70-cm Radar Properties as a Guide to Mega-Regolith Differences Across the Moon's Southern Highlands.
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Introduction. The distribution of small (1-16 km diameter) craters with radar-bright ejecta, as well as the overall background radar echo strength, at 70-cm wavelength are not uniform across the southeastern nearside lunar highlands. The region north of a line between Tycho and Janssen (~45° S) has a lower radar brightness, and a much larger population of radar-bright craters, than the highlands south of this line. The abundance of these small radar-bright craters likely reflects the depth of comminuted material above competent large blocks, while the general backscatter strength reflects the meter-scale rock population and loss properties of the upper 10-50 m of the regolith. These differences in the highlands "mega-regolith" may be associated with the age and thickness of basin ejecta deposits.

Radar Data. Dual-polarization radar image data at 70-cm wavelength were collected for the southern highlands in 2002-2006 by transmitting from the Arecibo (1000 foot) telescope and receiving the echoes at the Green Bank (300 foot) radio telescope [1]. The image data are focused to maintain the optimum achievable spatial resolution of a few hundred meters over the illuminated area. Figure 1 shows same-sense (SC), or depolarized, radar echoes for the southern highlands. The SC echoes result from diffuse scattering associated with meter-sized blocks/rocks on the surface or in the upper 10-50 m of the subsurface (Fig. 1).

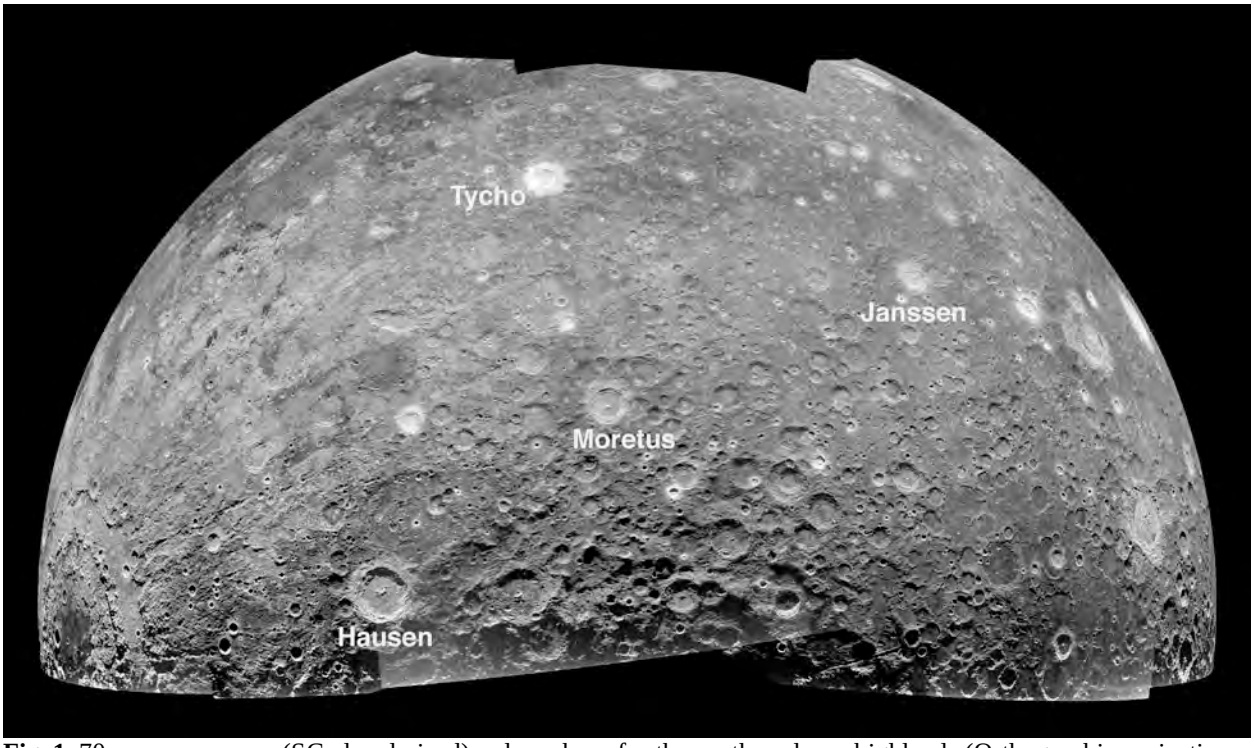

Fig. 1. 70-cm same-sense (SC, depolarized) radar echoes for the southern lunar highlands (Orthographic projection centered on the south pole). Bright radar echoes due to blocky ejecta surround Eratosthenian- and Copernican-period craters. There are few small (1-16 km) radar bright craters and a brighter overall background in the area of the south-eastern highlands below a line from Tycho to Janssen, while above this line there are significantly more radar-bright craters in an area with a darker radar background.

Observations.

70-cm Radar Brightness. The Moon's southern highlands are a complex, overlapping sequence of materials deposited by the major basins, going back to the South-Pole-Aitken event. The line defined approximately by Tycho and Janssen craters marks the transition between units mapped as pre-Nectarian basin materials and later Nectarian- and Imbrian-period deposits [2]. The radar data offer a new view of these changes and the effects of later events.

It is clear from Fig. 1 that Orientale ejecta has a large influence on the near-surface properties sensed by the 70-cm radar. There is a lobe of rocky Orientale ejecta that causes an increase in the overall radar brightness of the region north of Hausen and Moretus, and extending to Janssen. North and south of this bright region are lower-return areas with apparently much less near-surface debris from Orientale.

Craters with Radar-bright Ejecta. To the north of the Tycho-Janssen line, there are many more craters, 1-16 km in diameter, with radar-bright ejecta than are present in the highlands extending south toward the pole (Table 1). This change in crater density approximately follows the shift from low 70-cm return to higher returns in the Orientale-affected region, but the craters are so sparse that a gradual decline in their abundance toward the south is also possible. The density of small radar bright craters across the entire southern highlands is significantly less than in the maria.

Area	1-2 km Diam	2-4 km Diam	4-8 km Diam	8-16 km Diam
Mare Humorum	138	166	97	78
North of Tycho-Janssen Line	8	11	10	18
South of Tycho-Janssen Line	0	2	9	0

Table 1. Density of small radar bright craters, per 10^6 km^2, for the radar-dark and radar-bright highland areas and the floor of Mare Humorum.

Interpretation. The radar characteristics of small (1-16 km diameter) craters depend upon the target material (e.g., mare or megaregolith), as small impacts excavate ejecta to depths of ~1/10 of their diameter (i.e., from 100 m to 1.6 km). Small impacts into mare targets will have abundant competent meter-sized ejecta blocks excavated from solid lavas. These meter-sized competent ejecta blocks should survive to ages commensurate with a few meters of meteoritic gardening (approximately Eratosthenian-period age). The radar-bright ejecta disappears when gardening depths reach several meters (about late Nectarian age) [3]. In contrast to the maria, small craters in the highland mega-regolith will have ejecta that are a mixture of already-comminuted material and "fresh" meter-sized blocks. The thickness of well-comminuted material overlying large competent terra blocks likely differs across the highlands with proximity to the centers of various basins and their relative age [4-5].

Our preliminary analysis of the small crater distribution across the southern highlands suggests an increase in the depth of well-comminuted material as we move south across the approximate Tycho-Janssen boundary. Craters north of this line as small as a few km have excavated blocky debris to form radar-bright ejecta blankets, whereas most craters south of this line have not. The sizes of the radar bright craters, with the D/10 estimate for excavation depth, suggests a thickness of only a few hundred meters in the area north of the Tycho-Janssen line, and 2 km or more in the region south of this line.

This may result from an increasing depth of material emplaced by the South-Pole-Aitken and Australe basin events. These may be the only impacts large enough to have sculpted the highlands over a broad region on vertical scales of a few km. If correct, this suggests that subsequent Nectarian- and Imbrian-period basin ejecta had relatively little effect on the mega-regolith thickness difference from north to south on the nearside (e.g., tens to hundreds of meters rather than km).

Summary. The distribution of small, 70-cm radar bright craters across the southern lunar highlands is attributed to differences in the large-scale blockiness of the first few kilometers of the mega-regolith. These differences may be associated with the South Pole Aitken and Australe cratering events. Thus, the 70-cm radar data may provide a "calibration" for studies of basin ejecta thickness across the lunar nearside.

References: [1] Campbell, B.A., et al., *IEEE Trans. Geosci. Rem. Sensing, submitted*, 2006; [2] Wilhelms, D., Geologic History of the Moon, USGS #1348, 1987; [3] Thompson, T.W., et al. proc. Conf. Lunar Highlands Crust, 1980; [4] Moore, H., et al., *Proc. Lun. Plan. Sci. Conf. 5*, 71-100, 1974.; [5] Petro, N., and C.M. Pieters, LPSC XXXVII, abs. 1868, 2006.