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Mars environmental and soil simulating facility for geophysical and exobiological studies

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Introduction :

In the framework of the European Space Agency Mars exploration program ExoMars, our team is most involved in the development of geophysical instruments. We are using mainly seismic methods on GEP (Geophysical Environmental Package) that are planed to operate in conjunction with low frequency radars to characterize the Martian subsurface down to few kilometers deep. In order to achieve the optimal performance tests for the seismic experiment and provide a coherent physical relation between the ground mechanical and electromagnetic properties, we developed a "Mars Environmental and Soil Simulating Facility". This facility will allow to study the environmental effect on the instrument performances as well as to study the physical variation in the soil acoustic and electromagnetic properties as a function of temperature, UV, dust ionization and gas inclusions. This facility located at the IPGP campus in Saint-Maur (France) comes to support the performance studies for ESA planetary geophysical instruments and is open through this abstract to cooperation for NASA Martian missions.

Scientific objective :

The performances of subsurface exploration systems can be summarized to be mainly a function of the following:

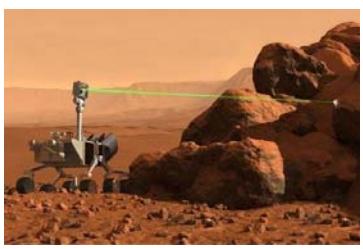
•The instrument ability to operate properly under constraining Martian surface conditions (thermal noise level, sensitivity variation etc.),

•The ground geophysical parameters (acoustical and electromagnetic properties) and their evolution as a function of the Martian environmental conditions (temperature, pressure, density, UV…),

In order to address those two issues, our "Environmental and Soil Simulating Facility" will, (1) test the geophysical instruments in Martian-like environmental conditions (2) Allow measurements for the environmental dependency of acoustic and electromagnetic properties in Mars-like environment.

Testing of instrumentation in Mars-like environment : firstly, from one hand, tests will be performed with pressure, temperature, gas inclusion and UV radiation variations and from the other hand with dust aspects (including electrostatic and magnetic properties associated to UV radiations and dust storms).

We already tested the Very Broad Band seismometer of the former NetLander CNES mission although as the STM (Structural and Thermal Model) of ChemCam instrument, part of MSL 2009 NASA mission. We plan also to test instruments developed by several French and European laboratories associated in the ExoMars mission.



on left side,is the laser of CHEMCAM experiment onboard NASA mission MSL ; on the right side is the Very Broad Band seismometer included in ExoMars ESA mission

This facility provides a unique opportunity for research teams in Europe and potentially for other collaborators to test their instrument in study and development phase with a very cost effective and interactive solution.

We are currently upgrading the existing facility in order to obtain:

•almost full compensation of earth magnetic field, this will be necessary not only for testing magnetometers but also for testing seismometers using ferromagnetic parts (spring) and for very accurate measuring of Martian analogs magnetic properties.

•simulating of UV radiations conditions, allowing a better approach for dynamics of Martian dust and, mainly, for their impact on electronics hardware, mechanisms and sensors.

Acoustic and geo-electrical properties in Mars-like environment : secondly, our project will allow simultaneously the parametric study of acoustic and geo-electrical properties of the Martian surface and subsurface as a function of the surface and subsurface environmental conditions. This will be done by measuring the seismic velocities, also as dielectric and magnetic properties of Martian surface analogs with a well controlled mineralogy and petrology. This t will be implemented inside the chamber with acoustic and impedance measurement cells. It will be then possible to better connect the acoustic properties to the geoelectric ones for the Martian subsurface. This will in term results in a better understanding of the data currently coming from MARSIS and SHARAD and, in the the future, of data to come from the seismic experiment on board GEP ExoMars payload (SEIS-ExoMars). Coupling the acoustic and electromagnetic properties will allow to constrain ambiguities of subsurface composition, types of found rocks, their content in ice or liquid water.

Facility description :

Our facility is composed by two general types of equipments, a Martian environmental chamber and specific instrumentation dedicated to dielectric characterization of Martian soil simulant.

Martian environmental chamber. On IPGP campus, we are already using these existing facilities:

•clean-room (class 10 000), including a laminar flux tent (class 100) for integrations of space instrumentation,

•seismic vault (including seismic pillar) for functional testing of space seismometers,

•Martian environmental chamber (pressure 6 hPa of CO2 gas, temperature from +20 to -120°C)

As this facility must be representative of Martian environment, it will be completed by a seismic pillar (under Martian chamber) and a magnetic field compensation. This will be done by an "a-magnetic room" (3 layers: µ-metal 15/10, µ-metal 20/10, pure iron 20/10). Its dimension (L=2.4 m, P=2.2 m, H= 2,00 m) will allow to contain Martian chamber and surface of seismic pillar. It will be possible to work inside (Martian analogs studies) this . "a-magnetic room"

Martian environmental chamber already operational

Dielectric characterization of Martian soil simulant-. We measure complex permittivity of different Martian surface sediments simulating the variety and complexity of the upper crust composition in order to study potential discharge effects on the instruments and to understand the intrinsic electromagnetic properties of such sediments under different environmental parameters. For that, we use two impedances analyzers (Agilent. Inc, model 4192A for band 40 Hz - 110 MHz and model 4991 for band 1 MHz -3 GHz).

Schedule and funding :

Martian environmental chamber and its data acquisition system have already been funded (CNES funding) and are operational. Seismic pillar, a-magnetic room and Agilent impedance analyzers are funded by IPGP, CNES, CNRS and "Région Ile de France" and will be implemented late 2007 and in 2008.