DEVELOPING A GLOBAL LUNAR CRATER DATABASE, COMPLETE FOR CRATERS ≥1 KM.

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Introduction and Background: Crater catalogs for Earth's moon have been developed for over 400 years. Cataloging focused on the lunar near side until the first Soviet satellites returned images of the far side, and cataloging accelerated as better imagery and techniques became available. Catalogs have tended to focus on non-uniform cataloging of more important features rather than generating a complete census [*e.g.*, 1, 2]. A few recent efforts were uniform [3-5], but despite the dedicated work, they are limited in utility due to the "small" numbers of features, representing craters with diameters $D \geq 20$ km [3, 4] and $D \geq 8$ km [5].

To wit, I have begun to develop a global lunar crater database with the goal of a complete census of all impact craters as small as 1 km in diameter. This will make it comparable to a global database of Martian impact craters [6] to facilitate cross-planetary studies; it has historical significance because the lunar crater chronology – and by extension, crater chronology throughout the solar system – is defined for $N(1)$ (the spatial density of impact craters with diameters $D \geq 1$ km); and it is to a diameter where the sheer number of impacts can inform numerous lunar processes that were not previously investigable.

Crater Mapping Process and Data Used: This manual effort is the same as used for the global Martian crater database, described in [6,7]. In brief, craters are manually identified and the rims are traced in *ArcMap* software using the "streaming" tool so many points define the rim. These digitized rims are exported in units of decimal degrees and imported to *Igor Pro* where custom algorithms correct for all projection effects using Great Circles [8] and fit both a circle and ellipse, saving the location, diameter, and ellipse properties (major/minor axes, tilt, ellipticity, eccentricity).

Data used are *Lunar Reconnaissance Orbiter* (*LRO*) Wide-Angle Camera (WAC) "morphometric," "dawn" nearside, and "dusk" farside mosaics. These mosaics are 100 m/px and are used in the first search to identify most craters $D \gtrsim 1$ km. The next search uses the *LRO* Lunar Orbiter Laser Altimeter (LOLA) Gridded Data Record (GDR) at 256 ppd (≈120 m/px equator) for most regions, but up to 10 m/px near the lunar poles. The third data set has only been employed to-date in *some* lunar maria and is the Kaguya Terrain Camera (TC) mosaics ("map," "morning," and "evening" products). These are ≈20 m/px which permit good crater identification for $D \gtrsim 0.2$ km. The 2013 TC mosaics were poorly constrained to the current lunar geoid, but the 2015 release is tied to LOLA and there are no registration issues at the hectometer level.

**Progress To-Date:** This initial effort (mapping the craters *only – i.e.*, deriving location and diameters) has been funded from several different projects and grants with their own emphasis, so mapping is a bit haphazard. First, the entire moon was mapped for $D \gtrsim 15$ km through the Maryland Space Grant in support of CosmoQuest. Second, ≈11% of the lunar nearside was mapped as pilot work during personal time for proposals. Third, *LRO*-LAMP (Lyman-α Mapping Project) has supported mapping craters at the lunar poles (poleward of ±60°). Fourth, NASA's SSW program is supporting part of this through an investigation of the lunar crater production function for $D \gtrsim 0.5$ km in the lunar maria (using Kaguya TC). Fifth, the remaining equatorial lunar highlands (equatorward of ±60° latitude) will be finished through NASA's SSERVI program (via the ISET award).

At the time of this submission (mid-January 2015), 478,280 craters have been mapped over 28% of the lunar surface (281,134 $D \geq 1$ km) (100% of the surface has been mapped for $D \gtrsim 15$ km craters). Of these, 9169 craters (5973 $D \geq 1$ km) have centers within PSRs (permanently shadowed regions) [9]. Analysis of these craters and correlations with LAMP data is ongoing and is the subject of future work. LAMP maps are produced at 240 m/px for the poles, so the database was extended within 5° of both poles to $D \geq 0.5$ km. Fig. 1 shows a global and polar lunar maps demonstrating progress to-date, and Fig. 2 shows a close-up of both lunar poles with PSRs overlaid.

Expansion Goals After Completion: The initial mapping (crater location and diameter) is expected to be completed by Summer 2016. Despite using four different funding sources in addition to personal time, funds are only available to complete the above-described mapping effort. A goal of the catalog itself is to calculate topographic information and classify crater morphology. These data would allow numerous science investigations that have never before been possible. Calculating these properties and performing the science will be the subject of future NASA proposals.

References: [1] Arthur, *et al.* (1965). [2] Losiak, *et al.* (2009). LPSC 40 #1532. [3] Head, *et al.* (2010) doi: 10.1126/science.119505. [4] Fassett, *et al.* (2012) doi: 10.1029/2011JE003951. [5] Salamunićcar, *et al.* (2012) doi: 10.1016/j.pss.2011.09.003. [6] Robbins, S.J. and B.M. Hynek (2012a) doi: 10.1029/2011JE003966. [7] Robbins, S.J. *et al.* (2014) doi: 10.1016/j.icarus.2014.02.022. [8] Vincenty, T. (1975). [9] Mazarico, E. *et al.* (2011) doi: 10.1016/j.icarus.2010.10.030.
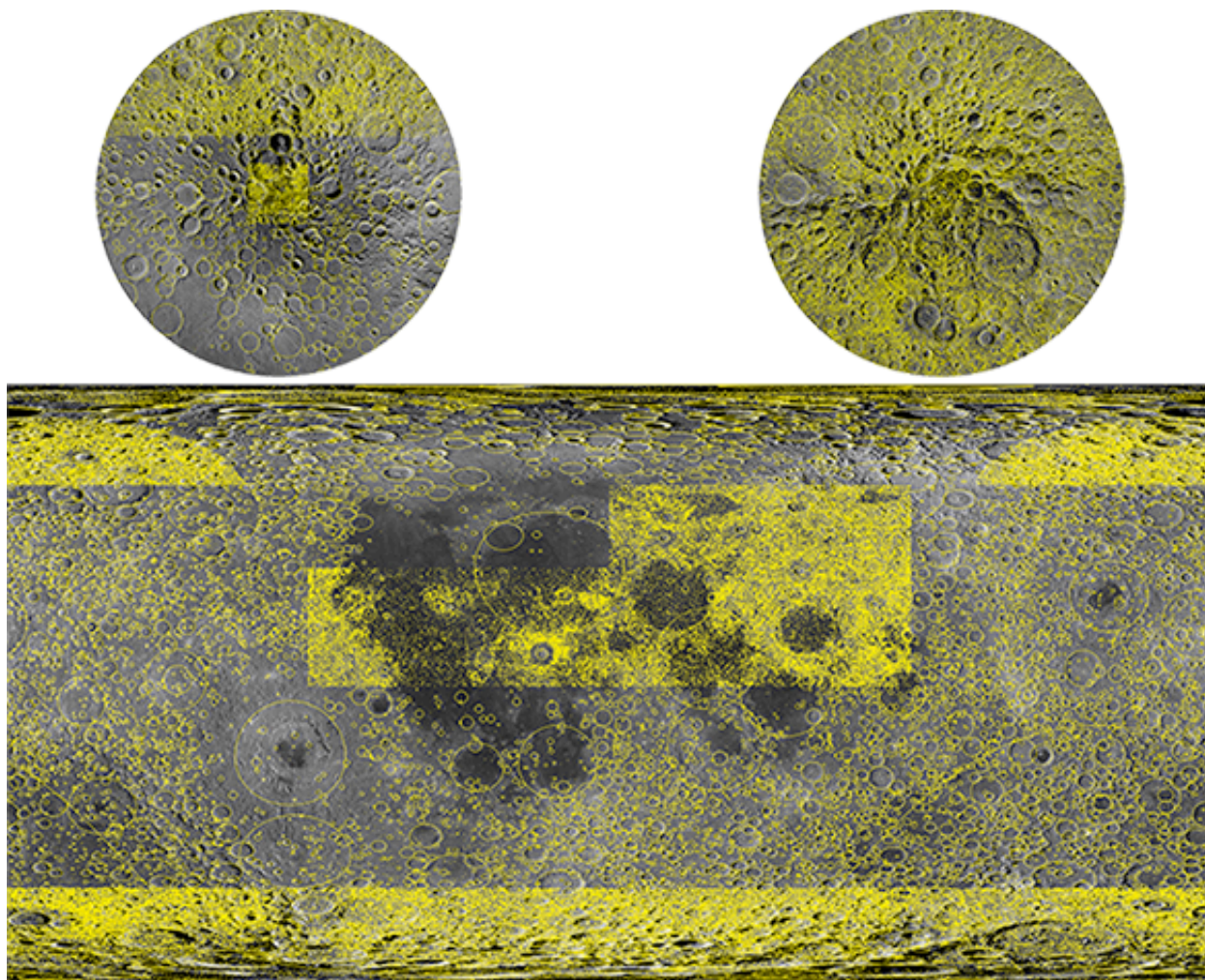
Figure 1: Global map of the lunar surface (*LRO* WAC "morphometric" mosaic). Overlaid in yellow circles are the rims of craters $D \geq 15$ km, and overlaid in yellow dots are craters $1 \leq D < 15$ km.
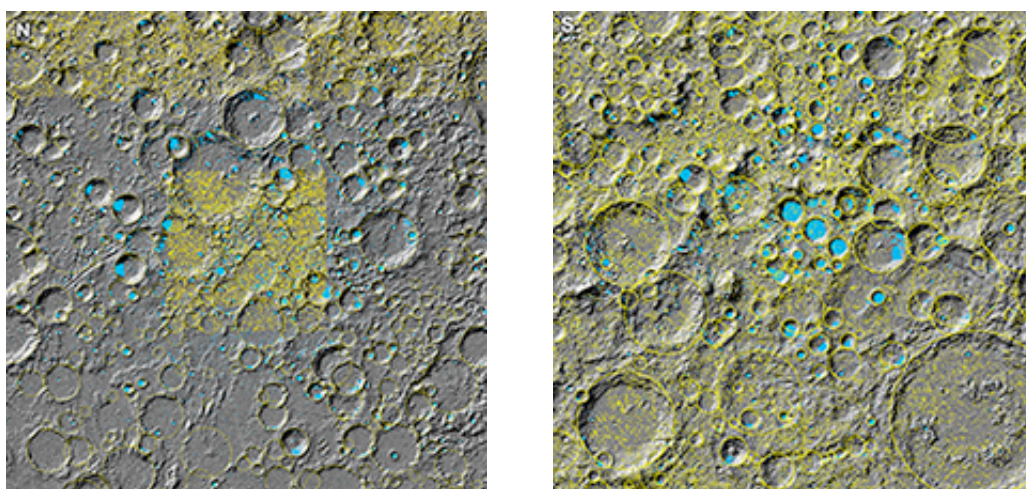
Figure 2: Close-up of lunar poles (*LRO* LOLA GDR hillshade of within 75° of the pole as basemap). Overlaid in yellow circles are the rims of craters $D \geq 15$ km, and overlaid in yellow dots are craters $1 \leq D < 15$ km. Overlaid in light blue are lunar permanently shadowed regions (PSRs) [ref], illustrating that there are numerous craters in this database that could harbor ices. At the time of this submission, only part of the north polar region was completed.