

Rapid fall in archeointensity during the 9th century in Japan confirmed by lower clinkers of lava flows

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Recent accumulation of archeointensity data has led to find several sudden changes in geomagnetic field intensity in global or regional scales. In eastern Asia, a large decrease of archeointensity around 1000 CE is one of most prominent features in the archeointensity variation and seems concurrent with similar decreases over the northern hemisphere or even in the southern hemisphere. Archeointensity data in eastern Asia primarily come from archeological materials (e.g., pottery sherds, kiln floor) as being quite rich in China, Korea and Japan. In addition to archeological materials, volcanic rocks are also available for archeointensity studies in Japan. Exact dates and sometimes even times of volcanic eruptions are recorded in ancient documents. These historic lava flows without age errors are obviously advantageous over archeological materials whose age errors usually amount to several tens of years.

A rapid fall in archeointensity during the 9th century seems observable in the existing archeointensity data in Japan from both archeological materials and volcanic rocks. However, the previous experiments used for archeological materials did not include pTRM check nor anisotropy correction, and high archeointensity from volcanic rocks should be considered with extreme caution in light of current paleointensity experiments. In this study we collected lower clinker samples from lava flows erupted in the late 8th century at two different volcanoes Sakurajima and Kirishima in southern Japan. Our previous studies using recent or historical lava flows showed that lower clinker samples give rise to reliable paleointensity data with much higher success rates compared to upper clinker or interior samples.

Lower clinker samples were taken from borehole cores into Nagasakibana Lava Flow (764 CE) of Sakurajima Volcano and outcrops of Kirishimajingu Lava Flow (788 CE) in Kirishima Volcano. Lowermost portions of only less than one meter thick from two boreholes into Nagasakibana Lava Flow (>100 m thick) represent lower clinker in which nearly pure magnetite is contained contrary to titanomagnetite in the thick upper portions. Lower clinkers found at two outcrops of Kirishimajingu Lava Flow also contain nearly pure magnetite along with titanomagnetite. These samples indicated high coercivities more than 20 mT that are suggestive of fine-grained magnetite reflecting rapid cooling of lower clinkers. We conducted Thellier experiments using our custom-made automated spinner magnetometer and furnace system Tspin. Temperature step was designed for each sample by examining the thermomagnetic curve.

We have obtained archeointensities about 70 microT for the late 8th century from two borehole cores of Sakurajima and one outcrop of Kirishima. These high archeointensities are concordant with the high value of 65 microT from Nabeshima (Yu [2012]) with the exactly same age of Nagasakibana Lava Flow and numerous pottery sherds in Japan. On the other hand, low archeointensity values of about 45 microT were recently reported for the early 10th century using kiln floor samples (Kitahara et al. [2018]). These data suggest that a rapid fall in archeointensity exceeding 20 microT occurred during the 9th century in Japan.

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