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Magnetic behaviors of sediment samples including maghemitized magnetite during progressive thermal demagnetization experiments of artificial remanences

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Low-temperature oxidized magnetite (maghemitized magnetite: Magh-Mt) has been recognized as a common magnetic mineral in sediments and soils. It is important to identify the presence of Magh-Mt and to clarify its magnetic property for environmental-magnetic and paleomagnetic investigations on sediments and soils. We present results of thermal experiments performed on Magh-Mt bearing sediments, especially progressive thermal demagnetization (PTHD) experiments of artificial remanences. Analyzed samples were taken from a sediment core (BIW07-5) of 14m long obtained by piston coring in Lake Biwa, central Japan. The core consisted of homogeneous lacustrine clay with 6 tephra layers, of which published age data indicate that the core covers the last 45 kyrs in age.

Low-temperature magnetometric results showed the presence of Magh-Mt in the clay samples. Warning curves from 5 to 300K of isothermal remanence (IRM) imparted at 5K in 1T after zero-field cooling showed a large decrease of IRM between 5 and 40K and suppressed Verway transition of magnetite between 90 and 120K. As S-ratios (maximum field of 2.5T and back filed of 0.3T) of the samples were higher than 0.965, Magh-Mt was regarded as a principal magnetic mineral.

PTHD experiments of artificial remanences in air and Ar were carried out for clarifying magnetic mineralogy. Freeze-dried samples were packed in small quartz cups. IRM was imparted along the cup axis in a DC field of 1.9T, and then anhysteretic remanence (ARM) was imparted perpendicular to the axis by a peak alternating-field of 100mT and a DC field of 0.1mT. PTHD up to 680 or 700°C were performed using a noninductively wound electric furnace in a six-layer mu-metal magnetic shield; the internal stray field was less than 5 nT. The initial magnetic susceptibility (Xo) was measured using a KLY-3S susceptibility meter at each demagnetization step.

During the PTHD in air, decay curves of ARM and IRM components showed inflections at about 280 and 360°C, respectively. The ARM components unblocked at 620°C. The IRM components unblocked at 680°C after small or no decrease at 620°C. Xo decreased gradually up to 680-700°C. During the PTHD in Ar, the ARM components increased at 280°C, accompanied with increase of Xo, and unblocked at 560°C. The IRM components decreased at 560°C and unblocked at 640-680°C. Xo increased from 280°C to 680-700°C. The ARM component is carried initially by Magh-Mt, while carriers of the IRM component are likely carried by Magh-Mt with higher coercivity and primary hematite. It is suggested that the conversion of Magh-Mt occur from 280°C and that magnetite converted during heating in Ar may acquire remanence newly or inherit remanence from parent Magh-Mt.

Additionally, PTHD experiments above 500°C in Ar were performed after demagnetizations in air at lower temperatures (200, 300, 400 and 480°C). Decay curves of ARM and IRM components above 500°C from samples demagnetized at 200°C in air were quite similar to the curves during the PTHD in Ar at all steps, indicating the complete conversion of Magh-Mt to magnetite. Samples demagnetized at 300-480°C in air provided the presence of remanence unblocking between 540 and 620°C during the PTHD in Ar. The amount of the unblocking remanence increased with increasing the demagnetization temperature in air. It is implied that a converted product from Magh-Mt during heating in air is stable for heating and carries the remanence unblocking up to 620°C.

A PTHD experiment of artificial remanences is a simple and useful method for identifying magnetic minerals. However, in the case of Magh-Mt bearing samples, it is inferred that decay curves of artificial remanences do not represent initial magnetic mineralogy because a converted product carries remanence during heating.