Brune, or ...