PHYSICAL CONSTRAINTS ON IMPACT MELT PROPERTIES FROM LROC NAC IMAGES. B. W. Denevi[1], M. S. Robinson[1], S. J. Lawrence[1], L. P. Keszthelyi[2], B. R. Hawke[3], W. B. Garry[4] V. Bray[5], L. L. Tornabene[5] , and the LROC Team. [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85251, USA. [2]Astrogeology Science Center, U.S. Geological Survey, Flagstaff, AZ 86001, USA. [3]Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI 96822, USA. [4]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC 20013, USA. [5]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA.

Introduction: Well-preserved impact melt deposits are commonly associated with Copernican-aged lunar impact craters [e.g. 1,2,3], yet there are still many unknowns concerning the physical properties and emplacement of these melts. The Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Camera (NAC) [4,5] provides a new look at these features at a resolution of up to 50-cm/pixel, and targeted off-nadir imaging is used to create meter-scale digital terrain models (DTMs) [e.g. 6,7]. This rich dataset will enable detailed studies of impact melt rheology (especially yield strength) and gives insight into its emplacement. These parameters, in turn, elucidate the temperature and shock pressures produced by the impact event.

Impact melt flow morphology: This study focuses on impact melt flows on the exterior of crater rims that occur on moderate slopes and typically are seen as channelized flows and lobes qualitatively similar to terrestrial basaltic flows (Fig. 1, 2). All of the craters in this study are in the lunar highlands and we assume they are anorthositic. Thus the similarities to terrestrial basaltic flows are in spite of compositional differences that would result in an order of magnitude higher viscosity for the lunar materials compared to typical dry terrestrial basalts at a given temperature [8].

Flows are often seen to start at or near crater rims, while others appear hundreds of meters from the rim. This distribution of source regions suggests larger bodies of melt were ejected only short or moderate distances beyond the rim during the excavation of the crater. Many of the channelized flows appear to have exhausted their source (i.e., are volume-controlled), and melt has drained out from the channel. All of the observed flows are seen to overlay crater ejecta deposited earlier in the impact event, and in some cases have entrained meter-scale blocks, suggesting some flows may have a significant clast component.

Our initial study concentrates on the melt flows observed on the western flank of the 17-km crater Mandel'shtam F (5.2° N, 166.2° E). These flows have well-developed channels and levees (Fig. 2) and DTMs for this region are currently in production.

Modeling of flows: Numeric models of terrestrial volcanic flows can be adapted to study impact melt flows [e.g. 3,9-11]. These models require a number of parameters such as the slope on which the flow is moving, the thickness, width, and length of the flow, and the height of the levees. DTMs and Lunar Orbiter Laser Altimeter (LOLA) data [5] will be used to characterize these flow parameters, and the assumed composition of the melt can be used to estimate density and the thermal diffusivity. The yield strength, τ_y, is calculated by the relationship

$$\tau_y = \rho g d \sin(\theta) \tag{1}$$

where ρ is density, g is gravity d is the flow thickness and θ is the slope [9]; we also test alternative methods of calculating yield strength (e.g., from levee widths) for comparison. We plan to also explore a number of different methods to estimate the flow viscosity (e.g.,

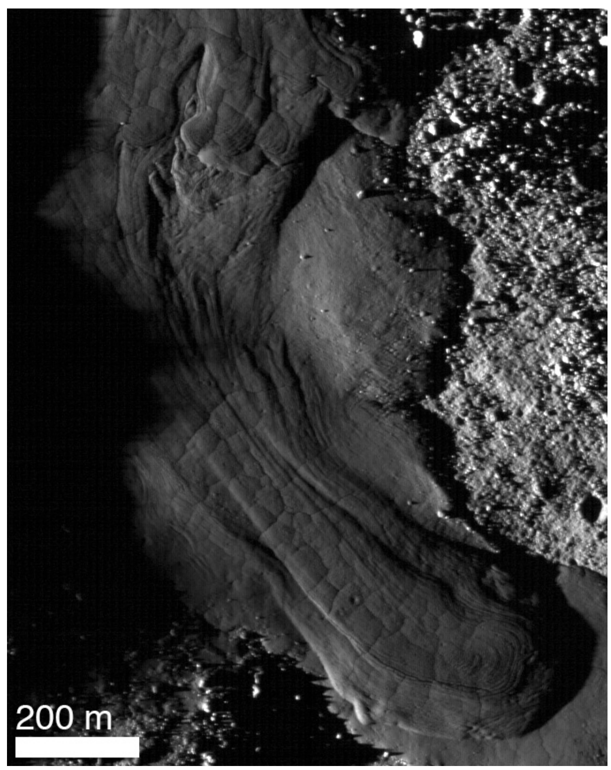

Fig 1. Well-preserved impact melt flows observed on the southern flank of Giordano Bruno crater (35.9° N, 102.8° E, 22 km in diameter). Image M101476840LE, 1.5 m/pixel, incidence angle of 86°.

laboratory studies of anorthositic melts and empirical relations between yield strength and viscosity). With flow volume, density, yield strength, and viscosity, we will be able to place constraints on flow rate, flow duration, and the timescale of cooling.

Discussion: Estimates of viscosity and temperature are complicated by several factors such as a possible initial horizontal velocity component due to the ejection process and the likely inclusion of clastic material within the melt. Future work will focus on comparing estimates of flow duration, viscosity, and cooling for flows that appear to have a large clast component and those that at least on the observed surface and at the effective spatial resolution have a low fraction of entrained clasts. A survey of flow features is currently underway to improve our understanding of the range of morphologies and the inferred physical properties of the melt.

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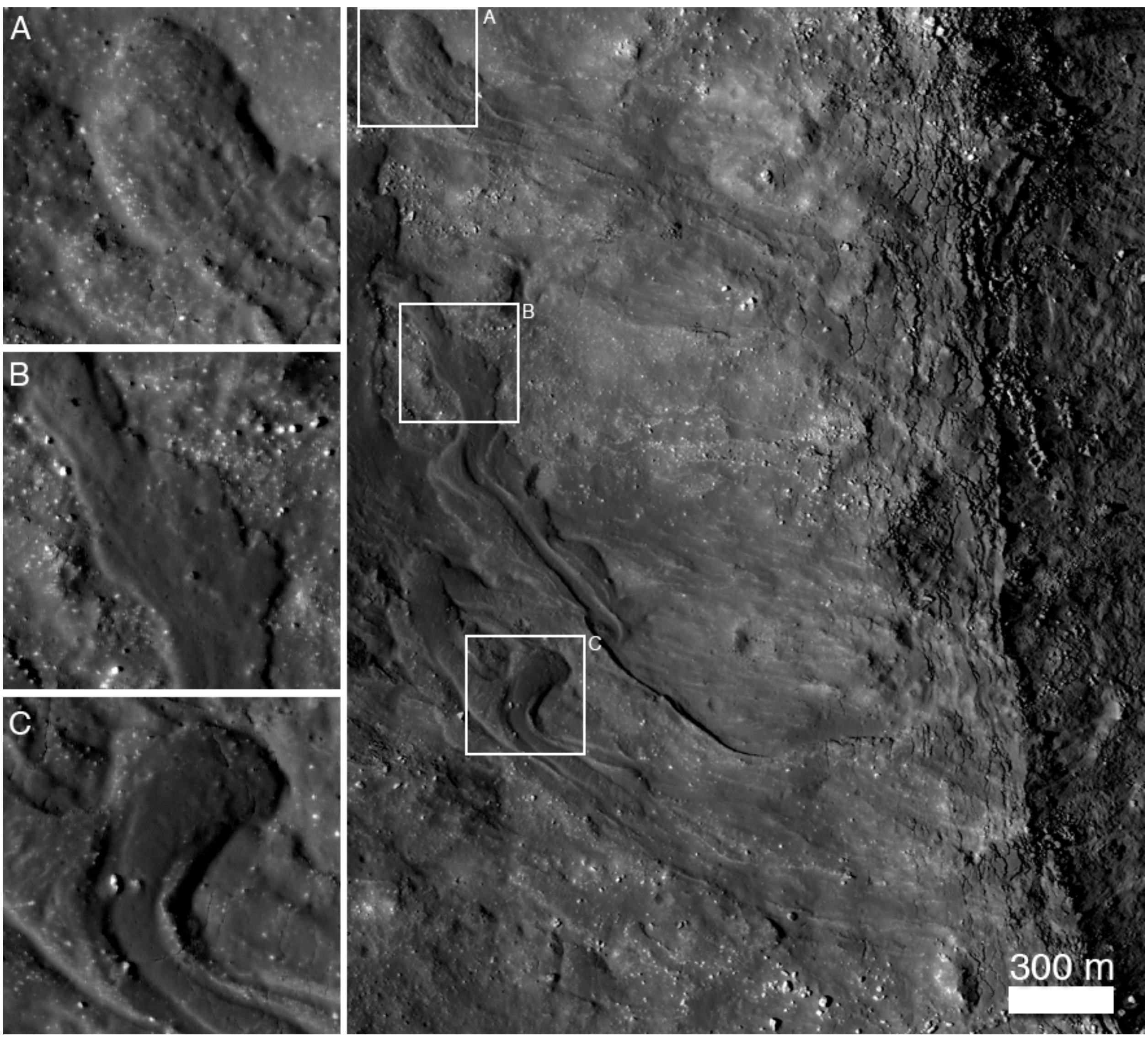

Fig. 2. Flows of impact melt observed on the rim (seen at the right) of crater Mandel'shtam F. NAC image M105787191LE with an incidence angle of 38° and a resolution of 1.3 m/p. Inset images A-C are 390-m across.