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Rock-magnetic properties of single zircon crystals sampled from the Tanzawa tonalitic pluton, central Japan

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Geomagnetic field paleointensity data provide critical information about the thermal evolution of the Earth, and the state of the geomagnetic field has been shown to be closely related to the surface environment. While it is pivotal to understand the variations in geomagnetic field intensity throughout the history of the Earth, data are still too scarce to resolve billion-year-scale geomagnetic field variation. This is primary because of the lack of geological samples for older eras, which often result in unsuccessful paleointensity experiments.

This study focuses on a paleointensity experiment using single zircon crystal. Zircon crystals play an important role in paleomagnetic studies because they have several mineralogical advantages: (1) they commonly occur in crustal rocks, (2) precise age determinations with U-Th-Pb and (U-Th)/He analyses are possible, and (3) they have highly resilient responses to alterations and metamorphism. Although rock-magnetic properties of single zircon crystal are essential for establishing the paleointensity method, few rock-magnetic studies have been conducted for single zircon crystals, which is largely because of their small size and weak magnetic moment.

To establish paleointensity method, we conducted systematic rock-magnetic measurements for single zircon crystals. Zircon crystals were sampled from fluvial sands of the Nakagawa River, which crosses the Tanzawa tonalitic plutons in central Japan. Young crystallization ages and the clear thermal history of the Tanzawa zircon crystals made them suitable for evaluating the feasibility of conducting paleointensity experiment using single zircon crystals.

Based on the results of rock-magnetic measurements for 1037 grains of zircon crystals, the zircon crystals can be classified into three groups. The first group contains little or no ferromagnetic minerals. The second group is characterized by low natural remanent magnetization (NRM)/isothermal remanent magnetization (IRM) ratios (0.004-0.02), pseudo-single-domain-like hysteresis parameters, and moderate low-temperature demagnetization (LTD) memory of IRM (20-90%). The third group is characterized by high NRM/IRM ratios (0.02-2), single-domain-like hysteresis parameters, and high LTD memory of IRM (60-140%). Results from low-temperature magnetometry analyses indicate that the main remanence carriers of the second group are nearly pure magnetite. Thermoremanent magnetization (TRM) acquisition experiments were also carried out for the second group zircon crystals. Consequently, the TRM intensity was comparable with that of NRM, and rough estimation of the paleointensity using bulk NRM/TRM ratios show field intensities consistent with the geomagnetic field intensity at the Tanzawa tonalitic pluton for last 5 Myr. A future study using the second group zircon crystals could provide reliable paleointensity data.

Keywords: Zircon, Tanzawa tonalite, Rock-magnetism, Paleointensity