WATSEN – A MID-IR SPECTROMETER, HUMIDITY SENSOR AND OPTICAL MICROSCOPE TO IDENTIFY THE SUBSURFACE WATER AND MINERALOGY OF MARS. M. M. Grady[1,2], T. Tomkinson[1], S. D. Wolters[1], W. Guthery[1], A. F. Bohman[3], A. T. Sund[4], [1]PSSRI, The Open University, Milton Keynes MK7 6AA, UK (t.o.r.tomkinson@open.ac.uk), [2] The Natural History Museum, London, SW7 5BD, UK, [3]Norsk Elektro Optikk AS, Solheimveien 62 A, N-1473 Lørenskog, Norway, [4]NavSys AS, Fjellhamarveien 46, 1472 Fjellhamar, Norway.

Introduction: Mars is currently the main focus of extra-terrestrial planetary investigation in terms of the number of surface and orbital instruments deployed there. Although several missions have scratched into the surface (most recently Phoenix) there have not been deeper measurements of the martian subsurface. Phoenix has discovered the surrounding soil to be comparable to soils found in Antarctica's Dry Valleys [1]. It seems clear from the initial results that the soil is pH alkaline (8.3 ± 0.5) [2] and that water has been involved in the formation of the soil, detected in the form of subliming ice [3]. The presence of $CaCO_3$ and soluble ionic species detected by TEGA and MECA [4,2] further suggests the presence of water interacting with soil at some point. Since conditions at the martian surface are unfavourable for the presence of water and potential organic signatures [5] it is necessary to look deeper into the subsurface. Recent classification of geological eras [6] suggests an early warm and wet martian environment in which phyllosilicates formed (called the Phyllosian era). Nili Fossae [7] is a region that the orbital VNIR and IR spectrometers OMEGA and CRISM [8,9] have indentified which correspond mineralogically and through crater counts to this early Phyllosian era. This location would be a prime candidate for the detection of Mars' fluvial past, with phyllosilicates detected and CRISM indentifying $MgCO_3$ [10] (known to be abundant in the presence of water, CO_2 and an alkaline pH; all conditions hospitable for most terrestrial life).

WATSEN: So were those early conditions warm and wet and potentially favourable to life? Hopefully these questions will be answered by looking into the martian regolith with *WatSen*, a miniaturized instrument consisting of a combined Attenuated Total Reflectance (ATR) IR spectrometer, optical microscope and humidity sensor. *WatSen* is designed to be part of a suite of instruments onboard a mole on a planetary lander similar to ExoMars. A burrowing mole would allow *WatSen* to make multiple readings at intervals of depth providing an insight into mineral variation, humidity, water presence and perhaps biological activity. As part of a mole, *WatSen* could penetrate down to 5 m in depth. These would be the first measurements of the non-oxidised subsurface and may be below the zone of sublimation [11]. The ATR sensor operates by measuring the changes that occur to the totally internally reflected infrared beam upon contact with the sample. Surface properties alter the spectral reflectance in a mineral grain, thus the ATR has a flat surface in intimate contact with the sampling surface [12]. The optical microscope will aid mineral identification with images of the grains in contact with the ATR being generated at each spectral location. The humidity sensor will continually detect any water present in the bore hole during *WatSen*'s descent, whether it is in the form of vapour subliming or direct contact with liquid water [11].

Spectral studies: Showed that soil components typical of Mars will be uniquely identifiable within the chosen wavelength range (5.5 - 10.8 µm) [12]. This wavelength range is a trade off between technical boundaries and the ideal wavelengths; H_2O absorption is stronger at 3 µm, but strong and distinct absorption peaks for minerals occur in the mid infrared spectrum (5 - 11 µm). An example is carbonate minerals, which have recently been identified by CRISM's orbital reflectance spectral data and through direct surface analysis, in the mid-infrared these carbonates display a unique spectral shape between 6.3 - 7.4 µm. Water IR spectral features are also displayed between 6 - 7 µm, but major features of anhydrous silicates occur at wavelengths greater than 9 µm. Furthermore, hydrated minerals such as clays display combined features of water and silicates. *WatSen*'s 0.015 $\Delta\lambda/\lambda$ resolution is sufficient to resolve distinct spectral features for water and minerals found on Mars.

Implications: As the surface of Mars is constantly weathered by the planet-wide dust storms that spread and mix the loose surface soil components it is the layered subsoil material that will reveal Mars' past history. In addition the surface oxidizing solar radiation makes conditions inhospitable, for life but beneath the surface in briny solutions this may not be the case. Rather than merely scratching the surface a penetrating mole would supersede its martian predecessors and with *WatSen*'s instruments would help characterize the past climate of Mars.

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