**EVIDENCE OF HYDROTHERMAL ACTIVITY AT APOLLINARIS PATERA, MARS.** M. R. El Maarry[1,2], J. M. Dohm[3], G. A. Marzo[4], R. Fergason[5], E. Heggy[6], W. Goetz[1], A. Pack[2], and W. J. Markiewicz[1]. [1]Max-Planck Institut für Sonnensystemforschung, 37191, Katlenburg-Lindau, Germany, First author email: elmaarry@mps.mpg.de, [2]Geowissenschaftliches Zentrum, Georg-August University, Göttingen, Germany, [3]Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona, [4]ENEA, C.R. Casaccia, Roma, Italy, [5]U. S. Geologic Survey, Astrogeology Science Center, USA, [6]Jet Propulsion Laboratory, Pasadena, California, USA.

**Introduction:** It is likely that, similar to Earth, the geologic record of Mars includes impact-generated [1,2] and magmatic-driven [3,4] hydrothermal activity. This is deduced from the widespread occurrence of impact, volcanic, and water-related features on the surface, which are often temporally and spatially associated.

Both impact- and magmatic-driven hydrothermal systems represent locations of exobiological interest due to the ability of such environments to sustain life on Earth. As a result, many efforts have been devoted to locating optimum hydrothermal targets on Mars for exploration. The work presented here is inspired by such efforts, particularly focusing on Apollinaris Patera, which has already been identified as a site of potential magmatic-driven hydrothermal activity on Mars [3,4]. In this study, we test the hydrothermal hypothesis by looking for key indicators of hydrothermal activity in the Apollinaris region.

**Apollinaris Patera:** Apollinaris Patera (Fig. 1) is a prominent 200 km-wide and 5 km-high shield volcano located near the boundary between the northern plains and southern highlands (174.4°E, 9.3°S) and approximately 200 km north of Gusev Crater, the target of investigations by the Spirit rover. It contains a multi-stage caldera complex approximately 80 km in diameter. The northern and eastern flanks of the edifice are surrounded by the Medusae Fossae Formation [5] and terminate with clear scarps. The southern flank, however, is characterized by extensive fan deposits that drape parts of the volcano from summit to base. The Viking-era mapping investigations pointed to the Apollinaris Patera shield volcano and surrounding region as a potential environment of significant magma and water interactions [5,6]. This includes possible presence of pyroclastic deposits, breaking up of parts of the volcano to form chaotic terrain, and a network of valleys along the southern margin of the above-mentioned Hesperian-aged fan deposit [5]. Our primary objective is to assess the role of Apollinaris in forming an extensive hydrothermal system in a region that could be of significant interest for future in-situ exploration. We address this objective through a detailed examination of a set of criteria used for identifying candidate hydrothermal sites on Mars similar to Apollinaris Patera [3]. A discussion of the relevant criteria is followed by our findings.

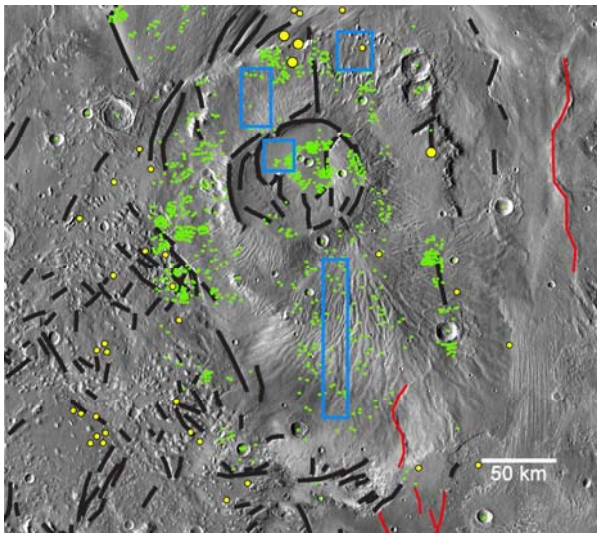


**Fig. 1**. Visual THEMIS mosaic of the Apollinaris Patera and surrounding terrain. Apollinaris occurs near the boundary that separates the northern plains from the Southern highlands. Medusa Fossae Formation partly surrounds the shield volcano to the north and east, and chaotic terrain is prevalent to the west of the volcano. The main construct is almost 200 km wide, displaying a caldera complex at its summit that is almost 80 km in diameter. The volcano is also notable for the extensive fan deposits that drape the southern flank and appear to originate from a small channel that dissects the southern rim. Also shown are the distributions of isolated mounds (small yellow circles) and clustered ones (large yellow circles; see Fig. 2), impact craters with associated fluidized ejecta (green) which were identified using CTX images, lineaments interpreted to be faults, fractures, and scarps formed by tectonism, collapse, and/or erosion (black lines), wrinkle ridges (red lines), and areas where crater counting was performed (blue boxes).

**Criteria for locating hydrothermal systems on Mars:** [3] made use of the recent improvements in data quality (i.e., Mars Global Surveyor and Mars Odyssey) to observe distinct geologic, paleohydrologic, paleotectonic, topographic, geophysical, spectral, and elemental signatures on the surface of Mars in search of sites of potential hydrothermal activity. In doing so, they proposed a set of criteria that a certain location should display in order to be deemed a location with high hydrothermal activity potential. These criteria include: (1) evidence of action of liquid water through erosion; (2) evidence of volcanic constructs and/or lava flows; (3) evidence for a center of magmat-

ic driven tectonism; (4) evidence for impact events in ice-rich regions; (5) presence of minerals that usually have a hydrothermal origin or that are indicative of hydrothermal alteration; (6) geological similarity to hydrothermal analog environments on Earth; and (7) geomorphological evidence for magma/water interaction. We have added criterion (7) to the previously published ones by [3].

**Findings and discussion:** Our investigation supports the Viking-era geologic investigations [5,6] which pointed to Apollinaris Patera as a prime site of magmatic/hydrothermal activity. This includes:

(1) A valley system, which dissects Medusae Fossae materials to the east of the volcano, is traced more accurately corroborating the previous assumptions [5] that the system marks geologically recent liquid water activity on the Martian surface.

(2) Ubiquitous presence of impact craters in both shield-forming (flank and caldera) materials and materials that surround the volcano that are indicative of water-rich target materials at the time of impact such as layered impact ejecta deposits (Fig. 1).

(3) Some chaotic-terrain-composing mesas which display terraces along their margins and flows near their summits, possibly marking aqueous activity.

(4) Numerous faults, fractures, and scarps possibly related to magmatic-driven tectonism, which were not observed during Viking–era geologic mapping investigations (Fig. 1)

(5) Mounds of diverse geometric shapes, many of which display summit depressions and occur among faults and fractures, possibly marking venting (Fig. 2).

(6) Evidence on the flanks of the volcano for lahar events (Fig. 3).

(7) A possible association in time and space among shield-forming materials and Medusae Fossae materials.

Our results also point to Apollinaris being a site of exobiological significance, which includes the mound-like features as prime candidate targets to test whether fossilized and/or extant life exists on Mars. Our findings will be detailed at the meeting.

**References:** [1] Newsom H. E. (1980) *Icarus, 44*, 207-216. [2] Abramov O. and Kring D. A. (2005) JGR, 110, doi:10.1029/2005JE002453. [3] Schulze-Makuch D. et al. (2007) *Icarus*, 189, 308–324. [4] Dohm J. M. et al. (2008) *Planet. Space. Sci., 56*, 985-1013. [5] Scott D. H. et al. (1993) *USGS* map I-2352. [6] Robinson M.S. et al. (1993) *Icarus, 104*, 301–323.

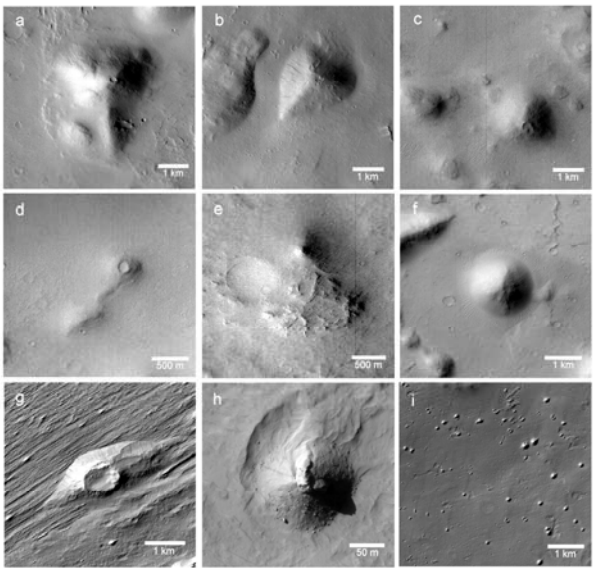


**Fig. 2**. Examples of mounds observed at Apollinaris. The mounds range in size from 0.1 to ~3 km in diameter and have variable shapes. Shadow analysis reveals a variation in width to height ratio, though quantitative information cannot be determined. The mounds form two distinct groups: Large 0.2 to 3 km-sized isolated structures that are pitted at times (d, e , and g), and clusters of smaller (100 m-sized) cone-like structures located on the northern flank of the main edifice and close to the MFF. Some appear to be spatially associated with faults and fractures, possibly indicting basement structural control. The variable morphologies can be indicative of different formation mechanisms.

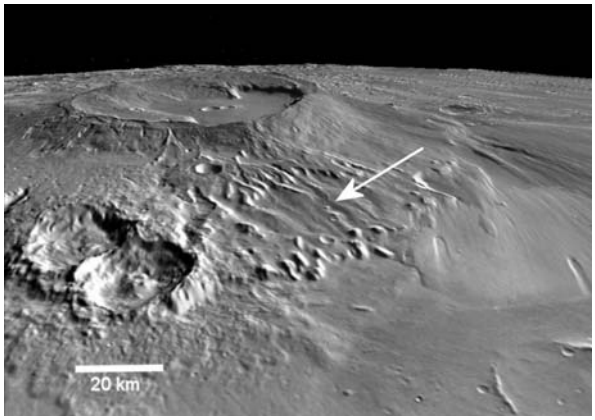


**Fig. 3**. Digital terrain model (vertical exaggeration: 3x) of the putative lahar deposits on the NE flank previously interpreted as a volcanic unit [5]. Notice the degradation of the old ejecta deposits of a 5 km-sized impact crater into dendritic landforms. Crater counts produced for the unit confirm their relatively younger age with respect to other flank material, fan deposits and inner caldera (see fig. 1 for locations of crater counts). Image credit: Google Mars.