BUILDING A GLOBAL MARTIAN VOLCANO DATABASE: CRITERIA, PROCESS, AND STATUS. H.C. Buban[1,2], J.A. Skinner, Jr.[2], and L.A. Skinner[1], [1]School of Earth Sciences and Sustainability, Northern Arizona University, Flagstaff, AZ, 86001, [2]Astrogeology Science Center, U. S. Geological Survey, 2255 North Gemini Drive, Flagstaff, AZ, 86001 (hbuban@usgs.gov).

Introduction: Volcanic units and features vitally contribute to mapping, interpreting, and analyzing any planetary body and understanding that planet's geologic evolution. By using volcanoes as evidence for the past, we can better understand how a planetary surface has evolved through time. Images from *Mariner 9* helped begin the systematic identification of volcanoes on Mars [1], which was significantly expanded by the near-global image coverage by the *Viking 1* and *2* orbiters [2]. *Viking* images in particular afforded more complete investigations of the morphology and distribution of volcanoes across the Martian surface. The assumption that volcanic processes on Mars are analogous to processes on Earth allows us to confidently describe the features we see on the Martian surface using techniques developed for terrestrial volcanoes. In the 1994 atlas, Hodges and Moore [3] used this assumption to conclude that the majority of volcanoes on Mars formed by the effusive eruption of basaltic magma due to the morphological similarities to terrestrial comparisons.

Nearly 30% (46.7×10^6 km^2) of the Martian surface is covered by volcanic units (mostly lava flows), meaning that these units display an outward volcanic appearance (*e.g.*, lobate flows, large-scale edifice) and have not been significantly eroded or reworked [4]. It is assumed that much more of the Martian surface is covered by volcanic terrains that have been eroded or modified [4-5]. The diversity and high spatial resolution of post-*Viking* datasets have ushered in an entirely new era of volcano-specific studies on Mars, including studies that identify, categorize, and spatially analyze specific edifices at local and regional scales (*e.g.*, [6-10]). Although these topical investigations have resulted in individual catalogs and inventories, a global dataset for all Martian volcanoes does not yet exist. Such a dataset, if leveraging previously-published information, has the potential to help advance volcano-specific research on Mars by providing a systematic context. Here, we present progress we have made compiling such a systematic database.

Data & Methods: Our global Martian volcano database is being constructed in ArcGIS using THEMIS daytime IR controlled image mosaics (100 m/px [11]) as well as the MOLA DEM (463 m/px) and MOLA-derived hillshade and slope. These datasets are the highest resolution, most aerially complete data sets currently available and are intended to provide global context for regional to local investigations. We augmented our base data sets with web-linked footprints of CTX (~6 m/px) and THEMIS VIS (~18 m/px) to provide higher resolution details that were used for cross-referencing certain areas, when necessary.

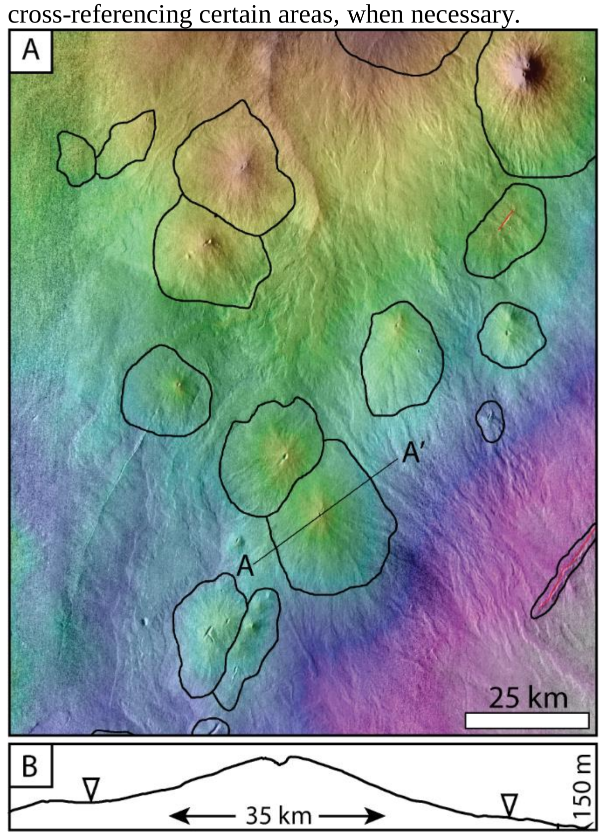

Figure 1. Example of mapped volcanoes in the current database. (A) Field of low-relief shields between Arsia and Pavonis Montes in the Tharsis region of Mars (centered -114.1ºE, -4.8ºN). Topography ranges from 7781 m (red) to 7152 m (violet). (B) Topographic profile from A-A' showing the extremely low relief (143 m) of the mapped features compared to the width (25 km). Flank slope is <1º. Also, note the summit pit.

We are completing our database by focusing on one 1:5M quadrangle at a time. Therein, we systematically scan the THEMIS daytime IR base image from edge to edge at a scale of 1:200K, using supplemental data sets as necessary. We map candidate volcanoes based on the following criteria: (1) minimum diameter of 5 km, (2) observable topographic relief (in MOLA), (3) evidence of flank flows, and (4) summit pit or fissure. Once we identified a candidate volcano, we placed a point at its apex and outlined the base with a polygon feature (using inflection points in topographic profile). Elongate apex depressions >2.5 km were identified with a line.

Our landform criteria have been slightly refined during the course of the investigation. The minimum diameter (5 km) was selected to ensure all large and prominent volcanic edifices are captured without incorporating many smaller-diameter edifices known to exist across the planet (*e.g.*, [4]). We acknowledge that there are features smaller than 5 km in diameter that have been identified as volcanoes in many areas across the surface of Mars (*e.g.*, [10]), but these features are difficult to identify in THEMIS and are therefore excluded at this stage. Our criteria specifically avoid the identification of elongate fissures that have emanating flows but no notable topographic relief (*e.g.*, Cerberus Fossae). "Observable topographic relief" is not defined by a quantity but rather that the feature stands out from adjacent topography when stretching the MOLA DEM across the 1:200K field of view. Inflection points at the base, as determined from topographic profile (**Fig. 1B**), also assisted in identifying features and delineating their boundary. This definition helped capture only features we believed to be constructional volcanic edifices.

We recognize that limitations exist when constructing any global landform database, including this one. The largest factors to consider are the defining criteria. If only the topographic relief and >5km diameter factors were considered, features such as craters and massifs could potentially be captured, so other parameters are included to aid in the decision making process to help weed them out. These include interpretation of the base of an edifice when it is concealed by a lava flow, interference of craters at the base of an edifice, presence of structural features such as rilles or catenae, or overlap with adjacent volcanoes.

Results: To date, our database consists of >600 volcanoes across the Tharsis (MC-09), Phoenicis Lacus (MC-17), and Elysium (MC-15) Quadrangles (**Fig. 2**). We focused on these quads first because (1) they represent the main areas of volcanism focused on in previous investigations [6-10], and (2) the known age differences between the Tharsis and Elysium regions forced us to address erosional effects of these edifices through time. We have not yet developed or applied a classification scheme for the mapped features. However, the immediate next step is to accumulate statistics per feature, including area, elevation, slope, circularity, height, width, unit of occurrence (features intersected with [5]), and spatial density. We anticipate these quantities will help subdivide the mapped features into potential landform classes. Potential statistical relationships might include ratios of circularity: height, height:slope, area:elevation, and (or) height:width.

References: [1] Kieffer et al. (1992) *Mars*, 13, 424-452. [2] Rosiek M. R. et al. (2005) *Photo Eng. Rem. Sens.*, 71, 1187-1195. [3] Hodges C. A. and Moore H. J. (1994) USGS PP1534 [4] Scott, D. H. et al. (1986) *USGS* I-1802, 1:15M. [5] Tanaka, K. L. et al. (2014) *USGS SIM* 3292, 1:20M. [6] Bleacher, J. E. et al. (2009) *JVGR*, 185, 96-102. [7] Hauber, E. et al. (2009) *JVGR*, 185, 69-95. [8] Hauber, E. et al. (2011) *GRL*, L10201. [9] Richardson, J. A. et al. (2013) *JVGR*, 252, 1-13. [10] Broz, P. et al. (2017) *EPSL*, 473, 122-130. [11] Fergason R. L. and Weller L. A. (2013).

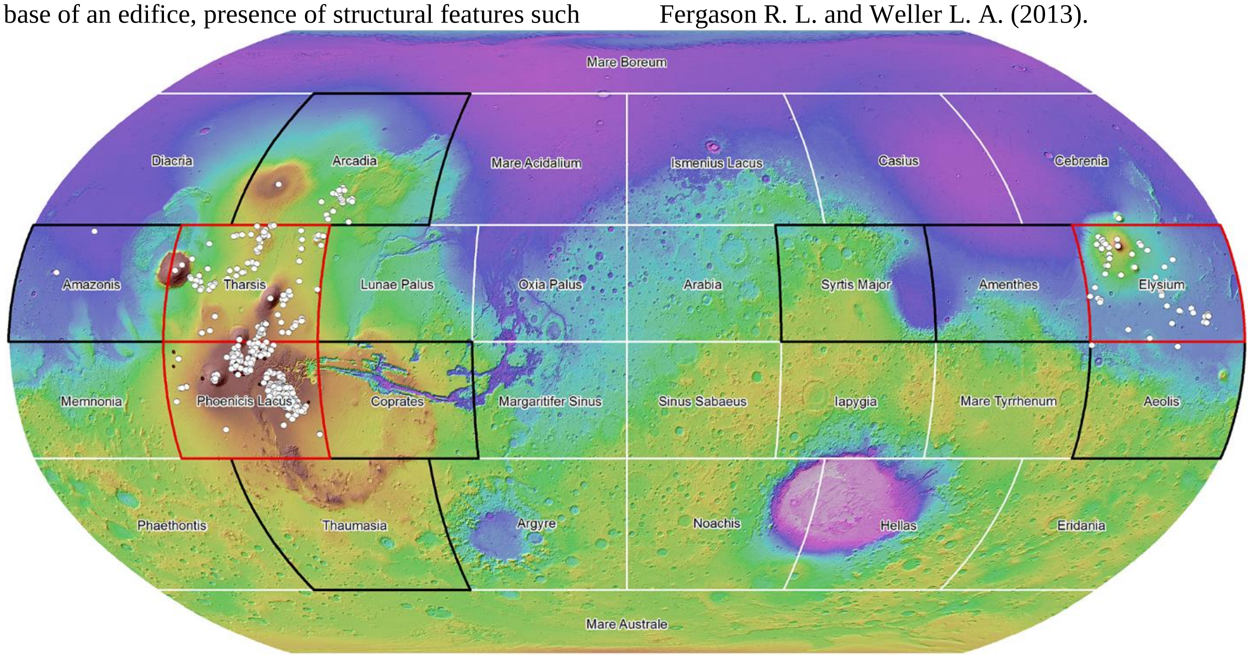

Figure 2. Current results of our Martian volcano database. White dots represent locations of mapped volcanic edifices (outlines too small to show at this scale). Red quadrangles have been completed; black quadrangles are queued for subsequent completion. Beginning with Tharsis (MC-09) and Elysium (MC-15) edifices allowed us to examine how our landform criteria held across differently aged units in order to refine the systemic investigation of Mars volcanic edifices. Basemap is a synthetic MOLA hillshade with MOLA DEM overlay (purple is low elevation, red is high).