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Geomagnetic changes in the active area of the 2000 eruption of Usu Volcano

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1. Magnetic change in the initial stage of the 2000 eruption of Usu

Marked change in geomagnetic total field (about 70 nT) was detected associated with the 2000 eruption of Usu Volcano, which resulted in the ground upheaval of about 80 m due to a shallow intrusion of magma beneath the western of Nishiyama, the NW piedmont of the volcano (Satoh et al., 2002). The observed magnetic change closely resembled the ground deformation. Hashimoto et al. (2007) investigated some mechanisms for this magnetic change and concluded that topography-related magnetic anomaly due to doming was a most plausible cause in place of the thermal demagnetization or the piezomagnetic effect. Their model, however, requires the reversed magnetization of the relevant area, that is still an open question, though it is indirectly deduced from aeromagnetic survey by Okuma et al. (2002).

2. Post-eruption change of the magnetic field

Meanwhile, the authors started the repeat magnetic measurements around the new mound in 2003, about three years after the main surface activity ended, anticipating the subsequent geomagnetic changes related to subsurface thermal activity. It has been revealed that markedly rapid magnetic changes up to 50 nT/yr is still going on. The change look quite linear with respect to the time, showing no plateauing even after seven years after the eruption calmed down. The magnetic total field has increased to the south, while it has decreased to the north of the new mound, suggesting the magnetization at a depth of some hundred meters. Such change is normally interpreted as cooling according to the thermal de/remagnetization mechanism. However, taking account of the reversed magnetization of this area, it might be an enigmatic process: the subsurface body is still heated.

3. Thermo-viscous magnetization, a possible mechanism

We here propose the viscous magnetization (VM) as another mechanism for this controversial magnetic change. Magnetic minerals generally acquire the VM along the external magnetic field in proportion to the logarithmic time (e.g. Dunlop, 1983). When a rock is re-heated due to an intrusion of magma, the relaxation time will be reduced to acquire more VM than at room temperature. For a reversely magnetized body, part of its initial remanent magnetization will be reversed to the present geomagnetic field, resulting in the larger change in the magnetization (or magnetic field nearby). We suspect this process as a possible re-magnetization mechanism under the relatively low temperature condition far below the Curie point. If this process is the case, the VM will be pinned as VRM in the subsequent cooling process of the intrusive body and the present ongoing magnetic change may never swing backward to the initial level in the future. Such VM/VRM model should be verified through laboratory experiments.