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Numerical modeling of the healing process for a fault strength using a 2-dimensional distinct element method I

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Earthquake generation processes consist of the healing process of a fault zone, tectonic loading, quasi-static nucleation process, and dynamic rupture propagation. These processes are controlled by the frictional constitutive law on a fault plane. In the former studies, these constitutive laws and corresponding models were proposed based on results of laboratory experiments. In the real fault zone, however, the healing process changes crucially depending on chemical interaction between water and rocks. In this study, we perform a numerical simulation of stick-slip based on a 2-dimensional distinct element method (2D DEM) to reveal detailed mechanism of the healing process of a fault zone. We study the healing process of a fault zone by assuming several time dependent laws to static frictional coefficients. Here, we do not take account of existence of water to simplify the problem.

In the 2D DEM, we examine the time evolution of each grain by solving the equation of motions for grains by a time-stepping, finite-difference approach. As the boundary condition, we employ the periodic boundary conditions to horizontal direction. Shear and normal stresses are introduced through the vertical and horizontal motion of the upper wall. We consider both of normal and shear forces as the interaction that acts on each grain. The forces are evaluated by assuming the springs and dashpot at the contact point of grains. We calculate the interaction forces owing to the Hertz's elastic contact law for the 3D sphere. We adopt the same formalism of DEM as Morgan et al. (1999)[1].

To discuss the detail processes of stick-slip, we consider effects of slip for shear direction. For constitutive law, we first employ Dietrich's type healing process, in which static friction coefficients depend on Log(t). Second, we consider pressure solution creep between asperities. In this case, friction forces between grains are thought to depend on the contact radius of asperities and their temperature [2]. Since growing velocity of the contact radius becomes larger for smaller contact radius, healing velocity is thought to be larger for asperities with small contact radius. In this presentation, we will report results of numerical simulations that take account of two healing processes mentioned above.

[1] Morgan, J. K., and M. S. Boettcher, J. Geophys. Res., 104, 2703-2719, 1999.

[2] Hickman, S. H., and B. Evans, Growth of Grain Contacts in Halite by Solution-transfer, in Fault mechanics and transport properties of rocks, 253-280, Academic Press, 1992.