The Morasko iron meteorite: magnetic mineralogy and stability of magnetic domains in cohenite.

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Introduction: Understanding of exotic magnetic phases like cohenite may provide a unique tool to approach magnetic field records of early solar magnetic fields (e.g. [1]). The Morasko iron meteorite, first found in 1914 near Poznan in Poland, is interpreted as a product of partial melting and impact events and it is classified as non-magmatic IIICD, a subgroup of the IAB group (e.g. [2]). Neumann lines, resulting from mechanical twinning at shock pressures >8 GPa are ubiquitous (e.g. [2]) and indicate a moderate shock metamorphic overprint. Compared to all known meteorite magnetic minerals, cohenite ($Fe_{2.95}Ni_{0.05}C$) exhibits very specific magnetic properties with a Curie temperature (T_C) at 215 °C, which is nearly identical to the one reported for cementite (synthetic form of natural cohenite, T_C at about 210 °). Sugiura and Strangway [3] discovered that cohenite carries the more stable component of natural remanent magnetization of the Abee meteorite and, therefore may be a good recorder of magnetic fields in the early solar system. Cohenite is also the main magnetic remanence carrier of lunar Apollo Mare basalt 14053 [4], suggesting that it may be an interesting mineral for lunar paleomagnetism. The aim of our study was to learn more about the origin of the magnetic stability in cohenite and we specifically investigated the magnetic domain configuration after field and thermal treatment.

Results: The investigated piece of Morasko iron meteorite consists of a Fe-Ni alloy matrix (about 98 vol%) and troilite (FeS) nodules occupying about 2 vol%. The matrix is mainly composed of kamacite (α-Fe) with and less than 6% of Ni, and taenite (γ-Fe) with more than 20% Ni. Accessory minerals, mostly occurring in the margins of the troilite nodules, are schreibersite ($[Fe,Ni]_3P$), cohenite ($[Fe,Ni,Co]_3C$), sphalerite (ZnS), graphite (C), daubreelite ($FeCr_2S_4$) and silicate minerals [2]. Magnetic properties, texture and microstructure of cohenite grains have been investigated using different magnetic imaging methods like the Bitter pattern technique, magneto-optical imaging and magnetic force microscopy [1]. Cohenite shows a high stability and reversibility of global stripe-like magnetic domain structures when applying high magnetic fields up to 1.5 T, and exposing it to high temperatures above the Curie temperature. Heating up to 700 °C under atmosphere conditions has shown that cohenite remains metastable and that the global magnetic domain structures mainly recover to its preheating state. This observation suggests that magnetic domains are strongly controlled by the crystal anisotropy of the orthorhombic cohenite, and substantiate the theory that cohenite can be a good recorder of magnetic fields in planetary core material.

References:

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