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WISDOM measurements in a cold artificial and controlled environment

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Abstract

The WISDOM (500MHz - 3GHz) GPR is one of the instruments that have been selected as part of the Pasteur payload of ESA's 2018 ExoMars Rover mission. One of the main scientific objectives of the mission is to characterize the nature of the shallow sub-surface on Mars and WISDOM has been designed to explore the first ~ 3 meters of the sub-surface with a vertical resolution of a few centimetres. Full polarimetric measurements in cold artificial and controlled conditions have been performed by the prototype to illustrate and quantify the instrument performance. Preliminary results are presented.

1. Introduction

The WISDOM (Water Ice Subsurface Deposit Observation on Mars) Ground Penetrating Radar (GPR) is one of the instruments that have been selected as part of the Pasteur payload of ESA's 2018 ExoMars Rover mission. The main scientific objectives of the mission are to search for evidence of past and present life on Mars and to characterise the nature of the shallow subsurface. WISDOM GPR has been designed [1] to obtain information about the nature of the subsurface along the rover path with the objective to explore the first ~ 3 m of the soil with a vertical resolution of a few centimetres. The sub-surface properties that can be addressed with WISDOM are variations in composition, texture, stratification (e.g., number, thickness and orientation of layers), the presence of unconformities and other structural characteristics (such as fractures and the deformation of strata). One the one hand, WISDOM has the capacity to investigate the distribution and state of subsurface water – both as a liquid and as ice On the other hand, the dielectric contrast between rock, soil and ice is small (comparable to what can result from variations in the composition and density of dry rock and soil alone), therefore, differentiating between intimate mixtures of ice-rich and ice-poor materials in the Martian subsurface is an extraordinarily difficult task.
It is then essential to quantify the performances of WISDOM in controlled conditions. Several full polarimetric measurements have been carried out with the prototype in a cold artificial environment and some preliminary results are given and will be compared with measurements performed by a commercial GPR (Mala-Ramac).

2. Experimental setup

The main objectives are the detection of different interface between homogeneous materials with WISDOM. The characterization of the material (porosity, % of water, dielectric properties, thickness and depth, temperature …) is well-controlled.

2.1 The cold room facility and the investigated materials

The cold room facility of IDES at Orsay (France) has been used, the ambient temperature ranged from -7°C to -10°C. A tank lying on the metallic floor (height: 0.5m, width: 0.80 m, length: 1.20m) in macrolon can contain liquid or frozen water or home-maid permafrost (Frozen saturated sand). The temperature inside the studied medium, ice or permafrost is controlled by a network of thermistances.

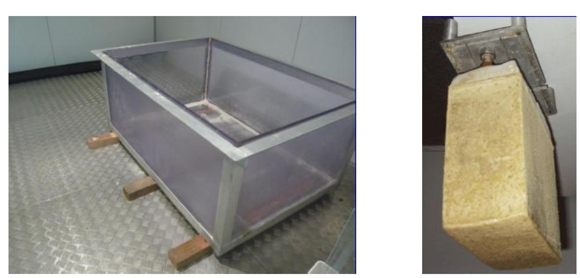

Figure 1: Tank and home-maid permafrost

2.2 the WISDOM positioning

The radar antennas are put on a sheet of polystyrene over the tank and the polarization is controlled (fig.2). Frequent measurements are performed (every 2cm) along a track from one side to the other side of the tank. Data are recorded and are presented in a form of radargrams

Figure 2: installation of WISDOM antennas on the polystyrene sheet and polarization configuration tracking

3. Preliminary results

First of all, in order to eliminate clutter effects from surrounding targets (walls, edges of the tank, etc…), we made measurements over the empty tank. Then, we made the same measurements over the tank with a metallic sphere inside (fig. 3, see the hyperbole). On the left side of fig. 3, the raw data are plotted. Oblique lines correspond to unwanted echoes coming from the edges, the first horizontal line is the reflection from the tank bottom and the second one comes from the floor. On the right side of fig. 3, the same data are plotted but after the subtraction of the mean value of each measurement

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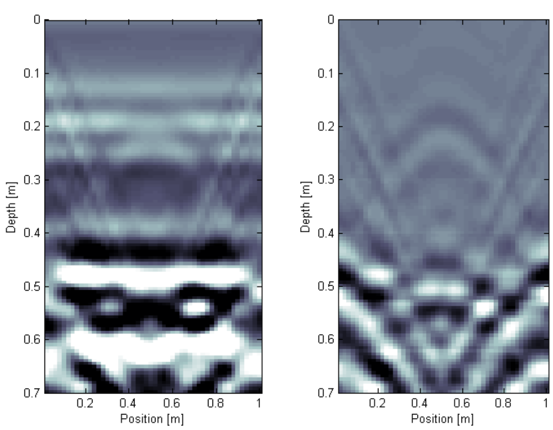

Figure 3 : measurements over a metallic sphere

The effect is the mitigation of horizontal echoes and the enhancement of the hyperbolic shaped echo coming from the sphere.

In addition, clutter effects are eliminated using another subtraction operation, leading to a large enhancement of the sphere echo. The difference of raw data with the sphere and without the sphere is plotted on fig. 4, the echo coming from the sphere is again enhanced.

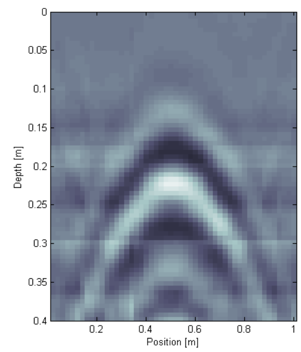

Figure 4 : measurements over a metallic sphere after the clutter effects have been subtracted

6. Conclusion and perspectives

Several full polarimetric measurements have been carried out with the WISDOM prototype in a cold artificial environment in order to quantify the radar performances. Preliminary and encouraging results show that the radar works well and that we are able to eliminate clutter effects. Processing of data acquired in permafrost conditions with and without embedded objects are now in progress, the results will be compared to Mala-Ramac measurements.

Acknowledgements

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References

[1] Ciarletti V., Corbel, C.,Plettemeier, D., Cais, P., Clifford, S.M., Hamran, S.E., WISDOM GPR Designed for Shallow and High-Resolution Sounding of the martian Subsurface, Proceedings of the IEEE, vol. 99, issue 5, pp 824-836, may 2011.