NEW LUNAR IMPACT MELT FLOWS AS REVEALED BY MINI-RF ON LRO. C. D. Neish[1], N. Glines[2], L. M. Carter[3], V. J. Bray[4], B. R. Hawke[5], D. B. J. Bussey[1], and the Mini-RF Science Team, [1]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD, 20723 (catherine.neish@jhuapl.edu), [2]Mount Holyoke College, South Hadley, MA, 01075, [3]NASA Goddard Spaceflight Center, Greenbelt, MD, 20770, [4]The University of Arizona, Tucson, AZ, 85721, [5]The University of Hawai'i at Manoa, Honolulu, HI, 96822.

Introduction: Flow-like deposits of impact melt are commonly observed on the Moon, typically around young fresh craters. These flows are thought to be mixtures of clasts and melted material that are emplaced during the late stages of impact crater formation [1]. Lunar impact melts have been primarily studied at optical wavelengths, but complementary information can be obtained by observing impact melts at radar wavelengths. Radar data is sensitive to surface and subsurface roughness, and thus can highlight these rough surface features, even when they not easily seen in optical data due to burial or imperfect lighting conditions (Fig. 1). Impact melts have been identified in radar data on the lunar near side [2], but they have yet to be studied in depth on the lunar far side, given the lack of global radar data prior to the launch of NASA's Mini-RF instrument on the Lunar Reconnaissance Orbiter (LRO) in 2009.

We have therefore undertaken a global mapping project to identify impact melt flows in the Mini-RF data set. We seek to use this data set to determine how the emplacement of melt deposits is influenced by pre-existing topography. Hawke and Head [1] noted that melt distribution patterns on crater exteriors tend to be asymmetric. They suggested that this asymmetry might relate to (a) the pre-impact topography or (b) the direction of impact. Given the available data, they found a better correlation between the pre-impact topography and the melt direction, with 86% of 42 craters exhibiting flows within 45° of the direction of the rim crest low. This led them to suggest that impact melt in the bottom of the crater is moved upward during the modification stage, as wall slumping and rebound move melt over topographic lows in the rim crest. However, 64% of 39 craters studied also had their most extensive flows within 45° of the downrange direction of impact.

We seek to update this data set with new impact melt candidates recently discovered by Mini-RF, to determine the relative importance of topography and impact direction in shaping exterior melt flows.

Observations: An initial survey of the Mini-RF data revealed nine candidate melt flows, with crater diameters ranging from D = 3 to 26 km (Table 1). We examined both total radar backscatter and circular polarization ratio (CPR) images to identify the melt flows. CPR is one of the most useful indicators of surface roughness, making this an effective tool for identifying impact melts. After a candidate melt is identified, data from the LRO Camera (LROC) was used to identify additional features associated with impact melt deposits, such as cooling cracks in ponds and tension cracks in veneers, confirming these features as impact melts.

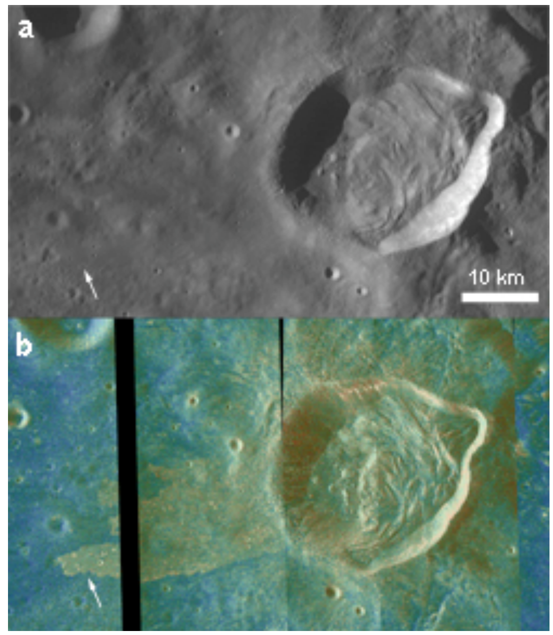

Figure 1: Image of Gerasimovich D (D = 26 km), as seen at (a) visual wavelengths by the LRO WAC and (b) at 12.6 cm by Mini-RF. An arrow indicates the edge of a newly discovered impact melt flow [3,4,5].

In this data set, we found melt flows that extended up to four crater radii from the rim of the parent crater (Fig. 2). This is considerably further than the melt flows studied by [1], which were generally less than one crater radii from the crater rim. In addition, of the nine candidate melt flows discovered, four of the parent craters were less than 10 km in diameter. Previous studies had found no evidence for melt flows around such small craters. Cintala and Grieve [6] had attributed this observation to the relatively small amount of melt becoming choked with cold clasts, increasing the melt's viscosity and chilling it rapidly. These new observations suggest that this mechanism does not operate at all small craters, or that oblique impact geometries and/or pre-existing topography can aid in melt emplacement at simple craters [7].

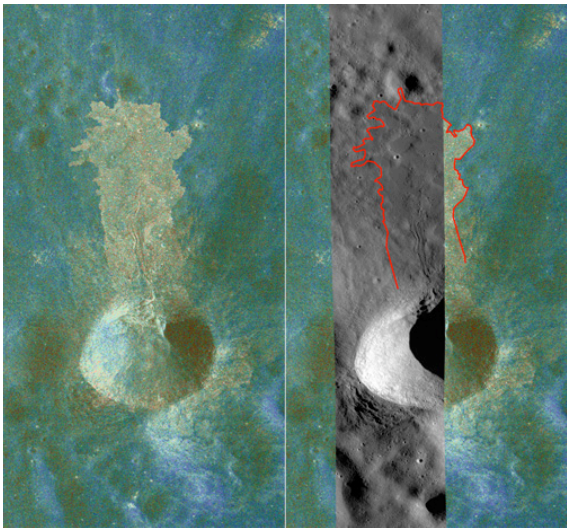

Figure 2: Image of a 7.5 km diameter crater on the south rim of Donner crater, with a candidate melt flow that extends nearly four crater radii from the crater rim.

Finally, we compared the direction of the most extensive melt deposits with the direction of the rim crest low, as determined from the Lunar Orbiter Laser Altimeter (LOLA) digitial elevation models (DEM). We found that in 5 out of 9 cases, these two directions coincided exactly (Fig. 3). This is consistent with the results obtained by [1], who found that 50% of the impact melts studied had flow directions coincident with the rim crest low. Of the remaining four cases, two showed flow directions that coincided with the downrange direction of impact, as determined by the observed ejecta pattern. Impact direction could not be determined for the final two craters.

Conclusions: We discovered nine new impact melt flow candidates in the Mini-RF data set. These melt flows extend further from the crater rim than previously thought possible, and include craters as small as 3 km in diameter. Of the candidate flows, 56% coincide with the direction of rim crest flow, suggesting pre-existing topography plays an important role in final melt flow morphology.

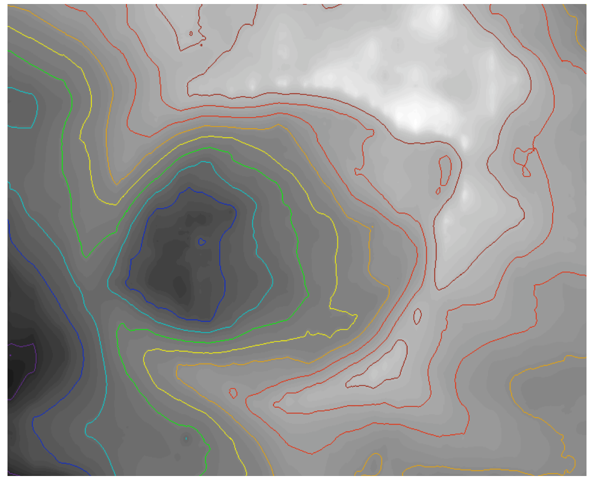

Figure 3: LOLA DEM of the crater Gerasimovich D, with elevation contours marked every 500 m. The lowest rim crest elevation correlates exactly with the direction of the candidate impact melt flow.

References: [1] Hawke B. R. and Head J. W. (1977) In: *Impact and explosion cratering,* Pergamon Press, New York, NY, pp. 815. [2] Campbell B. A. et al. (2010) *Icarus, 208,* 565. [3] Neish C.D. et al. (2011), *Icarus, 215*, 186. [4] Carter L.M. et al. (2011), *JGR*, in press. [5] Kramer G. Y. et al. (2011) *JGR, 116*, E00G18. [6] Cintala M.J. and Grieve R.A.F. (1998) *Meteoritics & Planet. Sci., 33,* 889. [7] Osinski G.R. et al. (2011) *EPSC, 310*, 167.

Table 1: Impact melt candidates discovered by Mini-RF. Bolded entries represent those craters whose flow directions coincide with the rim crest low. Italicized entries represent those craters whose flow directions coincide with the downrange direction of impact.

Crater	Diameter (km)	Lat. (°)	Long. (°E)	Max. distance of melt from rim (crater radii)	Direction of most extensive melt deposits	Direction of rim crest low
W of Riccius	*2.8*	*-37.5*	*23.1*	*3.4*	*SW*	*N*
NW of Compton	4	59.5	100.5	2.4	SW	SE
S Rim of Donner	**7.5**	**-32.2**	**97.9**	**3.8**	**N**	**N**
W Rim of Fizeau	**9**	**-58.7**	**-137.0**	**2.4**	**E**	**E**
N of Chebyshev	**11**	**-28.8**	**-132.8**	**1.6**	**S, NE**	**S, NE**
SE of Pavlov	*13*	*-30.9*	*145.5*	*1.0*	*W, NW*	*SE*
E of Michelson	**15.5**	**7.5**	**-116.3**	**1.0**	**NE**	**NE**
Whipple	15.7	89.1	118.2	2.4	S	W
Gerasimovich D	**26**	**-22.3**	**-121.6**	**2.0**	**W**	**W**