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Microstructures of pulverized fault rocks: Examples from San Andreas Fault and Arima-Takatsuki Tectonic Line

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Fault damage zone is gradually formed into the surroundings of the fault layer by the overlap of shear strain and the accumulation of wear (Sholtz, 1987Geology). However, it have been reported recently that 'pulverized fault rocks', characterized by no shear strain and remarkable shatter in situ, are distributed along large strike slip faults such as SAF (Dor et al., 2006EPSL). The development of such damage zones cannot be explained by the conception of wear. In recent study, it is thought that it formed in a moment when an earthquake rupture progresses on a fault plane. Moreover, it argues about the asymmetry of the fault damage zone, because 70% or more of pulverized fault rocks in the SAF are distributed over the northeast side of the fault (Dor et al., 2006EPSL). The factor of mechanism which asymmetrical fault damage zone formed are propagative direction of earthquake rupture (Di Toro et al., 2005Nature), hardness of the rock (Ben-Zion et al., 2005EPSL) and supershear rupture (Doan and Gary, 2009Nature Geo).

Nevertheless, there are the following questions in the lithological characteristic and mechanism of pulverized fault rocks. Because pulverized fault rocks have been studied mainly along the SAF (Dor et al., 2006EPSL), it is not understood whether the microstructure and fracture pattern of pulverized fault rocks change with different tectonic settings and rock compositions. Moreover, pulverized fault rocks reported in the SAF are mainly focused on the quartz particles in the granite (Dor et al., 2009PAGEOPH), so the characteristic of the fracture pattern on other rocks and minerals is not clear. It is also not clear that the difference from the deformation process by the weathering and the other brittle fault rocks such as the fault gauge.

We conducted field surveys on ATTL and SAF, and evaluated microstructures of pulverized rocks by using a scanning electron microscope. Pulverized fault rocks which consist of a granite shows thin black with mica, and white with quartz and feldspar. It easily pulverizes by rubbing between fingers. Under the microscope, the intense fractures were observed only in framework silicates (tectosilicates) such as quartz and feldspar. They are shattered to 10-100 micrometers and show fracture pattern of the web structure. However, the original igneous textures of the host rock is maintained and there are not fine-grained matrices which consist only of finely communicated grains like fault gouges. The fractured grains are in the state which left the outside, and the crack of uneven quality exists in the inside of particles. Some quartz particles were seen that the crack goes through different particles and the crack was radiately developed from the contact point of particles. The fracture planes of quartz are smooth with river patterns. The fragments are angler shape and do not show any effect of wear. On the other hand, the fracture planes of feldspar are rough. Inosilicates such as amphiboles are crushed to 10-100 micrometers and have been fragmented along cleavages. The fracture planes are smooth and fragments have angler shapes. Some of amphiboles fracture to different direction from cleavages. Biotite (phyllosilicate) was found to be hardly shattered but kinked along basal planes. They don't show any asymmetric shear structures like mica fish often observed in fault guoges. SEM analysis of these minerals shown above clarified that clay minerals like kaolinite and smectite, and the alteration minerals like sericite and chlorite have not been observed. From the analysis, pulverized rocks have following characteristics: 1) small amount of strains, 2) no shear deformation with asymmetric structures or grain rotations, 3) volume expansions. The observations indicate that pulverized fault rocks differs from the fault gouges formed by wear and shear deformation.

Keywords: pulverized fault rocks, damage zone, fracture pattern