STRUCTURAL ANALYSIS OF IMPACT INDUCED FRACTURES AND ITS IMPLICATION ON LONAR BASALTS.

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Introduction: Impact cratering is a geological process characterized by ultra-fast strain rates, which generates extreme shock pressure and temperature conditions on and just below planetary surfaces. The Lonar crater formed entirely within the Deccan Volcanic Province (DVP), making it a valuable analog site for studying degradation processes in application to other impact structures occurring on Mars, Moon and Earth [1, 2]. The Lonar crater was proposed to form by the hypervelocity impact of a chondritic asteroid that struck the pre-impact target basalt from the north east at an angle between 30º and 45º to the paleo-horizon [3]. The total duration of shock event at the Lonar crater was suggested to be approximately 1s [4], and the stress generated within the target basalts due to the asteroid impact branched out into a major northwest and southwest components [5]. In this studies lithology, structure and their inter-relationship have been discussed to understand the impact cratering processes that involved in deformation of basalt. The pre-and post-impact structural changes in basalt have been recorded.

Data Analysis and Interpretation: Total six (06 nos.) of basalt flows are demarcated in and around the Lonar crater based on several flow characterization parameters like vesiculated and/or amygdular flow top, basal clinkery, pipe amygdules, presence of red bole surface etc. Impact-related deformation of the target rock consists of upturned basalt flows (Flow No. 2 to 4) in the upper crater walls having raised crater rim with quaquaversal concentric flow dip pattern and intense fracturing all along the crater rim. Overturned flow dip (~ 40°-60º) all along crater rim, raised crater rim with quaquaversal flow dip and intense fracturing with development of multiple fracture sets suggest evidences of impact (Figure 1). One of the significant normal fault structure was observed in the inner crater wall that offsets slightly older layer-parallel slip faults in vicinity of Dhara temple. In that particular stretch, the basalt flows (Flow No. 2 and 3) were separated by a red bole horizon (thickness ~ 1 m) which acts as a marker bed and disrupted against the fault plane (Figure 2). Geometrically this is a normal fault (90°/84°S) with curvilinear fault trace / plane (generally dipping towards south) with a strong dextral (right lateral towards easterly) rotational component against which the marker bed (red bole) was displaced (offset / vertical throw of marker bed ~ 5m). The sub-vertical dip of the fault plane may be a later modification due to geomorphological and/or geotechnical adjustment. Evidence of listric fault has also been observed in the present study, as reported by [6]. [7] reported several normal slip faults and thrusts in this area based on their field observation which is also confirmed in this studies.

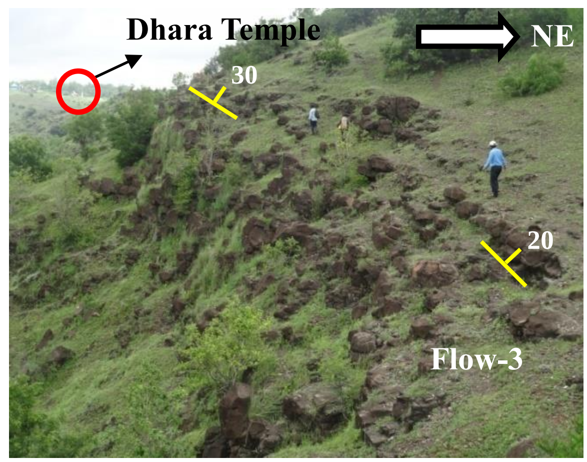

Figure 1: Basalt flow dip (>20º-30°) along raised crater rim (eastern segment) of Lonar crater

The present study also aims to document the impact deformational structures in the massive basalt flows (mostly Flow No. 3 and 4) well exposed along the outer crater wall, where the basalt shows upward turning of the flow sequence with quaquaversal flow dip pattern, resulting in a circular deformation layout [6,7]. Three fracture systems (radial, concentric, and flow parallel fractures) are exposed on the inner crater wall. Uplifting and tilting of the basalt sequence and formation of fractures inside the crater wall are clearly related to the impact event (Figure 3), and are different from the pre-impact structures such as cooling-related columnar joints and fractures (mostly flow parallel) of possible tectonic origin, which are observed outside the crater (Flow No. 5 and 6). Intense fracturing with multiple fracture sets, overturned flow dip (> 20^0) and tilting of basalt flows are absent in unshocked basalt (Flow No. 5 and 6).

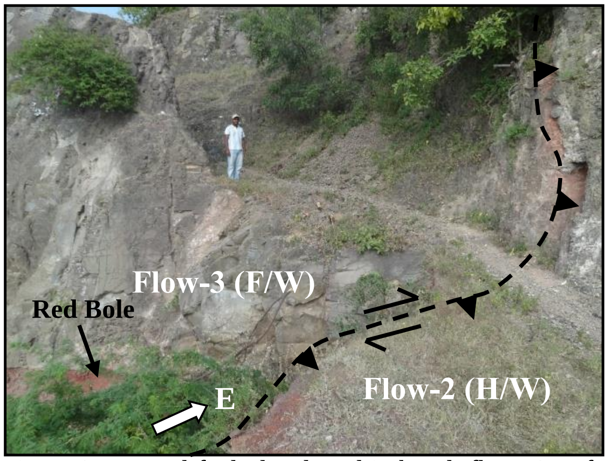

Figure 2: Normal fault developed in basalt flow, SE of Dhara temple

Concentric and flow parallel fractures are measured all along the crater rim and length-weighted rose diagrams show the variations in strikes of these fractures (Figure 4). Based on these diagrams it can be correlated that the fractures within NW and SE sectors show comparable mean strike orientations / variation with the inner crater rim probably suggesting an impact generated fracture system, while fractures developed within NE and SW sectors show comparable mean strike variation, but distinct from the earlier case likely represent tectonic and/or cooling fracture system. These impact induced fractures were generated due to extreme shock pressure with high strain rate, possibly maximum strain accommodation along NE-SW direction resulting impact induced fractures mostly along NW-SE direction as comparable with [3].


Figure 3: Curvilinear fractures developed in impact basalt, NW part of inner crater rim

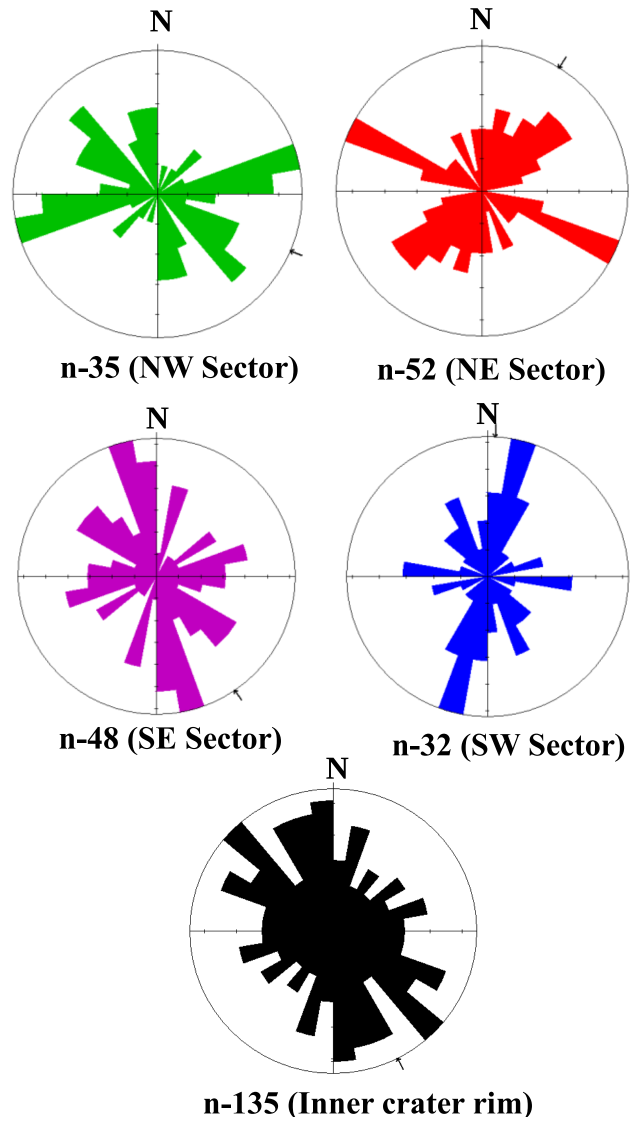

Figure 4: Length-weighted rose diagrams of concentric and flow parallel fractures along the four (04) different sectors of the crater wall / rim and inner rim to show strike variation (n-nos. of data). [the mean strike orientation is pointed by small arrows]

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