ASSESSING THE ROUGHNESS PROPERTIES OF CIRCUMPOLAR LUNAR CRATERS: IMPLICATIONS FOR THE TIMING OF WATER-ICE DELIVERY TO THE MOON. Ariel N. Deutsch[1], James W. Head[1], Gregory A. Neumann[2], Mikhail A. Kreslavsky[3], Michael K. Barker[2], [1]Department of Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI 02912, [2]NASA Goddard Space Flight Center, Greenbelt, MD 20771, [3]Department of Earth and Planetary Sciences, University of California - Santa Cruz, Santa Cruz, CA 95064 (ariel_deutsch@brown.edu).

Introduction: The timing of volatile deposition on the Moon is an important question that provides constraints on the origin of lunar ice because different delivery mechanisms have been active at different times throughout lunar history. Understanding the ages of cold-trap formation helps to address this question. We previously found that the majority of water-ice detections from Li et al. [1] are located within large, old impact craters >~3.1 Gyr [2]. However, many ice-detections are present within smaller craters as well, which are too small to date using robust cratering statistics [2]. Here we take a new approach to understand the ages of these small polar cold traps: analyzing the roughness properties of small ice-bearing craters.

It is well understood that impact crater properties (e.g., morphology, rock abundance, and roughness) evolve with time due to various geologic and space-weathering processes [3–8]. Topographic roughness is a measurement of the local deviation from the mean topography, providing a measurement of surface texture, and is a powerful tool for evaluating surface evolution over geologic time [e.g., 7–9]. In this study we analyze the roughness of >400 lunar craters (±40°–±90°) from all geologic eras using the LPI lunar crater database [10], and determine how the roughness of small (<~10 km) ice-bearing craters (*N*=88) compare. We discuss implications for the ages of ice-bearing polar craters and potential delivery sources of the ice.

Methods: We analyze the roughness of the lunar surface using the Lunar Orbiter Laser Altimeter (LOLA) Digital Roughness Map (pixel resolution of 1000 m; http://imbrium.mit.edu/DATA/LOLA_GDR/), which was derived from the root mean square variation in the surface elevation of the five adjacent spots returned from a single LOLA laser pulse [8].

Results and Conclusions: We highlight three main findings from our analysis: (1) Copernican craters are distinctly rougher than older craters, consistent with previous work [7,8]. The major differences in roughness domains exist between Copernican craters and craters of older eras. However, there are still statistically-significant differences ($\alpha = 0.001$) in surface roughness between the oldest lunar craters (Pre-Imbrian) and craters formed within the Imbrian and Eratosthenian periods.

(2) The distribution of ice-bearing craters is skewed toward roughness values higher than those of pre-Imbrian craters (Fig. 1a). The roughness within ice-bearing craters represents a minimum due to subduing effects of slope processes [8], the presence of volatiles [11], and oversampling of crater walls at the LDRM resolution.

(3) All of the 15 rough, permanently shadowed craters that are found within the Copernican-only domain (Fig. 1b,c) lack water-ice detections [1], suggesting that either ice has not been delivered to these young craters, or that it has since been destroyed.

Determining the timing of water delivery to the Moon is a critical step in understanding the nature of the lunar volatile cycle and how it is evolving with time, and future exploration focused on volatile chemistry and fluxes are essential in these investigations.

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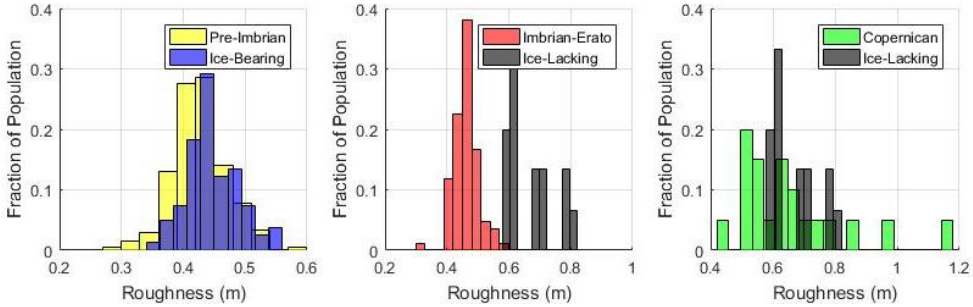

Fig. 1. Histograms comparing the roughness distribution of (a) ice-bearing and Pre-Imbrian craters, (2) ice-lacking and Imbrian–Eratosthenian craters, and (3) ice-lacking and Copernican craters.