I130-009 **Room: 301B** **Time: May 18 11:15-11:30**

Fractal geometry of fault populations and fault zones; their relations with earthquakes

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I. FRCTAL GEOMETRY OF FAULT POPULATIONS

Existing faults are the fractal backbone of earthquakes. Faulting as a dissipative process should be formulated as evolution laws.

I-1. Fractal size frequency of faults (Otsuki, 1998, GRL)

The cumulative number N of faults with displacement larger than D among total number Nt is approximated by the equation below.N/Nt=[1+(D/Dc)^A]^-Bs/A —- (1),

Dc:the characteristic slip, A:a parameter of ductility, Bs:fractal dimension. Let Nd and Dd as number density and slip density of faults, then equations below holds.

A=0.495*(Dc/Nd)^-0.335 R^2=0.962 —-(2)

Bs=1.695*[Dd/(DcNd)]^-0.253 (R^2=0.980) —-(3)

DcNd is a quantity proportional to the ratio of dissipative energy density to elastic strain energy density, resembling Reynolds number. The term Dd/(DcNd) is interpreted as input energy density measured by dissipative energy density, and Bs decreases as input energy density. Note pre-exponential constant to be very close to the golden section ratio.

I-2. Spatial distribution of faults (Goto & Otsuki, 2004, GRL)

This is a multi-fractal problem of slips which are supported by the spatial distribution of faults. The information dimension of the distribution of all faults in any population is very close to 1, indicating nucleation spatially at random. The information dimensions B0 of the fault populations with D larger than Dc is approximated as,

B0=1.12*(DcNd)^0.0397 R^2=0.868 —-(4).

This suggests that the spatial distribution of faults which can grow spontaneously is determined only by the non-dimensional material property DcNd.

The information dimensions B1 of the spatial distribution of fault slips follow the equation below.

B1=0.865*[Dd/(Dc/(DcNd)]^-0.0683 R^2=0.904 —-(5)

B1 also decreases as input energy density measured by dissipative energy density. Bs and B1 is tied by an universal law as,

B1=0.763*Bs^0.219 R^2=0.950 —- (6).

II. FRACTAL GEOMETRY OF FAULT ZONES

II-1. Hierarchical self-similar fault zone geometry (Otsuki & Dilov, 2005, JGR)

The inspection into growing experimental faults revealed that any fault zone is composed of fault segments and jogs, and that any large segment is nested by smaller segments and jogs. Let Ls(i), Lj(i) and Wj(i) as segment length, length and width of jog of hierarchical rank i, respectively. They are well approximated by,

Ls(i)=0.343*Ls(i-1)^0.999 R^2=0.956 —-(7)

Lj(i)=0.0935*Ls(i-1)^1.00 R^2=0.861 —-(8)

Wj(i)=0.0456*Ls(i-1)^0.642 R^2=0.691 —-(9)

Similar equations hold for 20 surface seismic faults in the world, indicating them as universal laws covering very wide size range, orders from mm to 100km.

II-2 Derivation of two empirical laws in seismology

Gutenberg-Richter law and another empirical law that M0 of main shocks is proportional to the seismic nucleation size to the power of 3 can be derived from the hierarchical self-similar fault zones with the plausible assumptions.

II-3 Derivation of surface fracture energy (Otsuki, 2007, GRL)

Comminution is most intensive in jog areas, and the fractal dimension D of microcrack distribution is 1.56 (probably a universal constant). Incorporating this and the fault zone geometry, the size dependence of surface fracture energy Gs can be derived as

Gs=C1*(L0/x0)^(D-1) C1: const. —-(10),

indicating that Gs is determined by the length of fault L0 scaled by the characteristic smallest grain size of fault gouge. Gs of jogs of the 1st, 2nd, 3rd rank are about 2, 1, 1/2 times of the mean Gs.

II-4. Size dependence of static stress drop (Nakamura & Otsuki, Poster)

Nadeau & Johnson (1998, BSSA) found an empirical relation for the size dependence of stress drop. The relation between segment length L and slip D of surface seismic faults is consistent with their relation as

D/L=0.0253*L^-0.665 R^2=0.964 —-(11),

depicting the larger fault, the smaller stress drop. This will be explained by fractal distribution of slip density on a fault plane.