Criteria for candidate maars on Mars. A. H. Graettinger[1] and C. G. Hughes[2], [1]University of Missouri Kansas City, Kansas City MO, USA, graettingera@umkc.edu, [2]Eastern Kentucky University, Richmond, KY, USA..

Introduction: Maar-diatremes represent a specific type of explosive volcanic activity that requires subsurface volatiles, namely water or water ice. The positive identification of maars can provide important data on the presence and distribution of subsurface volatiles at the time of eruption. There is evidence of both subsurface volatiles and volcanism on Mars, making it an obvious location to begin the search for maars beyond Earth. The recognition of the distribution and abundance of maars on Mars will give indication of the previous availability of subsurface volatiles, their availability for interaction with rising magma, and provide indications of the Martian paleoclimate. Previous studies of volcanic landforms on Mars have revealed candidate phreatomagmatic vents [1-3], but in order to leverage maars to investigate subsurface volatiles on Mars, a means of recognizing a larger population of maars is required.

Challenge in Identification: A maar is a small, rimmed depression with non-circular shape, formed through a series of subsurface explosions that eject brecciated surface and subsurface material around the depression [4]. Well-preserved terrestrial maars have been cataloged and measured to constrain the anticipated shape of maars on Mars [5]. This shape information and contextual information make it possible to distinguish maars from periglacial features, simple primary impact craters, oblique or binary impacts, pit craters, and volcanic rootless constructs [6]. However, maar morphology is highly similar to secondary impact craters, a common feature on many planetary surfaces. In order to confidently identify maars, the unique morphologic qualities of these features must be isolated.

Methods: Closed depressions between 1-20 km were investigated in Arena Colles (AC), Nepenthes Planum (NP), Simud-Tiu Valles (STV), and Ravi Vallis (RV) as locations where volcanism was previously proposed to interact with external volatiles [2,3,7]. The rim of the craters were digitized on Context Camera (CTX) images [8] and measured (major and minor dimension, area, perimeter) using JMars [9]. Shape parameters - Aspect Ratio (AR), Elongation (EL) and Isoperimetric Circularity (IC) - were calculated.

$$AR = \frac{\text{Dminor}}{\text{Dmajor}} \quad EL = \frac{\pi(\frac{\text{Dmajor}}{2})^2}{\text{A}} \quad IC = \frac{4\pi A}{P^2}$$

Depressions were then evaluated for required and exclusionary criteria. Remaining depressions were then scored based on the number of supporting characteristics present.

Criteria: Morphologic characteristics of maars can be divided into required and supporting characteristics. The presence of some morphologic characteristics indicate a different geologic process and are deemed exclusionary.

Required criteria. For consideration as a maar a feature must be a closed-basin depression and cut below the surrounding topography.

Exclusionary criteria. The presence of the following criteria rule out a feature from being a maar: butterfly ejecta pattern, occurring in radial patterns from a large impact crater, scalloped crater floor, located on a topographic high, occur as multiple features on a lava flow, moat, have extreme convolution in shape as measured by Aspect Ratio and Elongation < 0.5 where 1 is a perfect circle, or be one of several similar features within a graben structure.

Supporting characteristics. Characteristics that may indicate the target feature is a maar include: a raised rim, non-circular shape (having an isoperimetric circularity of <0.97 where 1 is a circle), being non-symmetrical along the long axis, proximity to other small volcanic features, a lack of raised ridges ("septa") between basins, or have a visible bedrock ejecta boundary in crater walls. These features are not preserved in all terrestrial maars, and are not required for recognition as a maar.

Preliminary candidates: From 350 features a total of 39 depressions were ranked with scores between 1 and 6, where the higher the rank the more maar-like characteristics were displayed. Of these 9 were in AC, 15 were in NP, 6 were in STV, and 9 were in RV. The top 10 ranked depressions were found in AC and RV. The ranking system is shown to be influenced by a preservation bias, where morphologically young depressions preserve more features and end up more highly ranked. Further, the current approach does not conclusively eliminate all secondary craters as there is no dataset for comparative evaluation to remove maar-like secondary craters. Figure 1 shows the craters from Arena Colles that display not only maar characteristics, but are distributed within a volcanic field in a manner similar to terrestrial volcanic fields [5]. Figure 2 shows candidate craters from RV that are maar-like, but show similar orientations suggesting a secondary crater origin, even when they cannot be correlated to a specific primary. Additional work characterizing secondary craters in this size range will be necessary to further divide these candidates.

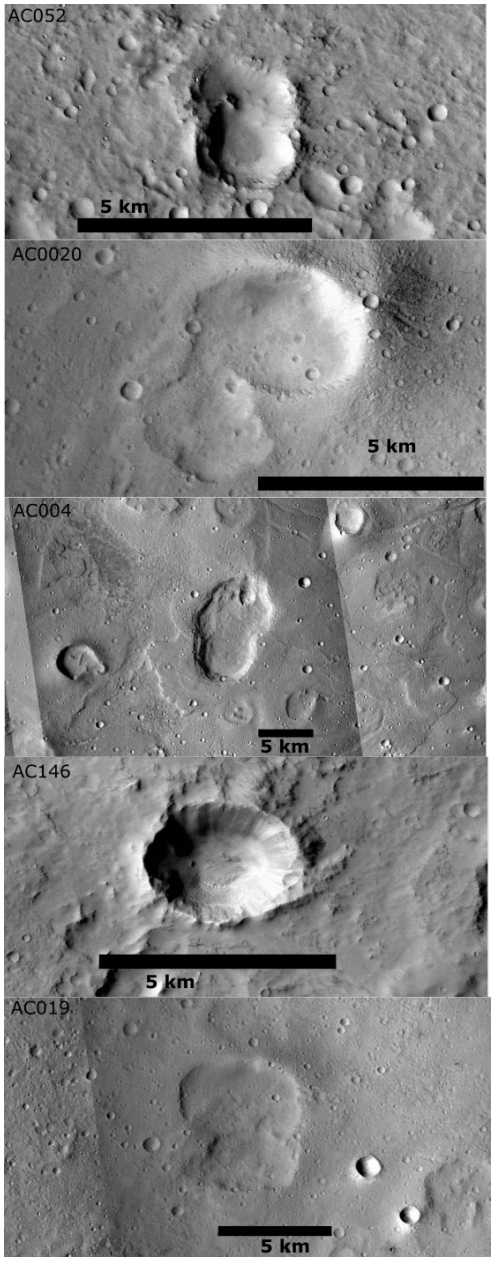

Figure 1: CTX images of candidate maar craters on Mars: AC052: 28.08621; 85.35241E; AC020 24.123254, 88.409688E; AC004: 23.649299, 88.939226E; AC 146: 28.454917, 86.061620E; AC019: 23.95253259, 88.412762E.

Summary: Morphometric comparisons of terrestrial maars with closed depressions on Mars supports the model that these phreatomagmatic constructs are to be found on Mars. While secondary craters were found within the top ranked maar-like features (all examples in Ravi Vallis) more than half of the examples from Arena Colles show strong maar-like characteristics and are distributed within a field of other small volcanic vents. The relative number of maar-like vents to cones in Arena Colles and larger crater diameter of candidate maars relative to craters on cones suggests that they are Martian maars. Morphologic analysis of small secondary craters on Mars and other bodies including spatial and orientation data would provide a useful point of comparison to refine this list of candidate maars and enable the expansion of the hunt for maars to other locations on Mars. Once a robust population of candidate maars is identified on Mars they will be useful for paleoclimate studies of subsurface volatiles.

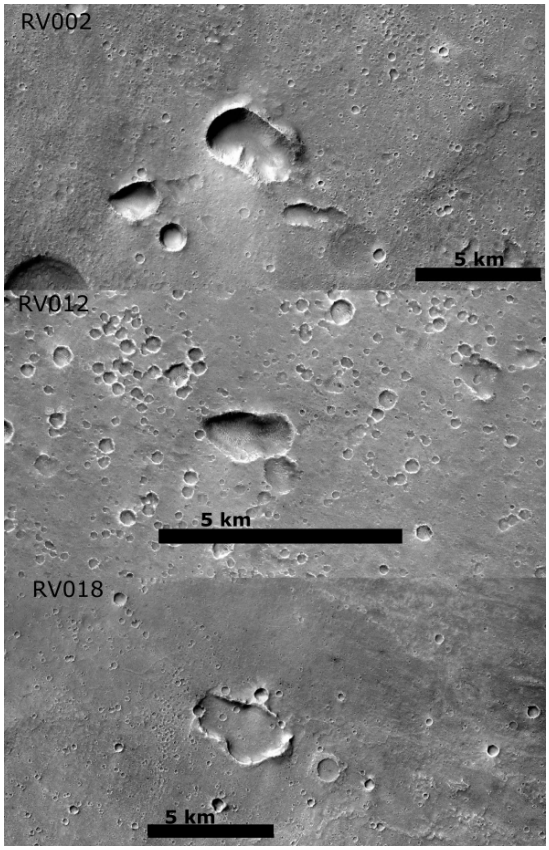

Figure 2: CTX images of closed depressions in Ravi Vallis with maar-like characteristics. The similarity in orientation suggests they are secondary craters. RV002; -2.18145, 318.87937E, RV012: -3.54376, 319.23512E, RV018: -0.80434, 319.2917E.

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