ROCK MAGNETIC CHARCTERIZATION OF TARGET BASALTS AT LONAR CRATER, INDIA.

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Introduction: A ~50 ka old Lonar impact crater in India (19°58'N, 76°31'E), is the well known terrestrial impact crater that is completely excavated in the basaltic target rocks of Deccan traps (~65 Ma) [1, 2]. Its unique features can be compared to those impact structures formed on planetary surfaces having basaltic crusts. This, near-circular impact crater has a diameter of ~1.8 km with an average rim height of ~30 m above the adjacent plains, whereas the crater floor lies ~90 m below the pre-impact surface [3]. It is understood that the impactor of this crater was a chondrite [4] that hit the pre-impact surface from the east at an angle of 30-45° with horizon [5] and it is seen that anisotropy of magnetic susceptibility (AMS) of the unshocked (UNS) and shocked (SH) target basalts show systematic variation with reference to the direction of impact [5, 6]. In the present work, we report further the magnetic properties of SH and UNS target basalts occurring around the Lonar crater as a method of characterizing samples.

Experimental Procedures: Samples cut from drill cores underwent stepwise alternating field (AF) demagnetization up to 100 mT with an average of 14 demagnetization steps using an ASC D-2000 AF demagnetizer; magnetic remanence after each demagnetization step was measured by an AGICO JR-6 spinner magnetometer. Rock chips recovered from drill cores were utilized for the measurement of temperature dependence (-200 to 700°C) of magnetic susceptibility using an AGICO KLY-4S Kappabridge attached with CS-3/CS-L furnace in an argon atmosphere. Room temperature hysteresis loops were measured using a Molspin NUVO vibrating sample magnetometer in an alternating field cycling between ±1 T.

Alternating Field Demagnetization of NRM: Demagnetization curves of some SH basalts are relatively flat compared to USH basalts, indicating that low coercivity fractions of these samples have been preferentially removed (demagnetized) due to impact **(Fig. 1)**. The median destructive field (MDF) can be used to obtain estimation on coercivity spectra**.** For USH Lonar basalts, collected from ~2 km east of the crater rim, the MDF value ranges between 54 and 58 mT. The SH basalts from the E, NW, and SW crater rim are characterized by the highest MDF between 78 and 90 mT. But the crater rim samples from N, W and SE show relatively low MDF of 39 to 63 mT, whereas the southern rim samples show the lowest MDF between 10 to 15 mT. In the demagnetization data, the UNS basalts possess a single component of magnetization, which is interpreted as the original TRM. Apart from the original TRM, some SH basalts possess a more stable secondary component isolated below 10 mT, which is interpreted as a shock remanent magnetization (SRM) acquired in the ambient field direction present during the impact. The directions of the SRM are not closely related to the ambient field at the time of impact but lie within the plane defined by the pre-shock NRM and the ambient field.

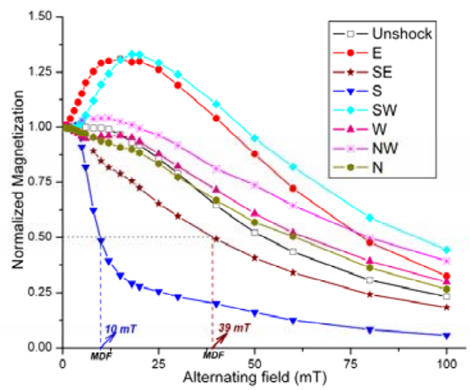

Fig. 1 AF demagnetization spectra of NRM of unshocked and shocked basalts.

Hysteresis Parameters: Hysteresis loop parameters reveal the domain state of the magnetic minerals. A typical hysteresis curve for all samples show complete saturation by 0.3 to 0.5 T, indicating the presence of soft carriers (magnetite or titanomagnetite).

The squareness of hysteresis (ratio of saturation remanence to saturation magnetization, Mrs/Ms) for SH basalts (0.16-0.25) are, in general, relatively high compared to UNS basalts (0.12-0.15). The coercivity ratio (ratio of coercivity of remanence to coercive force, Hcr/Hc) for the SH basalts vary from 1.05 to 2.23 compared to UNS basalts (1.28 -1.44) **(Fig. 2)**. The squareness verses coercivity ratios were plotted on the reappraisal of the Day plot [7] after Dunlop [8]. Most of the samples fall close to the boundary between multi-domain (MD) and single domain (SD) mixtures in the area of PSD, consistent with SD to PSD dominance **(Fig. 3)**.

Temperature Dependence of Susceptibility: Experiments performed on UNS basalts from the east display an increase in χ from room temperature to

~300°C with a gentle decrease until ~510°C, followed by a sharp drop at ~585°C indicating the presence of low-coercivity phases such as Ti-rich to Ti-poor titanomagnetites**,** which is also evident from low temperature susceptibility curves as the transition temperatures are <-173 °C. This is a characteristic behavior of SD and PSD titanomagnetite grains [9]. In the case of SH basalts from the crater rim, the warming χ (T) curves display an increase in susceptibility from 40^0C to ~300-325^0C with a noticeable hump, followed by a sharp decrease of susceptibility up to ~400-425^0C. The susceptibility then again display a rapid increase in slope with a broader peak at about ~475-495^0C, then drops sharply at ~585^0C similar to UNS basalts. The sharp gradient between 250^0C and 300^0C in SH basalts may be interpreted as resulting from an irreversible change in the domain structure of ferrimagnetic grains due to impact shock. A drop between 300 and 325^0C indicates the presence of Ti-rich titanomagnetite or pyrrhotite [10], which is not seen in the UNS basalts **(Fig. 4)**.

Conclusions: The SH and UNS basalt samples from Lonar crater are very difficult to distinguish only by petrography except the presence of some fractures in plagioclase phenocrysts in the former [11, 12]. Our preliminary observations on rock magnetic properties show that the UNS and SH basalts from Lonar crater differ significantly in: (a) bulk-coercivity (b) squareness of hysteresis, coercivity ratio and (c) low and high temperature susceptibility measurements. The observed changes in rock magnetic properties of shocked basalts are related to either sub-microscopic changes in the domain state of the titanomagnetite grains (movement from PSD towards SD state), or modifications in the crystalline structure of titanomagnetite grains (namely microfractures, lattice defects or dislocations) due to impact shock [13, 14]. Further studies are in progress.

References: [1] Nayak, V. K. (1972) EPSL, 14, 1-6. [2] Fredriksson, K et al. (1973) Science, 180, 862-864. [3] Fudali et al. (1980) The Moon and the Planets, 23, 493-515. [4] Misra et al. (2009) MAPS, 44, 1001-1018. [5] Misra et al. (2009) GSA Bulletin, in press. [6] Arif et al. (2009) 72nd Annual Meteoritical Society Meetings (abstract #5397). [7] Day et al. (1977) PEPI, 13, 260-266. [8] Dunlop (2002) JGR, 107. [9] Dunlop et al. (1974) EPSL, 21, 288-294. [10] Soffel, H. C. and Appel, E. (1982), PEPI, 30, 348-355. [11] Kieffer et al. (1976) Proceedings of 7th LPSC, 1391-1412. [12] Osae et al. (2005) MAPS, 40, 1473-1492. [13] Langenhorst et al. (1999) LPSC, XXX, abstract #1241. [14] Gattacceca, J. (2007) PEPI, 162, 85-98.

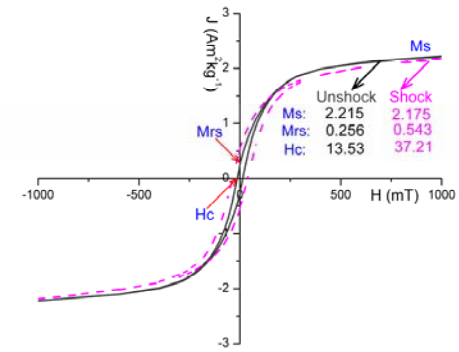

Fig. 2 Hysteresis loop of an unshocked (solid line) and shocked (dashed line) basalt.

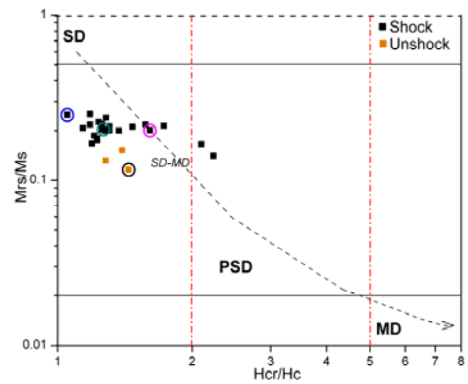

Fig. 3 Hysteresis ratios plotted on the Day plot (after Dunlop, 2002) for the unshocked and shocked basalts. Samples with different colored circles denotes the data for the respective measured temperature-dependence of susceptibility curves.

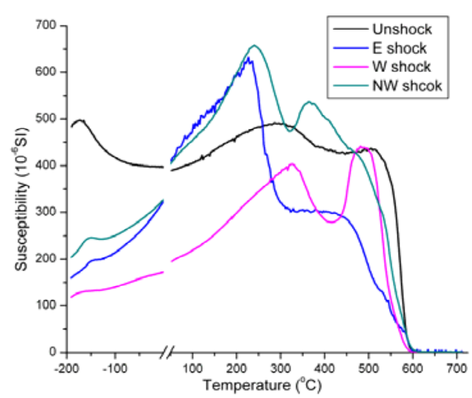

Fig. 4 Variation of temperature dependence of susceptibility for unshocked and shocked basalts.