ASTROBIOLOGY AND HABITABILITY IN MARTIAN TRANSIENT/LOCAL ENVIRONMENTS: FIELD ANALOGUE & SAMPLE STUDIES

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Transient and local habitable niches on Mars

Transient environments:
• fluvial and lacustrine deposits, gullies
• transient geothermal and/or hydrothermal conditions
• effects of large impacts or proximity with igneous activity

Local delivery and burial of constituents:
• volcanic ashes, spring deposits
• atmospheric deposits
• delivery of ejecta
• extraterrestrial material (also cometary/meteoritic organics)
EuroGeoMars Field analogue campaigns

**Goals: study habitability, analysing context & samples**

EuroGeoMars2009, DOMMEX/EuroMoonMars 2010-2011
(support of NASA Ames, ILEWG, ESA/ESTEC, and partners)

- Mars Desert Research station near Hanksville in Utah
- Diversity of sites relevant to Mars (cf MEX, MER & MRO)
- Simulating potential landing sites for MSL and ExoMars

In-situ instruments/techniques relevant to Mars habitability:

- Context imaging from remote to panoramic and microscopic
- Drilling, GPR, sample collection
- X-Ray Diffractometry/Fluorescence XRD/XRF, Raman
- Polymerase Chain Reaction PCR
- Soil and rock samples selected from diverse habitats & analysed

Samples sent for detailed analysis in remote laboratories
Juventae Chasmae, Mars Express HRSC

MDRS site Salt wash  Complex channels  Thinly bedded laminated sandstone
MDRS Analogue for Mars changing environments

MDRS Mars Desert Research Station located in a geological formation formed 150 million years ago, with a diversity of environments:

- Middle Jurassic Summerville Formation
- Late Jurassic Morrison Formation
  - lacustrine and fluvial clays
  - inverted paleochannels
- Early Cretaceous Dakota Sandstone
- Middle Cretaceous Mancos Shale Formation
- Mancos fluvial sandstone
- Bluegate carbonaceous pyritic units
- Small scale mineral and subsurface niches
- Concretions & endolithic environments

Sedimentary deposits of sands, evaporites and clays
Transient geological and geochemical episodes have affected local parameters (mineralogy, organics content, environment variations) and habitability
North-east flowing exhumed and inverted palaeochannels in the study area with sample concretion locations marked. Flow direction is to the northeast. KCR Kissing Camel Range arrowed (Clarke & Stoker 2011)
Comparison of terrestrial and martian inverted channels

• Channels at Aeolis, from Themis Image, Mars

• 50 m high silicified channel of Kissing Camel Ridge, MDRS site
In situ concretions on Mars and at MDRS (Clarke & Stoker 2011)

Concretions at “Berry bowl” location (Eagle Crater), Meridiani Planum (NASA MER)

In situ concretions on side of Kissing Camel Ridge, Utah, (diameter 5-10 mm)
Geochemistry sample measurements

- X-Ray Diffractometer/ X-Ray Fluorescence
- Visible-Infrared reflectance
- Raman spectroscopy
- Microscopy
<table>
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<tr>
<th>Sample</th>
<th>Depth</th>
<th>Formation</th>
<th>pH</th>
<th>P ppm</th>
<th>K ppm</th>
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Sample location, pH value and in-situ soil kit analysis
Post-analysis techniques

- Mineralogy investigations were performed using **Infrared spectroscopy, XPS and X-ray diffraction analysis**

- The concentrations of polycyclic aromatic hydrocarbons (PAHs) have been determined by using the **Solid Phase Microextraction (SPME) method** that provides good recoveries for small PAHs that are usually targeted by planetary missions

- **Amino acids were extracted** from soil samples and analyzed on a **Gas Chromatograph Mass Spectrometer (GC-MS)**

- Culture-independent molecular analysis directed at ribosomal RNA, was used to investigate the detailed microbiology of desert samples, including a **phylogenetic analysis**
Analysis of the clay fractions indicate that the phyllosilicates are interstratified illite-smectites.

The dominant smectites in the samples are montmorillonite and nontronite; the most common sulfate mineral in the samples is hydrated calcium sulfate (gypsum).

Water held in the expandable layer of smectites is released as the mineral is transformed to illite (non-expandable); smectites have the property of being able to expand and contract while maintaining an intact 2-dimensional crystallographic structure.
Transient and local habitability studies

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“Astrobiology field research in Moon/Mars analog environments”
(eds. Foing, Stoker, Ehrenfreund)

• Analogues of transient and local Mars environments
• Measured in –situ and analysed samples according to mineral, organics, biota, environment, geological local/transient history
• Composition of clay fractions (smectite/illite) determines environment for organics and microbes