EXOGEOLAB LANDER/ROVER INSTRUMENTS AND EUROGEOMARS MDRS CAMPAIGN

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Introduction: Building on remote sensing, the next planetary stepping studies will be obtained from landers and rovers the surface of the Moon, Mars and other planetary bodies. The ExoGeoLab research incubator project includes a sequence of activities:

- Data analysis and interpretation of remote sensing data (MEX, SMART-1, VEX, Cassini-Huygens) and in-situ (Huygens, MER) , and merging of multi-scale data sets
- Procurement and integration of geophysical, geochemical and astrobiological breadboard instruments in an surface station and rover (ExoGeoLab)
- Research operations and exploitation of ExoGeoLab test bench for various conceptual configurations (Moon, Mars, NEO, Titan)
- Contribution to the exploitation of surface lander results (MER, Phenix, MSL, preparation Exomars)
- Scientific simulation of planetary surfaces using laboratory and modelling tools
- Support research for definition and design of science surface packages on the Moon, Mars, NEO, Titan
- Research support to community preparation of payload for surface lander opportunities

Background: Surface science is one of the prime objectives of current and future Mars, Moon, Titan or planetary missions and encompasses a wide range of activities from global mapping via specific studies of localised regions until microscopic scales. The studies of rocks and soil in situ, or with sample return missions, require the development of systematic multi-instruments protocols, characterisation diagnostics, and merging of data from various techniques. Both photogeology and mineralogical wide scale mapping have been performed to some extent previously so significant new surface science results may only come from co-ordinated multi-instrument operations operating from the surface.

Constraints on the environmental conditions prevalent during the formation or subsequent modification of altered or weathered surface materials can be provided by careful observations of the chemistry, mineralogy, and morphology. The results will have implications for the study of surface evolution processes on solid planetary bodies.

The Moon is a laboratory for geophysics. It allows to study planetary processes working on solid Earth-like rocky bodies. On the Moon we can study geological processes shaping the surface and geochemical signatures of the evolution due to impacts, volcanism, space weathering. On Mars various processes control the distribution history of water, carbon dioxide and dust, the timing and duration of hydrologic activity on Mars, the evolution of sedimentary processes through time, as well as climatic/atmospheric evolution, as evidenced with data from Mars Express and the MER rovers. On Mars, hydrated minerals studies indicate constraints on the history of surface water and global atmosphere and climate. A coordination is needed with other diagnostic techniques tracing the related processes.

Fig. 1: ExoGeoLab tests of a Geophone system and Ground Penetrating Radar at ESTEC Planetary Robotics Testbed

Specific goals and methods of ESTEC ExoGeoLab: We have started to have instruments integrated in an ExoGeoLab crossing various techniques, including:

- low mass imaging systems from aerial view, panoramic context, 3D stereo, close-up, microscopic imaging,
- atmospheric, ionospheric, meteo, UV radiation
- geophysical study of surface and subsurface seismometry
- geochemistry package to measure elemental and mineral composition from lander and rover
- robotic mobility with instrumented regional rover, mole, arm and local nanorover
- sub-surface water and volatiles detection/characterisation

- sample extraction, handling and analysis systems

The methodic steps for this hands-on research are:

1) We have started to procure and adapt instruments to equip a mid-size ExoGeoRover (made available in collaboration with ESTEC robotics section), and a small surface station.

2) This terrestrial payload (instruments, sensors, data handling) will be deployed, operated and used as collaborative research pilot facility (ExoGeoLab), first tested and operated at ESTEC, and later transportable

3) We shall perform functional tests of these instruments, and operate them in terrestrial conditions to correlate measurements using various techniques.

4) We shall implement progressively the possibility of remote control of instruments from an adjacent habitat (ExoHab 6-crew caravan recently acquired as part of ESTEC skunks pilot project), and a remote science desk.

5) The suite of measurements includes a comprehensive set with telescopic imaging reconnaissance and monitoring, geophysical studies, general geology and morphology context, geochemistry (minerals, volatiles, organics), subsurface probe, sample extraction and retrieval, sample analysis.

6) We shall reproduce some simulation of diverse soil and rocks conditions (mixture of minerals, organics, ice, penetrations of water, oxydant, organics) and diagnostics

7) We shall use these instrument packages to characterise geological context, soil and rock properties,

8) Science investigations will include geology, geochemistry, measurements relevant to penetration/survival of water, oxydant, organics, mineral and volatiles diagnostics.

9) After first validations we shall exploit the facility for collaboration with partners that will provide some additional guest instruments, and perform specific investigations,

10) We shall organise field campaigns in specific locations of scientific and exploration interest, making use of the ExoHab habitat for logistics support and local operations

In the frame of ESTEC skunks pilot project, we have started a small pilot facility with a ExoGeoLab and a mini-Habitat, supported by two design and control offices in the European Space Incubator (ESI), as well as infrastructure support and manpower. We have in addition to contribution on external instruments and manpower from partner institutes. A support habitat to run the experiments has already been installed (6 crew caravan). A set of instruments has been incorporated in the facility . This includes some telescopes and cameras and environment sensors.

What is new is the ability to cross-validate the techniques and enhance design and operations, to exploit science data in terrestrial environments, and to build expertise for development of instruments for future science and robotic exploration missions. From this test bench and kit of ExoGeoLab instruments, we plan to operate comprehensive instruments packages that could help in the technical research and science preparation of lander missions studied in the frame of Cosmic Vision or the Exploration programme.

Fig. 2: ExoGeoLab Test of Electromagnetic interference of a Ground Penetrating radar with a mid-size rover platform

EuroGeoMars MDRS campaign: The goal of the mission (from 24 January to 1 March 2009) is to demonstrate and validate a procedure for Martian surface in-situ and return science. This chain begins with characterisation of the local surface and close sub-surface environment, before moving on to sample extraction and analysis. The characterisation stage involves a survey of a sample area in the vicinity of the MDRS site by our geologists and other team members. This utilises satellite and aerial photography to inform the overallmorphology and geological unit distribution, with the specific geological and geochemical context being provided through the use of imagers and spectrometers. Further reconnaissance is used to plan sample-extraction EVAs at sites of geochemical and astrobiological significance. Characterisation of larger-scale features is conducted in-situ (for example using ground penetrating radar to investigate the close subsurface). Results from these sorties inform the choice and planning of sites for surface and sub-surface sampling. The sample extraction step – the nature of which is dependent on the identified areas of interest – involves standard geological tools such as rock drills and scoops etc, as well as more specific techniques such as lacquer peels. These samples are returned to the MDRS for analysis using microscopes and other analysis techniques. These documented samples are afterward taken to ESTEC and collaborators institutes for analysis by various techniques.

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