Periodic change of magnetic susceptibility observed in the dolerite

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In Shimane Peninsula, located in eastern Shimane Prefecture, sedimentary rocks of the Josoji formation in the Miocene are intruded by dolerite. In this study, we confirmed periodic change of magnetic susceptibility after continuous measurement of magnetic susceptibility using about 8 meters columnar sample from the dolerite which has the thickness of >50 meters. We report this phenomenon.

The columnar sample is part of a borehole core obtained in Kashima, Matsue City, Shimane Prefecture. The intrusion age of dolerite is ca.14 Ma, which produced silicification of tuffaceous shale in the Josoji formation. There is fine grain near the boundary of intrusion, and the grain size gradually increases toward the depth. It is confirmed that the dolerite shows the ophitic texture of plagioclase and clinopyroxene and has opaque minerals in matrix. Part of clinopyroxene has altered to chlorite. The opaque minerals turned out to be magnetite and ilmenite as a result of EPMA.

The magnetic susceptibility of dolerite is on the order of 10^{-3}~10^{-2}SI, and it is nearly one-hundredth of that within one meter of the boundary of intrusion at a depth of 79.33 meters. This measurement value is considered common since it is known that the magnetic susceptibility of basalt rock is most often on the order of 10^{-2}SI and occasionally on the order of 10^{-4}~10^{-1}SI [*Society of Exploration Geophysicists of Japan*, 2012]. The existence of magnetite and ilmenite in the dolerite has been confirmed. Since the susceptibility of magnetite is on the order of 10^{-0}SI [*Society of Exploration Geophysicists of Japan*, 2012], it is possible that these magnetic minerals may affect the susceptibility.

The value of the magnetic susceptibility changes periodically in the range of 7 to 13×10^{-3}SI. At 1 meter from the intrusion boundary at a depth of 81 meters, the period is less than 1 meter, whereas at 6 meters from the intrusion boundary at a depth of 85 meters, the period is about 2 meters. It is confirmed that the period tends to increase with distance from intrusion boundary.

Such a periodic structure is also found near the intrusion boundary of the dolerite exposed at the coastal outcrop about 1.5 km west of the borehole point. It is thought that this dolerite intruded in the same age that the dolerite intruded, whose magnetic susceptibility was measured, and in this place a periodic layered structure having relief parallel to the intrusion boundary is recognized. Atsumi dolerite distributed in Tsuruoka city, Yamagata Prefecture is known as an example of a periodic layered structure having relief of dolerite. This is a layered structure of several tens of centimeters parallel to the intrusion boundary at the coastal outcrop. The structure is formed because the more vesicles there are, the more easily it is eroded by the waves, and the width of the layer increases regularly from the intrusion boundary to the inside [*Toramaru et al.*, 1996]. This structure is explainable on the basis of the idea that, due to the balance between the rate of heat transfer in magma and the diffusion rate of magmatic volatiles in melt, the growth of vesicles such as the Liesegang rings proceeded heterogeneously and with a spatial and temporal periodicity (double diffusion model) [*Takahashi and Ishiwatari*, 2012]. It is thought that these dolerites around the survey site built a periodic structure during magma cooling since a layer structure similar to Atsumi dolerite is found near the intrusion boundary of the dolerite at the coastal outcrop.

Based on the periodic change in magnetic susceptibility that we found in this study, it is possible that periodic growth occurred when magnetic minerals such as magnetite crystallized and grew as matrix during magma cooling, similar to the gas component which caused the layered structure of Atsumi dolerite.

Keywords: dolerite, magnetic susceptibility, periodic change