Volcanism and Giant Polygons within Argyre Basin, Mars

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Introduction: The Argyre impact basin, with a diameter > 1200 km and depth of > 4 km, has experienced a complex geologic history and has been a sink for volatiles and other materials [1][2]. The discovery of a large (~ 60 km diameter) topographic feature, Argyre Mons, on the floor of the basin was first reported by Williams et al. [3] and interpreted to be volcanic in origin. More recent analysis of image and topography data in the vicinity of Argye Mons reveals additional features consistent with magma-volatile interaction. This includes additional cones, vents, mounds, and collapse features, many of which are associated with extensional tectonics and fluvial erosion indicative of melting and/or dewatering of the regolith. This represents a previously unrecognized aspect of the geologic history of the basin with astrobiological implications.

Volcanism: Argyre Mons consists of a quasi-circular rim of high-standing material forming a conic structure with a central, caldera-like pit with a diameter ~ 25 km (Fig 1). The flanks of the feature extend $10 - 20$ km outward from the central depression. Steeper sloped, irregular arcuate ridges at the crest of the north and south flanks, form the highest elevations and may be possible remnants of a rim structure. A smaller cone is observed on the northern flank ~ 5 km in diameter, with a circular central depression ~ 2 km in diameter. A few additional examples of features resulting from volcanism and magma-volatile interation near Argyre Mons are shown in Fig 2.

Giant polygons: Giant polygons are observed on the west margin of Argyre Mons (Fig 1) and are confined to a ~ 2000 km^2 relatively flat area with an elevation ~ -2600 m. The original extent of the polygons is unclear but their restricted elevation implies they formed within a particular stratigraphic horizon within the basin deposits. The polygons are highly irregular and angular in shape ranging in size $\sim 1 - 10$ km with rounded, convex, bounding trough walls. Trough widths vary with the larger troughs ~ 500 m wide. Kilometer-scale polygons have been observed in several locations within the northern lowlands with major occurrences in Acidalia Planitia, Chryse Planitia, Utopia Planitia, and

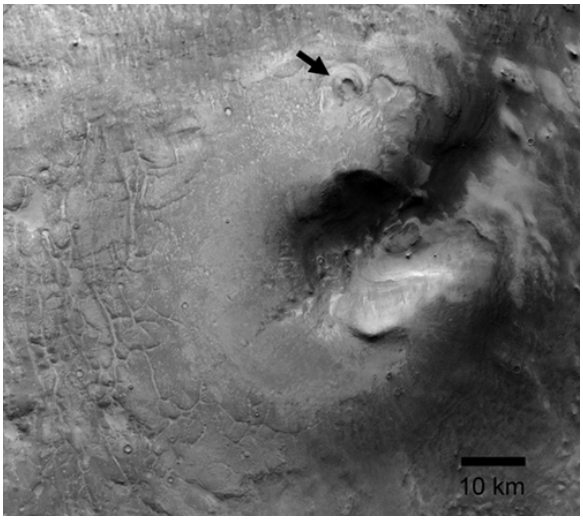

Figure 1: Argyre Mons and giant polygons on the floor of Argyre Basin. Arrow highlights smaller cone.

Arcadia Planitia [4]. The origin of giant polygons is unclear though suggested mechanisms of formation generally involve water, either as ice, water-rich sedimentation, or standing bodies of water. Hence, their discovery within Argyre Basin supports the hypothesis that the basin contained large amounts of water at some point in its past [1].

Crater counts: Crater counts were conducted on the flanks of Argyre Mons and the polygons (Fig 3). A model age of ~ 3 Ga is obtained for both surfaces using the Hartmann [5] chronology system indicating formation of the polygons and Argyre Mons may have been contemporaneous. Dohm et al. [1] compiled crater statistics to evaluate the formation and modification ages of the Argyre rock units using craters with $D > 3$ km. The total crater population, which included partly buried, degraded, and pristine impact craters, yielded a model age of ~ 3.5 Ga. The pristine craters with distinct rims and ejecta blankets and lacking visible evidence for resurfacing, produced a model age of ~ 1.3 Ga indicating a period of major resurfacing occurred during the Middle and Late Amazonian epochs. Argyre Mons and the polygons predate this more recent resurfacing. Many of the superposed craters are highly degraded with a signif-

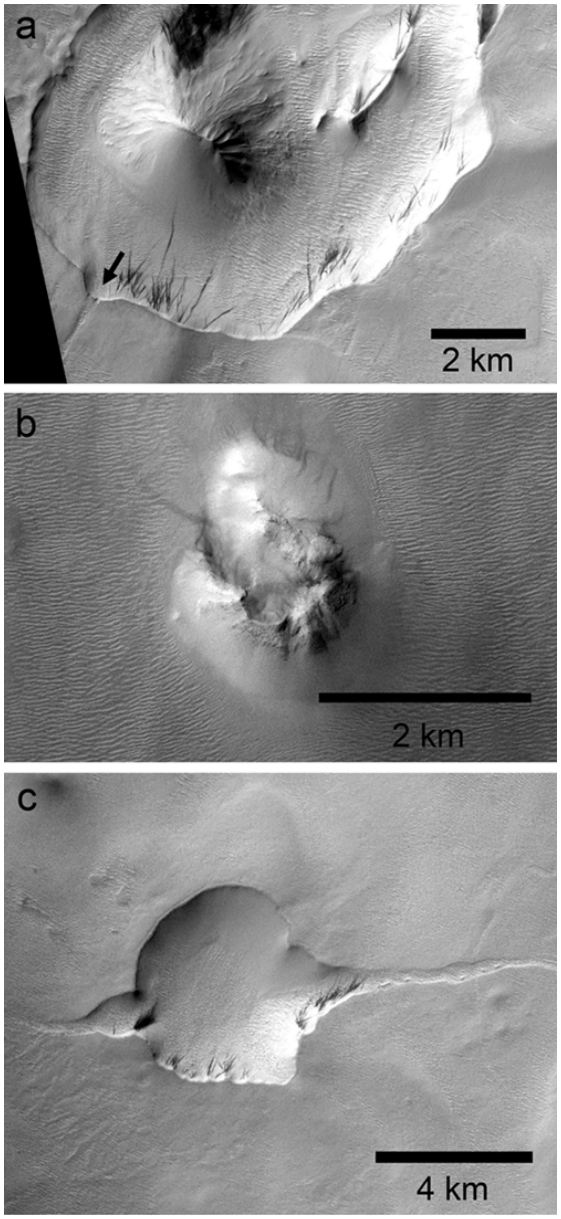

Figure 2: (a) Mounds and ridges within a depression resulting from intrusion of magma into ice-rich regolith. A saddle in the southwest rim with channel extending down slope (black arrow) indicates the rim was breached by fluid. (b) Structure $\sim 1-2$ km wide with summit depression. (c) Maar formed by intrusion into ice-rich regolith resulting in an explosive eruption.

icant deficit of craters $D \lesssim 300$ m. The presence of several pedestal craters indicates that their surfaces have experienced deflation. A severe lack of craters with a fresh appearance at any size implies some deflation of the surface has persisted to at least the recent past.

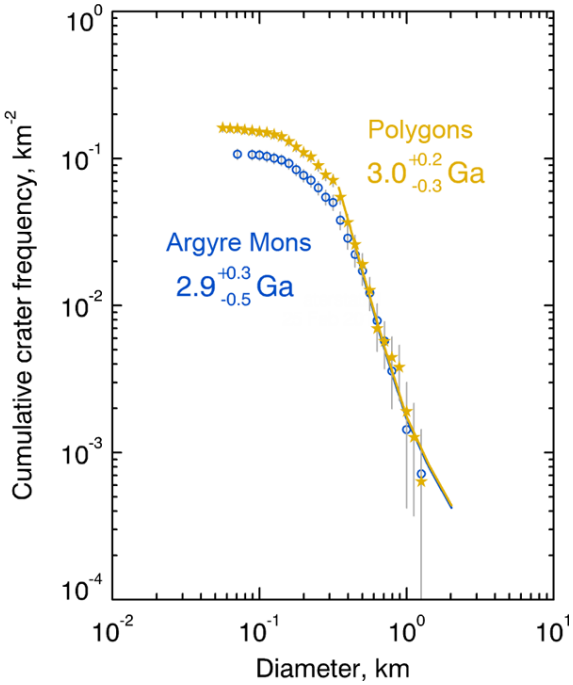

Figure 3: Cumulative crater-size frequency distribution of craters on the flanks of Argyre Mons and the giant polygons. Model ages derived using [5] and plotted with Craterstats [6].

Astrobiology: Evidence for volcanism within the floor of Argyre Basin, coupled with the basin's water-rich past, further supported by the giant polygons, make Argyre a site of astrobiologic significance. The apparent contemporaneous age and location of giant polygons and a sizeable volcanic feature provide the possibility for steep thermal and geochemical gradients available for microbial colonization.

References

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