VARIATION OF PRIMARY MAGNETIZATION OF BASALTIC TARGET ROCKS DUE TO ASTEROID IMPACT: EXAMPLE FROM LONAR CRATER, INDIA.

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Introduction: Lonar lake, India [1, 2] is one of the few known terrestrial asteroid impact craters that is fully excavated in Deccan Trap basalts (~65 Ma) [3], and thus comparable to those craters formed on rocky planetary bodies in our Solar System having basaltic crusts [4]. This simple, bowl-shaped, 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 [5]. The age of the crater is controversial and could be ~52±6 [6] or 656±81 ka [7]. This crater was formed by an oblique impact of a chondrite that hit the pre-impact target at an angle bewteen 30-45° from the east [8, 9]. Our preliminary observations showed that the unshocked and shocked basalts from Lonar significantly differ in their bulk-coercivity, squareness of hysteresis, coercivity ratio, and low and high temperature susceptibility measurements [10]. It is also understood that anisotropy of magnetic susceptibility (AMS) of unshocked and shocked target basalts show systematic variations with reference to the direction of impact [9, 11]. In the present work, we report variations in primary magnetization component between the unshocked and shocked target rocks of Lonar crater and their relation to the direction of impact.

Sampling and experimental procedures: In the Lonar area six basalt flows of ~8-40 m thickness have been reported, the four bottom flows of which are only exposed along the crater wall [12]. We have collected oriented drill core samples of apparently unshocked and shocked basalts from the top of fourth basalt flow; the unshocked samples were collected from the base of Durga Tegri at ~2 km ESE of Lonar crater rim and the shocked basalt samples were collected from around the crater rim [9].

The cylindrical samples of 2.54 cm diameter and 2 cm height obtained from drill cores were used for palaeomagnetic measurements. The NRM was measured by a Molspin spinner magnetometer. Alternating field demagnetization (AFD) was performed 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. The primary and secondary magnetization components were derived from these data by principal component analysis [13], guided by visual inspection of orthogonal demagnetization plots [14].

Primary magnetization: Our measurements on the unshocked target basalt from the base of Durga Tegri (n=12) show that the site-mean high-temperature (HT) component (Fig. 1a) has a declination (D_m)= 194.1°, inclination (I_m)= +65.9°, α_{95}= 3.8°. This direction is, however, different from the data reported earlier (chron C29R; at Lonar D= 157.6°, I= +47.4°) [15, 16].

The HT component of most of the shocked basalts (n=52) from around the Lonar crater rim are mostly oriented toward the ESE to SSE (Fig. 1b) and have a site-mean D_m= 117.9°, I_m= +39.6°, α_{95}= 4.6°, which are similar to the published data of fourth basalt flow exposed on the Lonar crater wall (D_m= 126.4°, I_m= +44.7°, α_{95}= 4.1°) [17]. The HT direction for shocked basalts from sourthern and southwestern crater rim, however, are different. The shocked basalts (n=9) from southern crater rim have contrasting NE orientation of HT component and have a site-mean of D_m= 51°, I_m= +15.6°, α_{95}= 16.1°. Those from the SW crater rim (n=10) have the same orientation (SE) of site-mean HT component but all inclinations are negative (D_m= 117.3°, I_m= -27.4°, α_{95}= 7.1).

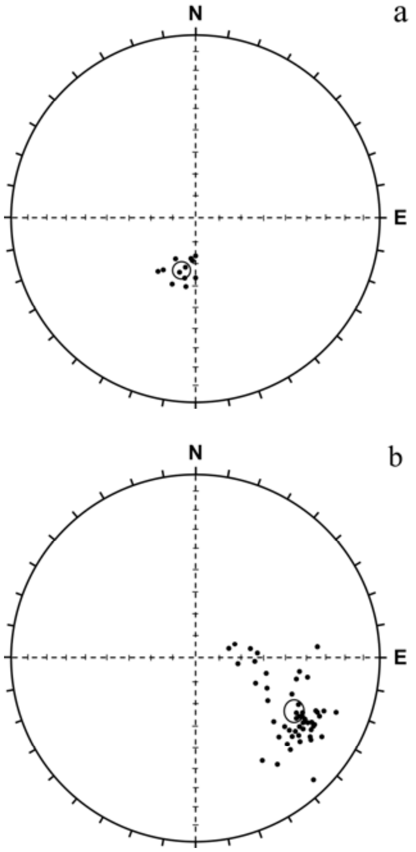

Fig. 1. Equal area projections of HT component and their associated α_{95} confidence ellipses of (a) unshocked Deccan Trap basalts from the base of Durga Tegri hillock at ~2 km ESE of Lonar crater; (b)

shocked target basalts from the E-, SE-, W-, NW- and N-sectors of crater rim. The impactor of Lonar crater hit the pre-impact target obliquely from the east. Note the rotation of HT component towards the uprange direction of impact.

Secondary magnetization: The low-coercivity/ low-temperature (LC/LT) component of both the unshocked and shocked basalts (n=83) show wide scattered in orientations, although most of them are directed toward N (Fig. 2). We also observe both positive and negative inclinations in LC/LT component of Lonar samples. The site-mean LC/LT magnetization component is D_m= 354.9°, I_m= 44.6°, α_{95}= 10.2°, which is roughly parallel to the present-day local geomagnetic field direction (PLF) and follows the observation of [17] (i.e., D_m= 7.4°, I_m= +30.7°, α_{95}= 5.5°).

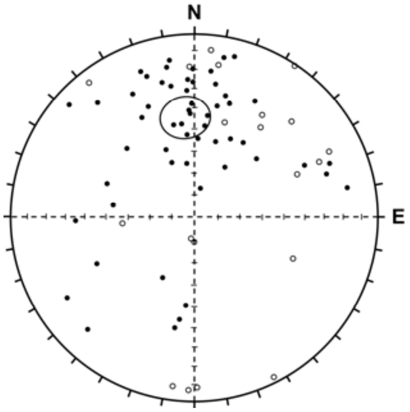

Fig. 2. Stereoplots and associated α_{95} of LC/LT component of both unshocked and shocked basalts from Lonar crater. Closed (open) symbols indicate projections onto the lower (upper) hemisphere, respectively. Note wide variations of data.

Discussion: Our present observation shows that the orientation of HT component of the unshocked Lonar flow from the base of Durga Tegri is towards SSW (Fig. 1a), which is quite different from the average Deccan Trap lavas at Lonar [15, 16]. This magnetization must have acquired by the Deccan Traps during their initial emplacement and cooling of the basaltic lava flows at Lonar.

Our studies on the shocked basalts from Lonar crater rim (Fig. 1b), and additional observations on shocked basalts from the crater wall [17] suggest that the target basalts must have lost all of its primary magnetization of cooling due to impact and acquired a new primary magnetization, which is directed uprange and mostly oriented towards SE although a minor NE component is present. The inclination of this shock induced magnetization is also gentle compared to the unshocked target at the base of Durga Tegri.

The exact reason of wide variation of the secondary magnetization (LC/LT) component of both unshocked and shocked at Lonar (Fig. 2) is not clearly understood. However, it is certain that both types of basalts have undergone similar history of magnetization after the impact. This magnetization could be the viscous (and/or chemical) remanent magnetization, which the Lonar basalt acquired during last 52 or 656 ka [17].

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