EVIDENCE FOR ANCIENT EXPLOSIVE VOLCANISM WITHIN ARABIA TERRA, MARS. J. R. Michalski[1,2], J. E. Bleacher[3] and S. P. Wright[4], [1]Planetary Science Institute, Tucson, Arizona, 85719, USA; michalski@psi.edu, [2]Dept. of Earth Sciences, Natural History Museum, London, UK, [3]NASA Goddard Spaceflight Center, Greenbelt, Maryland, USA. [4]Dept. of Geology and Geography, Auburn University, Auburn, Alabama.

Introduction: Arabia Terra, an extremely ancient region of Mars, contains layered, fine-grained materials including sulfate-bearing sedimentary rocks [1-2], and friable rocks composing fretted terrains [3], which may have a volcanic origin [4]. However, one challenge to this idea is the lack of a viable volcanic source region that can be linked to the deposits [5]. In fact, much of the ancient martian crust has been resurfaced by volcanic materials from unidentified sources [6]. It is unclear if ancient volcanism remains poorly understood because evidence for such activity has been obliterated by erosion [7] or if evidence has, in some cases, been overlooked because ancient volcanoes are of fundamentally different character than those associated with well-characterized Hesperian shield volcanoes.

We have identified a new type of ancient volcanic construct within Arabia Terra, Mars [8]. The features are characterized by the presence of large collapse structures, with low overall topographic relief (i.e. lower than that of typical paterae), and associations with fine-grained deposits and ridged plains lavas. We refer to the features as "plains-style caldera complexes." Northern Arabia Terra contains many examples of theses features, (Figure 1) each of which likely produced huge volumes of pyroclastic materials and lava. The large calculated erupted volumes, evidence for collapse, low relief, and evidence for resurgent domes are all consistent with characteristics of terrestrial examples of supervolcanoes.

Identification of features: The type-example of a plains-style caldera complex is Eden Patera (Figure 2), 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 depression is unlikely to be of impact origin. It lacks any morphological indicator of meteor impact, such as the presence of ejecta, a raised rim, inverted topography, a central peak, or nearly circular geometry. Because it retains a number of morphologic features predating the final episode of collapse that have not been removed by erosion (such as ridged plain lava textures) and because it has a high depth-diameter ratio inconsistent with resurfacing and filling of the cavity, we conclude that the feature is unlikely to be a degraded impact crater. The volume of the depression within Eden Patera (>4000 km^3) is likely greater than the amount that could have been produced by collapse linked to removal of subsurface ice. For these reasons, we interepret Eden Patera as a complex caldera formed through structural collapse associated with withdrawal or migration of magma at depth, and explosive eruptions.

Other features in northern Arabia Terra contain evidence for collapse associated with volcanic activity. 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 or lava lake high stands. Semeykin Crater is a large, scalloped depression surrounded by lava plains and friable deposits, which also contains mounds of friable materials in its interior and ridged plains along the exterior. A suite of features, Ismenia Patera, Oxus Patera, and Oxus cavus are located together near 0E, 38.5 N. The two patera exhibit scalloped, breached rims composed of layered materials.

Taken together, these features constitute a new category of martian volcano that can be described as plains style caldera complexes, of which Eden Patera is the type-example [8].

Implications: The discovery of a new type of volcanic feature within the ancient crust of Mars fundamentally changes the view of ancient martian volcanic processes, and expands known volcanic source regions and processes. Explosive volcanism might have occurred in Arabia Terra due to crustal thinning related to extension and/or thermal erosion [9], though we cannot yet rule out the possibility of ancient subduction beneath northern Arabia [10]. Evolved magmas are not required to produce supervolcanoes on Mars. Basaltic magmatism is more likely to result in explosive volcanism on Mars than on Earth, due to the lower gravity on Mars, which leads to reduced pressures and therefore bubble nucleation at greater depths compared to Earth [11]. Gas-charged magmas could have explosively erupted from shallow depth within the crust, producing significant amounts of pyroclastics, that could potentially be the source material of layered, sulfate-bearing, friable deposits and fretted terrains in the region.

References: [1] Malin, M. C. & Edgett, K. S. *Science* **290**, 1927-1937 (2000). [2] Gendrin, A. *et al.*. *Science* **307**, 1587-1591, doi:10.1126/science.1109087 (2005). [3] Sharp, R. P.. *JGR* **78**, 4073-4083 (1973). [4] Hynek, B. M., Phillips, R. J. & Arvidson, R. E. *JGR* **108**,10.1029/2003je002062 (2003). [5] Kerber, L. et al.. *Icarus* **219**, 358-381 (2012). [6] Greeley, R. & Spudis, P.*, Rev. Geophys., 44.* **19**, 13-41 (1981). [7] Golombek, M. P. *et al. JGR* **111**, doi:10.1029/2006 je002754 (2006). [8] Michalski, J.R. & J.E. Bleacher, *Science*, (submitted). [9] Neumann, G. A. *et al.*, *JGR* **109**, E08002 (2004). [10] Sleep, N. *JGR* **99**, 5639-5655 (1994). [11] Wilson, L. & III, J. H.*, Rev. Geophys., 44, doi:10.1029/2005RG000188.* **32**, 221-263 (1994).

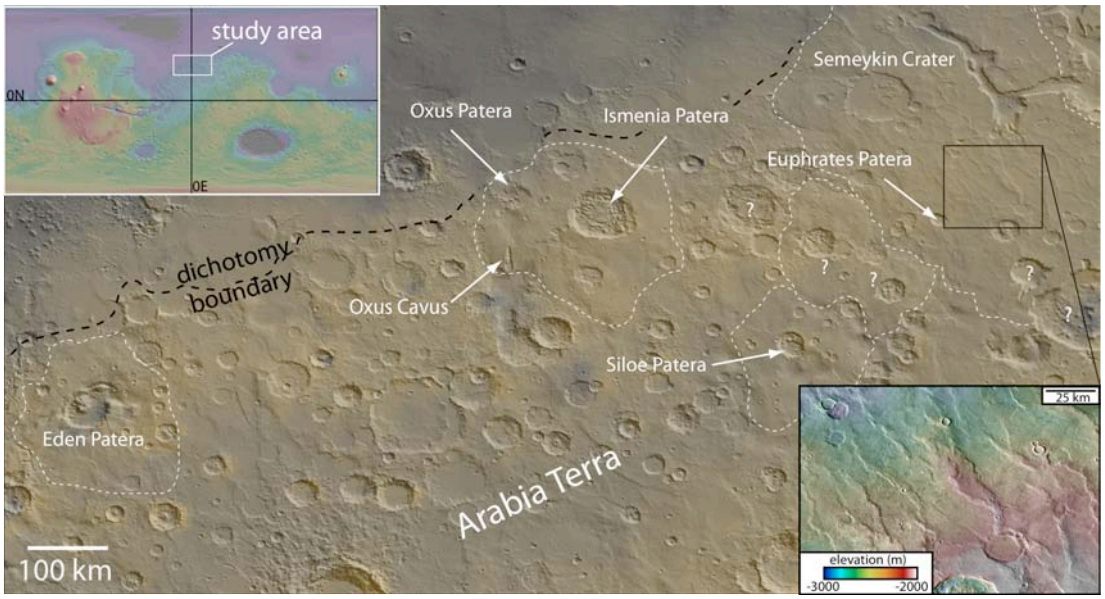

Figure 1: The dusty nature of the northern Arabia Terra region of Mars is shown in false color TES-derived albedo data draped over MOLA hillshade data, where bright colors correspond to dusty surfaces. Recently named geographic features discussed in the text are labeled.

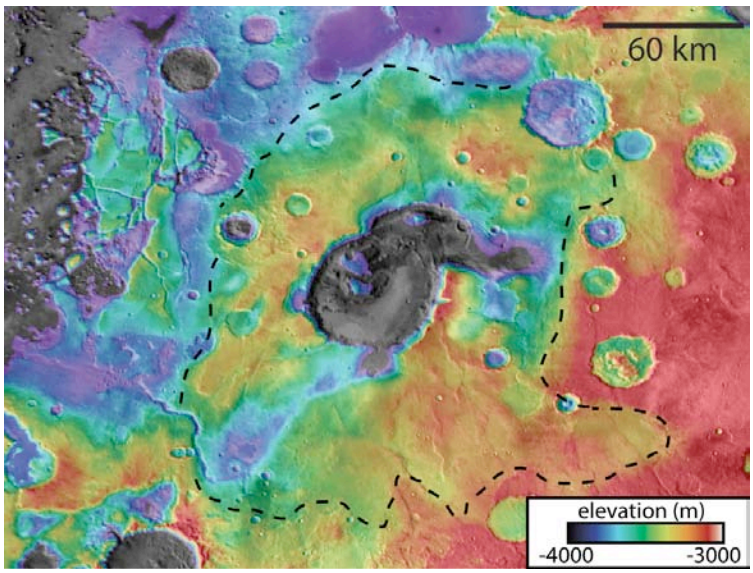

Figure 2: MOLA topographic data are draped over THEMIS daytime IR data showing the morphology of Eden Patera.