KING CRATER IMPACT MELT COMPOSITIONS: POSSIBLE IMPACTOR CONTAMINATION.

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Background and Purpose: Frictional melting experiments with ordinary chondrites demonstrate the importance of shear deformation in the mixing and dispersion of different components within melt veins and at larger scales on meteorite parent bodies [1][2].

Frictional melting, by its very nature, involves viscous drag along the target-impactor interface, thereby ensuring the retention of a mixed melt within or near the crater. Certain shear-generated impact melts may retain a high fraction of the impactor due to this process [3]. Simple shock melts with high temperatures due to waste-heat and proportionately high particle velocities should be deposited on average at much greater distances from the crater than shear-related melts. Such impact melt characteristics are enhanced for oblique impacts, where the component of non-vertical momentum is increased [4].

Fate of the Impactor: Oblique impacts in laboratory experiments reveal that the impactor signature contributes to the downrange melt compositions because of increased viscous drag involved in mixing impactor and target. These experiments further demonstrate that portions of impactors can survive hypervelocity oblique collisions, while shear-heating occurs at the target/impactor interface [3]. Recent calculations now confirm and extend the viability of impactor survival as a process during oblique impacts at larger scales [5]. If this does occur, then the impact melt should have varying compositions based on its location with respect to the impact angle. One test is to investigate craters in the lunar highlands where these processes are potentially visible because of the mineralogical contrast between anorthosite and potential iron and ordinary chondrite impactors.

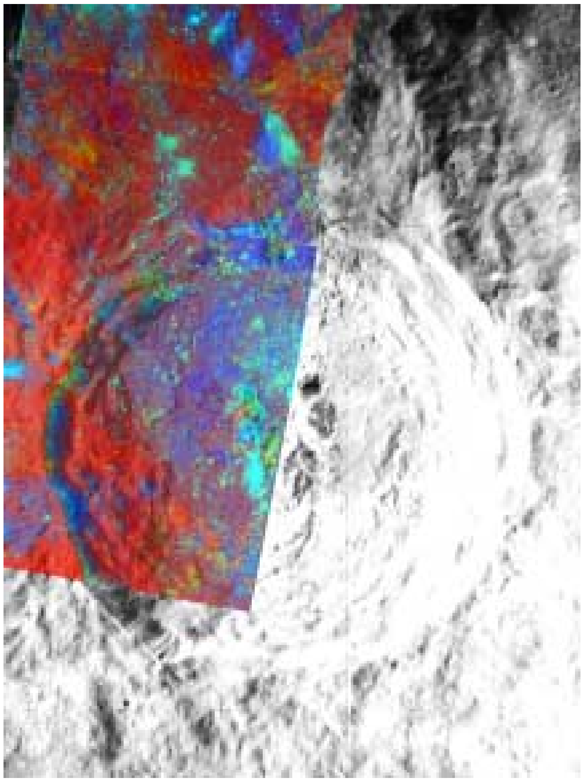

Figure 1. Clementine multispectral color ratio mosaic for a portion of the 75 km diameter King Crater. (R) Anorthositic soil, (G) pyroxene/olivine-rich materials and (B) fresher anorthosite.

King Crater: King, a fresh 75 km diameter crater in the lunar highlands, is one example of these processes. It is located in the lunar highlands away from areas affected by dark halo craters and cryptomare deposits [6]. Asymmetrical structural features and ejecta and impact melt distributions indicate that King Crater was generated during an oblique impact with a trajectory of about 30 degrees [7, 8]. There are two distinct types of impact melt associated with King Crater: (1) highly fluid melt-pond materials mostly found downrange and (2) ropy, clast-laden melts remaining within the crater.

Spectral Data: Clementine multispectral data, calibrated and corrected as described in [9], can be used to compare and contrast spectra in three color ratio images. Using four Clementine scenes showing most of the western side of King Crater, the spectral properties of several different impact-related units are compared. The red, green and blue channels in Figure 1 represent: (R) feldspathic soils (750/415 nm), (G) pyroxene-rich mafic materials (750/950 nm) and (B) fresher feldspathic soils (415/750 nm).

The spectra from the highland target material are characteristic of anorthosite and anorthositic soil (*Fig.*

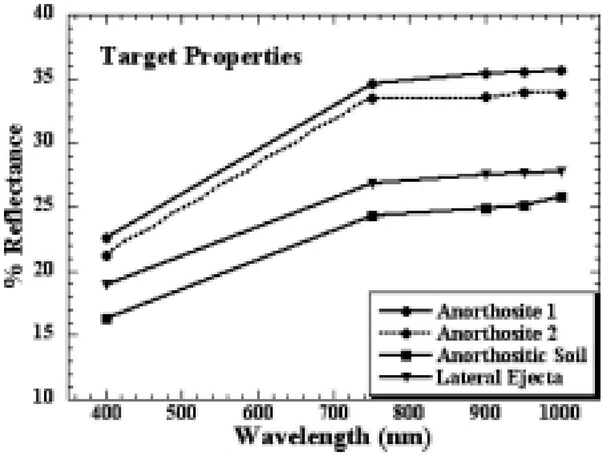

Figure 2. The highland target materials at King Crater are consistent with the overall feldspathic nature of anorthosite without contamination.

2). Note that the lateral ejecta lies between the freshest anorthosite spectra and the soil spectra, suggesting that either the two components were mixed together during ejecta deposition or the ejecta is more weathered than the anorthositic units in the crater.

Spectral analysis of several impact melt units exhibit a wide range in compositions (*Fig. 3*). The downrange "dark ray" unit, which includes the dark rays which extend downrange, has the lowest albedo of this group and spectra indicative of a somewhat weathered pyroxene mineralogy. Two spectra representing the overall surface of the large downrange melt pond indicate that there is a feldspathic component (Melt Pond 1) and a pyroxene/olivine-rich component (Melt Pond 2). Spectra for some of the major impact melt flows that enter the melt pond (Flow) fall between the "dark ray" and "melt pond" units, likely representing a mixture of the two.

Small craters in the impact melt pond provide fresh probes of the mineralogy and thus more distinct spectra are obtained for this unit (*Fig. 4*). Parts of the melt pond (Pond Crater 3) resemble the "flow" unit. The other crater spectra (Pond Craters 1, 2) are similar to their corresponding melt units, but more clearly demonstrate the presence of pyroxene and olivine within the melt pond body.

Interpretation and Discussion: While it is generally not disputed that the dark units associated with King Crater are impact melts, the origin of the mafic signature has not been fully established. One possibility is that the impact occurred in an area of the highlands that has subsurface igneous bodies [e.g., 10] and/or cryptomare [11]. However, a specific mafic unit has not been unambiguously identified. Based on the results of laboratory experiments [3] and hydrocode calculations [5], an alternative interpretation can be proposed: the distinct melt units result from impactor contamination at levels of as little as a few percent.

Indeed, King Crater should not be the only crater where such a process can be identified. If King Crater formed during a low velocity, low angle impact the effects of this process would be maximized and retains this component in close proximity to the crater. Other similar craters should exhibit similar ranges in melt properties as those seen at King Crater. Studying craters in the lunar highlands allows a unique opportunity to see the dramatic results because of the major compositional differences between anorthosite and the ubiquitous ordinary chondrite/iron impactors.

Conclusions: The distribution and composition of the contrasting highland and impact melt units around King Crater suggest that portions of an iron-rich impactor (e.g., ordinary chondrite, iron meteorite) survived the collision and contributed to the distinct melt units downrange. Frictional melting and drag during impact-directed flow enhances such contamination. Other oblique craters also may show similar impactor contamination, particularly for downrange melts. Frictional melting experiments and a targeted survey of other potential examples on the Moon are underway.

References: [1] van der Bogert C.H., *et al.* (1998) *LPSC* **29**, #1693. [2] van der Bogert C.H., *et al.* (2001) *LPSC* **32**, #2167. [3] Schultz P.H. (1996) *JGR* **101**, 21117-21136. [4] Schultz P.H. (1996) *GSA Abstracts* A384. [5] Pierazzo E. and H.J. Melosh (2000) *MAPS* **35**, 117-130. [6] Schultz P.H. and P.D. Spudis (1979) *PLPSC* **10**, 2899-2918. [7] Howard K.A. and H.G. Wilshire (1975) *Jour. Research USGS* **3**, 237-251. [8] Schultz P.H. and R.R. Anderson (1996) In *The Manson Impact Structure, Iowa: Anatomy of an Impact Crater,* 397-417, Boulder, Colorado: Geological Society of America Special Paper 302. [9] McEwen A.S. and M.S. Robinson (1997) *Adv. Space Res.* **19**, 1523-1533. [10] El-Baz F. (1972) *NASA SP-315* 29-62 - 29-70. [11] Heather D.J. and S.K. Dunkin (1999) *LPSC* **30**, #1179.

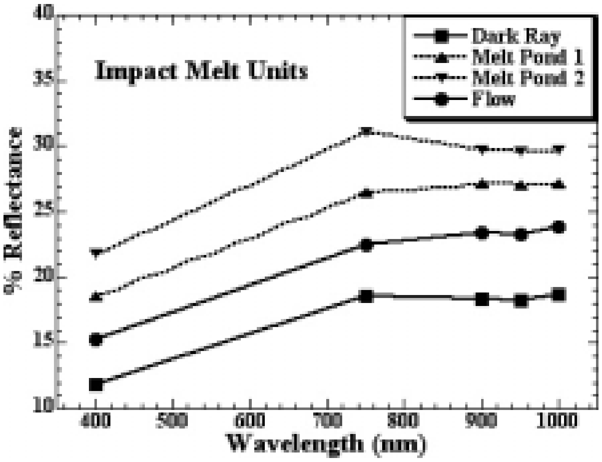

Figure 3. Spectral characteristics of the impact melt units associated with the melt pond to the north of King crater indicate glassy and mafic components.

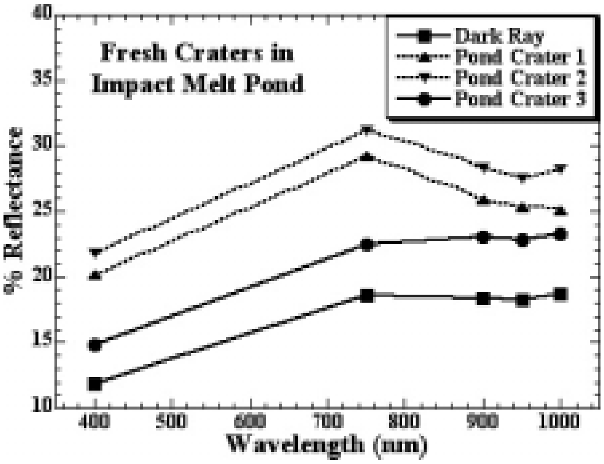

Figure 4. Using the "dark ray" spectrum as a reference, spectra from three fresh craters in the impact melt pond indicate a wide range in mafic mineralogy.