ASSESSMENT OF A POSSIBLE VOLCANIC PALEOLAKE AT APOLLINARIS PATERA, MARS: CONSTRAINTS ON THE COMPOSITION OF THE INNER CALDERA AND FAN DEPOSITS USING THE SHALLOW SOUNDING RADAR (SHARAD).

M. R. El Maarry[1,2], E. Heggy[3], and J. M. Dohm[4]. [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]Jet Propulsion Laboratory, Pasadena, California, USA, [4]Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona.

Introduction: Mars displays an abundance and great diversity of features that point to a long history of water and volcanic activity, including widespread hydrothermal activity. Many localities, mainly within impact basins, show evidence of lakes [1,2]. Studying such lakes is a key element in the understanding of the geologic evolution of Mars in addition to being primary targets for future exobiological exploration [3]. Lakes on Mars have been mainly attributed to a wetter ancient climate, including precipitation [4], magmatic-driven flooding [5], or impact-generated aqueous activity, including hydrothermal systems [1]. However, a lake occupying a volcanic caldera has never been detected despite the fact that they are commonly associated with magmatic/hydrothermal systems on Earth. In this work, we explore the hypothesis that a volcanic paleolake existed in the caldera of Apollinaris Patera and has been responsible for the formation of extensive fan deposits draping the volcano's southern flank [6] using data from the shallow sounding radar SHARAD [7].

Site Description: 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 cratered highlands (174.4°E, 9.3°S), approximately 200 km north of Gusev Crater. Extensive fan deposits extend approximately 150 km down the southern flank of the volcano from summit to base. The age of construction is estimated to range from Late Noachian to Late Hesperian based on both stratigraphic relations and impact crater statistics [8,9]. The first detailed geologic mapping of Apollinaris Patera was carried out using Viking images, results of which pointed to a similar age and composition for the fan deposits and inner caldera materials [8,9]. Alternatively, a paleolake at the summit of the volcano was more recently hypothesized based on an interpretation of the fan deposits being alluvial in origin [6] . In addition, recent investigations corroborate the Viking-era assumptions that the Apollinaris Patera volcano is a site with high potential for magmatic-driven hydrothermal activity [9, 10], activity which often associated with volcanic crater lakes on Earth. Geophysical measurements using shallow sounding radar can help determine whether volcanism or alluvial activity resulted in the formation of the fan deposits which is not possible using only geomorphological considerations.

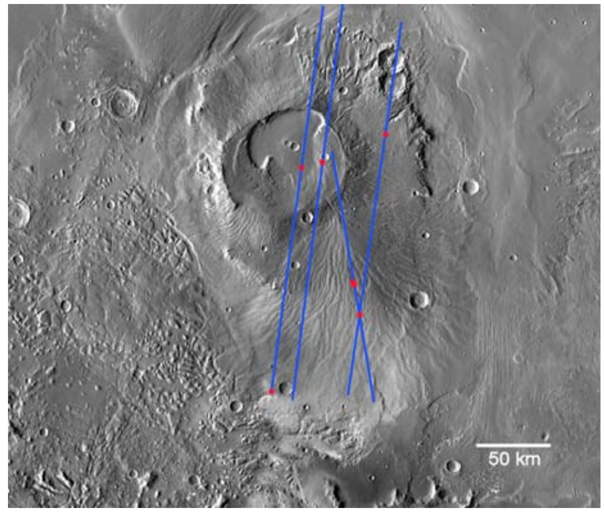

Fig. 1. Daytime-IR THEMIS mosaic of Apollinaris Patera and surrounding terrain. Apollinaris occurs near the boundary that separates the northern plains from the southern highlands. The main construct is almost 200 km wide, displaying a caldera complex at its summit that is almost 80 km in diameter. Extensive fan deposits drape its southern flank, appearing to source from a small channel that dissects the southern rim. Also shown are the SHARAD ground tracks that transect the prominent volcano, including parts of the inner caldera and fan deposits.

SHARAD data: SHARAD is a 20 MHz nadir-looking sounding radar onboard the Mars Reconnaissance Orbiter. SHARAD has a vertical resolution of 5 to 10 m in common geologic materials, allowing for the detection of finely spaced interfaces at depths up to 1000 m [11]. The observed attenuation between two interfaces and the signal decay in smooth surface makes it possible to differentiate between the signals from volcanic materials and sedimentary ones [11,12] on account of their different dielectric properties. However, radar detection of the Martian subsurface echoes in non-icy environments is controlled by several surface roughness and dielectric factors that limit the SHARAD data analysis. The ice dielectric signature cannot be distinguished from the signature of low-loss silicate materials such as volcanic ashes or dry sediments of high porosity [13] (if only the real part of the complex dielectric constant is considered). Moreover, analysis of Martian radar data is subjected to uncertainties due to surface and subsurface scattering losses that remain widely unquantified for several types of terrains. In view of these difficulties, we have devised a "calibration" technique to compare between the relative surface reflectivity and signal decay losses of the Apollinaris caldera and a site of known volcanic composition with similar surface roughness: the Arsia Mons caldera (9.2°S, 239.6°E, Fig. 2). Arsia Mons is a major volcanic edifice in the Tharsis region of Mars standing over 10 km above the surrounding terrain and exhibiting a 100-km-wide caldera. We chose Arsia Mons for calibration purposes since its caldera has similar dimensions to those of Apollinaris and a relative age that suggests volcanic activity from Late Noachian/Early Hesperian to as recent as 40 Mya [14,15]. The aim is to compare the signal decay in both calderas to assess whether Apollinaris caldera is infilled with volcanic materials, as suggested by early studies, or sedimentary deposits which could be derived from a paleolake and/or magmatic/hydrothermal system. It should be noted that both of our comparative sites have a smooth surface roughness [16] for the SHARAD wavelength that is well reproduced in the two study areas. Hence, back scattering and signal decay losses can be attributed to dielectric attenuation that is in turn indicative of the material bulk composition.

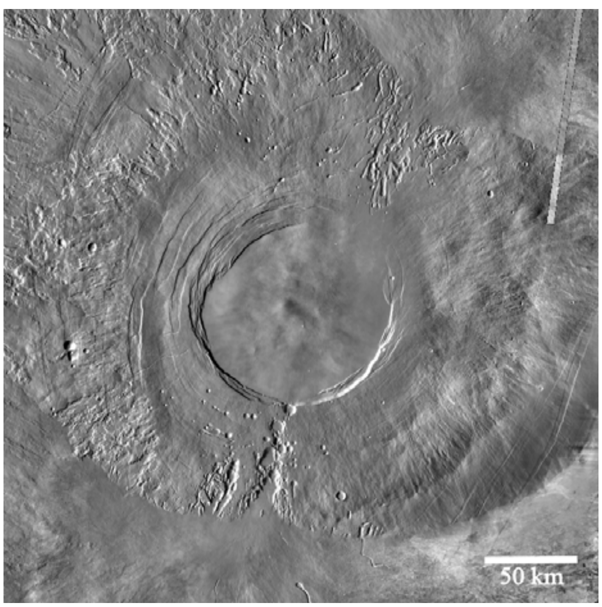

Fig. 2. Daytime-IR THEMIS mosaic of Arsia Mons in the Tharsis region. Arsia Mons has a relatively young caldera, making it ideal for volcanic calibration in the assessment of the Apollinaris Patera caldera.

Preliminary Results: It can be seen in the amplitude and gain normalized radargrams (Fig. 3) that the Arsia caldera surface displays a single bright and continuous reflection suggesting the presence of a higher surface dielectric contrast that can be attributed to volcanic material. This is also supported by the rapid signal decay due to the strong dielectric attenuation. In the case of Apollinaris, however, the caldera displays two types of reflecting surfaces that are not as bright as the one in Arsia which suggests that the material in the Apollinaris caldera is not similar to that of Arsia and displays a lower dielectric contrast.

Comparative surface roughness, clutter forward modeling, estimates of the dielectric properties for the materials and radiometric data analysis of these two caldera fills will be presented in detail at the meeting in addition to the results for the fan deposits.

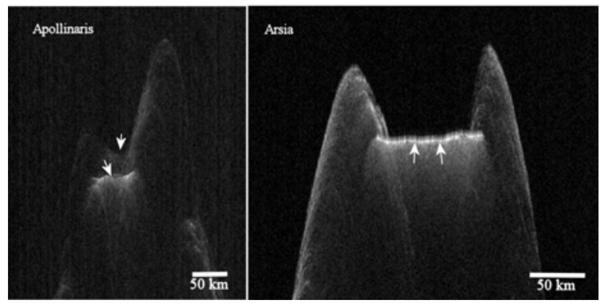

Fig. 3. Radargrams of the calderas of Apollinaris (left) and Arsia Mons (right). The Arsia caldera displays a single bright reflection surface that is a strong indication of volcanic flows due to the strong attenuation of the radar signal. In the case of Apollinaris, however, the caldera displays two reflecting surfaces.

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