A Large Vent Structure within Argyre Basin, Mars

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Introduction: The Argyre Basin, an impact basin in the southern highlands southeast of Tharsis at $-51°$ S and $317°$ E, is one of the largest impact basins on Mars with a diameter > 1200 km. The basin formed in the Early Noachian and has experienced a complex geologic history. The basin has been a sink for volatiles and other materials experiencing a significant influx of sediments and partial infilling with water. Eolian activity has played a substantial role in contributing to the present day morphology of the basin floor. Detailed descriptions of the basin and its geologic history can be found in [1]. Here we describe a previously unidentified vent-like struture on the floor of Argyre.

Description: The feature 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 from the rim. Steep, ridge structures are preserved on the north and south rims forming the highest topography, while the rim topography is more subdued to the west with some evidence of sapping near the crest. The eastern side of the feature is absent creating a horseshoe-like shape in topography with the central depression opening eastward. A smaller vent structure, possibly a parasitic cone, is observed on the northern flank (Fig 1). It is ~ 5 km in diameter with a circular central depression ~ 2 km diameter. Fine scale layering, most apparent around the rim of the central depression, is fairly concentric to the depression however is appears to be deformed in places by folding, reminiscent of soft sediment deformation.

Volcanism: Volcanic landforms are abundant on Mars and display a diversity of constructional styles. Jovis Tholus ($18.41°$ N, $242.59°$ E) [2] provides an example of a shield structure of comparable vertical and horizontal dimensions with a complex caldera similar in scale to the central depression of the Argyre feature (Fig 2). The Ngorongoro Crater of northern Tanzania provides a terrestrial example of a volcanic shield structure and caldera of comparable size and is one of nine Plio-Pleistocene volcanoes that comprise the Nogorongoro Volcanic Highlands (NVH) complex of the East African Rift System [3].

Given the geologic history of the Argyre basin involving an aqueous and ice rich environment, phreatic and phreatomagmatic eruptions may have played a role in forming the feature. Tuff cones, tuff rings, and maars result from the explosive interaction of magma with standing water or ground water. These features however tend to be much smaller in scale. The largest known maars on Earth, the Espenberg Maars on the Seward Peninsula in northwest Alaska, are $4 - 8$ km in diameter and resulted from a series of basaltic eruptions through thick permafrost [4]. The largest tuff cones are the Menan Buttes in the Snake River Plain of southeast Idaho, part of a late-Pleistocene complex of basaltic tuff cones [5], formed by a basaltic dike intruding into shallow water-saturated alluvium. The Menen buttes are much smaller in scale however with elevations ~ 250 m above the surrounding plains and base diameters < 4 km in the widest dimensions. Tuff rings and cones have been tentatively identified in the Amenthes region of Mars [6] with the larger cones of similar scale to the Menan Buttes.

Mud volcanism: Fluid expulsion in compacting deposits has been recognized to form volcano-like structures in terrestrial sedimentary basins, both onshore and offshore. Pore fluid pressure builds when the pressure cannot dissipate adequately through the sediment and can be focused through fractures or zones of enhanced permeability to breach the capping layer. The extrusion of fluid and entrained sediments can result in a cone shaped edifice, or mud volcano. Such a formation mechanism has been proposed for many of the mounds observed in the lowlands of Mars (e.g. [7]). The Touragai Mud volcano in eastern Azerbaijan is considered to be one of the biggest onshore mud volcanoes with a diameter ~ 3 km and a height of 500 m [8]. The lack of evidence for volcanism in the floor of Argyre basin and its water-rich, depositional history, makes mud volcanism an attractive hypothesis. Terrestrial mud volcanoes can have a conical shape and summit crater similar to volcanic cones; however, the feature in Argyre is much larger than the other candidate mud volcanoes on Mars or identified on Earth.

Impact origin: An alternate hypothesis is that rather than being a constructional feature, it is a

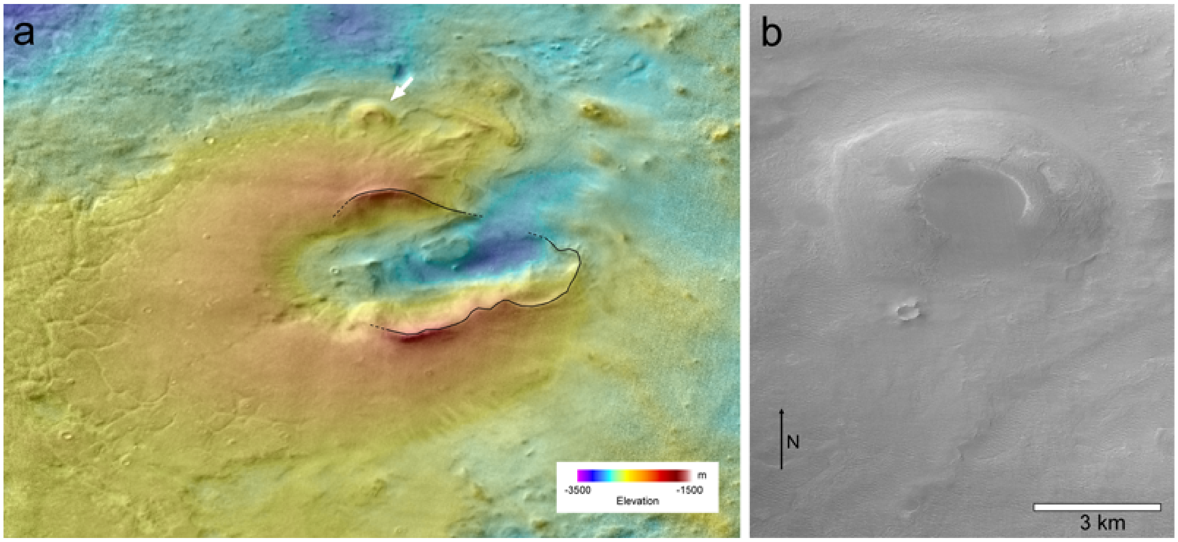

Figure 1: (a) THEMIS IR daytime mosaic color shaded with MOLA topography. Black lines outline topographic ridges, possible remnants of crater rim structures. (b) Smaller cone structure on the north flank of the edifice (CTX image: G13_023463_1283_XN_51S047W).

remnant impact feature. The irregular, east-west elongation of the depression and flanks could be partly due to differential erosion but could also result from an oblique impact. This would require deflation of the surrounding basin floor of $\gtrsim 500$ m to explain the elevation of the rim. Eolian activity on the basin floor is evident with deflation and the accumulation of dunes modifying the basin floor. If the rim of the feature represents the approximate elevation of the basin floor at the time of an impact, i.e. the basin floor was $\gtrsim 500$ m higher than the present-day level, this would require a removal of $\sim 3.8 \times 10^{14}$ m^3 of material from the basin interior.

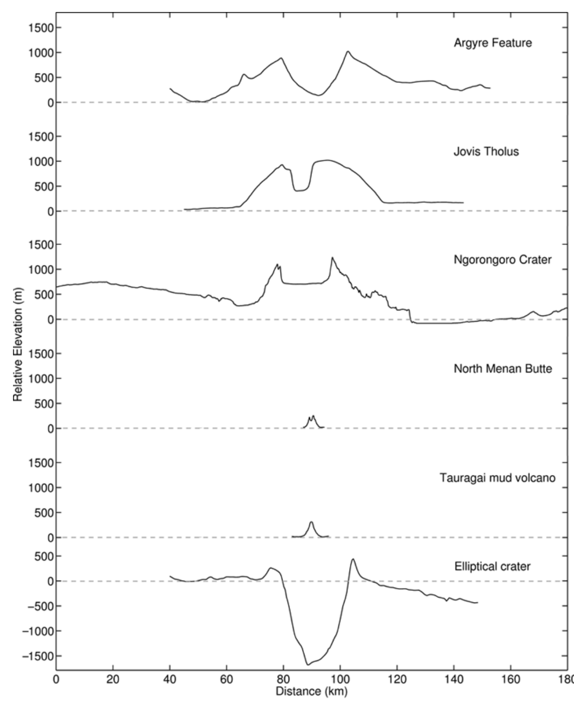

Figure 2: Elevation profiles of Argyre feature and possible analogs.

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