YOUNG, RAYED, AND RADAR-BRIGHT CRATERS AT THE LUNAR POLES.

L. M. Carter[1], R. R. Ghent[2], J. L. Bandfield[3] and D. B. J. Bussey[4], [1]NASA Goddard Space Flight Center, Planetary Geodynamics Lab Code 698, Greenbelt, MD 20771, lynn.m.carter@nasa.gov, [2]Department of Geology, University of Toronto, 22 Russell St., Toronto, ON, M5S 3B1, Canada, [3]Earth and Space Sciences, University of Washington, Seattle, WA, [4]The Johns Hopkins University Applied Physics Lab, Laurel, MD, 20723.

Introduction: The lunar poles are interesting for their extreme environment and shadowed terrains. Like the rest of the Moon, the poles have been extensively shaped by impacts. The lunar south pole is particularly interesting because of its proximity to both very old (South Pole Aitken) and very young (Orientale) basin impacts. The poles are also possible sites for future exploration missions.

Radar orbital instruments typically use a uniform viewing geometry and provide a consistent illumination pattern in polar areas that are partially or permanently shadowed at optical wavelengths. Radar waves are also capable of penetrating into the surface and can reveal buried rocks and structures. Radar data can be used to track extended ejecta (including rays) and to identify impact directions, and identification of rays and secondary craters provides constraints on surface ages [1].

Radar images and polarimetry of craters can also be used to understand lunar regolith development. Lunar craters of Lower Imbrium age or younger typically have a radar dark halo that appears farther from the rim than the blocky continuous ejecta [2]. These dark haloes are not seen for older craters, and it is likely that they are gradually removed as the regolith is altered through subsequent impacts [2]. Observations at shorter, 12.6-cm wavelengths show that the inner halo boundary occurs farther from the rim at shorter wavelengths, because the shorter wavelength radar can detect small rocks that traveled farther from the impact site [3]. However, the outer boundaries of the halos are the same at both wavelengths, suggesting that the halos are thick mantling deposits and not simply reworked regolith that was present prior to the impact [3].

Here we focus on young, radar-bright, and rayed craters at latitudes higher than 70 degrees. We use a variety of data sources to better understand the ejecta patterns, rock abundance, degree of burial by regolith development, and relative age of the craters.

Data sources: Near-side polar regions have been previously observed by ground-based radar at S-band (12.6 cm wavelength) and P-band (70 cm wavelength) [4, 5], while far-side polar areas were imaged at decimeter wavelengths for the first time by radar instruments on Chandrayaan-1 and Lunar Reconnaissance Orbiter (LRO).

The Mini-RF instrument on LRO operates at wavelengths of 12.6 cm (S-band) and 4 cm (C-band) with a resolution of 15x30 meters [6]. Mini-RF polarimetric imaging data have been collected over 98% of the lu-

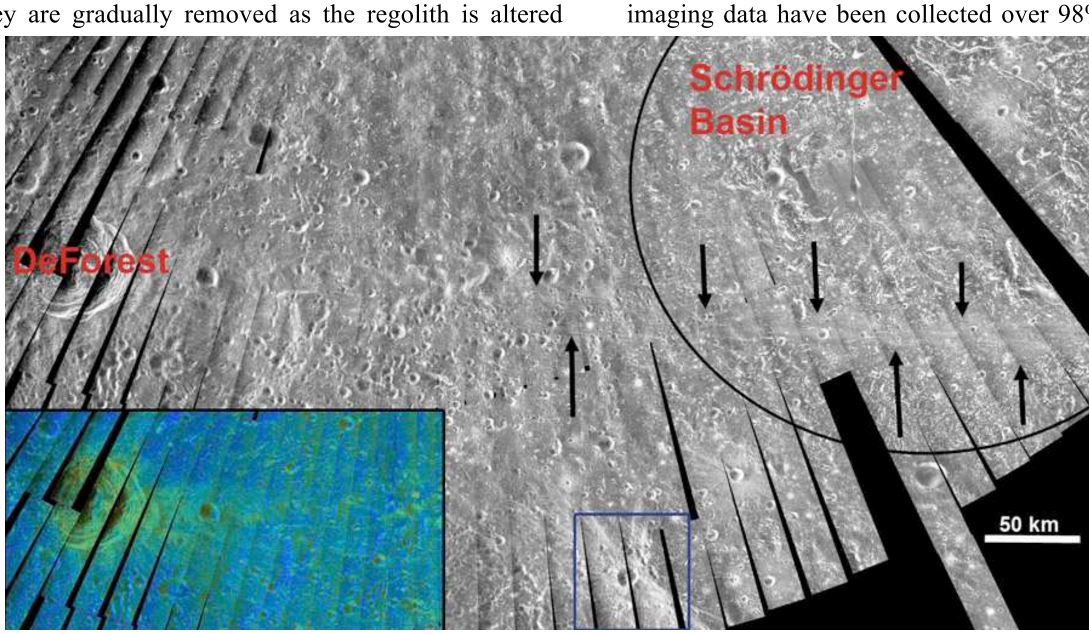

Fig. 1: A total backscatter power mosaic of Mini-RF S-band data showing deForest crater and streaks crossing Schrödinger Basin. The inset is a circular polarization ratio image overlaid on the total power image. A blue box marks the crater in Figure 3. Image is a polar projection with south pole towards the top.

nar poles, and most locations were mapped in both a right- and left-looking geometry. This data set allows for mosaicing of large areas of the pole, and the different look angles help to constrain the effects of viewing geometry on the polarimetric data. Two polarimetric products often used for geologic analysis are the circular polarization ratio (CPR), which can be used as a measure of roughness, and the degree of linear polarization, which can be used to find areas with enhanced subsurface scattering [7].

Thermal infrared (8-100 μm) data, such as those collected by the Diviner radiometer on LRO [8], are sensitive to the thermophysical properties of the surface and near-surface, and provide complimentary information to the radar data. For some areas at latitudes less than 80 degrees, we use Diviner-derived rock abundance and regolith temperature maps [9] to provide additional information about the presence of surface and near-surface rocks.

Results: Mini-RF data have revealed a number of previously unknown ejecta features associated with polar craters. The most dramatic of these is a radar-bright streak that extends from DeForest crater may be a newly discovered crater ray.

DeForest is a 57 km diameter crater located at 77.3° S and 197.9° E. A mosaic of S-band data strips shows that high-CPR values are concentrated on the side of the crater closest to Schrödinger Basin (Fig. 1). The radar-bright and enhanced-CPR streaks are sporadically visible in a path toward the basin (arrows). Bright streaks are also clearly visible against the dark smooth terrain within the basin (Fig. 2). The radar-bright streaks look similar to those seen in radar images of Tycho and Copernicus [1]. The streaks within Schrödinger Basin are up to ~550 km from the DeForest crater rim. Other craters could potentially have produced the ray, but the orientation of the ray suggests that DeForest is a likely source crater. No enhancement in rock abundance or regolith temperature is observed along the ray or surrounding DeForest, suggesting that the rocks comprising the ray may be partially buried.

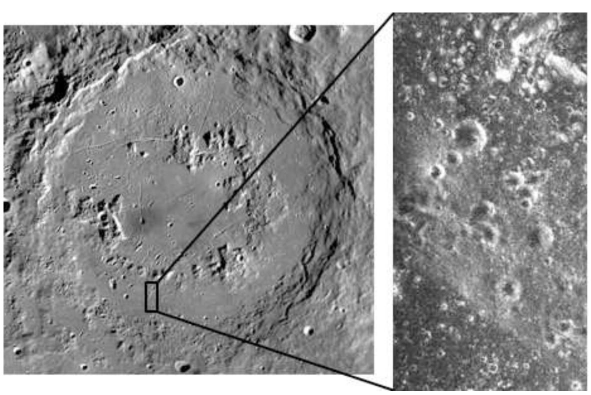

Fig. 2: Close-up of radar-bright streaks (right) crossing flat terrain in Schrödinger Basin (LROC WAC image, left). Radar image is ~15 km across.

Mini-RF data have also revealed interesting extended ejecta patterns surrounding smaller craters. An unnamed crater at 71.5° S and 162.5° E has a clear zone-of-avoidance pattern in the radar data (Fig. 1) and an unusual comb-like ejecta pattern (Fig. 3). The proximal ejecta blanket surrounding this crater has an increased rock abundance and regolith temperature which suggests that there are abundant surface rocks. Other polar craters display radar dark haloes and unusual polarization properties. A survey of these young craters in the polar regions can be used to better understand the relative ages of some of the craters, as well as to assess regolith properties and development across the poles.

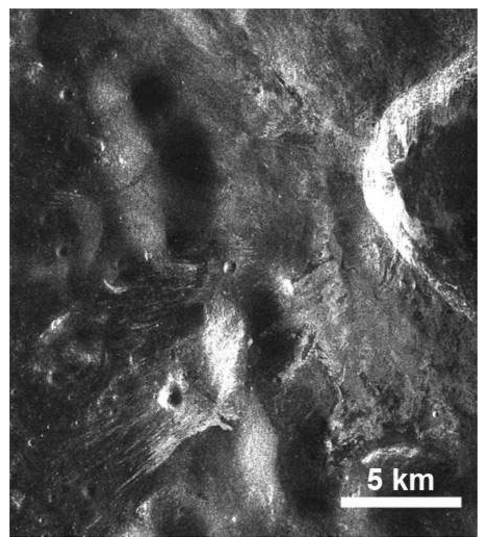

Fig. 3: Mini-RF S-band total power image of complex ejecta associated with an unnamed oblique impact crater. North is towards the top; image is cylindrical projection.

References: [1] Wells, K. S. et al. (2010) *JGR, 115,* E06008, doi:10.1029/2009JE003491. [2] Ghent, R. R. et al. (2005) *JGR*, *110*, E02005, doi:10.1029/ 2004JE002366. [3] Ghent, R. R. et al. (2010) *Icarus, 209,* doi:10.1016/j.icarus.2010.05.005. [4] Campbell, B. A. et al. (2007), *IEEE Trans. Geosci. Rem. Sens.*, *45*, 4032. [5] Campbell, D. B. et al. (2006), *Nature*, *443*, 835. [6] Raney, R. K et al. (2011), *Proc. IEEE,* 99, doi: 10.1109/JPROC.2010.2084970. [7] Carter, L. M. et al. (2011), *Proc. IEEE,* 99, doi: 10.1109/JPROC.2010.2099090. [8] Paige, D. A. et al. (2010), *Space. Sci. Rev., 150*, 125-160. [9] Bandfield, J. L. et al. (2011) *JGR, 116,* E00H02, doi:10.1029/2011JE003866.