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Composition of the impact melt sheets of the Orientale and Nectaris impact basins

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Abstract

Detailed mapping of the impact melt sheets of two lunar basins of comparable size, Orientale and Nectaris, was undertaken to determine their composition and possible variations. Initial results indicate that these melt sheets are chemically homogeneous and this work does not support the notion that melt sheets of impact basins on the order of 1000 km diameter on the Moon might differentiate in place, creating a series of quasi-plutonic highland rocks that might be mistaken for indigenous lunar magma products.

1. Introduction

Basin-forming impacts create enormous volumes of shock-melted rock, which settle at the bottom of the completed landforms and may contribute significantly to lunar rock populations [3]. Although considerable study of these processes has occurred over the last decades, we still do not fully understand the processes and products of shock melting during these enormous events. The basins Orientale and Nectaris are similar in size (~900 km diameter) but separated by age [6]. I have undertaken detailed studies of the impact melt sheet of these two basins with the aim of better quantifying their properties and inferring the processes responsible for their creation.

2. Mapping Impact Melt

Both basins are partly flooded by subsequent mare lavas, but some exposures of the original melt sheet are evident [1,3]. The greatest exposure occurs in the younger Orientale basin; impact melt here displays variable morphology, including smooth plains, cracked and fissured deposits, and knobby plains [1,6]. The relatively unmodified morphology of Orientale permits us to study its chemical and mineral composition from remote sensing data. In Fig. 1, a map of the observed melt sheet of Orientale is shown. The figure at bottom shows the composition of iron in this melt sheet (in FeO wt.% x 10). Note that this histogram of FeO values is strongly peaked (high kurtosis), indicating a very narrow range of composition. This relation is consistent with the conventional wisdom on impact melt sheets, viz., that although impact melts may show extreme textural variations, they tend to be chemically very homogeneous. Although several impact craters of tens of kilometers diameter occur on the melt sheet, they show no significant change in melt sheet composition with depth. The bulk of these observations suggest that the Orientale basin produced a very large, chemically homogeneous volume of impact melt. No obvious indications of melt sheet differentiation are evident.

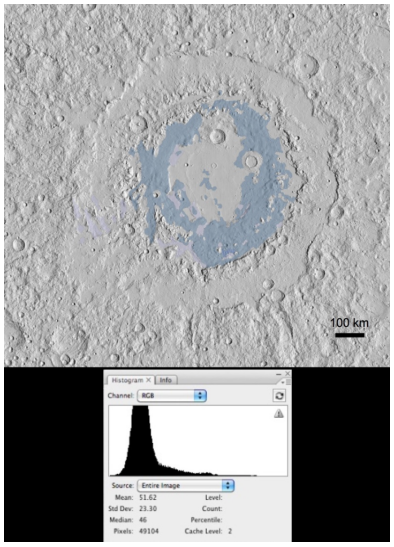

Figure 1: Geological map of Orientale melt deposits. Iron composition shown at bottom (FeO wt% x 10).

The Nectaris basin is significantly older than Orientale [6] and in fact, defines the beginning of the lunar Nectarian stratigraphic system [5]. Although considerably degraded by both mare flooding and impact erosion, traces of its original morphology (identified on the basis of comparison with Orientale; [1,2]) can be identified. Small plains near inner basin

ring massifs and inter-massif "draped" deposits are likely remnants of the Nectaris basin impact melt sheet. A map of these remaining exposed deposits is shown in Fig. 2. These units are greatly restricted in extent but enough are exposed as to permit us to estimate the composition of these deposits.

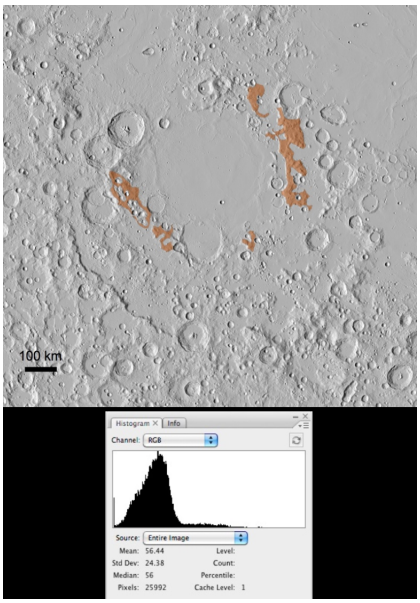

Figure 2: Geological map of Nectaris melt deposits. Iron composition shown at bottom (FeO wt% x 10).

Two features of the Nectaris melt deposits are evident. First, the mean iron content of the Nectaris basin is somewhat high (FeO=5.6 wt.%), compared to Orientale (FeO= 4.6 wt.%). This difference might suggest a slightly more mafic target for the Nectaris basin, as both features are comparable in size and should have had excavation craters of similar dimension. Second, the width of the FeO histogram for Nectaris is markedly broader than that of the Orientale basin. In part, this may be caused by the unintended inclusion of non-melt components (caused by the degraded state of Nectaris) or the presence of pure anorthosite massifs within the mapped unit (these also occur at Orientale). In any event, the melt units of Nectaris are also remarkably homogeneous and there is no evidence for any differentiation or changes in composition with depth, as would be evident by differing compositions of small crater ejecta on features superposed on the basin melt sheet.

Summary and Conclusions

Two lunar impact basins of comparable size display impact melt sheets of similar morphologies, distributions and compositions. The impact melt is remarkably homogeneous, showing dispersions of less than a couple wt.% in the concentration of selected elements. These results suggest that basin impact melt sheets, despite being large (100's km^3) volumes of molten silicates do not chemically differentiate. Such lack of differentiation is probably caused by the inclusion of much cold clastic debris in the melt and subsequent rapid quenching, precluding significant heat retention and differentiation. Work continues to understand these variations and their implications for the crater- and basin-forming process.

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