SYNTHESIS OF 3-D, GPS, FIELD DATA, AND HIGH RESOLUTION IMAGERY OF LONAR CRATER, INDIA
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Introduction: Lonar crater is an ~1.8 km diameter impact crater (Fig. 1) located in Maharashtra, India (19°58' N 76°30' E). This well-preserved impact crater is emplaced in the basaltic Deccan Traps, which makes it a good Earth analog for studying post-impact modification of craters on Mars [1]. The approximate crater age is 570 ka [2].

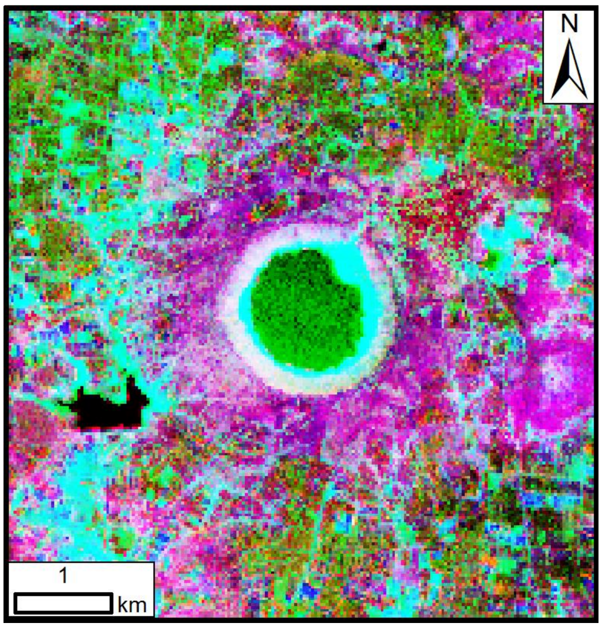

Figure 1. ASTER false-color composite image of Lonar crater (see text for bands used). In this composite, iron-bearing minerals are red, vegetation is green, and OH bearing minerals and clays in blue. Dimensions are the same as Figure 2.

Lonar crater is approximately 222 m deep, as measured from the rim crest, with a saline lake located within the crater. Drill core samples show unconsolidated sediments of 100 m thickness that overlie a breccia lens on the crater floor. The continuous ejecta extends approximately 1350 m from the rim crest [3, 4].

Understanding the ejecta composition at Lonar crater could be useful in constraining past conditions on Mars. The mineralogical signatures of the ejecta at Lonar crater show phyllosilicate and aqueous alteration of basalt (probably by groundwater) [5]. If the ejecta at Lonar crater can be used to determine environmental conditions at the time of impact, there is the potential for using Martian crater ejecta compositions to check the extent of potentially habitable (i.e., water-rich) environments in the past [5].

The formation of gullies and drainage patterns on and around Lonar crater help to constrain post-impact modification processes of a formally hydrologically active Mars. Surface runoff most likely controls the formation of the drainage channels at Lonar crater, which originated at the crater rim and extend radially [6].

Methods: A ~1 m/pixel resolution Quickbird image [7] was georectified in ArcGIS 10 using a Landsat 8 image as the base. The georectified Quickbird was used as an overview image as well as for mapping drainages.

Using the Quickbird image and a Digital Elevation Model from [7], the drainage patterns mapped by [6] were expanded. Channels in the interior walls of the crater were mapped if they appeared to have a visual hydrological connection to exterior drainages.

An ASTER Band math false color composite image (Fig. 1) was created using ENVI Classic 5.0. The band ratios are as follows: red = B4 (1.6-1.7 μm) / B3 N (0.78-0.86 μm); green = B3 (0.78-0.86 μm) / B2 (0.63-0.69 μm); blue = B4 (1.6-1.7 μm) / B5(2.145-2.185 μm). The red highlights iron-bearing minerals, blue highlights OH and clay bearing minerals, and the green is vegetation. The image was equalized to increase the contrast between the ejecta (dominated by red) and surrounding farmland (green). Attempts to mask pixels corresponding the farmlands, vegetation, a reservoir, the lake, and the lakeside are ongoing. The goal is to quantitatively compare pixels of ejecta preserved by the Indian Department of Forest.

GPS points from previous field work obtained using a hand-help GPS were overlain on Quickbird and ASTER images were used in mapping a ejecta distribution, drainage and notable features on and around the crater. Extensive farming activity in the surrounding area make the exact boundary of the ejecta blanket using satellite imagery difficult to determine.

Field Observations: Whereas the Department of Forest has called for the preservation of near-rim ejecta, the uppermost surface and mostly all of the edges of the continuous ejecta blanket (CEB) have been destroyed by farming over the last thousand years. Further, the largest blocks of impact breccia clasts have been removed by ancient man (Dravidians ~1100 years ago) to build temples and other man-made structures.

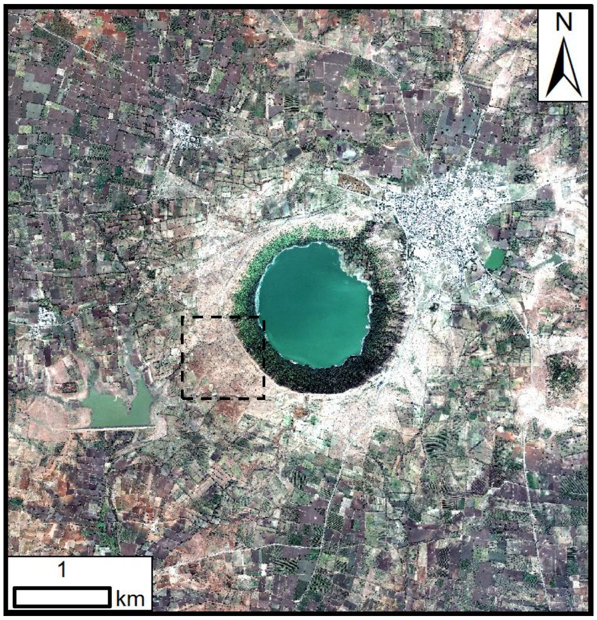

Figure 2. Quickbird true color image of Lonar. .Dimensions are the same as Figure 1. The box indicates the region shown in Figure 3 as the same Quickbird image and field data.

Where mapping lithic breccia and suevite breccia, it was decided to field map the extent of lithic ejecta lobes and their precise alteration mineralogy, as several alteration types were found. These include: fresh basalt, gray basalt, hematite basalt, zeolite basalt, green amygdule basalt, iddingsite basalt, chalcedony basalt, baked zones or “bole”, and others. The altered basalts represent the earliest ~65 Ma basalt flows that were aqueously altered by groundwater before impact [7].

Figure 3 shows a Quickbird image of the southwest ejecta (shown as a box in Figure 2) along with field images showing “cobble fields” of gray basalt, though with a red matrix between clasts and a red iron oxide and perhaps an iron clay coating such as smectite or monmorrilonite.

The fine, red matrix of the impact breccia that is found with ~50% of Gray Basalt lobes is likely due to their pre-impact stratigraphic relation, as red *bole* or baked zone overlies Gray Basalt in outcrops 5 to 30 km away from Lonar. The bole is pulverized to become the matrix of the lithic breccia with nondescript Gray Basalt being the clasts. Another common “lithologic association” seen in lithic ejecta lobes include clasts of basalt containing (separately) iddingsite, hematite, and green amygules. We suggest these pre-impact alterations were mixed as ejecta lobes.

Results: An integrated map of remote sensing and field data will be presented following the synthesis of the additional field data collected. This will include the location of ejecta types in the field and the distribution of channels and gullies surrounding Lonar crater.

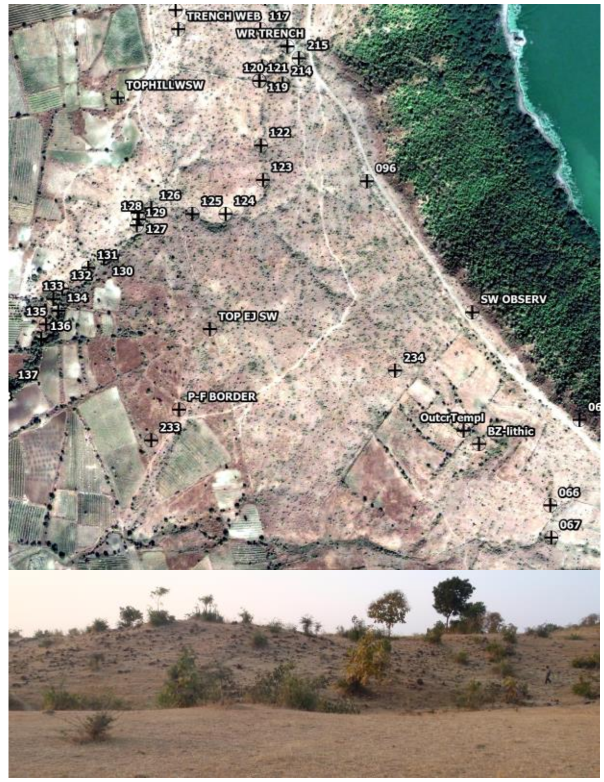

Figure 3. Top – inset of box show in Figure 2. Bottom – field image taken to west near bottom of Figure 2 showing boundary of grassy, “clast free” ejecta in foreground versus “cobble field” in background that is described here under “Field Data”. A gulley separates the two. See man at upper right at bottom of cobble field for scale.

Use of remote sensing data to determine ejecta boundary yielded vaguely similar results to previous mapped boundaries, but further work will need be done to increase the accuracy of this step. Remote multispectral spectra of Fe-bearing and OH-bearing pixels will be compared to laboratory visible and near-infrared and short-wave infrared spectra of variously altered basalt described here, including those high in hematite, augite, and clays.

References: [1] Newsom and Wright (2011) 42nd LPSC, abs. 6026. [2] Jourdan et al. (2011) Geology 39.7, 671-674. [3] Fredriksson K. et al. (1973) Science, 180, 862-864. [4] Fudali R. F., et. al. (1980) Moon and the Planets 23:493-515. [5] Wright and Newsom (2013) 44st LPSC, abs. 4032. [6] Komatsu et al. (2014) Planet. and Space Sci., 95, 45-55. [7] Maloof et al (2010) GSA, 122.1-2, 109-126.