# Getting ready to sound the Martian sub-surface: WISDOM/ExoMars 2020 data processing and lessons learned from the ExoFit 2019 field-trial

Valérie Ciarletti, Alice Le Gall, Yann Herve, Nicolas Oudart, Dirk Plettemeier, Charlotte Corbel, Vivien Tranier, Wolf-Stefan Benedix, Sebastian Hegler, André-Jean Vieau, et al.

EPSC Abstracts
Vol. 13, EPSC-DPS2019-632-3, 2019
EPSC-DPS Joint Meeting 2019


EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

# Getting ready to sound the Martian sub-surface: WISDOM/ExoMars 2020 data processing and lessons learned from the ExoFit 2019 field-trial.

Valérie Ciarletti (1), Alice Le Gall (1), Yann Hervé (1), Nicolas Oudart (1), Dirk Plettemeier (2), Charlotte Corbel (1), Vivien Tranier (1), Wolf-Stefan Benedix (2), Sebastian Hegler (2), André-Jean Vieau (1), Christoph Statz (2), Yun Lu (2), (1) LATMOS/IPSL, UVSQ (Université Paris-Saclay), Sorbonne Univ., Guyancourt, France, (2) Technische Universität Dresden, Dresden, Germany (valerie.ciarletti@latmos.ipsl.fr)

## Abstract

The ExoMars2020 mission will land a rover on Mars to search for evidence of past and/or present life in the Martian subsurface. The ExoMars Rover will be equipped with a drill able to sample material at depth. The WISDOM polarimetric ground penetrating radar also accommodated on the rover will sound the shallow sub-surface to help selecting the best locations to collect samples at depth. In this paper, we first describe the data processing chain that has been developed in order to rapidly analyze the data collected by WISDOM and also present the results and lessons learned from the operation simulation trial (ExoFit 2019) that took place in Chile in Feb-March 2019.

## 1. Introduction

In 2021, the second part of the ExoMars mission will land on Mars in the ancient terrains of Oxia Planum to search for evidence of past and/or present signs of life. If such evidence is to be found, it will most likely be in the subsurface, where organic molecules are protected from the destructive effects of radiation and oxidation. For this reason, the ExoMars Rosalind Franklin Rover will be equipped with a drill able to sample material at depth down to 2 m. The collected samples material will be then analyzed by a suite of analytical instruments inside the rover body. In order to characterize the sub-surface before drilling and also to guide the drilling operations, the ExoMars Rover's Pasteur payload also includes a polarimetric ground penetrating radar WISDOM (Water Ice Subsurface Deposits Observation on Mars). The radar's aim is to characterize the shallow sub-surface geological structures and provide information useful for the selection of the best locations to collect samples at depth.

## 2. The instrument

WISDOM (Water Ice and Subsurface Deposit Observations on Mars) is a polarimetric step-frequency GPR operating between 500 MHz and 3 GHz. Its main objective is to characterize the subsurface below the ExoMars Rover and along its path by non-destructive electromagnetic soundings [1] [2]. WISDOM will provide high-resolution (a few cm) images of the subsurface structure and stratigraphy down to a few meters' depth. It will also help selecting optimal sites for drilling and ensuring the drilling operations safety by identifying potential buried hazards.

On Mars, WISDOM will perform subsurface soundings at various locations along the Rover track, typically every 10 cm along a several meter-long transverse. A sounding consists in transmitting electromagnetic waves into the subsurface and measuring the signal that returns to the radar. WISDOM main products will be radargrams i.e., images showing the amplitude of the signals reflected by permittivity contrasts in the sounded volume as a function of the propagation delay (ultimately converted into depth from the measured delay and the knowledge of the mean subsurface permittivity value) on the vertical axis and the sounding location on the horizontal axis. WISDOM radargrams will open the third dimension of Mars revealing the geological structures buried in its shallow subsurface.

## 3. Data processing

One of the objectives of WISDOM is to detect potential buried hazards that might jeopardize drilling activities. The greatest concern is the

presence of buried rocks that could damage the drill. After data are received on Earth, the WISDOM team will have a limited time (about 40 min) to process the raw data, detect and localize buried structures such as layers and potential buried rocks (which signature on radargrams are hyperbolas). The data processing pipeline has to be fast and reliable to meet the strict time constraints imposed by the orbiter's communication windows. We have therefore focused our effort on the development of algorithms as automatic and as fast as possible. In particular, we have developed automatic tools for the detection of interfaces and hyperbolic signatures in the radargram, and the derivation of the ground permittivity from the amplitude of the surface echo. This later is indeed needed to convert times of arrival of echoes into distances and thus to estimate the depth of the detected buried structures. The data processing pipeline also includes corrections aiming at removing the parasitic signals of various origins (electronic coupling, antenna crosstalk, multiple surface echoes, etc.) that affect the interpretation of WISDOM radargrams. These corrections rely on a careful and accurate characterization of the different versions of the instrument (prototype, spare model, flight model) that will be described in [3].

## 4. ExoFit 2019 Field test in Chile

Once validated on synthetic data, the WISDOM signal processing tools are tested and validated on experimental data acquired either in a semi-controlled environment (e.g., a "Mars yard" built at LATMOS, Guyancourt) or during field surveys in natural potential Martian analogs. In particular, WISDOM took part in operation simulation campaigns during which several instruments of the ExoMars Rover were operated from a remote control center to test and improve the efficiency of the data processing pipeline, decision-making process and operation planning under conditions similar to those expected during the ExoMars mission [4] [5] [2]. During the latest of these simulation operation field trials, ExoFit 2019 [6] (ExoMars-like rover and science operations simulation through field-trials), a flight-like version fully representative of the WISDOM flight model was mounted on a rover (Figure 1) in the Atacama Desert in Chile and remotely controlled from a Rover Operation Control Center located in Harwell, UK. Several WISDOM profiles with various configurations were then acquired. Results obtained during the ExoFit 2019 campaign will be shown and commented in terms of lessons learned in order to optimize the scientific return of the WISDOM experiment on Mars.

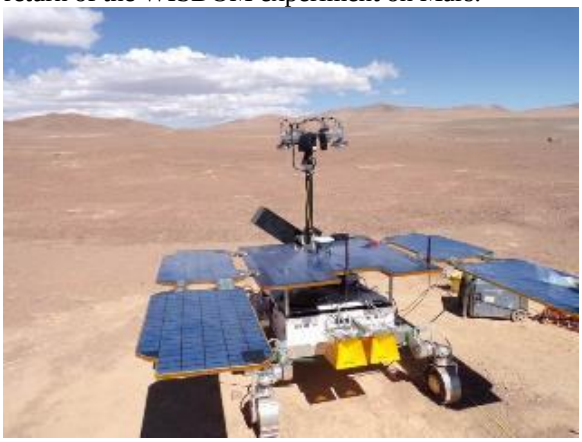

Figure 1. The Charlie Rover in Atacama Desert (Chile) during the ExoFit trial. The WISDOM yellow antennas can be seen at the rear of the rover

## Acknowledgements

The WISDOM development has been supported by the CNES French agency and DLR German agency. The work presented has been supported by CNES and UVSQ.

## References

[1] Ciarletti et al. (2011), Proceedings of the IEEE, vol. 99, no. 99, 1-13.

[2] Ciarletti et al. (2017), Astrobiogy 17 (6-7), 565 - 584.

[3] Hervé et al. (2019), this conference.

[4] Joudrier et al. (2012), *In* I-SAIRAS 2012, Turin, Italy, September 4–6, 2012.

[5] Gunes-Lasnet et al. (2014), *In* I-SAIRAS 2014: 12th International Symposium on Artificial Intelligence, Robotics and Automation in Space, 17–19 June 2014, Montreal, Canada.

[6] Hall et al., (2019), *In* ASTRA 2019: 15th 27 - 28 May 2019, Noordwijk, the Netherlands.