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HUMAN AND ROBOTIC PARTNERSHIPS DURING EXOGEOLAB FIELD CAMPAIGN AT UTAH DESERT RESEARCH STATION

Abstract

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The EuroGeoMars campaign was proposed in order to assess several human and scientific aspects of future robotic and manned missions on planetary surfaces,, as part of the ExoGeoLab pilot project developed at ESTEC in collaboration with European and US investigators. The EuroGeoMars campaign lasted 5 weeks encompassing four sets of objectives: 1) Technology demonstration aspects: a set of instruments were deployed, tested, assessed, and training was provided to scientists using them in subsequent rotations 2) Research aspects: a series of field science and exploration investigations were conducted in geology, geochemistry, biology, astronomy, with synergies with space missions and research from planetary surfaces and Earth extreme environments. 3) Human crew related aspects, i.e. (a) evaluation of the different functions and interfaces of a planetary habitat, (b) crew time organization in this habitat, (c) evaluation of man-machine interfaces of science and technical equipment; 4) Education, outreach, communications, multi-cultural public relations aspects

Results will also contribute to ongoing studies on Robotic and Human Moon-Mars Exploration by space agencies, ILEWG, IMEWG, IAF, COSPAR, IAA, etc...

1) Technology field demonstration: Several science and exploration instruments were either brought from Europe or lent by US collaborators. Most were deployed and installed during the technical crew week under the responsibility of commander Bernard Foing (24-31 Jan) with Carol Stoker, Jhony Zavaleta, Pascale Ehrenfreund, Philippe Sarrazin: - geology: drilling equipment, Ground Penetrating Radar (GPR), Raman Spectrometer, Visible Near Infrared Spectrometer (VIS/NIR), Magnetic Susceptibility Meter (all lent by NASA-Ames), X-ray Diffractometer/X-ray Fluorescence Meter (XRD/XRF) (by inXitu Co), sampling collection and curation, scientific and HDTV cameras for field and lab studies (lent by ESTEC ExoGeoLab), installation of geochemical lab; - biology: Adenosine Tri-Phosphate (ATP) Meter (lent by Ames), microscope (MDRS); - engineering supporting projects: rover (lent by Carnegie Mellon Univ.), visualization tests for rover, camera system and image data for outreach.

Additional instruments used during EuroGeoMars Crew 77 rotation from 1 Feb included: - biology: Polymerase Chain Reaction (PCR) lab from ESTEC ExoGeoLab project; - engineering supporting projects: enhanced Cyborg field reporting capability, Mars navigation experiment preparation; - astronomy: Musk observatory (MDRS)

2) Scientific research: Field science experiments were started as soon as the corresponding instruments were assembled, tested and deployed. More than one hundred of documented samples were collected by the crew 77 for geology (50), astrobiology (11 + 5 samples divided to 8 investigators groups) and biology (30 samples divides to 4 collaborating groups), and were screened/analysed in the lab at the Hab. Data were sent to remote science support teams in Europe and the USA for further evaluation and detailed analysis. These data are complementing the interpretation of missions such as Mars-Express, SMART-1, Chandrayan-1, Mars Exploration Rovers, MRO and prepare for future lunar and planetary lander missions. The geoscience investigations concerned mostly geological context survey and geochemical

analyses of returned samples from the surrounding rock formations. For this, several advanced and miniaturized instruments specially developed for future space missions were used, including an integrated X-Ray Diffractometer/X-Ray Fluorescence Meter (Terra 158), a Raman Spectrometer (InPhotonics) and a VIS/NIR Spectrometer (OceanOptics). Approximately 40 samples have been analysed for chemical composition (XRF) and mineralogy content (XRD, Raman, VIS/NIR), varying from clays, sandstones and volcanic ash layers of the Jurassic Morrison formation, pure crystals such as gypsum and calcite, petrified wood, desert varnish, endoliths and salt efflorescence. The sampling and analyses involved the set-up and maintenance of a detailed sample database with description of sample, context geology and test results. In situ measurements were also taken with a handheld magnetic susceptibility meter. Subsurface characterisation has been carried out with a miniaturized Ground Penetrating Radar (GPR), to study the top of Dakota layer.

For astrobiology, soil oxidation sensors (preparatory to ExoMars Mars Oxidation Instrument) containing thin films of amino-acids and metals have been incubated with specific soil samples collected (rich in carbonates, gypsum and nitrates). Salt concentrations were estimated by obtaining soil conductivity. The pH, nitrogen-, potassium-, phosphorous-, magnesium-, calcium- and water content were determined.

The primary goal of the biology investigations was the analysis of microbial communities living in the soil in interesting areas the MDRS area. This investigation had a field aspect and a laboratory aspect: soil sampling was done in the field at depths of 10cm, 30cm and 60cm, in and out of EVA working conditions. DNA extraction and Polymerase Chain Reaction (PCR) analysis were then done in the laboratory. Extracted DNA from 9 soil and water samples of 5 different sampling sites (Gully-Cora‘s Edge, green thing / petrified wood; green tree, Lago Minore, frozen pond-Lith Canyon) were analyzed in a first Polymerase Chain Reaction (PCR) run (Primus25 advanced; PeqLab) to detect bacterial DNA. Microscopy was used to investigate water samples for micro-organisms as well as floating particles concentrated by centrifugation.

3) Human and crew aspects: The commander summarised daily the matrix of overall timeline of activities for each crew, complemented by individual questionnaires and daily location and time sheets. We contributed to a food study investigation, and performed our own study with multiple tools and methods (pictures, spectra, jokes). Further human and crew aspect analysis will include synthesis of inputs from the EuroGeoMars three crew rotations (Technical, rotation 1 and 2). Results of these investigations could then be used as inputs for future studies on a next generation of planetary habitats and test-benches From a field operational point of view, some 40 EVAs were conducted for geology, biology, technology, reconnaissance, and outreach purposes.

In conclusion, the whole of Crew 77 has obtained and documented an impressive set of results relevant to demonstrate in the field the technology of instruments, perform research in geosciences and biology in the diverse and exciting geology sites surrounding DRS, in support of current space missions, and to prepare future planetary robotic and human missions and inspire the next generation. Sample analysis will be conducted in some 15 collaborating institutes. Further in-depth analysis of data will be pursued by Crew 77 and a large range of collaborators. We plan to organise a dedicated ESTEC ExoGeoLab workshop discussing the EuroGeoMars results at ESTEC on 2-3 April, and present results at various conferences and journals. Results will also contribute to ongoing studies on Robotic and Human Moon-Mars Exploration by space agencies, ILEWG, IMEWG, IAF, COSPAR, IAA, in preparation for an International Lunar Base and an Expedition to Mars.