Rock-magnetic study of Precambrian granitic rocks in Minnesota

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We have made a rock-magnetic study of Precambrian granitic rocks in order to check the origin of their remanences and their applicability to paleointensity study. Samples were collected from multiple sites of the Sacred Heart Granite (2.6 Ga U-Pb zircon ages) and the St. Cloud Granite and Reformatory Granodiorite (1.8 Ga U-Pb zircon age) in Minnesota.

For most of the bulk samples from the granitic rocks, the Verwey transition at 120K is clearly recognized. Susceptibility-temperature curves show an abrupt drop at about 580 degree. Hysteresis parameters of bulk samples are distributed along a mixing line between the multi-domain (MD) and pseudo-single-domain (PSD) areas on the Day plot. Saturation isothermal remanent magnetization (SIRM) cooling and warming curves indicate that low-temperature memories range in 20-90% of the initial SIRM. These results indicate 20-90% of remanences is carried by single-domain (SD) (or PSD) magnetite grains.

Rock-magnetic properties of separated crystals of feldspar and quartz are similar to those of bulk samples. This indicates that the magnetite inclusions in the feldspar and quartz represent the bulk magnetic properties of the granitic rocks. Under microscope, we observed small magnetite grains of several microns in the feldspar and quartz crystals. Synchrotron radiation submicron-beam X-ray fluorescence (XRF) analyses on thin sections were made at BL47XU of Spring-8 and high-resolution (200 nm) Fe maps were obtained for the crystals of the granitic rocks. We detected submicron Fe-rich grains, which are magnetite, in some alkali-feldspar and quartz crystals.

These rock-magnetic and microscopic results suggest that the MD and SD (PSD) magnetite are homogeneously distributed in feldspar and quartz, suggesting that those magnetite grains are primarily formed and included in the feldspar and quartz crystals during the initial formation. Solidification of feldspar and quartz generally complete above the Curie temperature (580 degree) of magnetite, therefore, those magnetite inclusions probably acquired thermoremanent magnetization (TRM). We conclude that the granitic rocks measured in this study can retain primary TRM and have applicability to paleomagnetic and paleointensity studies.