NEW INSIGHTS INTO LUNAR PROCESSES AND HISTORY FROM GLOBAL MAPPING BY MINI-RF RADAR, D.B.J. Bussey[1], and P. D. Spudis[2], and the Mini-RF Team [1]Applied Physics Laboratory, Laurel MD 20723, [2]Lunar and Planetary Institute, Houston TX.

Introduction: Mini-RF is a lightweight Synthetic Aperture Radar (SAR) on NASA's Lunar Reconnaissance Orbiter, launched in June 2008. It is the sister instrument to the Mini-SAR which flew on the Indian Chandrayaan-1 lunar orbiter [1]. Mini-RF operates in either S band (12.6 cm) or X-band (4.2 cm), and can acquire data at two different spatial resolutions; baseline (150 meters) or zoom (30 meters). Mini-RF uses an hybrid dual polarization architecture, transmitting a left circular polarized signal and then receiving Horizontal and Vertical linear polarization signals, as well as the phase information between the two [2]. This arrangement preserves all of the information conveyed by the reflected signals and from these data, we determine all four Stokes parameters of the backscattered field. The Stokes parameters offer a very powerful tool to investigate the nature of lunar radar backscatter. In addition to calculating the response at both circular polarizations, and therefore also the circular polarization ratio, it is also possible to ascertain properties which should help to distinguish between multiple surface reflections versus volume scattering. This distinction is key to determine if the nature of the returned signal is due to an ice-regolith mixture, or simply rocks on the lunar surface. Examples of these derived Stokes properties include the Degree of Polarization and the Degree of Linear Polarization [2].

Operations: Mini-RF activities primarily fall into one of three categories: 1. LCROSS support, 2. Polar mapping and 3. Non-polar imaging.

LCROSS Support. During the commissioning portion of the LRO mission, whilst the spacecraft was in an elliptical orbit, Mini-RF acquired data of potential impact sites in support of the LCROSS mission [3]. Mini-RF obtained S-band zoom data of a large fraction of the south polar region, including at least 5 potential LCROSS target sites (Fig. 1). These were one of the data sets used by the LCROSS team to select their final target site inside Cabeus crater. Post impact, analysis of the Mini-RF data provides additional insight into the nature of the volatiles that LCROSS detected. We do not see any enhancement in Circular Polarization Ratio (CPR) values inside Cabeus. Additionally, mean CPR vaues for the Cabaeus floor are very low (~0.2 or less), indicating a very smooth, block-poor surficial layer. It is likely that water ice here is in the form of a pore-space fill deposit, rather than decimeter-sized, cohesive blocks.

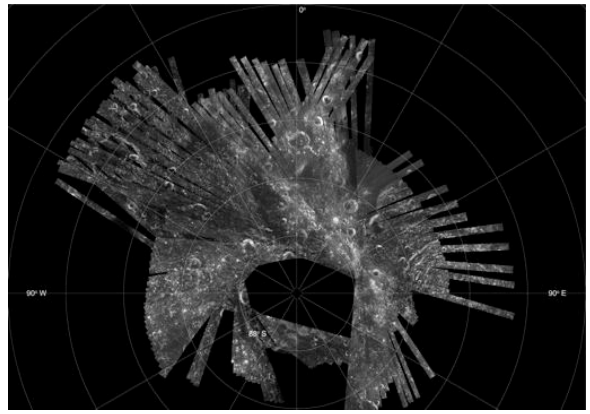

Figure 1. S-zoom mosaic of the south polar region acquired in support of LCROSS targeting.

Polar Mapping. Mini-RF has conducted two polar mapping campaigns. The first occurred June-August 2010 and concentrated on acquiring S-zoom data within 20° latitude of both poles. This campaign was highly successful and succeeded in acquiring >95% areal coverage at both poles (Fig. 2).

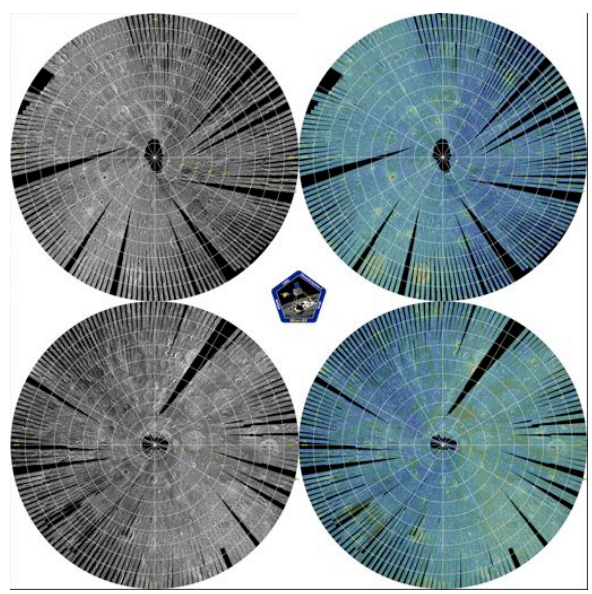

Figure 2. West-looking polar mosaics for both poles. Covering from 70° to 90°. The left-hand mosaics show radar albedo; right-hand mosaics show CPR.

Comprehensive polar coverage was obtained in both east and west look directions. Coverage include some

significant small craters, inside the craters Rozhdestvensky and Peary craters near the north pole, which analysis of Mini-SAR data had shown to have elevated CPR values in their permanently shadowed interiors which is consistent with the presence of ice deposits [4]. Additionally, we were able to slightly roll the spacecraft during data takes to image the interior of the south pole crater Shackleton, an area whose geological context and meaning has been in dispute [e.g., 5, 6]. The new data indicate that CPR within Shackleton has a complex distribution that is consistent with different interpretations [7], but we now see the full crater intrior at optimum view geometry. Work continues to place these data in their proper context. During December 2010 Mini-RF is conducted another polar campaign, this one focused on acquiring X-baseline data within 10° of the north pole.

Non-Polar Imaging. Mini-RF has been taking advantage of excess downlink capacity to acquire nighttime imaging of non-polar targets. The Mini-RF target database includes the potential Constellation exploration and landing sites of scientific and exploration interest. The optimal goal is to acquire global S-zoom coverage of the entire Moon. During the first year of operations Mini-RF acquired ~46% of the surface in S-band zoom (Fig. 3). With additional imaging campaigns, we hope to vastly increase that number.

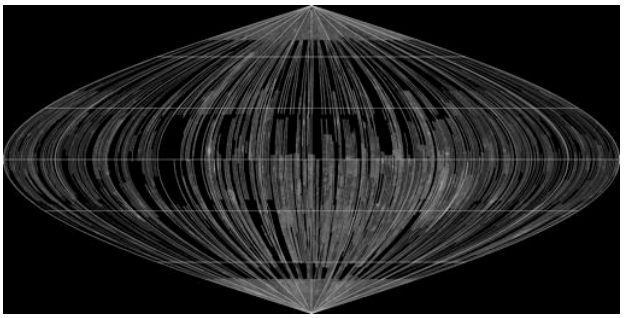

Figure 3. Sinusoidal-projection global mosaic showing the first year's S-band coverage. The projection has a center longitude of 180°.

Mapping large portions of the lunar surface with contiguous, systematic radar has provided new information about geologic processes. One of the most striking processes illustrated is impact cratering. The Mini-RF data are very useful in the study of ejecta blankets , their surface roughness and how they change with time, and the distribution and setting of impact melt deposits (Fig. 4). The radar data clearly show the boundaries between the continuous and discontinuous parts of ejecta blankets. They also show the presence of ejecta (particularly impact melt ejecta) that are not always visible in the optical images (Fig. 5). Such images can be used to map the transition between aa and pahoehoe style flow emplacements.

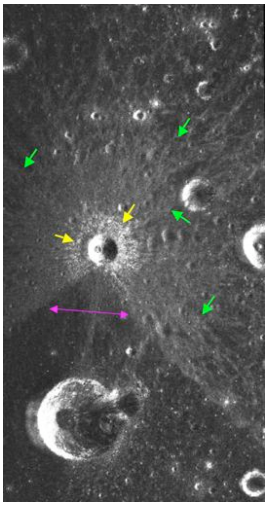

Figure 4. SAR image showing a portion of Mare Nubium, showing the inner continuous ejecta (yellow arrows), discontinuous outer field (green arrows), and asymmetric ejecta distribution (purple arrow shows excluded ejecta zone), indicating formation in an oblique impact.

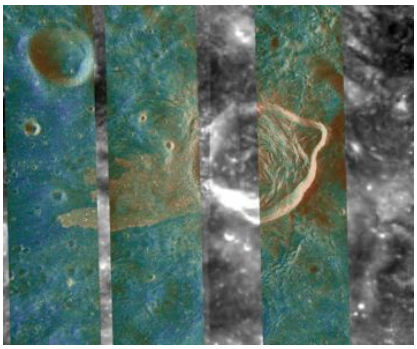

Figure 5. Flow of impact melt west of the crater Gerasimovich D, indicated by high CPR.

Conclusions: Mini-RF is acquiring high quality data of the radar backscatter properties of the entire lunar surface. The data are archived in NASA's Planetary Data System are available to all lunar researchers.

References: [1] Spudis P.D. et al., (2009) *Current Science*, **96**, 533. [2] Raney K. et al. (2010) IEEE Proc. In press [3] Neish C.D. et al., (2010) *LPSC* XLI. [4] Spudis P.D. et al. (2010) GRL 37, L06204, doi:10.1029/2009GL042259. [5] Nozette S. et al. (1996) Science **274**, 1495. [6] Campbell D. et al. (2006) Nature **443**, 835 [7] Thomson B. et al. (2011) this volume