Fractal fault zone geometry and scale-dependent static stress drop

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I have shown that fault zone geometries, composed of fault segments and jog, are hierarchically selfsimilar (Fig.1a). This inhomogeneous structure breaks down the wellknown relations among fault length, averaged seismic slip and seismic moment. The distribution of seismic slip also is pinned hierarchically by jogs, showing a spectral distribution (Fig.1b). Based on the high quality data of fault traces and slip distributions from 21 surface earthquake strike-slip faults, here I show that average static stress drop $\Delta \sigma$ decreases as $L_0$.

**Key Point 1**

If $D_{av}$ of a fault ($L$, $D_{max}$) is $\pi D_{\text{max}}/4$, $\Delta \sigma = C \pi D_{\text{max}}/4L$.

For a fault composed of linked $n$ faults with ($L/n$, $D_{\text{max}}$) also $D_{av} = \pi D_{\text{max}}/4$, while $\Delta \sigma = nC \pi D_{\text{max}}/4L$.

[Symbol for j-th segment of hierarchical rank $i$, segment length:$L_s(i,j)$, averaged slip:$D_{av}(i,j)$, static stress drop:$\Delta \sigma(i,j)$, proportional constant:$C$]

**Key Point 2**

Slip distributions $D_x$ on fault segments are approximated by two simple cases below.

Cases of homogeneous frictional resistance $D_x = 2(1 - \nu)/G \times (\sigma_{yx}^r - \sigma_{yx}^c) \times (a^2 - x^2)^{0.5}$.

Cases of frictional resistance with a linear gradient $D_x = (1 - \nu)/G \times (2\sigma_{yx}^r - \sigma_{yx}^c(x/a)) \times (a^2 - x^2)^{0.5}$.

[Symbol half length of fault segments:$a$, Poisson's ratio:$\nu$, remote stress:$\sigma_{xy}^r$, frictional resistance:$\sigma_{yx}^c$]

**Key Point 3**

When $L_s(i,j) < W_s$, $\Delta \sigma_{av}(i,j) = (7\pi G/8)(D_{av}(i,j)/L_s(i,j)$.

When $L_s(i,j) > W_s$, $\Delta \sigma_{av}(i,j) = (2G/\pi)(D_{av}(i,j)/W_s)$.

The static stress drops averaged over the whole fault length $L_0$ is $\Delta \sigma = \sum \Delta \sigma_{av}(i,j) L_s(i,j)/L_0$.

[Symbol for j-th segment of hierarchical rank $i$, segment length:$L_s(i,j)$, averaged slip:$D_{av}(i,j)$, static stress drop:$\Delta \sigma_{av}(i,j)$, thickness of seismogenic crustal layer:$W_s$, rigidity:$G$]

**Analytical Results**

17 among 21 data are approximated to the equation below (Fig.1c).

$\Delta \sigma = 79.0 \times 10^{-0.519}$ (units km and MPa)

Keywords: static stress drop, scale dependence, fault zone geometry, hierarchically selfsimilar