AN INSTRUMENT SUITE TO SEARCH FOR BRINES IN THE SHALLOW MARTIAN SUBSURFACE.

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Introduction: This abstract is submitted in reponsed to Challenge Area 1 of the Concepts and Approaches for Mars Exploration: *Instrumentation and Investigation Approaches.* In particular, it addresses large portions of near term goals 1 and 3: Interrogating the shallow subsurface of Mars from orbit; and Orbital measurements of surface characteristics such as composition and morphology.

Large amounts of water ice exist on Mars, but the presence of pure liquid water at the surface and shallow subsurface is inhibited by the planet's low temperature [1]. However, liquid brines can be present in these areas because many salts can depress the freezing temperature below current values [1-8]. The Phoenix Mars Mission discovered salts [9,10] in the soil of its landing site in the martian Arctic capable of depressing the freezing temperature enough to allow liquid brines to form under today's local near surface environmental conditions [11,12]. Phoenix also found physical and thermodynamical evidence for liquid brines at its landing site [10,11]. Since Phoenix initial discoveries, independent results suggesting the presence of liquid brines on Mars have been mounting [12-19]. The theoretical idea that freeze/thaw cycles lead to the formation of liquid brines, where ice and salts coexist in the shallow subsurface [11], suggests that liquid brines should be common on Mars.

Soundings of mid-latitude features in the eastern Hellas region by the Shallow Radar on the Mars Reconnaissance Orbiter (MRO) suggest that they are debris-covered ice deposits formed by glaciation [20]. If this hypothesis is correct, these structures would be the most extensive ice deposits outside Mars polar region [20]. Byrne *et al.* [21] show evidence that recent meteor impacts, hundreds of km apart, exposed clean subsurface ice at Mars' midlatitudes. The existence of shallow (tens of cm deep) clean ice at midlatitudes is puzzling because it is difficult for the ice to form and be stable there on Mars' current climate [21]. However, eutectic mixtures of salts such as perchlorates could easily melt and form layers of brines and clean ice in this region by the process proposed by Renno *et al.* [11]. Moreover, salts could reduce evaporation by more than 50% and allow subsurface brines to be stable at Mars' midlatitudes, even in its current climate. Therefore, recent impacts might have exposed frozen brines, not clean ice. The instrument suite proposed here can be used to test the hypotheses described above.

The Mars Thermal Infra-Red (MTIR) Imager: MTIR uses proven remote sensing technologies and methods to measure thermal radiance with horizontal resolution of ~100 m and radiometric resolution of ~0.1 K noise-equivalent temperature differential (NEΔT). MTIR's ~150 nm spectral resolution across the 7-12 μm spectral range [22] allow studies of morphology and the detection and discrimination of a multitude of gaseous and solid materials such as acqueous-derived minerals (e.g., carbonates, hematite) and atmospheric water vapor and methane.

MTIR's high-precision spectroscopic capability enables retrieval of the spectrally-resolved surface emissivity. When processed using a temperature-emissivity separation (TES) algorithm these surface emissivity spectra will permit high-fidelity computation of the kinetic surface temperature. TES uses an iterative procedure entailing spectral matching and unmixing procedures based on spectral libraries to optimize retrievals of surface spectral content. MTIR will be optimized to search for salts and their hydrates.

The Mars L-Band Radar (MLBR): MLBR is capable of probing the subsurface of Mars tens of cm deep by making multispectral and multipolarimetric measurements of radar brightness between 500 MHz and 1 GHz, and using advanced methods to analyze the data [23-25]. When combined with measurements of the surface composition by MTIR, the MLBR measurements allow: (i) the search for radar brightness anomalies caused by near-surface brines; and (ii) the search for depth-dependent radar brightness anomalies, indicating the presence of ice and brine layers. MLBR is capable of performing radar measurements with an adjustable spatial resolution down to 10 m. This enables the detection of localized brightness anomalies with horizontal extensions of a few tens of meters.

MLBR will employ a measurement frequencies between 500 MHz and 1 GHz which offers a good balance between the desire to probe deeper and the need for detecting cm-thick brightness anomalies with high spatial resolution, with a constraint on the size of the antenna. In addition, a fully polarimetric operation will be possible at 1 GHz to provide additional information about the polarimetric scattering characteristics. MLBR is optimal for probing areas just below the surface where liquid brines are most likely to be found [11].

MLBR is capable of producing the first global map of Mars' shallow subsurface. Thus it contributes to the understanding of brine formation and the aqueous processes that control the exchange of volatiles between the surface and the atmosphere. MLBR is a technically mature instrument that leverages on more than 30 years of end-to-end system know-how in microwave sensors at DLR, encompassing all aspects from hardware development to data analysis techniques.

Searching for Liquid Brines on Mars: Mars Odyssey revolutionized our understanding of Mars by mapping the hydrogen content of the shallow subsurface and showing convincing evidence that water ice is present globally [26,27]. An investigation of the shallow martian subsurface has the potential to revolutionize our understanding of Mars again by testing the hypothesis that brines are ubiquitous on Mars [12].

The instrument suite here proposed is capable of searching for evidence of aqueous processes such as geothermal activity and serpentinization in the shallow martian subsurface. MLBR detects aqueous processes in the shallow subsurface by measuring their multispectral radar brightness. Then, radar brightness anomalies in the shallow subsurface are correlated with the presence of salts on the surface to search for the fingerprint of liquid brines.

References: [1] Haberle, R.M., *et al.,* (2001), *JGR*, 106, 23,317-23,326. [2] Farmer, C.B. (1976), *Icarus*, 28, 279-289. [3] Clark, B.C. (1978), *Icarus*, 34, 645-665. [4] Brass, G.W. (1980), *Icarus*, 42, 20-28. [5] Clark, B.C. and D.C. Van Hart (1981), *Icarus*, 45, 370-378. [6] Moore, J.M, and M.A. Bullock (1999), *JGR*, 104, 21,925-21,934. [7] Bryson, K.L., V. Chevrier, Sears, D. and R. Ulrich (2008), *Icarus,* 196, 446-458. [8] Chevrier, V. F. and T. S. Altheide (2008), *JGR*, 35, L22101. [9] Hecht, M. H., *et al.* (2009), *Science,* 325, 64-67. [10] Smith, P. H., *et al.* (2009), *Science*, 325, 58-61. [11] Rennó, N. O., *et al.* (2009), *JGR*, 114, E00E03. [12] Zorzano, M.P. *et al.* (2009), *GRL*, L20201. [13] Kereszturi, A., *et al.* (2009), *Icarus*, 201, 492-503. [14] Möhlmann, D. (2010), *Inter. J. of Astrob.*, 9, 45-49. [15] Mehta, M. (2010), *PhD Dissertation*, The University of Michigan, 186 pp. [16] Niles *et al.* (2010), *Science*, 329, 1334-1337. [17] Cull, S. *et al.* (2010), *JGR*, *37*, L24203. [18] McEwen, A. *et al.* (2011), *Science*, 333, 740-743. [19] Martinez, G. *et al.* (2012), *Icarus*, to be submitted [20] Holt, J. W. (2008), Science, 322, 1235-1238. [21] Byrne, S. *et al.* (2009), *Science*, 325, 1674-1676. [22] Hall, J.L., *et al.* (2008), *Proceedings of SPIE*, 7082, 70820M. [23] Campbell, B. *et al.* (2004), *Proc. Aerospace Conf.* [24] Freeman, A. and Farr, T. (2007), *Proc. PolInSAR.* [25] Reigber, A.,*et al.* (2012), *Proc. EUSAR*. [26] Boynton, W. *et al.* (2002), *Science*, 297, 81-85. [27] Feldman, W.C. *et al.* (2002), *Science*, 97, 75-78.