Continuum model for interacting many faults: emergence of main fault and Gutenberg-Richter’ s law

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Although the origin of the Gutenberg-Richter’ s (GR) law has long been discussed, we are still far from the decisive conclusion. Historically, the Burridge-Knopoff model and similar discrete models have played a certain role in understanding the origin of the GR law. However, they are essentially discrete models and therefore the relation to continuum (i.e., the Earth’ s crust) has not been clear. Additionally, the large-scale morphology of many faults, such as the emergence of strain concentration zones and tectonic lines, lacks any physical models, although such geological structure has long been discussed in geodesy and geology.

To address the above questions, here we construct a large-scale continuum model for seismicity based on the elasticity theory and the micromechanics theory for defects in solids [1]. In our model, earthquake faults are regarded as point sources, and the seismic moment of a point source is translated into the “eigenstrain” in the context of micromechanics. Then the local stress and released energies of individual earthquake are calculated based on micromechanics, and these earthquakes interact each other via the elastic continuum. We adopt the Mohr-Coulomb failure criterion as the earthquake occurrence condition. Our simulation reproduces a clear band structure, in which the seismic moment accumulates. The GR law is also reproduced with a range of b-value that is consistent with the observations. We discuss how the b-value depends on the pressure and other physical conditions.

[1] T. Mura, Micromechanics of defects in solids (Springer Science & Business Media, 2013).

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