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Why magnitude-frequency relationship of fault motions seems like a power-law distribution?

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Most earthquakes are caused by rupture of Earth's crust which results into fault motion. It is known that the magnitude frequency of occurrence relationship in globally compiled earthquake data follows the Gutenberg-Richter law (GR law). However, the mechanical background of GR law has not been investigated. It is because actual fault motions which cause earthquakes can hardly be observed and the number of recorded events is too small in the geologic time scale.

Therefore, we conducted numerical experiments to simulate a series of fault motions with various sizes in a large system under differential stress conditions using Discrete Element Method (DEM). The minimum size of fault motion is defined by the inter particle slip and the maximum one is the shear fault which cross from one edge to the other.

Based on the numerical simulations, we found some important facts: 1) the smallest fault motion is mobilized due to initial inhomogeneity in granular packing. This means that the stress distribution can never be microscopically homogeneous in whole through the system due to unavoidable imperfection of the particle arrangement in the system, just like defects in crystals. Therefore, the local stress condition does not follow the global stresses. At some part, the local differential stress is greater than the global one and at other part it is smaller. Then, the local highest differential stress leads the local slip in the direction of lower differential stressed zone. As a result of this local slip, self local compaction proceeds; 2) once self local compaction occurs, the material which includes the compacted zone becomes more homogeneous and stronger in relatively large area; 3) consequently, the size of the shear fault enlarged depending on the process 2). When the well compacted zone reaches to the system boundary, it is the largest shear fault; 4) when the largest scale event occurs, intensive inhomogeniety is recreated and it goes back to 1).