PROGRESS TOWARDS A NEW GLOBAL CATALOG OF MARTIAN CRATERS AND LAYERED EJECTA PROPERTIES, COMPLETE TO 1.5 KM. S. J. Robbins[1,2] and B. M. Hynek[2,3], [1]APS Department, UCB 391, University of Colorado, Boulder, CO 80309, [2]LASP, UCB 392, University of Colorado, Boulder, CO 80309, [3]Geological Sciences Department, UCB 399, University of Colorado, Boulder, CO 80309.

Introduction: The first global database of martian craters $D \geq 5$ km was created from Viking images in the late 1980s by Barlow [1]. Since then, many other researchers have cataloged craters to smaller diameters but in isolated sections of the planet. The same is true of layered ejecta craters – craters that have one or more lobate, layered debris aprons surrounding them. To test the two main formation hypotheses of these uniquely martian craters, a uniform, global crater database complete to the same diameters as a layered ejecta craters is necessary. Consequently, in support of our lobed crater research, we are working to map all craters across the planet, and we estimate our statistical completeness to be ~1.5 km in diameter. We have completed preliminary mapping of over 288,993 craters (165,498 $D \geq 1.5$ km) and are in the process of characterizing morphologic properties and morphometric ejecta properties. We present several preliminary trends in the craters, as well as other applications to which our database may be applied once it is completed.

Layered Ejecta Craters: Layered ejecta (LE) craters are a so-far unique class of craters to Mars, having not been observed elsewhere in the solar system. They are characterized by one or more layers of smooth, continuous ejecta that usually terminate in a small bulge/rampart with a sinuous perimeter (Fig. 1). Two different formation mechanisms have been proposed. Carr *et al*. [2] argued that impacts into volatile-rich surfaces caused fluidization of the ejecta, producing the LE morphology, while Barnouin-Jha [3] hypothesized that they form when the severity of the impact causes atmospheric vortes and winds [3].

We are working to create the first complete global catalog of all lobed craters $D \geq 1.5$ km to examine their morphology, morphometry, thermal inertia values, geologic unit on which they are emplaced, and other properties from all available datasets from such missions as *Mars Odyssey*, *Mars Global Surveyor*, *Mars Express*, and *Mars Reconnaissance Orbiter*. With this large dataset, we hope to determine with what formation mechanism these data are most consistent, with respect to a global "background" crater population.

Previous Crater Databases: Barlow's original crater database [1] has become the foundational work for most other crater databases, including the recent compilation by Salamunićcar & Lončarić [4]. Barlow has since been revising her original catalog based on THEMIS and MOC imagery, though she is still limiting her completeness to 5-km-diameter craters [5]. Alternatively, Tomaz Stepinski has worked on automated computer algorithms to detect and catalog craters from MOLA gridded topographic data [6]. While parts of the planet seem complete to ~2-3 km, we estimate his catalog's statistical completeness to be ~5 km via a different method; we compare our results with his and Barlow's in Fig. 2. We note that all three databases are preliminary. To-date, there is no planet-wide crater database complete to ~1.5 km; such a product would give new insights into the nature of LE craters in the context of the most complete martian crater database to-date.

Construction of Our New Crater Database: All craters for our database are identified manually in THEMIS Day IR mosaics (or Viking MDIM 2.1 where gaps exist in THEMIS coverage). With a resolution of ~230 m/px, we use *ArcGIS* software to outline each crater rim and lobe (if present) at ~500 m cadence. *Igor Pro* software is used to calculate best-fit circle and ellipse parameters for each crater. Each $D \geq 3$ km crater is re-identified in MOLA 1/128° gridded data to determine rim height, surface elevation, and floor depth. THEMIS data are to classify crater interior and ejecta morphology and degradation state.

Our database includes MOLA- and THEMIS-based latitude, longitude, diameter, and ellipse parameters; MOLA-based rim, surrounding surface, and floor elevation; crater degradation state; crater interior morphology and three ejecta morphologies (one after Barlow [7], the others based on shape, such as "butterfly"); whether or not the crater is an obvious secondary; and probability the feature is a true impact crater. In addition to those parameters, each lobed crater has additional columns that include the number of lobes, and then for each lobe the perimeter, area, equivalent circular ejecta radius, lobateness (Γ), and ejecta mobility (average crater radii the ejecta traveled).

Preliminary Results: As of December 2009, we have completed all THEMIS identification globally, MOLA analysis of $D \geq 3$ km craters globally, and ejecta quantification and classification of $D \geq 5$ km craters in the northern hemisphere. At present rates, we expect to have all crater attributes in our database completed by the end of 2010.

We have examined the *depth*/*Diameter* (d/D) distribution across the planet (*e.g.*, Fig. 3) as well as the preliminary distribution of LE craters by latitude. Our major result from the *d*/*D* analysis confirms the crater depth dichotomy with a distinct shallowing above ±40° latitude, and we find the deepest craters are within Utopia Planitia and around Tharsis.

For our LE crater analysis, we identify a few features: (1) We verify the relative enhancement of LE craters in the high (>60°) northern latitudes. However, we find there are ~2-4× as many LE craters in the mid and equatorial latitudes by percentage than Barlow [1]. We also identify a significant enhancement of double-LE between ~45-65° N latitude. However, we do not observe an enhancement of multi-LE craters near the equator. (2) Ejecta mobility appears to be statistically greater for craters north of ~45° N, correlating with sub-surface hydrogen. (3) We find no lobateness trend with latitude, agreeing with previous studies, indicating a probable independence with volatile content. (4) LE craters appear to have a statistical cut-off point, with fewer than 1% being larger than $D > 50$ km, indicating a probable age or size dependence. Additionally, the mode of multi-layered lobes' diameters is ~20 km, much larger than single and double. (5) We identify a new sub-class of double-layered ejecta where the inner layer is fairly circular and ends in a convex pancake-like shape, while the outer layer has a sinuous, rampart-like terminus. These craters are not observed south of 25-30° N latitude, despite the general double-layered lobed ejecta being present over the entire surface. (6) We observe preliminary evidence that single vs. double layered are distinct morphologies with different formation criteria, based on different $\Gamma(D)$ properties. More geographic analysis and complete coverage is necessary to make conclusions on this trend.

Future Work: We have already begun to mine the database for additional trends, and once complete, we hope to paint a more complete picture of the martian crater population. Besides studying the LE craters, this database will also be used to: (1) assist with global geologic mapping currently underway, (2) revise the Mars isochrons, (3) study planet-wide erosion and resurfacing based on crater infilling and rim erosion, and (4) study the formation times of very large impact craters as well as refine the volcanic history of the planet. In addition to these tasks, other researchers may find the database useful for purposes such as (1) studying ellipticity with respect to models and other planets, (2) act as a ground truth catalog for researchers working on automated detection, and (3) act as a "first cut" in assessing future landing site safety.

References: [1] Barlow N. G. (1988) *Icarus*, *75*, 285-305. [2] Carr M. H. *et al.* (1977) *JGR*, *82*, 4055-4065. [3] Barnouin-Jha O. S. and Schultz P. H. (1998) *JGR*, *103(E11)*, 25,739-25,756. [4] Salamunićcar G. and Lončarić S. (2008) *P&SS*, *56*, 1992-2008. [5] Barlow, N. G. (2006) *Meteoritics Planet. Sci.*, *41*, 1425-1436. [6] Stepinski T. F. and Urbach E. R. (2009) *LPSC*, 40, p. 117. [7] Barlow N. G. *et al.* (2000) *JGR*, *105(E11)*, 26,733-26,738.

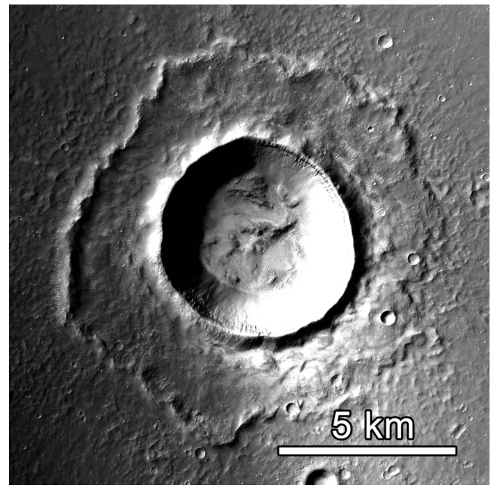

Figure 1: A ~5-km example crater located at ~139°E, ~6°N. Crater ejecta displays the classic sinuous lobe with a well-defined rampart terminus.

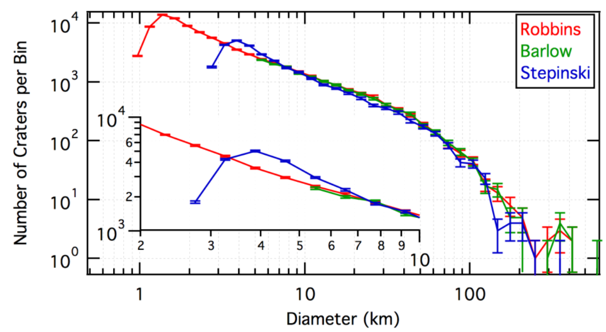

Figure 2: Incremental size-frequency graph comparing this work, Barlow's preliminary new database (personal communication), and Stepinski's preliminary database (personal communication). Inset shows key small-crater range. Error bars are $\pm\sqrt{N}$.

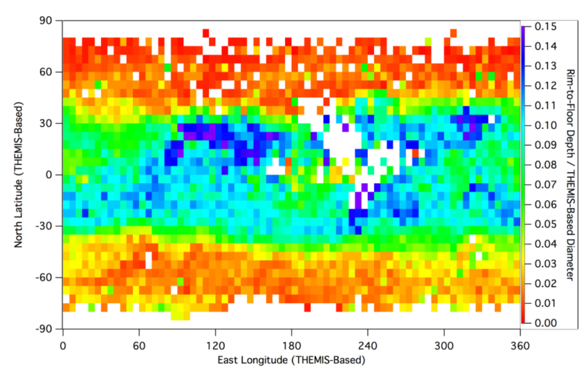

Figure 3: Color map showing, in 5°x5° bins, the *d*/*D* ratio of all analyzable $5 > D \geq 3$ km craters (22,158).