

Lunar Crater, India: An analog for Mars in the field and in the laboratory
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Introduction: “There is no perfect analog for Mars on Earth” (1st line [1]). The primary geologic processes on Mars are basaltic volcanism, sedimentation, impact cratering, and alteration. The 1.8 km diameter Lunar Crater in the state of Maharashtra, India includes morphological features of cratering and impactite deposits. The pre-impact strata consisted of fresh basalt overlying aqueously-altered basalt.

Geologic History/Stratigraphy/Samples: Lunar Crater is a young (~570 ka) [2] impact site emplaced in ~65 Ma Deccan basalt, which is an excellent analog material for Mars with ~45-50% labradorite and ~35% augite/pigeonite before lower flows were altered and then shocked. In ejecta, both fresh and aqueously-altered basalt are found as impact breccia clasts in a ~8 m thick lithic (relatively unshocked; “throw out”) and ~1 m suevite (all ranges of shock pressure; “fall out”) ejecta. Two geologic histories are possible at Lunar after the initial basaltic volcanism: 1.) the alteration of impactites/glasses of a range of shock pressures (“post-impact alteration”), which likely increase the rate of alteration where compared to pristine, igneous minerals, and 2.) the existence of altered basalt protoliths (“pre-impact alteration”) now vitrified as in-situ breccia clasts or float. Both geologic histories have implications for the discoveries of alteration minerals found solely in Martian ejecta blankets with remote VNIR data. Alteration minerals are briefly listed here, and these mirror those suggested for Mars: chlorite, serpentine, zeolites, hematite, palagonite, calcite. Two aspects of studies of Lunar Crater can be described: fieldwork and sample analyses. Fieldwork demonstrates that underlying, altered basalt (by groundwater) is only exposed in the ejecta due to impact. Otherwise it would be at depth and not available to the field geologist (or rover). There are two goals of sample analyses performed for Lunar Crater samples: 1) those that characterize the mineralogy and geochemistry (petrography, XRF, XRD, SEM) for detailed descriptions of what the samples were and are, *i.e.* the determination of the state of alteration of the protolith and constraints on the amount of shock pressure received, and 2) those that mirror spectral and instrumental analyses sent to Mars via rovers, such as TIR, VNIR, Mossbauer, LIBS, APXS, and, again, XRD.

Merit: Lunar includes mineralogical signatures of alteration in basaltic ejecta and a crater-floor breccia deposit: phyllosilicates and aqueous alteration. Impactites are found as shocked and melted rocks in a layered ejecta blanket. On Mars, we must be able to unravel the geologic histories of sedimentary rocks, al-

tered rocks, and soils. Evidence for the climate history is reflected in the alteration of materials in the ejecta blanket. The erosion processes producing gullies on crater walls can also be studied on the rim and interior walls at the site. The basaltic lava flows of the target and interflow deposits are analogous to the Martian crust. The engineering merit of the Lunar site includes the preservation of ejecta topography of a simple impact crater. The site can support tests of drilling into ejecta blankets and exploration tests on the surface and excavated cross sections of ejecta.

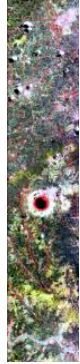


Figure 2



Figure 1. Aerial view of Lunar from the southwest. The town of Lunar on NE rim developed ~1 ka near largest gully (due to a pre-impact spring and fault). Suevite drapes a lithic breccia unit in localities throughout near-rim ejecta.

Table 1: Characteristics of proposed analog site

Site Name	Lunar Crater, India
Coordinates	19°58' N, 76°31' E (central India)
Elevation	~500 m (rim is ~30 m above plains)
Areal Extent	ejecta blanket + crater = ~5 km by ~5 km
Prime Science Questions	Mineralogical signatures of aqueous alteration; post-impact climate history from ejecta (lapilli, <i>etc.</i>), alteration of impact melts/ glasses, nature of erosion processes
Accessibility of Science Targets	Lithic breccias – everywhere. Suevite ejecta – several outcrops are ~100 m from road. Gully on east ejecta – 50 m from road. Drilling required for lake & melt sheet deposits.
Environmental characteristics	Temperatures ~80° F in winter. Summers: ~2 months of monsoon & high humidity. Vegetation: seasonal.
Previous studies at site	Fredriksson et al., 1973; Kieffer et al., 1976; Fudali et al., 1980; Hagerty & Newsom, 2003; Maloof et al., 2010; Wright et al., 2011; Komatsu et al., 2014; this LPSC abstract volume #2086, #2409, #2758
Remote Data Sets	QuickBird, Hyperion hyperspectral VNIR (Figure 2), ASTER VNIR, SWIR, TIR
Mars Landing Site Targets	<i>e.g.</i> , sites with exposed proximal or distal ejecta layers, impact breccias, and craters exposing buried lithologies.

References: [1] Hipkin et al. (2013) *Icarus*, 261-267 [2] Jourdan et al. (2011) *Geology* 39, 671-674 + see Table 1