Small-volume Igneous Landforms and Edifices Statistics (SMILES): A database of dimensionless parameters of terrestrial analogs for remote sensing volcanic landforms. J. A. Nolan[1] and A. H. Graettinger[1], [1]University of Missouri-Kansas City, 5100 Rockhill Rd., Kansas City, MO, 64110, janolan@protonmail.com., [2]University of Missouri-Kansas City, 5100 Rockhill Rd., Kansas City, MO, 64110, graettingera@umkc.edu

Introduction: Accurate classification of terrestrial and non-terrestrial volcanic landforms requires a robust suite of morphometric parameters. The Small-volume Monogenetic Igneous Landforms and Edifices Statistics (SMILES) catalog contains the morphometric characterizations of mafic terrestrial small-volume volcanic landforms and was created using uncrewed aerial system photogrammetry, open-source LiDAR, and digital elevation model repositories [1]. The SMILES catalog contains the morphometric parameters of maars, lava collapse features, scoria cones, and spatter landforms. The SMILES database emphasizes dimensionless parameters which define the morphology of terrestrial landforms. Dimensionless parameters are vital for comparison to non-terrestrial targets, such as Martian volcanic landforms. While, terrestrial analogs collected in SMILES will exhibit differing numerical ranges from the parameters of Martian volcanic landforms, this study demonstrates the feasibility and value of a suite of dimensionless morphometrics parameters to remotely identify these landforms.

Method. This study utilizes 72 digital elevation models (DEM) from both open-source data repositories [2–6] and data collected via uncrewed aerial system (UAS) photogrammetry [7, 8]. UAS data were processed using Agisoft Metashape. LiDAR datasets were rasterized using CloudCompare [9]. Spatial resolutions of the analyzed DEM range from 0.1 to 0.4 m/pixel for UAS data, 2 m/pixel for ArcticDEM, and 1–5 m/pixel for LiDAR data.

Inclusion criteria. Landforms selected for inclusion in SMILES are maars, lava collapse features, ring scoria cones, and spatter landforms. Maars and lava collapse features were constrained to ~2 km or less across the depression, and scoria cones and spatter landforms were constrained to a basal width of ~2 km or less and volumes less than 1 km3.

Morphometric Analysis. Parameters include aspect ratio (AR), isoperimetric circularity (IC), crater depth ratio (DR), interior slope angle (SA) crater/base area, crater/base perimeter, major chord ratio, and base/height ratio.

Negative Volcanic Landforms. Simple maars parameters are AR >0.74, IC >0.90, SA <47°, and DR <0.26. Lava collapse features parameters are AR 0.26 - 0.95, IC 0.46 - 0.98, SA 16 - 86°, and DR 0.25 – 0.52. Maars generally have a lower DR, SA than lava collapse features. A simple maar has a distinct range of IC and AR, while the lava collapse features exhibit a broad spectrum. The topographic profile of a maar generally is more bowl shaped or flat bottomed with smoothly sloped walls, while lava collapse landforms have high angles with a flat or jagged bottom. The internal components of a complex exhibit similar parameters range as solo simple maars.

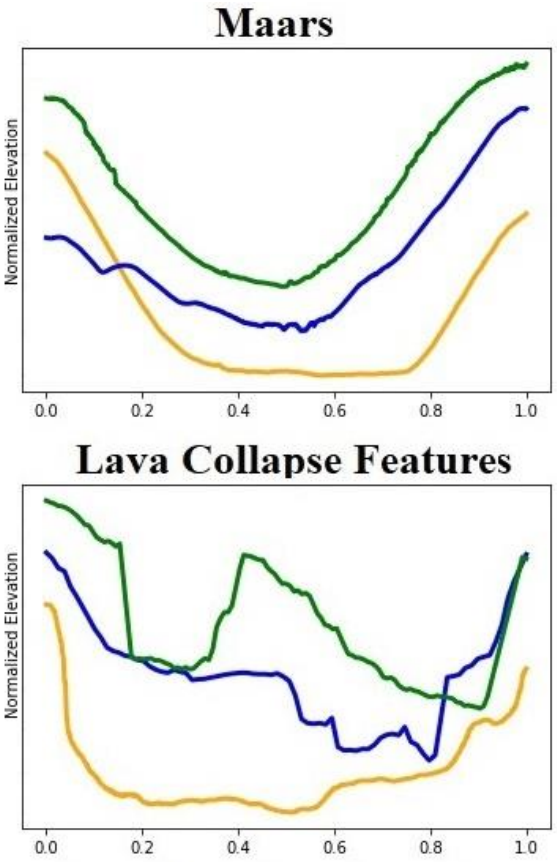

Figure 1: Negative volcanic landform dimensionless topographic profiles.

Positive Volcanic Landforms. Scoria cone craters have a distinct range of AR (>0.54), IC (>0.81), interior slope angle (<34°), and lower depth ratio (<0.25). Spatter landforms have a wider range of variability in AR (0.25–0.94), IC (0.43–0.98), SA (<63°), and DR (0.04–0.37). Spatter landforms parameters are AR 0.25 – 0.94, IC 0.43 – 0.98, SA <63°, and DR 0.04-0.37). Spatter landforms have higher crater/base area ratios and crater/base perimeter ratios than scoria cones. Scoria cones have a topographic profile which can be similar to spatter landforms, however, a spatter

landforms topographic profile can breach the pre-existing surface. The crater of a scoria cone features a bowl shape with smooth walls. The topographic profile of a spatter landform crater can range from a bowl shape to saw-toothed. Often spatter landforms craters are comprised of overlapping semi- or half circles inside a more complete circular outline.

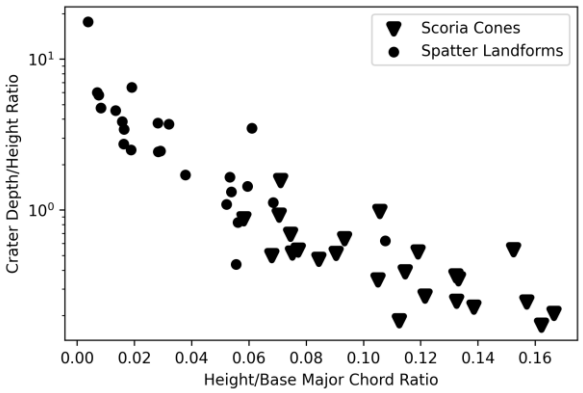

Figure 2: Positive volcanic landforms height/base ratio and crater depth/height ratio

*Conclusion***.** The morphology of simple maars and ring scoria cones exhibits a narrow range of morphometric parameters. This narrow morphometric range places a quantitative boundary on these endmember landforms. Complex maars can be separated into multiple distinct internal volcanic landforms. The morphology of an internal volcanic component is the same morphometric parameters as the simple variant. Although no individual parameter is solely diagnostic, the suite of identified parameters paired with the novel parameters and observational context is fundamental to the characterization of volcanic landforms. These terrestrial observations will help lead to a better understanding of remote sensing volcanic landforms on both Earth and Mars.

Acknowledgments: A very special thank you to ArcticDEM, OpenTopography, DOGOAMI, and INEGI, and other open repositories which help increase the value of already collected data and for providing this data for no cost to download, allowing accessibility to all.

References: [1] 1. Nolan JA. and Graettinger AH, (2022) Frontiers in Earth Sci. [2] (2015) Harney Basin LiDAR by OR Dept. of Geo. and Min. Ind. [3] (2021) INEGI. [4] OpenTopography (2021) Lunar Crater VF, Central NV. [5] Porter C, and et al (2018) ArcticDEM. [6] Sugarbaker LJ, and et al (2014) The 3D Elev. Prog. Init. [7] Nolan J, and et. al, (2019) Geo. Soc. of Amer. Abs. with Prog., Phoenix, AZ. [8] Nolan J, and Graettinger A. (2020) Geo. Soc. of Amer. Abs. with Prog. Vol 52, No. 6. [9] (2021) CloudCompare 2.12.1