Amorphous Material in Crushing-originated Pseudotachylyte:A Case Study of the Iida-Matsukawa Fault, Nagano Prefecture

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Pseudotachylytes, fault rocks, are generally divided into melting-originated one and crushing-originated one whether there are melting textures, especially glass, or not. Glass, or amorphous material, however, is known to be formed not only by rapid cooling of melt but also by alteration (e.g. Henley and Ellis,1983) and comminution (e.g. De Carli and Jamieson, 1959; Sakabe et al., 1998); this is called the mechanochemical effect. Moreover, the results of rotary shear sliding experiments using samples of granite have shown that the amorphous silica formed by comminition is related to the weakening mechanisms of faults during earthquakes (e.g. Yund et al., 1990; Di Toro et al., 2004), suggesting that the presence of amorphous materials formed by comminution is essential factor in understanding the strength of faults, however, it has not been reported in natural fault rocks so far. This study describes the electron microscopic textures on a submicron scale, and presents the amorphous materials formed by comminition that were obtained by TEM analyses of the crushing-originated pseudotachylyte from the Iida-Matsukawa fault, Nagano Prefecture, central Japan.

The pseudotachylytes used in this study were collected from the fault outcrop corresponding to Loc. 2 which has been described by Lin et al. (1994) and Lin (1996). The pseudotachylyte veins that are a few millimeters in thickness are black in color in granitic cataclasites. The pseudotachylytes comprise angular fragments of quartz and feldspar and fine-grained matrix with pale brown to dark brown in color under the plane- polarized light. Some thin layers, like flow structures, with dark brown in color can be observed in the matrix. Results of analyses using SEM-EDS (scanning electron microscope with energy dispersive X-ray spectrometer) revealed that the chemical compositions in the pseudotachylyte matrix are distributed heterogeneously on a submicron scale, and the dark brown parts under the plane-polarized light are enriched with Fe, Mg, K and Ti, equivalent to biotite composition. The selected area diffraction (SAD) patterns obtained from the areas consisting of submicron fragments with acicular or feathery shapes and tabular particles of several tens nanometers showed the diffuse ring patterns and ring patterns with biotite spacings. The acicular or feathery fragments whose biotite content are randomly oriented, and layers parallel to (001) in some fragments are torn apart and bent, suggesting cataclasis.

The results of the TEM and SEM-EDS analyses indicate that the regions which show biotite composition contain the amorphous materials, on the other hand, revealed that the host rock contains only single crystals of biotite. In addition, the peaks for mica clay minerals obtained by XRD were only detected in the host rock, not in the pseudotachylyte. Hence, amorphization of biotite may occur in the pseudotachylyte. The results of pore size analyses suggest that fluid is unlikely to pass through the pseudotachylyte, because the pseudotachylyte is much denser than the host rock. It is therefore unlikely that the amorphous materials in this pseudotachylyte may occur by alteration after the movement of faults. The appearance and characteristics of this amorphous materials in the pseudotachylyte obtained by TEM are distinct from glass, formed by melting, which has sharp, accurate boundaries and uniform contrast (e.g. Dell'Angelo et al., 1987). A comparison of grain-size distribution between the pseudotachylyte and host rock clearly shows that the pseudotachylyte is finer than the host rock. Moreover, the SAD patterns for grains larger than 1 micrometer in the pseudotachylyte show only diffraction spots, indicating single crystals. Consequently, the amorphous materials in the pseutotachylyte from the Iida-Matsukawa Fault have been formed by comminution.