STICK-SLIP INDUCED COLLECTIVE RESPONSE IN SHEARED GRANULAR FAULT

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Granular gouge is commonplace in natural faults. Revealing the particle motion and rearrangement inside the granular gouge during stick-slip cycles can help better understand the mechanism of tectonic earthquakes. Here, the microscopic kinematics and collective response of a granular gouge during the two distinctive states – stick and slip phases – are analyzed based on a numerically simulated sheared granular fault system using the combined finite-discrete element method (FDEM). During stick phases, the gouge locks the fault plane like a solid, but a few tiny active particle clusters exist due to scattered local contact failures between particles. When slips occur, part of the gouge flows like a liquid, and the particles in the principal slip zone are the most chaotic. The correlation of the collective response of granular particles is weak during stick phases, and the particles barely rearrange themselves, which gives opportunities for storing potential energy in the system. However, when fault slips, the gouge particles' collective response is strongly correlated, and the stored energy is released, indicating that the particles are effectively rearranged. The rearrangement of the gouge can be explained by the stress chain structures. These stress chains make the slip tend to cascade, which reveals why granular gouge inhibits pre-slips. This study shows how the granular gouge reacts and rearranges during stick-slip cycles from a microscopic viewpoint and may shed light on the dynamic nucleation process of natural earthquakes.