

# Astrobiology field research in Moon/Mars analogue environments

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**Abstract:** Extreme environments on Earth often provide similar terrain conditions to landing/operation sites on Moon and Mars. Several field campaigns (EuroGeoMars2009 and DOMMEX/ILEWG EuroMoonMars from November 2009 to March 2010) were conducted at the Mars Desert Research Station (MDRS) in Utah. Some of the key astrobiology results are presented in this special issue on ‘Astrobiology field research in Moon/Mars analogue environments’ relevant to investigate the link between geology, minerals, organics and biota. Preliminary results from a multidisciplinary field campaign at Rio Tinto in Spain are presented.

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## Introduction

Robotic and human operations on planetary surfaces can be well-practiced in terrestrial analogue environments. Field expeditions at such planetary analogue sites and supporting laboratory research enhance our scientific knowledge for planetary exploration and allow us to test technologies, methodologies and protocols, and train instrument and operations teams.

In this special issue of the International Journal of Astrobiology, we report on the astrobiology results obtained from field analogue campaigns at the Mars Desert Research Station (MDRS) in Utah. The research was supported by NASA Ames Research Center, the International Lunar Exploration Working Group (ILEWG), ESA/ESTEC and several academic partners and by facilities provided by the Mars Society.

## Summary of results and articles

In paper 1, ‘Field astrobiology research in Moon–Mars analogue environment: instruments and methods’, Foing *et al.* (2011b) describe the experimental approach, validation of instruments and *in-situ* measurements during the EuroGeoMars2009 campaign. The paper describes sample handling as well as the analysis of rocks and soils using microscopy, spectrometry, X-ray diffraction and fluorescence XRD/XRF. Specific results on endolithic microbial mats are reported.

In paper 2, ‘Concretions in exhumed and inverted channels near Hanksville Utah: implications for Mars’, Clarke & Stoker

(2011) discuss a diversity of Mars analogue features in the landscape near MDRS. These include exhumed and inverted paleochannels. Concretions of 0.5–1 cm size were investigated with morphology and surface expression similar to haematite ‘blueberries’ found at Meridiani planum on Mars, but with different composition.

In paper 3, ‘PCR-based analysis of microbial communities during the EuroGeoMars campaign at Mars Desert Research Station, Utah’, Thiel *et al.* (2011a) demonstrate the technical feasibility of a Polymerase Chain Reaction (PCR) based analysis of microbial communities in soil and water samples performed on-site in the MDRS habitat laboratory. They successfully investigated the microbial diversity in collected samples by PCR-mediated detection of ribosomal DNA from bacteria, archaea and eukarya.

In paper 4, ‘A wide variety of putative extremophiles and large beta-diversity at the Mars Desert Research Station (Utah)’, Direito *et al.* (2011) performed culture-independent molecular analysis directed at ribosomal RNA for the three domains of life on returned samples from the EuroGeoMars campaign. Spiking experiments revealed that the absence of life in some samples is due to adsorption or degradation of DNA on the mineral surface. The phylogenetic analysis revealed a variety of putative extremophiles.

In paper 5, ‘Analysis of Mars analogue soil samples using solid-phase microextraction, organic solvent extraction and gas chromatography/mass spectrometry’, Orzechowska *et al.* (2011) used solid-phase microextraction (SPME) for screening and characterization of two- and three-ring polycyclic aromatic hydrocarbons (PAHs) in soil samples. Complementary liquid extraction was used to measure five- and six-ring

PAH compounds. The measured samples showed very low PAH concentrations from 1 to 60 ng/g.

In paper 6, 'Analysis of mineral matrices of planetary soils analogs from the Utah Desert', Kotler *et al.* (2011) measure the mineralogy of returned soil samples using X-ray diffraction and Fourier-transform Infrared spectroscopy. Hydrated sulfates, phyllosilicates and carbonates with different composition (bearing Ca, Mg, Fe and Mn) were identified. Special emphasis is given to the composition of smectites.

In paper 7, 'Extraction of amino acids from soils close to the Mars Desert Research Station (MDRS), Utah', Martins *et al.* (2011) find a large difference of amino acid abundances among the collected soil samples, with values ranging from 0 to 100 000 parts per billion (ppb). These data, interpreted in the context of clay matrix content, have implications for future organics and life detection missions.

In paper 8, 'Astrobiology and habitability studies in preparation for future Mars missions: trends from investigating minerals, organics and biota', Ehrenfreund *et al.* (2011) compare the measurements of mineralogy, organics and biota of ten selected sample sites from the vicinity of MDRS collected during the EuroGeoMars2009 campaign. The results are interpreted in the context of future missions that target the identification of organic molecules and biomarkers on Mars.

In paper 9, 'Human crew related aspects for astrobiology research', Thiel *et al.* (2011b) describe the boundary conditions for astrobiology research, the habitat and laboratory layout, the biology instruments and technical aspects. Social and operational aspects for conducting astrobiology and other investigations are discussed.

In paper 10, 'Mineralogical, chemical, organic and microbial properties of subsurface soil cores from Mars Desert Research Station (Utah, USA): phyllosilicate and sulfate analogues to Mars mission landing sites', Stoker *et al.* (2011) describe the analysis of subsurface soil cores collected in November 2009 and March 2010 (DOMMEX-EuroMoonMars campaigns). The soil cores were collected from four geological formations and mineralogy was measured with Terra, a field version of the CheMin XRD to be used on Mars Science Laboratory MSL (to land in 2012). The results indicate the presence of phyllosilicates, evaporates and sulfates, analogues to what is expected for the MSL landing site. The depositional environment, geological history and how the mineralogy affects the ability to preserve and detect organics are discussed.

In paper 11, 'Multidisciplinary integrated field campaign to an acidic Martian Earth analogue with astrobiological interest: Rio Tinto', Gómez *et al.* (2011) study the mineral context and the chemolithotrophic activity of micro-organisms thriving on local pyrite. Results from a cross-instruments study (CAREX campaign) of Rio Tinto as an extreme acidic Mars analogue environment are discussed.

## Perspectives

The results from EuroGeoMars2009 and DOMMEX-ILEWG EuroMoonMars 2009–2010 field campaigns in the Utah desert

confirm that this environment is well suited as planetary analogue site. Research performed in this geological diverse arid desert can address questions relevant to Mars processes and astrobiology and be used to interpret data from current Mars orbiters and rovers, and to support the upcoming Mars landers. Key issues include the optimization of instrument performance, techniques and methods, sample acquisition and extraction, the correlative analysis of minerals, organics, environmental parameters, geological/geochemical history and biosignatures.

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