

ANALYSES OF AMBOY CRATER, MOJAVE DESERT, CALIFORNIA, AS AN ANALOG FOR SMALL MARTIAN VOLCANOES. Jeffrey M. Byrnes¹, David C. Finnegan², Steven W. Anderson³, and Michael S. Ramsey⁴, ¹U.S. Geological Survey, Astrogeology Team, 2255 North Gemini Drive, Flagstaff, AZ 86001-1637 (jmbyrnes@usgs.gov), ²Cold Regions Research and Engineering Lab (CRREL), 72 Lyme Road, Hanover, NH 03755-1290, ³Planetary Science Institute, 1700 East Fort Lowell Road, Suite 106, Tucson, AZ 85719-2395, ⁴Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA 15260.

Motivation and Approach: Volcanic surface units, including lava flows and pyroclastic materials forming plains and edifices, are widespread on the surfaces of rocky planetary bodies. Understanding the formation and degradation processes that produce and modify such geologic units is crucial to understanding the geologic evolution of these bodies. In order to characterize primary, eroded, and mantled characteristics of volcanic surfaces, we are developing a data fusion approach to examine the Amboy Crater cinder cone and lava flow field. Our approach utilizes a suite of complementary remote sensing datasets that has been collected for Amboy Crater, including laboratory TIR emission spectra, airborne LiDAR (light detection and ranging) and radar (radio detection and ranging) data, and airborne and spaceborne visible and near infrared (VNIR), shortwave infrared (SWIR), and thermal infrared (TIR) data. Quantitative comparison of these remote sensing datasets acquired at a range of spatial resolutions provides constraints on the ability to discriminate morphologic and spectral characteristics of exposed surface units. In conjunction with field analyses, these comparisons provide means to remotely identify topographic and spectral signatures that are diagnostic of specific volcanic and degradational processes and are applicable to the study of extraterrestrial bodies.

Amboy Crater Study Area: Our study area is the Amboy Crater cinder cone and lava flow field, located in the Mojave Desert near Amboy, California. The flow field stretches from approximately 34.48-34.57°N and 115.75-115.87°W, covering ~70 km² [1]. It was erupted onto a flat, alluvial plain, dividing it into two playas: Bristol Dry Lake to the east and Bagdad Dry Lake to the west. The alkali basalt flow field represents some of the youngest basaltic volcanism in southern California, recently dated at ~80 ka [2-3]. The flow morphology is primarily hummocky, vesicular pahoehoe, exhibiting surface relief of 2-5 m. Surface irregularities have been attributed to both inflation (tumuli) and deflation (collapse) processes, although lava tubes have not been identified within the flow field and only a few lava channels are evident [4-6]. Lava flows emanate from the vent at the Amboy Crater cinder cone complex. Other vents within the flow field are difficult to identify due to the irregular

nature of the flow surface and the partial cover of sand, although a probable vent is located ~3 km WSW of the cinder cone and additional vents have been proposed to account for local lava drainback features [5-6]. The mantle of sand, where present, varies in thickness from a few centimeters to >1 meter thick. The dominant wind direction in the southern Mojave Desert is from the NW to the SE. This wind in conjunction with the abundant sand supply is responsible for a mottled pattern of alternating mantled and sand-free zones. A large, low-albedo wind streak extends from Amboy Crater toward the southeast, as described by Greeley and Iversen [5].

The Amboy Crater cinder cone is an ~75 m-high, 460 m-wide, complex cinder cone located at 34.5°N, 115.8°W, in the northeast portion of the flow field [5-6]. The construct is composed of at least four coalesced cinder cones formed during at least six eruptive phases [4]. Subsequent extrusive activity may have occurred from the same vent, but the relative timing of lava flow emplacement at that volcanic center is indeterminate.

Remote Sensing Analyses: Our analyses use data collected by several instruments, including a laboratory spectrometer, ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer), LiDAR, MASTER (MODIS/ASTER airborne simulator), and AIRSAR (Airborne Synthetic Aperture Radar).

Laboratory spectroscopic analysis. Samples collected within the Amboy Crater flow field were analyzed to aid in interpreting the spectral information provided by ASTER (see below). Rock and sand samples were separated and loaded into copper sample cups. Samples were then heated and TIR emission spectra were collected in the ASU Thermal Infrared Mineral Spectroscopy Laboratory following the methodology of Ruff et al. [7]. These spectra were then convolved to 5-point spectra (ASTER Spectral Resolution), and the average 5-point spectrum for each of the two materials was used to deconvolve ASTER TIR data.

Spectral analysis of airborne and spaceborne data. Preliminary results indicate that the ability to discern spectral signatures of geologic features is strongly dependent on the available spatial and spectral resolution. Additionally, the method used to determine

surface characteristics affects the overall results. For example, the proportion of exposed rock vs. sand within the extents of the flow field is different if determined by spectral deconvolution using laboratory spectra of samples relative to the proportion determined by calculating apparent thermal inertia for the flow field.

Morphologic analysis. Preliminary results indicate that morphologic signatures are also dependent on resolution and the measurement method used. For example, the relief measured within a portion of the flow field is different in the LiDAR-derived digital elevation model (DEM, interpolated at a 30-m bin size) based on altimetry data relative to the ASTER-derived DEM (sampled to 30-m posting) based on digital stereo correlation and parallax techniques (Figure 1).

Further analysis is required to incorporate additional field and remote sensing datasets to better

understand the utility and limitations of each type and resolution of data. Furthermore, additional field work is required to correlate identified spectral and morphologic signatures with the volcanic, aeolian, and fluvial processes that they represent.

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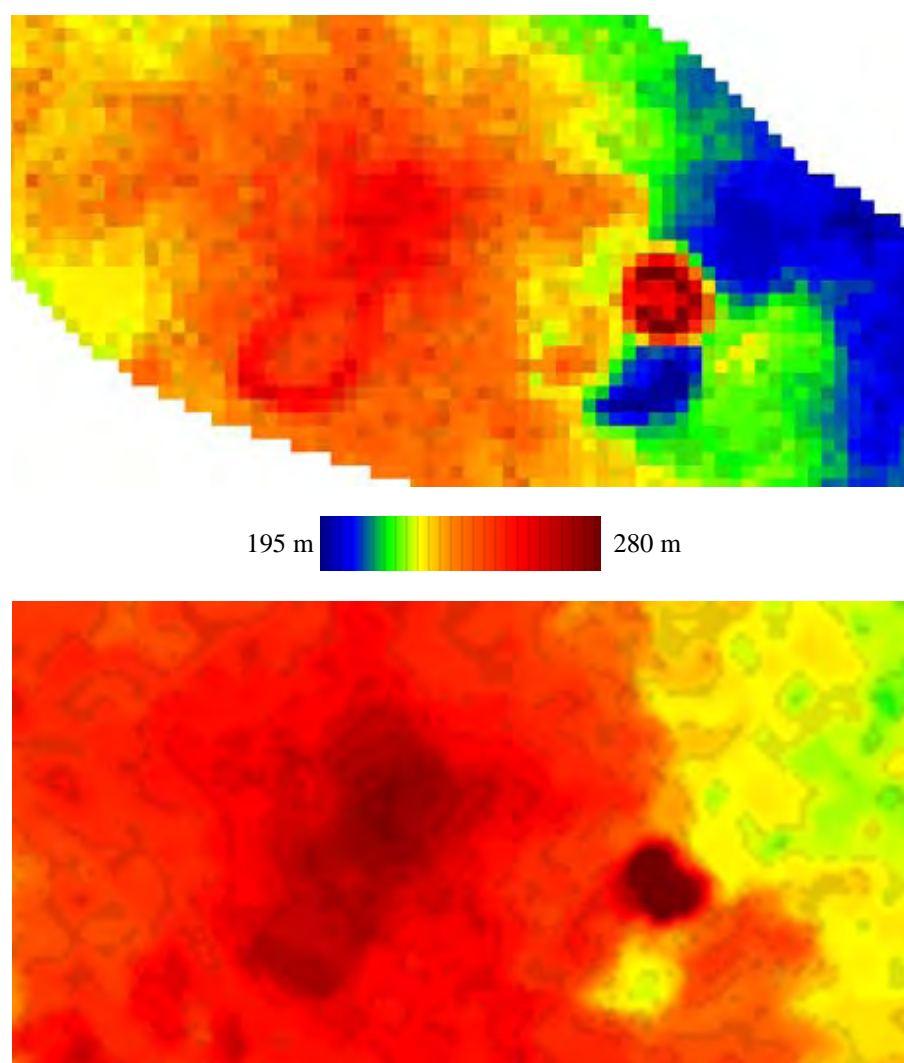


Figure 1. Comparison of 30-m DEMs, illustrating that the LiDAR data (top) shows more relief and better represents flow field morphologies than the ASTER stereo data (bottom); color bar is the same for both images. Note that although the ASTER DEM has the same initial posting as the LiDAR DEM, it has a smaller apparent pixel size in this image because it has been resampled to co-register it with the LiDAR data; nearest neighbor resampling is used so that the elevation values and ability to identify morphologies is not affected.