# WATSEN – A MINIATURIZED PACKAGE TO DETECT WATER ON MARS.

T.Tomkinson[1], S.D.Wolters[1], A.Hagermann[1], W.T.Fraser[2], A.F.Bohman[5], A.T.Sund[4], J.K.Hagene[5] and M.M.Grady[1,3] , [1]PSSRI, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK (t.o.r.tomkinson@open.ac.uk), [2]Dept. of Earth and Environmental Sciences, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK, [3]Dept. of Mineralogy, The Natural History Museum, London, SW7 5BD, UK, [4]NavSys AS, Fjellhamarveien 46, 1472 Fjellhamar, Norway, [5]Norsk Elektro Optikk AS, Solheimveien 62 A, N-1473 Lørenskog, Norway.

**Introduction:** Over the past few decades Mars has been investigated directly by means of numerous surface and orbital instruments. Despite various indications of its presence on the surface, no direct detection of water has been made. Satellite imagery from orbit show many features such as valleys and channels that indicate mass outflows of liquid at times in Mars' history [1]. Surface measurements from Mössbauer spectrometers on the *Spirit* and *Opportunity* rovers indicated the presence of haematite and jarosite [2]; the occurrence of these minerals on Earth is typically dependent on the action of water. Further evidence for Mars' fluvial past is found within martian meteorites. Although typically igneous in origin, small quantities (< 1% by weight) of secondary alteration components (carbonates, sulphates and clay minerals) are present, particularly in the nakhlite sub-group. These secondary minerals are produced by an aqueous medium, and are concentrated along cracks within the meteorites. Isotopic measurements show that the minerals are martian, and not terrestrial contaminants [3].

We are currently experiencing an era of unprecedented martian exploration, with opportunities for new instruments to characterize different aspects of Mars' history. To this end, we are developing a miniaturized water sensor package, *WatSen*, a combined infrared spectrometer and microscope plus humidity detector.

**WatSen** is set to answer the most fundamental question that the above evidence poses; is there water on Mars? The instrument consists of a combined Attenuated Total Reflectance (ATR) spectrometer, optical microscope and humidity sensor which will be inserted into the martian regolith to investigate any presence of water and the variations in mineralogy with depth. *WatSen* is designed to be suitable for carrying as part of a suite of instruments onboard a mole on a planetary lander similar to ExoMars. 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 to intimate contact with the sampling surface. The humidity detector will record the release of water vapour in the bore hole during burrowing and the ATR will determine water content of soils.

The burrowing mole will 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 up to 5 m in depth. These will be the first measurements of the non-oxidised subsurface and may be below the zone of sublimation (see figure 1). The zone of sublimation has yet to be accurately determined although recent orbital data suggests $H_2O$ ice is present in the upper metre with a concentration between 2-10% equatorially and above 55% in the northern latitudes [4]. The most likely scenario is that any water discovered will be in the form of $H_2O$ ice. This may instantly sublime when the mole bores through or exposes the material to atmospheric pressures. However, depending on the porosity of the regolith and if the atmospheric or subsurface pressure is higher than anticipated, water may be sustained at depth and also water in brine might be detected.

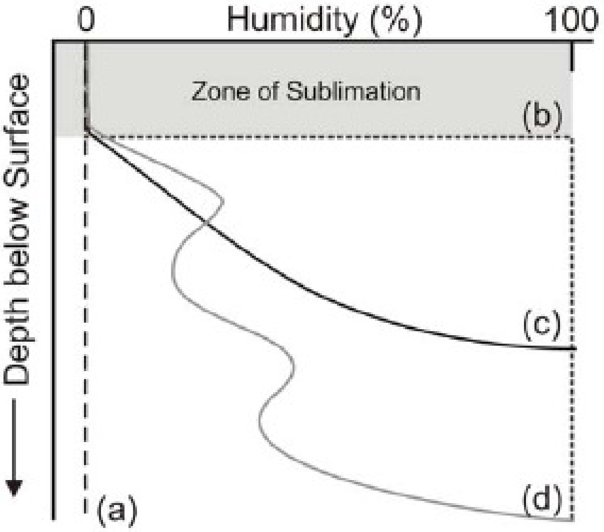

**Figure 1:** Illustrating four possible variations in humidity with depth a) represents no water in regolith b) complete saturation beneath zone of sublimination c) gradual increase in water content with depth d) alternating saturation after Grady et al [5].

Currently we are investigating the spectra of minerals characteristic of Mars saturated with water using ATR-Fourier Transform infrared spectroscopy (FTIR). The minerals are also frozen with and without water to ~268 K and ~77 K and spectra taken (see figure 2) in order to construct a reference database.

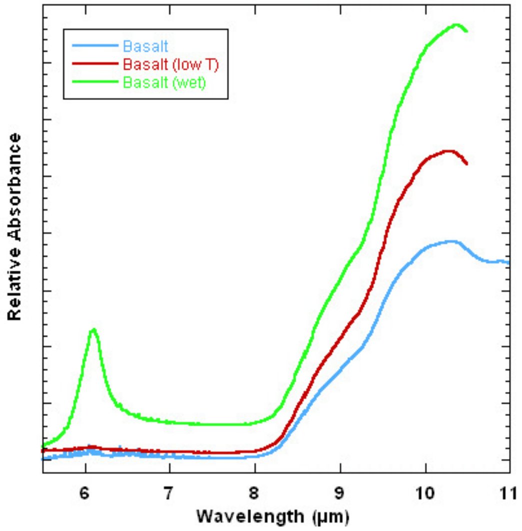

**Figure 2:** IR spectra of powdered dry basalt taken at 295 K and 268 K, and of water-saturated basalt, also at 268 K.

The IR database will be used to interpret results from testing the *WatSen* prototype in the Mars Environment Chamber at the Open University.

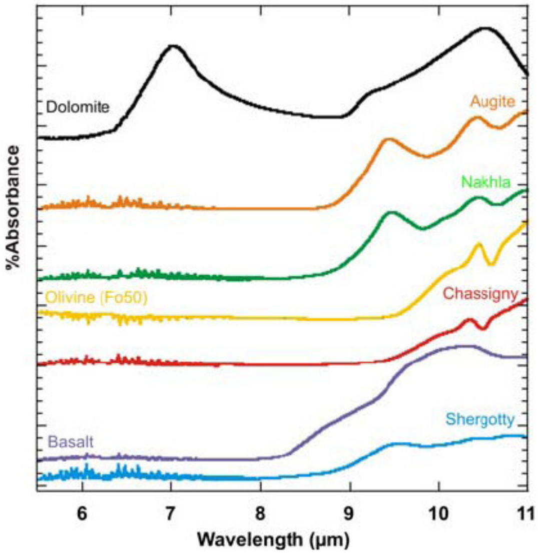

**Figure 3:** IR spectra of powdered samples of Shergotty, Nakhla and Chassigny, along with a basalt, augite, olivine and dolomite. The spectra were acquired using an ATR at 295 K, and are offset for clarity.

Our results show that the soil components typical of Mars will be uniquely identifiable with the chosen wavelength range (figure 3). *WatSen* will be able to detect across the wavelength range 5.5 - 10.8 µm. This wavelength range is a trade off between technical boundaries and scientific achievement; $H_2O$ 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 yet to be identified by direct surface analysis, display a unique spectral shape between 6.3 - 7.4 µm. These characteristic spectra match the martian surface dust spectrum collected by the Thermal Emission Spectrometer (TES) [6]. 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 silicate. *WatSen*'s 0.02 µm resolution is sufficient to resolve distinct spectral features for water and minerals typical on Mars.

**Detection of life –** With more and more discoveries of extremophiles in hostile conditions it seems plausible that biological activity could be detected in the subsurface of Mars. If temperatures of -20°C existed within the last 10 Myrs [7] a liquid brine solution could support micro-organisms in an ice-soil mixture. One of the additional parameters that we intend to test with *WatSen* is the detection of biological materials by spectroscopy. Even if there is no signature in the upper cms that are thought to be more favourable for life, evidence for extinct life may be found deeper within a martian regolith, accessible to an instrument such as *WatSen* carried on a mole.

**Summary** - With the humidity sensor and ATR spectrometer minerals will be characterised according to their chemistry and any water will be more easily detected. The sensitivity of *WatSen* (0.02 µm) is also sufficient to recognise organic signatures if present. The moles ability to penetrate rather than merely scratch the surface exceeds its martian predecessors, and *WatSen*'s high resolution infrared spectrometer and unique humidity experiment, introduces this instrument as the next generation of Mars exploration.

**Acknowledgements:** This work has been supported by ESA and STFC.

**References:** [1] Carr, M.H. (1995) *JGR*, 100, 7479-7507. [2] Schröder, C. et al. (2006) *PSS*, 54, 1622-1634. [3] Bridges, J.C. et al. (2001) *Space Sci. Rev.*, 96, 365-392. [4] Mungas, G.S. et al. (2007) *LSPC XXXVIII*, Abstract # 2002. [5] Grady, M.M. et al. (2006) *Int. J.Astrobiology*, 5, 211-219. [6] Bandfield, J.L. et al. (2003) *Science*, 301, 1084-1087. [7] Jakosky, B.M. et al. (2003) *Astrobiolgy*, 3, 343-350.