LUNAR CHRONOLOGY THROUGH REMOTE SENSING: UNDERSTANDING THE POPULATION OF YOUNG CRATERS ON THE MOON. R. R. Ghent[1,2] , E. S. Costello[3, 4], C. J. T. Udovicic[1], S. Mazrouei[1], and W. F. Bottke[5] [1]Dept of Earth Sciences, University of Toronto, Toronto, Canada; ghentr@es.utoronto.ca, [2]Planetary Science Institute, Tucson, AZ, USA; [3]Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI, USA; [4]Dept. of Geology and Geophysics, University of Hawaii, Honolulu, HI, USA; [5]Southwest Research Institute, Boulder, CO, USA.

Introduction: The bombardment history of the Moon holds the key to understanding important aspects of the evolution of the Solar System at 1AU. It informs our thinking about the rates and chronology of events on other planetary bodies and the evolution of the asteroid belt. In previous work [1], we established a quantitative relationship between the ages of lunar craters and the rockiness of their ejecta. That result was based on the idea that crater-forming impacts eject rocks from beneath the regolith, instantaneously emplacing a deposit with characteristic initial physical properties, such as rock abundance. The ejecta rocks are then gradually removed and / or covered by a combination of mechanical breakdown via micrometeorite bombardment, emplacement of regolith fines due to nearby impacts, and possibly rupture due to thermal stresses. We found that ejecta rocks, as detected by the Lunar Reconnaissance Orbiter Diviner thermal radiometer [2], disappear on a timescale of ~1 Gyr, eventually becoming undetectable by the Diviner instrument against the ambient background rock abundance of the regolith.

The "index" craters we used to establish the rock abundance—age relationship are all larger than 15 km (our smallest index crater is Byrgius A, at 18.7 km), and therefore above the transition diameter between simple and complex craters (15-20 km). Here, we extend our analysis to include craters smaller than the transition diameter. It is not obvious a priori that the initial ejecta properties of simple and complex craters should be identical, and therefore, that the same metrics of crater age can be applied to both populations. We explore this issue using LRO Diviner rock abundance and a high-resolution optical maturity (OMAT) dataset derived from Kaguya multispectral UV/VIS data [3] to identify young craters to 5 km diameter. We examine the statistical properties of this population relative to that of the NEO population, and interpret the results in the context of our recently documented evidence for changes in the flux of impactors that create larger craters [4].

Rocky craters to 5 km: Using the latest LRO Diviner rock abundance dataset (available from the PDS at http://pds-geosciences.wustl.edu/missions/lro/diviner.htm), which covers the region between 80ºN and 80ºS, we find 354 craters with d ≥ 5 km with surviving ejecta rocks within one crater radius outward from the rim (Fig. 1). We verified the presence of exposed ejecta rocks for each of these craters using LROC narrow angle camera (NAC) images. The cumulative size-frequency distribution for this population shows no appreciable difference in slope for those craters located in the maria vs. those in the highlands above d = 8 km (Fig. 2). Below 8 km, the relative abundance of rocky craters is higher in the maria than in the highlands, indicating that 8 km is the diameter below which the thicker highlands regolith influences rock production.

Because we take the rocky craters to represent a young population [e.g., 1], we could treat this population as representative of a time horizon, and thus fit it to a lunar isochron derived from a particular production function. Figure 2, however, shows a relative paucity of rocky craters in the middle of the size distribution, in the ~10-40 km diameter range that produces a significant misfit to, e.g., the Neukum 2001 [5] production function. Two possible reasons for this are: a) our craters do not represent a production population, but rather, a retention population, and some process either preferentially inhibits production of rocks, or accelerates removal of rocks, for craters in a particular diameter range; or b) the relatively small number of rocky craters leads to undersampling of what *is* essentially a crater production population. We will examine both hypotheses, and will interpret the implications for lunar chronology.

High OMAT craters to 10 km: Using a new 512 ppd-OMAT dataset derived from Kaguya multispectral data for the region 50ºN to 50ºS [3], we have identified 123 craters with diameter > 10 km whose ejecta show higher OMAT values than adjacent background regolith values. Consistent with the results of Grier et al. [6], we find these craters to be relatively young. This dataset provides an independent catalog of relatively young craters. In the region of overlap between the OMAT and rock abundance datasets (50ºN to 50ºS), we find 90 rocky craters, of which 79 also show high OMAT values. The fact that this region shows ~36% more high OMAT craters than rocky craters suggests that the OMAT signature persists longer than the rock abundance signature, with rocks producing new immature / fresh material as they break down via relevant surface processes.

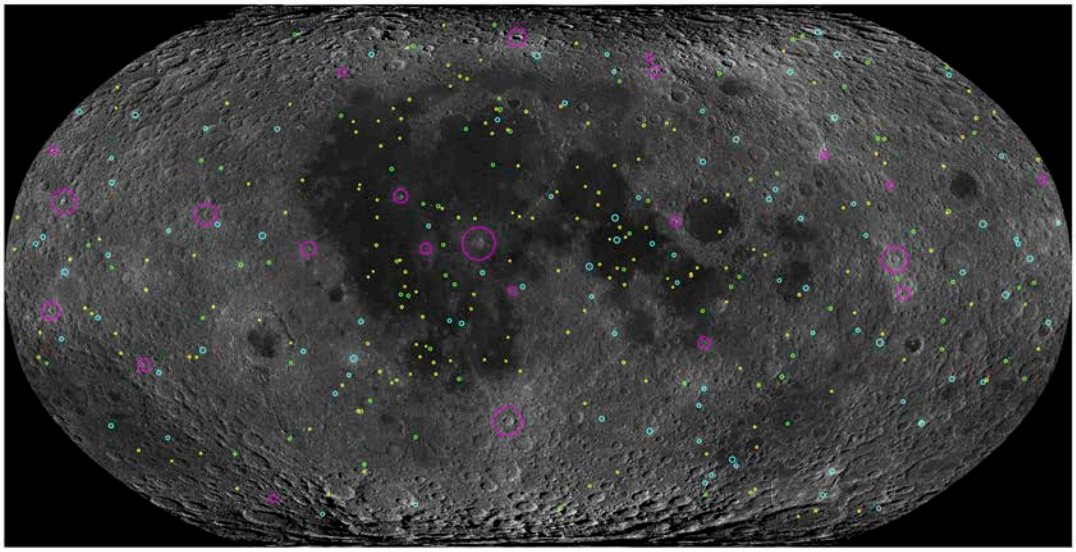

Figure 1. Map showing locations of 354 rocky craters with d>5 km from 80ºN to 80ºS. Circle diameters are proportional to crater diameters. Yellow: d = 5 to 8 km; green: d = 8 to 10 km; cyan: d = 10 to 20 km; magenta: d > 20 km.

Implications for chronology: We have previously shown that the population of rocky craters with d≥10 km can be used to investigate fundamental questions surrounding the lunar bombardment rate [4]. Ultimately, we would like to be able to extend these ideas to include smaller craters. Therefore, the results of the work presented here—for instance, understanding whether or not the observed population of rocky craters represents a production population—will be valuable for examining how the record of impact processes is influenced by crater size and target terrain. Because the population of rocky / high OMAT craters represents the youngest population of lunar craters, our results will also provide constraints on dynamical models of the present-day delivery of objects to Earth-crossing orbits [e.g., 7, 8].

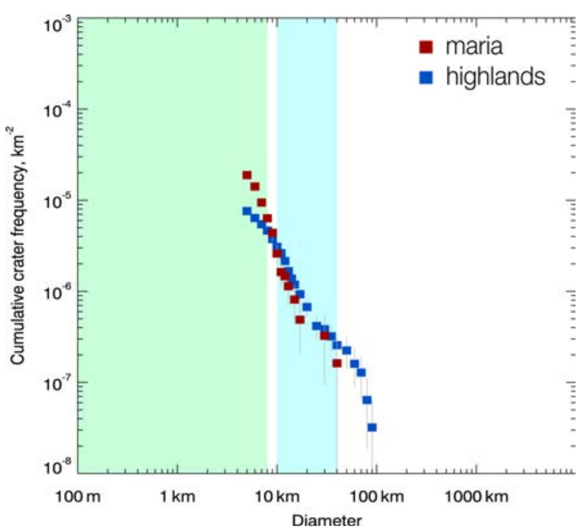

Figure 2. Cumulative size-frequency distribution for rocky craters (normalized to area). The highlands and mare curves are coincident for crater diameters > 8 km; below 8 km (green region), the relative abundance of rocky craters in the maria is higher than that in the highlands, indicating that the highlands regolith influences rock production for craters with diameter < 8 km. The blue region indicates the diameter range for which the relative crater abundance is lower than expected.

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