Analysis of Melt Flows observed by SIR-2 and LROC NAC: Stevinus A

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Abstract
Impact melt structures occur in and around young craters from 200 m to hundreds of kilometers in diameter. Impact events lead to melting and vaporization processes. Through the combination of high-resolution LROC NAC images and measurements made by the SIR-2 point spectrometer carried by Chandrayaan-1, compositional aspects can be investigated in a manner hitherto impossible. We will present and discuss as a specific example first results for the small lunar crater Stevinus A.

1. Introduction
Fluid-like morphological features observed in the vicinity of lunar impact craters were attributed to a volcanic origin by Strom and Fielder [1]. Based on Surveyor VII and Lunar Orbiter photographs, Shoemaker et al. [2] and Guest [3] put forward the idea that flow-like structures observed at Tycho and Aristarchus are material partially molten during the impact event. Howard and Wilshire [4] investigated 20 lunar craters and showed that similar melt materials can be recognized in consistent patterns at impact craters. They showed that the melt was distributed in the same manner as other impact ejecta and concluded from their observations that it was formed by the impact event rather than by volcanic processes. Impact events are able to generate a sufficiently high amount of shock energy to create molten rock. Although the ratio between the impact melt volume and the volume of the transient cavity is lower for the Moon than for the other terrestrial planets [5, 7], lunar impact melt structures have been studied by a variety of authors. Hawke and Head [6] described impact melt flows and ponds associated with craters of diameters down to 4 km. Recently, impact melts have been increasingly put into the focus of contemporary planetary research due to the availability of high-resolution lunar images from LROC (Lunar Reconnaissance Orbiter Camera). According to Orsinski et al. [7], observational data of impact melt structures on different terrestrial planets indicate that the existing models describing impact melt formation in a single stage during crater excavation are insufficient to account for the observed varieties of impact ejecta and crater-filling material.

2. Compositional Aspects
The exact proportions of the melt constituents, which are made up by solid chunks of target material, quickly cooled glass, and slowly cooled crystalline material [8], are currently neither predictable by laboratory experiments nor by hydrocode simulations. Knowledge about the composition and spatial distribution of impact melt is important for such models as it may reveal information about the excavation depth and the mixing processes. It is generally known that remote sensing techniques do not reveal impact melt properties easily [8], since most spectral absorptions do not only depend on the content of specific minerals and elements but also on the degree of crystallinity of the material [8]. The cooling rate of impact melt may be different inside and outside of a crater, resulting in glass or crystalline material of variable grain size. While the influence of the degree of crystallinity on the spectral appearance is examined in [8] based on laboratory experiments, compositional information about impact melt structures is still difficult to obtain based on remotely sensed spectra ([8], cf. also [9]).

3. Investigating Stevinus A
The lunar crater Stevinus is located south of Mare Fecunditatis at 54.2°E and 32.5°S. The NIR point spectrometer SIR-2 flown on Chandrayaan-1
measured reflectance spectra integrated over circular footprints with a diameter of 200 m in the wavelength range 934–2410.8 nm [10] across the 8 km diameter crater Stevinus A at low phase angles.

Figure 1: Stevinus A as seen by Clementine (left image) and by LROC NAC (right image).

To precisely place the SIR-2 spectra into their spatial context, we coregistered the SIR-2 track to a synthetic image generated relying on the M³-based single-scattering albedo map and DEM. Locations belonging to overexposed spectra have been omitted. (Right Panel) Topographically corrected spectra normalized to standard geometry of the locations indicated in (a). The solid curves are smoothened versions of the measured reflectances indicated by points.

Figure 2: (Left Panel) Coregistration of SIR-2 track to a synthetic image generated relying on the M³-based single-scattering albedo map and DEM. Locations belonging to overexposed spectra have been omitted. (Right Panel) Topographically corrected spectra normalized to standard geometry of the locations indicated in (a). The solid curves are smoothened versions of the measured reflectances indicated by points.

References


