Differences in the subsurface block distributions across the Moon's Southern Highlands.

Thomas. W. Thompson[1], Bruce A. Campbell[2], Rebecca R. Ghent[3], and B. Ray Hawke[4]

[1] JPL, Pasadena, CA 91109: Thomas.W.Thompson@jpl.nasa.gov; Ph: +1 818 354-3881, Fax: +1 818 393-5285; [2]Center for Earth and Planetary Studies, Smithsonian Inst., MRC 315, Washington, D.C 20013, [3]Dept. of Geology, University of Toronto, Toronto, ON, Canada, M5S 3B1 [4]Hawaii Inst. of Geophysics and Planetology, University of Hawaii, Honolulu, HI 96822.

Introduction. The distribution of small (1-16 km diameter) craters with radar-bright ejecta is not uniform across the southeastern nearside lunar highlands. The region north of a line between Tycho and Janssen (~45° S), a region associated with Imbrian-aged basin deposits, has more radar-bright craters than the highlands south of this line. The abundance of these small radar-bright craters likely reflects a difference in the distribution of the larger (100 m to 1 km) blocks in the Imbrian-aged basin ejecta to the north as compared with older pre-Nectarian- and Nectarian aged ejecta deposits to the south. Thus, this difference in the populations of these small radar bright craters provides insights into the nature of the highlands "mega-regolith".

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. Fig. 1 shows same-sense (SC, depolarized) radar echoes for the southern highlands. The SC echoes are dominated by diffuse scattering associated with meter-sized blocks/rocks on the surface or in the upper 10-50 m of the subsurface. Thus, high 70-cm SC returns result from an abundance of blocks, whereas low returns signify a paucity of wavelength-scale scatterers in the upper 10-50 m of regolith.

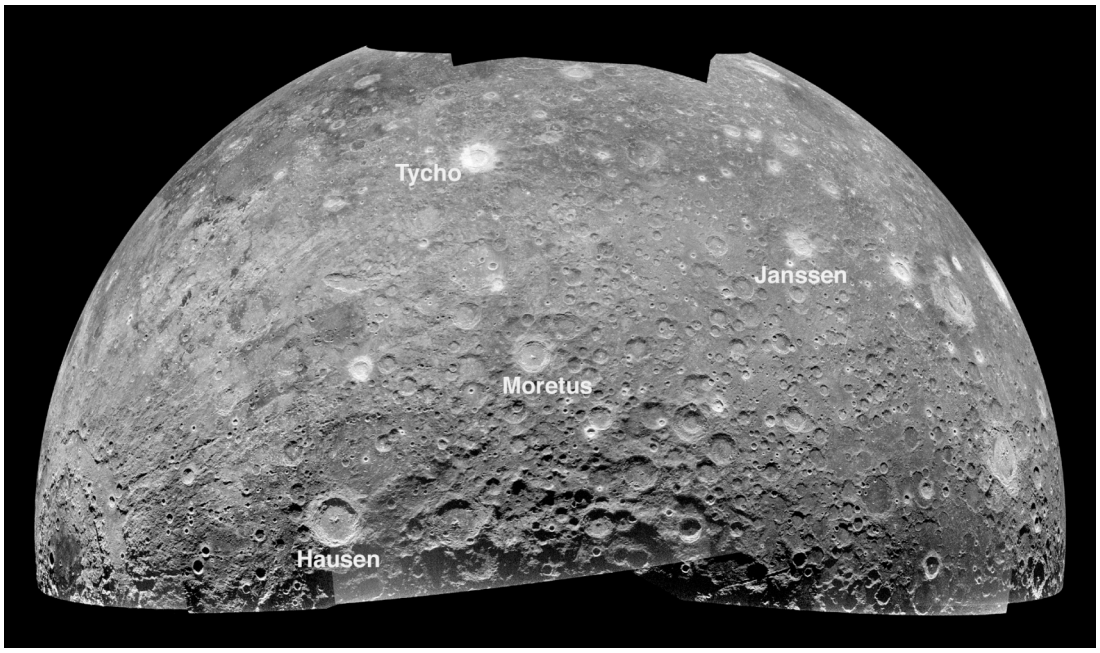

Fig. 1. 70-cm same-sense (SC, depolarized) radar echoes for the southern lunar highlands (orthographic projection centered on the south pole). Bright radar echoes due to blocky ejecta surround Eratosthenian- and Copernican-period craters. There are few small (1-16 km) radar bright craters in the area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

Observations.

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 at about 45° S marks the transition between units mapped as younger Imbrian-aged basin materials to the north and older pre-Nectarian and Nectarian deposits to the south [2]. Our radar data offer new insights into differences between these two general areas.

Craters with Radar-bright Ejecta. To the north of the Tycho-Janssen line, there are 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 Imbrian-aged deposits to older basin deposits to the south. The density of small radar-bright craters across the entire southern highlands is significantly less than in the maria (represented here by Mare Humorum).

Area	1-2 km Diam	2-4 km Diam	4-8 km Diam	8-16 km Diam
Mare Humorum	138+/-44	166+/-48	97+/-37	28+/-20
North of Tycho-Janssen Line	8+/-2.3	11+/-2.7	13+/-2.9	18+/-3.4
South of Tycho-Janssen Line	5+/-2.7	8+/-3.3	12+4.1	10+/-3.6

Table 1. Density of small radar bright craters, per 10^6 km^2, for the floor of Mare Humorum as well as the northern and southern portions of the south-eastern lunar highlands. Density of 4-8 km mare craters is close to a production curve with a decrease in the 1-4 km diameter range due either to loss of detection from resolution or from shorter radar-bright lifetimes of these smaller craters.

Interpretation. The 70-cm radar characteristics of small (1-16 km diameter) craters depend upon the abundance of blocks ~1m and larger in diameter excavated by the impact. Small impacts excavate ejecta to depths of ~1/10 of their diameter (i.e., depths from 100 m to 1.6 km), which coincides with the approximate depths of the mega-regolith. The availability of blocks in turn depends upon the target material. Mare targets are characterized by competent lavas overlain by relatively thin regolith, and thus provide a ready source of blocks. For small craters in the maria, meter-sized competent blocks in the ejecta should survive to ages commensurate with a few meters of meteoritic gardening (approximately Eratosthenian-period age). The radar-bright ejecta disappear when gardening depths reach several meters (about late Nectarian age) [3]. By contrast, highland megaregolith is much thicker, and small craters in the highland megaregolith will have ejecta that are a mixture of already-comminuted material and "fresh" meter-sized blocks. Distinct highland terrains differ from one another in megaregolith thickness as well as in the relative densities of large (100 m - 1 km) blocks, depending on their ages and proximities to basin centers and their relative ages [4-5].

Our preliminary analysis of the small radar-bright 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 on average impacted more 100 m-1 km sized blocks in the megaregolith than those to the south, providing more blocky debris to form radar-bright ejecta. Most craters south of this line have impacted an older, more comminuted megaregolith with significantly fewer km-size blocks.

References: [1] Campbell, B.A., et al., *IEEE Trans. Geosci. Rem. Sensing, submitted*, 2007; [2] Wilhelms, D., Geologic History of the Moon, USGS #1348, 1987; [3] Thompson, T.W., et al. proc. *Proc. Highlands Crust Conference*, 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.