DETECTION OF WATER AND MAGNESITE WITH WATSEN: THE NEXT GENERATION OF INSTRUMENTATION FOR MARS T.Tomkinson[1], S.D.Wolters[1], B.W.Guthery[1], A.F.Bohman[5], B.Sund[4], 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), [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.

Water: The presence of water ice at the martian poles has been known since the first spacecraft orbited the planet. Much more recently, the occurrence of large volumes of subsurface water ice at depth was confirmed by Mars Express with its MARSIS instrument [1]. Even more recent in situ studies by instruments onboard the Phoenix lander observed subliming ice within the top few cm's of regolith. Liquid water, however, has not been detected, even though there are abundant signs of its presence in Mars' history. The detection of water is an intriguing topic as we commonly associate it as a key resource to the support of life whether it existed on past or present Mars. Furthermore any future long term manned missions or colonisation of the planet could utilise this resource.

Carbonates: Another material that has also gained considerable interest is carbonate, that until recently was only observed within martian dust [2]. These minerals are of interest owing to their typical formation components of water and carbon dioxide, both of which are known to exist on past and present Mars. They are also commonly associated with organics on Earth. Discoveries of calcite by Phoenix [3] and orbital detection of magnesite with MROs instrument CRISM have confirmed the presence of surface deposits [4]. In addition to these discoveries we also have carbonates found within martian meteorites [5]. The carbonates currently observed either appear to be in small quantities within meteorites (~1% vol) and martian dust component (~5 %) [2], subsurface deposits (Phoenix) or characterized as a surface layer deposit.

Despite these discoveries direct detection of carbonates together with liquid water still eludes us. It was for this purpose that WatSen (Water Sensor) was developed.

The WatSen Instrument: WatSen is equipped with an Attenuated Total Reflectance (ATR) mid infra-red spectrometer, microscope and humidity sensor. Its dimensions are 26 x 128 mm and it only weighs 180g. Initially it was produced to be part of a subsurface instrument package attached to a burrowing mole similar to that planned for the HP^3 [6] developed for ExoMars. This suite of sensors as part of a mole would be inserted into the martian regolith to observe the first measurements of the non-oxidised subsurface. WatSen could penetrate down to depths of 5 m potentially reaching past the zone of sublimation [7]. At these new greater depths and regolith porosities' liquid water may be sustained or detected in a brine solution as hinted to by images from Phoenix [8].

ATR spectrometer – The spectrometer detection covers the wavelength range 6.1 - 10.2 μm. This spread provides an ideal region to detect carbonates (6.3 - 7.4 μm) and water (6 - 7 μm). The ATR sensor operates by introducing IR radiation into a diamond window where the beam is internally reflected. Upon each beam contact with the regolith it penetrates a finite amount before being reflected to the detector. Unlike most other forms of sample spectroscopy it requires no sample preparation making it an ideal remote analytical tool. The instrument has a 0.015 $\Delta\lambda/\lambda$ resolution which is sufficient to resolve distinct spectral features (figures 1 & 2).

Microscope – With a field of view of 14.5 x 8.5 mm the microscope will act as an additional visual confirmation of the materials being detected and their grain sizes.

Humidity Sensor - The humidity detector has been fitted to trail behind WatSen and will record the release of water vapour in the bore hole during burrowing.

Detection of Water and Carbonates with WatSen: WatSen is now being tested under martian conditions (pressure and temperature) using the Open University's environmental chamber. Initial tests have looked at the spectrometers sensitivity to water mixed with basalt at room and martian conditions (figure 1). Furthermore we have started experiments looking at the ATR spectrometers detection limits for carbonates. Owing to the discovery of large surface deposits of magnesite [4] we choose magnesium carbonate as the first test candidate (figure 2). Data have also being aquired using the Open University's ATR Fourier Transform infrared spectroscopy (FTIR) to produce a spectroscopic transmittance reference of various minerals to their composition to enable a comparison of data transmitted from WatSen.

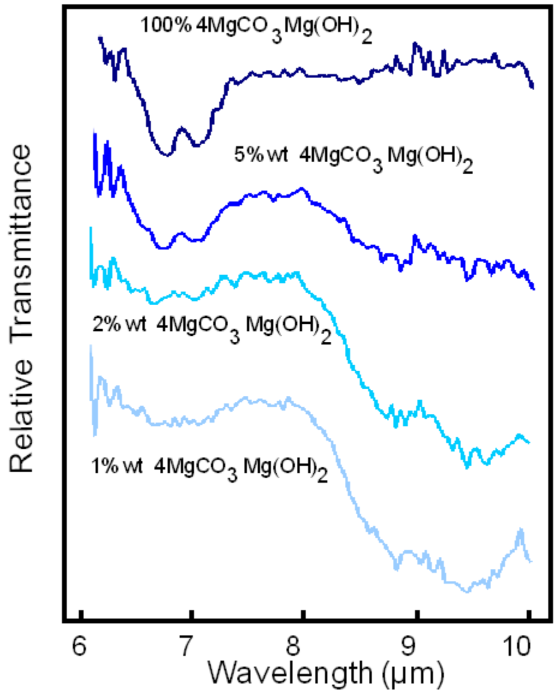

Figure 1: Mid-IR spectra of powdered samples of different weight % of $4MgCO_3$, $Mg(OH)_2$ mixed at different wt % with basalt. The spectra were acquired using Watsen's ATR spectrometer at 295 K, and are offset for clarity.

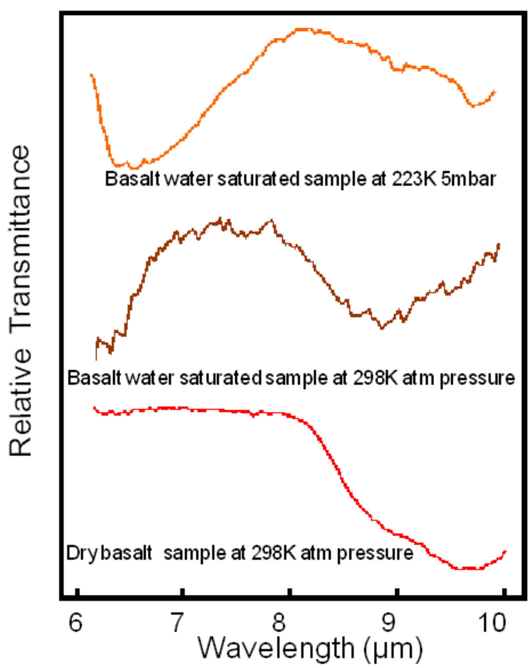

Figure 2: IR spectra of powdered dry basalt taken at 298 K and, and of water-saturated basalt at 298K, also at 223 K.

These initial studies show that the instrument can function under martian conditions and achieve spectra and images of a quality that allows detection of carbonates and water.

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.

Future Work: Tests will be conducted on a range of carbonates under martian conditions with the addition of varying water contents.

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References:

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