EXPLOSIVE VOLCANISM, LAYERED DEPOSITS AND COLLAPSE FEATURES IN ARABIA TERRA: THE "SUPERVOLCANO" HYPOTHESIS. J. R. Michalski[1,2], J. E. Bleacher[3]. [1]Planetary Science Institute, Tucson, Arizona, 85719, USA; michalski@psi.edu, [2]Dept. of Earth Sciences, Natural History Museum, London, UK, [3]NASA Goddard Space Flight Center

Introduction: The Arabia Terra region of Mars is one of the most ancient and enigmatic parts of the planet. It contains complex landforms [1-3] with characteristics suggestive of impact, volcanic, tectonic, and glacial processes [4-5]. In addition, the region contains vast amounts of ancient layered, friable materials [6-7] that likely represent airfall dust and/or ash deposits [8]. We suggest that some of the enigmatic geology of Arabia Terra can be connected if the area experienced an early phase of intensely explosive volcanism, leaving collapse features which are structurally similar to large terrestrial calderas, informally referred to here as "supervolcanoes," thereby indicating source areas for some of the most explosive eruptions in martian history [9].

Collapse features: In northern Arabia Terra, we have identified several large (20-100 km-diameter) basins that are unlikely to have formed from meteor impact. Many of these features have not previously been distinguished from degraded impact craters. Yet, these features generally do not preserve any clear evidence for impact processes; no morphologic evidence for central uplifts, uplifted rims, ejecta, or inverted stratigraphy is observed in remote sensing data. While all of these features could have been removed by erosion, significant resurfacing of ancient impact craters generally results in lower crater depth/diameter ratios than what is observed in these basins (Figure 1).

For example, an unnamed feature located at 16.26 E, 29.42 N has a very high depth/diameter ratio, and despite its apparently well-preserved state, it exhibits no evidence for an impact origin (Figure 2a). Instead, the feature has a scalloped rim, circumferential fractures and a two-tiered floor, indicative of sequential collapse. Another feature located at 346.2 E, 31.45 N has a higher degradation state, but yet has a large depth/diameter ratio. The feature also exhibits ring fractures and faults, and massive slump blocks on the depression floor related to collapse (Figure 2b).

Other features in northern Arabia Terra contain evidence for collapse. Siloe Patera (6.6 E, 35.2 N) is a set of nested, deep depressions that reach ~1750 m below the surrounding plains. Euphrates Patera is an irregularly shaped depression that reaches 700 meters depth below the surrounding lava plains and contains several benches in the interior that might be explained by sequential episodes of collapse.

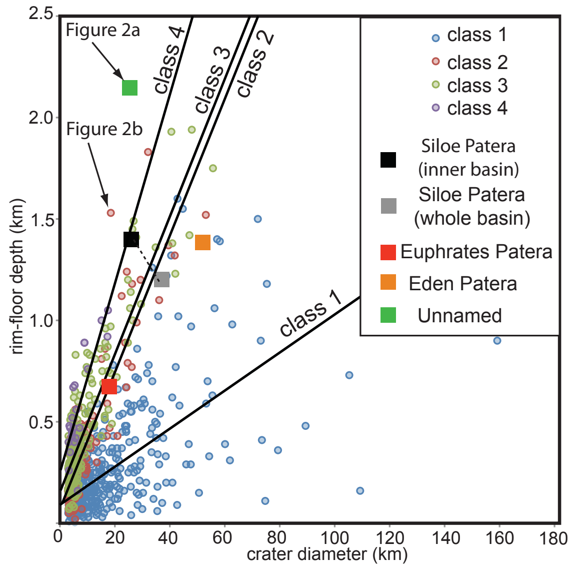

Figure 1: A plot of crater measurements for all of the craters within northern Arabia Terra [9] with diameters ≥1km that have been categorized according to their level of preservation [10]. Class 1 craters are the most degraded and Class 4 are the least (essentially pristine). The proposed collapse features plot along trendlines associated with moderately modified craters that preserved impact morphologies – yet the proposed collapse features retain no evidence for impact, despite their relatively high depth/diameter ratios and inferred preservation state.

Evidence for volcanism: The collapse features are associated with characteristics that can be explained through volcanic origins. The best example of a caldera complex is Eden Patera (Figure 3), which is a large, irregularly shaped topographic depression (~55 km by 85 km in diameter, NW-SE and SW-NE respectively) located at 348.9 E, 33.6 N within Noachian-Hesperian ridged plains of likely volcanic origin. The complex, which reaches a maximum depth ~1.8 km below surrounding plains, includes at least three linked depressions bounded by arcuate scarps and associated with numerous faults and fractures. We interpret Eden Patera as a caldera complex based on its association with features that indicate formation via collapse and volcanism both within and exterior to the depression. Within the complex are fault-bounded blocks that tilt towards the crater center and are unrelated to headwall scarps that would suggest a process similar to landslides. Graben associated with the interior fault blocks may have originally been linked with circumferential graben outside of the complex related to older collapses or progressive formation through "piecemeal," mul-

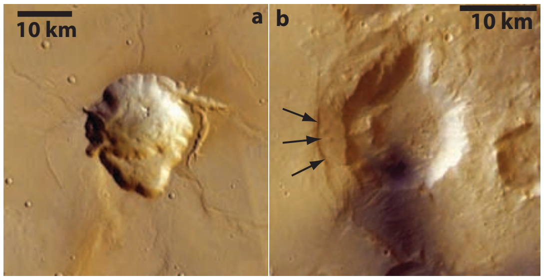

Figure 2: The “unnamed” feature from Figure 1 is shown in “a.” The class 2 crater identied in figure 1 is shown in “b.” We suggest this feature might be a collapse feature rather than a degraded impact crater. The arrows point to fractures.

ticyclic evolution [11]. We interpret a ~ 700 m high mound (11x23 km N/S-EW respectively) within the complex to be a graben-related vent. Two sets of nearly continuous terraces are found ~100 and 150 meters above the caldera floor. These terraces are strikingly similar to the “black ledge” described during the Kīlauea Iki eruption in 1959 [12], indicating high stands of a drained lava lake [13]. A small mound (1 km across) several hundred meters high and located between the two terraces displays surface cracks similar to a tumulus [14]. Although tumuli clefts form during inflation, we suggest that these cracks formed as the lava lake drained and the sinking lake crust was draped onto caldera wall rocks.

Other collapse features within Arabia Terra do not exhibit as many pieces of evidence for volcanism as does Eden Patera. However, the other features identified above and in [9] do show associations with friable materials, ridged plains and multiple episodes of collapse.

Implications: Basaltic volcanoes are likely to be more explosive on Mars than on Earth due to the lower gravity environment on Mars [15]. Indeed, evidence for explosive volcanism has been identified on Mars previously [16-17]. This work is different and important for several reasons: a) this work represents the first strong evidence for volcanism in Arabia Terra (in particular, Eden Patera exhibits the strongest evidence); b) the collapse features described here represent a new type of highland patera – features that erupted explosively, did not build up a central edifice, and were dominated by collapse (similar to “supervolcanoes” on Earth); and c) the presence of candidate volcanic sources in Arabia Terra could potentially explain the origins of vast deposits of fine-grained materials through Arabia Terra [18] and other low-latitude regions. Further work is needed to evaluate evidence for a volcanic origin of these features in Arabia Terra. However, if correct, this hypothesis would reveal new links between collapse features and fine-grained deposits throughout the planet and open a new window in to ancient volcanism.

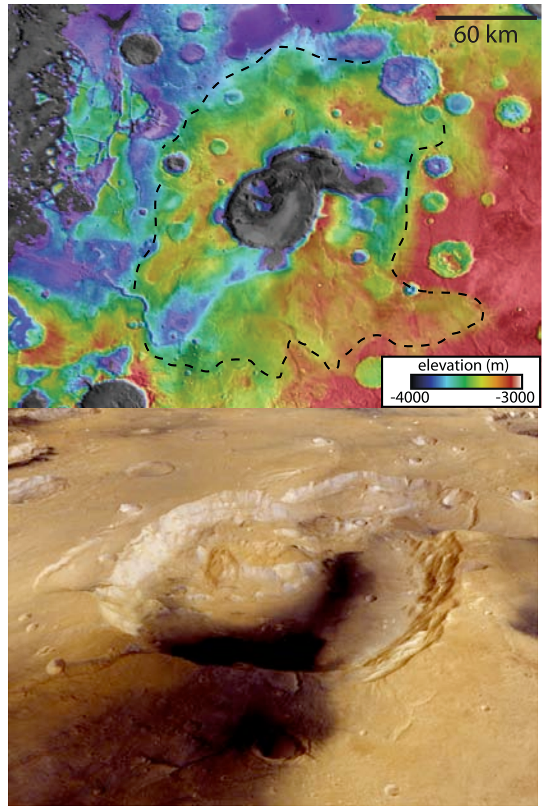

Figure 3: MOLA data draped over THEMIS daytime IR show Eden Patera (top), a complex collapse feature associated with ridged plains and chaotic, friable materials in northwestern Arabia Terra. The lower image shows Eden Patera in HRSC data in 3D (HRSC/ University of Berlin/MEx-ESA).

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