SHOCK DEMAGNETIZATION OF SINGLE DOMAIN MAGNETITE. K. L. Louzada[1,2], S. T. Stewart[2], and B. P. Weiss[3], [1]Netherlands Office for Science and Technology, Royal Netherlands Embassy, 4200 Linnean Ave N.W., Washington, D.C. 20008, [2]Department of Earth and Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138 (louzada@post.harvard.edu, sstewart@eps.harvard.edu), [3]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, 54-724, 77 Massachusetts Avenue, Cambridge, MA 02139 (bpweiss@mit.edu).

Introduction: Renewed interest in the shock demagnetization of crustal materials has been fueled by satellite observations of the demagnetization of the impact basins on the Moon and Mars [e.g., 1, 2]. Magnetite's presence as a magnetic phase in, e.g., Martian meteorites [3, 4] indicates that it is an important potential magnetic carrier on planetary bodies. In particular, single-domain (SD) magnetite, with its high spontaneous magnetization and saturation potential, is an important contender for planetary crustal magnetization. Hence, understanding changes in the magnetic remanence and properties of magnetite due to shock pressures of varying amplitude is important.

In this study, we shocked *Cryptochiton Stelleri* teeth, which are covered in a thin layer of SD magnetite [5]. The advantage of using individual chiton teeth is that the SD magnetite is pure, fixed onto a nonmagnetic substrate (therefore not in a powder form), and measureable by a 2G Enterprises superconducting rock magnetometer.

Methods: Shock recovery experiments on the chiton teeth were performed on the 40-mm gas gun in the Shock Compression Laboratory at Harvard University and magnetic analyses were performed at the Paleomagnetics Laboratories at MIT and Yale. Experimental details of similar demagnetization experiments on pyrrhotite are discussed elsewhere [6].

Two chiton teeth were shocked to 10 GPa and one tooth was shocked to 27 GPa. All teeth were pressed into thin layers of Al 1100 (a close impedance match to magnetite) and polished prior to insertion into Al 2024 (10 GPa experiment) or nonmagnetic Nitronic50® (steel, for the 27 GPa experiment) capsules. Shock pressure in the teeth was determined using the well known shock equations of state of aluminum and steel and the measured impact velocities of the flyers [6].

A number of characterization experiments were performed on the chiton teeth to determine (1) bulk tooth density, (2) low-temperature magnetic transitions, (3) magnetic hysteresis parameters, and (4) rock magnetic properties.

Magnetic methods and data presentation. Here we present the data in the form of changes in the coercivity spectra [after 6]. Coercivity (or the 'hardness' of the magnetization) spectra are easily obtained from alternating field demagnetization curves, routinely measured on rock magnetometers. Changes in the distribution of low and high coercivity magnetic components have been shown to be a sensitive indicator of shock in magnetic minerals [6]. Single domain grains tend to have higher coercivities.

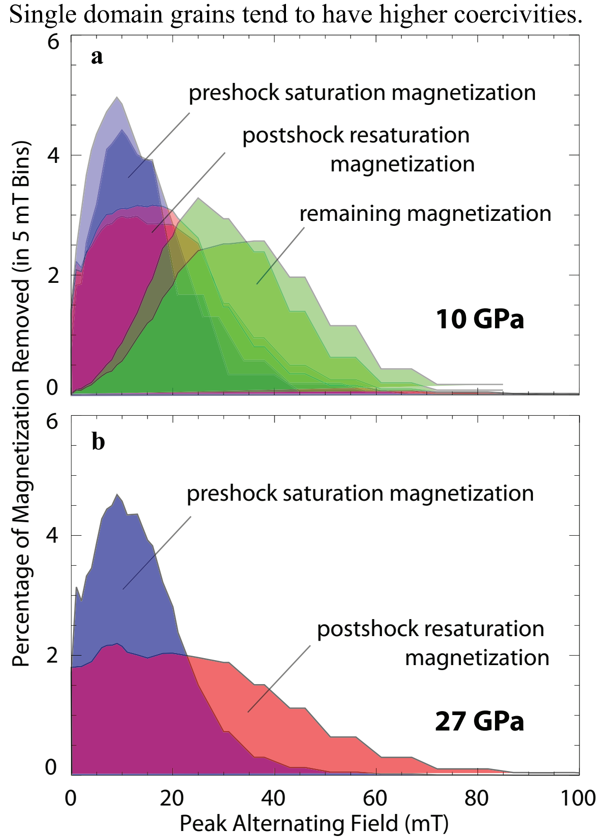

Figure 1. Coercivity spectra (slopes of alternating field demagnetization data) of *Cryptochiton Stelleri* teeth shocked to (a) 10 GPa (2 samples) and (b) 27 GPa. After shock, the Nitronic50® capsule is no longer 'nonmagnetic'; its saturation remanence increases 600 fold (not shown). The coercivity spectrum of the postshock resaturation magnetization in b was determined after removal of the tooth from the capsule.

Results: The first order result of shock is the decrease in absolute magnetization of the samples. Before shock the chiton teeth were saturated in a 110 mT field; after shock the remanence decreased by 87 and 88% in the two samples shocked to 10 GPa and by a minimum of 94% in the sample shocked to 27 GPa.

The coercivity spectra of the preshock saturation magnetization of the chiton teeth (blue in Figures 1a,b) indicate that before shock the bulk of the magnetization was concentrated in fractions sensitive to 0 to 20 mT fields. After shock, the bulk of the magnetization remaining is removed by peak fields between 20 and 60 mT (green curve), consistent with preferential removal of low coercivity remanence [7].

Resaturation after shock led to an increase of 20% to 26% at 10 GPa in the saturation remanence with respect to preshock saturation intensities. Coercivity spectra (red in Figure 1) for the postshock saturation remanences are also of a different shape than their preshock equivalents (blue).

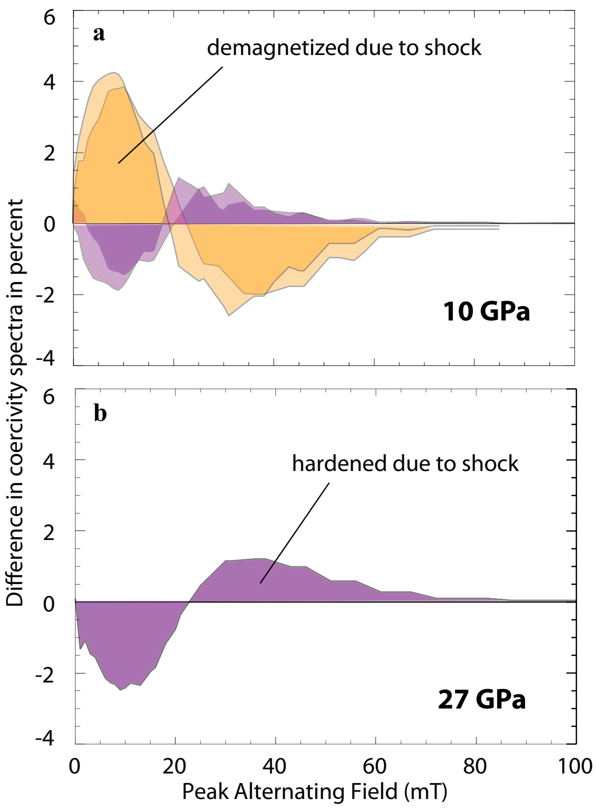

Figure 2. Differences in coercivity spectra shown in Figure 1. The orange curve shows the preshock coercivity spectrum (blue in Figure 1) minus the remaining magnetization (green in Figure 1) coercivity spectrum. The purple curve shows the postshock resaturation coercivity spectrum (red in Figure 1) minus the preshock coercivity magnetization (blue in Figure 1).

Differences between the coercivity spectra provide insight into the coercivity ranges affected most by shock. Figure 2a shows that the bulk of the magnetization removed by shock in the 10 GPa samples is indeed removed in the 0 to 20 mT range (where the orange curve is greater than zero). The broadening and leveling of the saturation remanence coercivity spectra is evident by magnetic fractions between 20 and 60 mT carrying a greater fraction of the remanence (where the purple curve is greater than zero in Figures 2a,b). The changes in magnetic properties (in particular the increase in saturation remanence) are likely due to a decrease in the magnetic interactions in the single domain magnetite.

Discussion: We show that shocked chiton teeth can be recovered intact and that planar shock demagnetization recovery experiments can be performed at these pressures using aluminum capsule materials and Nitronic50®.

Preferential demagnetization of the lower coercivity components and shock (or stress) hardening is consistent with other recent work on pressure demagnetization of magnetite and other magnetic minerals [6]. Observations of demagnetized lunar and Martian impact basins combined with estimates of the spatial distribution of shock pressures indicate that the transition to completely demagnetized crust occurs around 1 GPa [8], well below the pressures achieved in these experiments.

Unlike explosion experiments on synthetic magnetite [9] or magnetite-bearing diabase samples [10], the planar shock recovery experiments presented here did not induce significant heating. Therefore, changes in the magnetic remanence and properties are indicative of pressure effects alone. Other shock experiments on magnetite bearing rocks were conducted on inefficiently magnetized microdiorites [11] or at hydrostatic pressures [12]. More shock data at pressures of a few GPa are needed to determine the shock demagnetization characteristics of magnetite.

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