RADAR CIRCULAR POLARIZATION RATIO DETERMINATION OF TYCHO SECONDARY CRATERS. K. S. Wells,[1] D. B. Campbell,[1] B. A. Campbell,[2] and L. M. Carter[2], [1]Cornell University, 514 Space Sciences Building, Ithaca, NY 14853, kassiew@astro.cornell.edu, campbell@astro.cornell.edu, [2]Smithsonian Institution, campbellb@si.edu, carterl@si.edu.

Introduction: The study of impact craters has important implications throughout planetary science, particularly for determining the age of surfaces for which no radio-isotope information is available. In particular, the number density of "small" craters (D < 1 km) must be well constrained for accurate dating of "young" surfaces in the Solar System [1,2]. Contamination by secondary craters increases the uncertainty in counts of the small diameter population [1,2], and we present here a method by which small secondary craters at large distances from their forming primaries can be identified via circular polarization ratio (CPR) radar maps. Once identified, the secondary craters can be removed from the "true" crater count to achieve corrected size-frequency distributions that can be used for age determination.

Discussion: Using radar maps obtained from bistatic observations with the Arecibo Telescope 2.38 GHz transmitter and the GBT receiver, craters were counted in a 1000 km^2 region near the lunar South Pole. The Newton-A Crater (D=64 km; 79.7° S, 19.7° W) basin lies in the southern-most extent of a Tycho Crater (D=85 km; 43.3° S, 11.2° W) ray at a distance of approximately 1000 km from that fresh (~96 Myr [3]) primary. Small craters on the floor of this large crater were counted from opposite-sense circularly polarized (OC) radar images. Then, the secondary population in this total sample was classified using circular polarization maps of the same area (Figure 1). A circular polarization ratio map is obtained by dividing the received sense of circular polarization that is the same (SC) as that transmitted by the signal received in the opposite sense (OC) as transmitted. For specular reflection, then, the circular polarization ratio (CPR) is zero. Rough, blocky terrains and ices can have high CPR values [4,5], a property which allows fresh ejecta blankets to be mapped in the CPR.

In particular, the CPR maps of Newton-A Crater reveal linear clusters of small craters with elongated ejecta blankets (henceforth: "tails") parallel to the direction of the Tycho ray. Craters exhibiting these tails were classified as secondary craters. In "unresolved" areas where a CPR bright tail extended across more than one crater, ownership of the bright ejecta was attributed to fresh-rimmed craters. This is because Tycho secondaries would be concurrent with the primary formation around 96 Ma, and therefore appear fresh. Conversely, craters with significant rim erosion in unresolved tails were presumed to lie beneath the bright ejecta and as such were not classified as secondary craters. At Newton-A, the secondary count totaled 56, or 43.8% of the population. In addition to total counts, the size frequency distributions (SFD's) of the secondary and corrected small primary populations were determined. SFD's are typically expressed as a power-law in cumulative crater density above a given diameter versus diameter. The secondary population identified here was found to have a power-law index of *b=-2.5*, while the corrected primary population was characterized by a slightly steeper slope of *b=-3.2*.

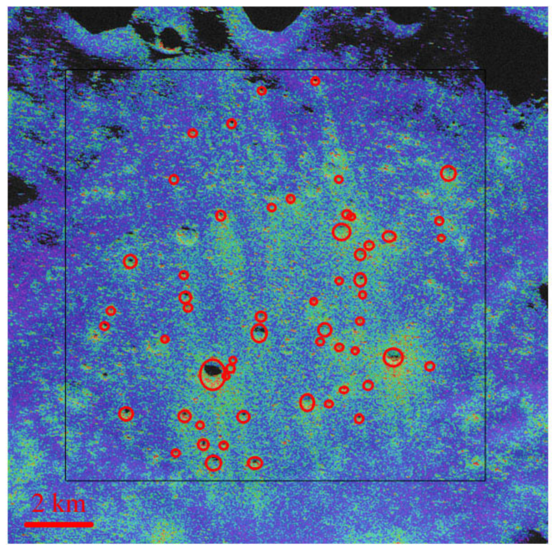

Figure 1. Secondary craters identified on the floor of Newton-A Crater near the lunar South Pole. Green "tails" of high CPR associated with the secondary craters run parallel to the Tycho crater ray that stretches across the crater floor.

To interpret these values, we consider several competing perspectives. In his preliminary work in the 1960's, Shoemaker studied the cratering rates on the Moon as a function of diameter and identified two "branches" of differing slope in the power law characterizing the relationship between crater diameter and cumulative density [6,7]. The shallower branch, with power law index around *b=-2*, he labeled "primary" and attributed to impacts from materials originating from space. In contrast, the steeper (power law index around *b=-3* or *b=-4*) "secondary" branch he interpreted as the footprints of ejecta from large primary impacts [6,7].

Since the days of Shoemaker's early work, arguments concerning the origin of the secondary and primary branches have come under increased scrutiny. Some workers [1,2,8-10] claim that the secondaries comprise the steep branch and act as a significant contaminant (~95% of craters with D < 1 km on Europa [8]) of crater counts used for age dating. Others [11] provide evidence that the contamination from secondary impacts on Martian surfaces, for instance, may be minimal (~10% of craters with D <1 km [11]). Still others [12,13] argue that the steep secondary branch stems not from primary ejecta fragments at all, but from a smaller class of inter-planetary bolides. The steep slopes of the small primary crater populations in our preliminary work seem to support this latter opinion. Another example of a primary crater population with steep power-law SFD occurs on the asteroid Gaspra, which exhibits the typical lunar secondary and primary SFD branches despite a surface gravity too weak to hold onto the primary ejecta necessary to form a "secondary" crater [13,14].

Summary: In this study, 128 small craters were counted in a larger crater basin within the furthest extent of a Tycho Crater ray. Secondary craters were identified within the total sample counted by their elongated CPR ejecta blankets parallel to the Tycho ray. Presumably, the 56 secondary craters classified here are associated with the Tycho primary event. The power-law slope of the size frequency distribution of the secondary craters in Newton-A was $b=-2.5$, while the corrected primary population had a power-law slope of $b=-3.2$. The shallow secondary slope and steeper small primary slope could lend credence to the hypothesis that the "secondary branch" identified initially by Shoemaker is not in fact the result of secondary catering, but perhaps of a small-diameter asteroid population. However, additional regions need to be examined before this evidence can be considered conclusive.

References:

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