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Behavior of clay minerals in fault zones - amorphization and recrystallization of kaolinite

Koichiro Fujimoto[1*], Kiminori Sato[1]

[1]Tokyo Gakugei Univ.

Nanoparticles in fault zones are recently paid much attention since they give significant influences on the frictional properties (Ma et al., 2006). Nanoparticles are considered to be formed not only bay mechanical grinding but also by mechanochemical processes. Amorphous nanoparticles were found in Iida-Matsukawa fault, Central Japan (Ozawa and Takizawa, 2007). It is well known that clay minerals are easily transformed into amorphous phase by mechanochemical processes. In nature, Kaolinite is selectively decomposed in Chelungpu fault, Taiwan (Hirono et al., 2008). We performed experimental studies on amorphization and recrystallization of kaolinite.

Amorphization: Dry grinding experiment using a planetary ball mill. Some portion of kaolinite is transformed into amorphous phase after several 10 minutes milling. Aggregates of nanoparticles were observed with FE-SEM. Changes in size distribution of nanopores were also detected by measurement of positronium life time. The injection energy during these experiments is considered to be comparable to M7 earthquake. Heat treatments were also performed. Starting materials were completely decomposed and transformed into amorphous phase after 1 hour heating at 600 degrees C and also after 1 minutes heating at 1000 degrees C.

Recrystallization: Starting amorphous materials were provided by heating experiment (600 degrees C, 1 hour heating). Starting materials were hydrothermally treated in 0.01N hydrochloric acid solution (pH3) at temperatures between 140 to 250 degrees C. Degree of recrystallization was determined semi-quantitatively using peak area of kaolinite (002) by X-ray diffraction. About 10% of starting materials were crystallized after a few hours at 250 degrees C, after 1 day at 200 degrees C and after 4 days at 170 degrees C. The estimated recrystallization rate revealed that the starting material might be recrystallized after several hundred years at room temperature.

Kaolinite can be transformed into amorphous material both by heating and mechanochemical process during seismic slip. The amorphous materials can be recrystallized during interseismic interval.

Keywords: fault, clay mineral, kaolinite, mechanochemical, amorphization