EPSC Abstracts
Vol. 7 EPSC2012-163 2012
European Planetary Science Congress 2012

Rock- and palaeomagnetic properties of randomly oriented basaltic blocks from Lonar crater ejecta, India

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Abstract

The preliminary investigation of rock and palaeomagnetic properties of the basaltic blocks deposited within the continuous ejecta around the Lonar crater during impact shows that these ejecta basalts, in general, have low NRM/χ compared with the average unshocked basalt from the ESE of Lonar crater. These ejecta basalts also have low REM with few exceptions. The HC component of these ejecta basalts are random but showing a broad concentration around the average HC component of shocked basalts from around the crater rim suggesting influence of shock induced magnetic field beyond the modification stage of formation of the Lonar crater.

1. Introduction

The ~570±47 ka old Lonar crater (19°58'N, 76°31'E), India [1], is a simple, near-circular, asteroid impact crater with a diameter of ~1.8 km and a depth of ~150 m [2]. It is completely excavated on the basaltic target-rocks of Deccan traps (~65 Ma) and hence comparable to those formed on the rocky planets or planetesimal bodies of our inner-solar system having basaltic crusts. The Lonar crater is suggested to have formed by an oblique impact of possibly a chondritic impactor that stuck the pre-impact target from the east at an angle between 30 and 45^{o} to the horizon [2]. Our ongoing studies suggest that some of the rock magnetic properties of the shocked target of the Lonar crater, e.g. low-field AMS, NRM/χ, and HC-HT component, are almost symmetrically disposed with reference to the E-W plane of impact and impact direction [3, 4]. In our present study, we report the rock- and palaeomagnetic properties of selected randomly deposited basaltic blocks within the continuous ejecta blanket (we called these blocks as ejecta basalts) around the Lonar crater that were formed due to the impact.

2. Sampling & experimental details

The samples of shocked ejecta basalts were collected from N and NE (n= 3 sites), and S and SE directions (n= 2) of the crater at ~1 to 1.5 km distance from the crater centre. For palaeomagnetic directional analysis, samples were subjected to alternating field (up to 100 mT in ~15 discrete steps) demagnetization analyses. The LC and HC magnetization components were derived from these data by principal component analysis coupled with orthogonal demagnetization plots [5]. The magnetic mineralogy of basalts was investigated by measuring isothermal remnant magnetization (IRM) acquisition and their back field curves, susceptibility versus temperature curves, and hysteresis loops.

3. Results

The IRM acquisition curves of the shocked ejecta basalts saturated at low field of <300 mT (Fig. 1) indicating low coercivity magnetic mineral as the main remanence carrier. Their IRM backfield curves (Fig. 1, inset) indicated a broad range of H_{cr} from 10 to 60 mT. The Curie temperatures of measured samples varied between 205 and 580°C suggesting that the mineralogy of these ejecta basalts were Ti-rich to Ti-poor titanomagnetite and their oxidized phases. In the Day plot on hysteresis [6], samples were plotted within the pseudo-single domain (PSD) field and trending linearly toward the single-domain (SD) field suggesting mixtures of SD and multi-domain (MD) grains.

Most of the shocked ejecta basalt sample (n= 23) had NRM/χ <400 Am^{-1} with an average of ~132 Am^{-1}. These samples also had low REM (<1%) with an average of ~0.38%. Only four (4) samples had NRM/χ between ~650 and 990 Am^{-1} with high REM between 1.5 and 7%.

The majority of the shocked basaltic blocks in ejecta showed either two or three NRM components or a stable single magnetization component (Fig. 2). Some of the samples (n= 4) from the randomly oriented basaltic blocks showed increase in NRM after AF demagnetization to 7.5 mT, which could be the shock-related remanence (SRM). Although highly scattered, the average LC component of the shocked ejecta blocks was statistically identical to the present day field (PDF) direction (D= 342.5°, I= 39.8°, α_{95}= 38.7°), whereas their HC component, which includes both positive and negative inclinations, appears to be random (Fig. 3).

4. Conclusions

The unshocked target basalts from ~3 km ESE of the Lonar crater centre have an average NRM/χ of ~116 Am^{-1}. Our present observation shows that the majority of samples (60%) from the ejecta basalt population have NRM/χ lower than that of the average unshocked basalts. Except few exceptions, these ejecta basalts, in general, also have low REM (<1%). So it can be concluded that the ejecta basalts, in general, are poorly magnetized due to impact although exception exists. The HC component of these ejecta basalts is although random and different from that of the unshocked target (D=196.1°, I=+68.9°, α_{95}=13.4°), these data show a broad concentration around the average HC components of the shocked target from around the crater rim (D=120.5°, I=+34.2°, α_{95}=10.3°). This observation suggests that the impact shock induced magnetic field could have existed beyond the modification stage of formation of Lonar crater [7] when the newly formed ejecta with the randomly deposited basaltic blocks had weekly remagnetised. Further studies are in progress.

5. References

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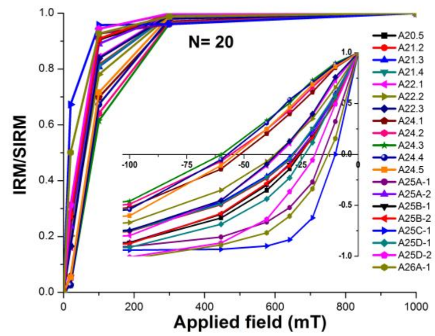

Fig. 1 Normalized IRM acquisition curves for the Lonar ejecta basalts and their respective back-field IRM curves (in inset).

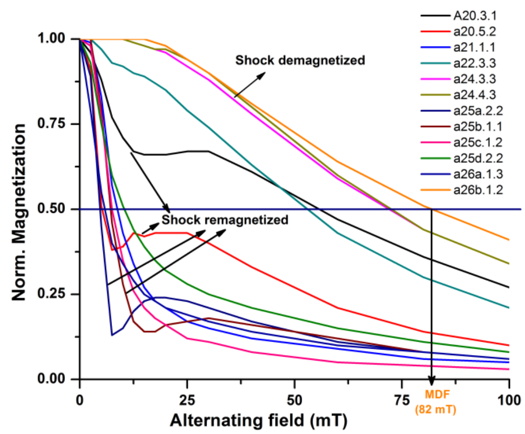

Fig. 2 AF demagnetization spectra of NRM of shocked ejecta basalts, Lonar crater.

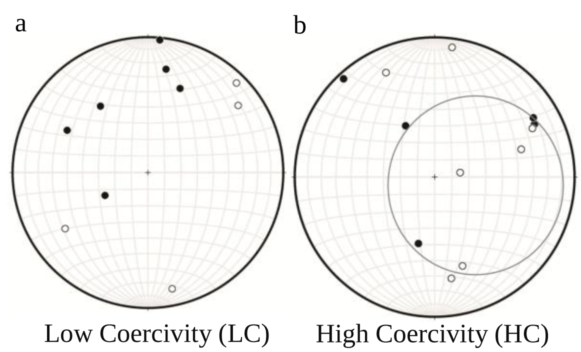

Fig. 3 Equal area stereographic plots of (a) HC, and (b) LC of shocked Lonar ejecta basalts, solid circle-data with positive inclination, open circle- negative inclination, blue ellipse in (b) indicates the zone of distribution of HC component of ejecta basalts.