Magnetization mechanism of pseudotachylyte derived from granitic rock

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[Introduction]

Electromagnetic anomalies were often observed in past earthquakes (e.g. Shiratori, 1925; Rikitake et al., 1966), and various hypotheses have been proposed as a generation mechanism of coseismic electromagnetic phenomena (Ishido & Mizutani, 1981; Vatotsos & Alexopoulos, 1986; Ikeya, 1998; Slifkin, 1993). Recently, Fukuchi (2003) proposed that instantaneous magnetization of pseudotachylyte by frictional heating may have induced subsequent electromagnetic induction and coseismic electromagnetic phenomena. We thus examine magnetic properties of fault rocks distributed along the Uchinoura shear zone in southern Kyushu, Japan (Fabbri et al., 2000). Here we present the experimental results and consider the magnetization mechanism of fault rocks.

[Samples and procedure]

The fault rock samples used for our experiments are the Uchinoura pseudotachylyte, foliated cataclasite intruded by the pseudotachylyte and their source rock (Osumi granitic rock). We separated the fault rock samples by observation with the naked eyes and a polarizing microscope, and carried out ESR (electron spin resonance) measurements and magnetization measurements with a vibrating sample magnetometer (VSM). In addition, we examine X-ray diffraction (XRD) patterns of bulk samples of the fault rocks and magnetic materials separated with neodymium magnets to identify the magnetic minerals in the fault rock samples. Furthermore, we carried out heating experiments at 1000 degree C in air and low vacuum (24-36Pa) to elucidate the magnetization mechanism.

[Experimental results and discussion]

By observation with a polarizing microscope, we confirm that the pseudotachylyte vein contains glass, vesicles, amygdules and microlites-like acicular microstructures showing partial melting of the pseudotachylyte. According to ESR measurements, the pseudotachylyte and foliated cataclasite have a strong ferrimagnetic resonance (FMR) signal whereas the granitic rock and other fractured rocks show no predominant signal. Magnetization measurements also reveal that the pseudotachylyte and foliated cataclasite have hysteresis loops peculiar to ferro- and ferrimagnetic materials. These results indicate that the pseudotachylyte and foliated cataclasite were most probably magnetized at the time of faulting. The line-shape of the FMR signal detected from the pseudotachylyte and foliated cataclasite is very similar to that detected from maghemite (gamma-Fe2O3) which is a ferrimagnetic mineral. However XRD patterns of magnetic materials separated from the pseudotachylyte and foliated cataclasite with neodymium magnets show that magnetite (Fe3O4) is also contained, so both ferrimagnetic minerals probably exist in these fault rocks. Furthermore, heating experiments at 1000 degree C reveal that the granitic rock is magnetized by heating and the magnetization intensity of the foliated cataclasite increases with heating time, however the line-shape of the FMR signal detected after the heating is different with that from the pseudotachylyte or foliated cataclasite. We thus need to carry out more detailed heating experiments. On the other hand, the XRD patterns indicate that the peaks of biotite in the pseudotachylyte or foliated cataclasite are much smaller than those in the granitic rock. The decomposition of biotite is confirmed also by the heating experiments. Hence, the ferrimagnetic minerals in the pseudotachylyte and foliated cataclasite may have been newly formed from Fe-rich minerals such as biotite decomposed by frictional heating.