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Using analog field and sample data to understand remote data of Mars

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The primary geologic processes on Mars are basaltic volcanism, sedimentation, impact cratering, and alteration. All potentially create amorphous materials and complex mineralogies, and these must be measured by rovers sent to Mars to characterize the geology. This paper addresses the field measurements and sample analyses of a terrestrial analog impact crater to interpret rover and perhaps orbital data of Mars.

Motivation: OMEGA and CRISM have shown alteration minerals in Martian ejecta blankets. These phyllosilicates may represent altered crust that was excavated, and only exposed, by the impact, or could represent ejecta that was altered in part during impact or fractured/fragmented material that was altered at higher rate than surrounding terrain after ejecta emplacement.

Study Site and Geologic History: Lonar Crater, India is a young (∼570 ka), ∼1.8 km 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 excavated and/or shocked. Pre-impact stratigraphy was not complex: 3 flows of fresh basalt overlying 3 flows of aqueously-altered basalt, and both are found as impact breccia clasts in a ∼8 m thick lithic (unshocked, "throw out") and ∼1 m suevite (all ranges of shock pressure, "fall out") breccia units in the ejecta. Two geologic histories for shocked clasts in the Lonar suevite breccia are compared: 1.) the alteration of impactites (impact glasses and melts) of a range of shock pressures ("post-impact alteration"), which likely increase the rate of alteration and affects the order 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 of these geologic histories and their alteration pathways are compared to those of unshocked fresh and unshocked altered basalts found in the lithic breccia and surrounding flows. Altered basalts alone from the Lonar region are excellent samples for analyses described below. Alteration minerals are briefly listed here, and these mirror those suggested for Mars: chlorite, serpentine, zeolites, hematite, palagonite, calcite.

Analyses: Two aspects of studies of Lonar Crater will be described - fieldwork and sample analyses. Fieldwork demonstrates that underlying, altered basalt (by groundwater/aqueous alteration) is only exposed in the ejecta due to impact. Otherwise it would be at depth. Sample analyses of shocked basalt are measured from a wide range of instrumentation and compared to unshocked (both fresh and altered) basalt. There are two goals of sample analyses performed for Lonar Crater samples: 1) those that characterize the mineralogy and geochemistry (petrography, XRD, XRF, 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, such as TIR, VNIR, and Mossbauer spectrometers, LIBS to proxy MSL ChemCam, and, again, XRD and XRF, but to proxy MSL CheMin and all APXS instruments. Both field and sample data will be shown.