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Effect of annealing on intrinsic magnetic properties in experimentally shocked magnetite

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Magnetite is an important magnetic carrier on planetary bodies and one of the most significant magnetic minerals in shocked crustal rocks on Earth. This study focuses on the intrinsic magnetic properties and chemical stability of magnetite, shocked experimentally between 5 and 30 GPa and subsequently heated in argon atmosphere up to 700°C. From pre-shocked, shocked and afterwards annealed samples temperature-dependent magnetic susceptibility and saturation isothermal magnetization as well as the Curie and Verwey transition temperature were measured. Shocked magnetite used for the heating experiments is characterized by decreasing magnetic susceptibility, increasing SIRM, a multidomain to pseudo single domain transition, and a decrease in apparent crystallite size seen in X-ray diffraction pattern with increasing shock pressure (Reznik et al., 2016). All these features are in agreement with magnetic domain size reduction caused either by grain fragmentation or a pinning of domain walls at crystal defects and dislocations. However, an increasing width and temperature of the Verwey transition, along with a very small expansion in the lattice cell parameter indicates also distortion of the tetrahedral and octahedral crystal sites. Annealing of the shocked samples strongly modifies the intrinsic magnetic properties and suggests a significant amount of non-permanent magnetic changes in impacted rocks. Therefore, special attention was given to the identification of the iron oxidation state and its coordination geometry in shocked and annealed magnetite using synchrotron-assisted X-ray absorption spectroscopy. In addition to defect healing, the ordering of ferric and ferrous iron on tetrahedral and octahedral sites seems to play a crucial role in the interpretation of the intrinsic magnetic properties modifications in shocked and annealed magnetite.

Reznik, B., Kontny, A., Fritz, J., Gerhards, U., 2016, Shock-induced deformation phenomena in magnetite and their consequences on magnetic properties. Geochem. Geophys. Geosyst., 17, doi:10.1002/2016GC006338.