

## UTAH DESERT ANALOGUE SITES FOR MARS RESEARCH AND MISSIONS.

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**Introduction:** The geological site near Hanksville, Utah, contains a range of Mars analogue features relevant for geology and astrobiology studies. It contains a series of sediments derived from weathering and erosion from marine to fluvial and lacustrine deposits containing also volcanic ashes. The landscape consists of mesas and scarp-bounded surfaces, with alternating layers of clay-rich units more eroded than sandstones units [1]. The landscape also includes segmented and inverted paleochannels exhumed from the Morrison formation that hosts small concretions, morphologically similar to meridiani “blueberries” [2]. This analogue site can help to test instruments, and perform scientific investigations [1-9], as well as operational traverses relevant for the MSL rover or the ExoMars rover, or for the acquisition and context characterization of samples in preparation for Max-C and Mars sample return.

**Mission Description:** The analogue scenarios will simulate planned activities after landing [1, 9].

1. Definition of campaign objectives and trade-off from science, technical or operational constraints
2. Analysis of remote sensing data and existing maps
3. Imaging reconnaissance
4. Monitoring of the local environment and meteorology
5. Geology and geophysical context
6. Field geology and geomorphology investigations
7. Field geochemistry characterization
8. Field subsurface studies
9. Sample handling (extraction and collection) methods
10. Analysis of soils and rocks in-situ (physical, mineral, chemical, organic, biological measurements)
11. A posteriori sample analysis using advanced facilities in international institutes.

**Science Merit Related to Mission Objectives:** The MDRS analogue site can address the science objectives of different planning scenarios for MSL, ExoMars rovers and for the acquisition of samples in a documented geological, geochemical and astrobiological context. We have demonstrated some of these scenarios during precursor generic campaigns EuroGeoMars2009 [1-8], and DOMEX-EuroMoonMars2010 [2,9]. Dedicated campaigns more representative of consolidated Mars missions objectives and constraints can be organized as discussed at the 2011 Woodlands workshop.

Precursor investigations following that methodology were performed during EuroGeoMars campaign (Foing et al 2011). The field traverses included an in-situ inspection and recognition of the characteristic petrology. A camera system with images at various embedded scales (panoramic, high resolution, close-up camera) was used in order to document the location, protocol and samples. The soil mechanical properties could be measured in situ using penetrometry, or by studying the tracks left by rovers. The mineralogy and mineral assemblages of rocks was mostly determined in situ by close up visual inspection. The various minerals identified include quartz, gypsum, clays, calcite and sulfates. The Xterra (by InXitu) Field XRay Diffractometer for mineralogy and XRay Fluorescence for elemental chemistry, and the Raman spectrometer (InPhotonics) were tested in outdoor conditions as the instruments could be transported. Drilling equipment included a Milwaukee hand-operated electrical drill that could reach depths down to 1 m. Another manual rotary drill was used to sample soft clays areas. The drill cores provided information on the vertical structure of soils and the distribution of minerals within rocks. These observations were compared to the lateral variations in rock layers observed from the edges of cliffs to determine the scale of heterogeneity of individual strata. A comparison was also made with data obtained from Ground Penetrating Radar (GPR) subsurface test measurements. The samples were catalogued and curated. The samples were analysed using a Raman Spectrometer (InPhotonics), a Visible/NIR Spectrometer (OceanOptics), an integrated X-Ray diffractometer/X-Ray fluorescence meter (Terra 158), as well as an optical microscope. The samples were divided and sent to Earth-based laboratories for sophisticated analysis of PAHs (Orzechowska et al 2011), of mineral matrix composition (Kotler et al 2011) or of amino-acids (Martins et al 2011). Post-analysis studies determined the total carbon content

(Orzechowska et al. 2011). A study of solid phase microextraction (SPME) method for fast screening and determination of PAHs in soil samples was performed, minimizing sample handling and preserving chemical integrity of the sample. Complementary liquid extraction was used to obtain information on five and six-ring PAH compounds. The measured concentrations of PAHs are, in general, very low, ranging from 1 ng/g to 60 ng/g (Orzechowska et al 2011).

In the different formations near MDRS there are multiple soil and rock units of diverse morphology and mineralogy that display systematic trends and clear stratigraphy and cross-cutting relations (diversity). Regarding the geologic framework and chronology of the site (geologic context), the MDRS is surrounded by a series of early Jurassic to late Cretaceous sediments derived by weathering and erosion from Paleozoic sedimentary rocks to the west, with mineralogical or geomorphic evidence that can be used to test mission hypotheses. There is some high resolution aerial imagery of the analogue site on scales relevant to HiRISE, CTX, and hyperspectral measurements can be acquired relevant to CRISM.

#### Most Important Question Answered by Site:

How to optimize the reconnaissance and selection of samples to be analysed in situ?  
What is the interaction of minerals with organics and biomarkers?

**Logistic and Environmental Constraints:** The site is quite accessible (near Hanksville or from Grand Junction). MDRS is used for research and simulation campaigns. The region around Hanksville is characterised as arid desert, cold in winter and hot in summer with an average annual temperature of 12 °C. The diurnal range is given as 16-37 °C in July, and -7 to +7 °C on 1 Feb. The area is subjected to wind erosion and was shaped by fluvial erosion. The availability of the Mars Desert Research station for logistic support and habitat is a great asset, also for telecontrol of rovers, and as laboratory for engineering preparation, scientific evaluation and preliminary screening and analysis of samples.

#### Standard Information Required for Analogue Sites:

**Table 1:** MDRS analogue site proposed.

Site Name	Mars Desert Research Site, MDRS Utah
Center Coordinates Latitude, longitude	Between 38.40 and 38.44 N, W110.78 to W110.90
Elevation	1.3 to 1.5 km
Areal Extent	Core 4x 25 km (extendable)
Prime Science Questions	How to optimize reconnaissance and selection of samples & analysis in situ? What is the interaction of minerals with organics and biomarkers?
Distance of Science Targets from nearest road	Clay layers & concretions – near MDRS Inverted channel at 2 km
Environmental characteristics	Max temp: 37 C in summer day Min temp: -7 C in winter night Precipitation: 140 mm annual Vegetation coverage: arid
Previous studies at analogue site/refs	Special Issue: “Astrobiology field research in Moon/Mars analog environments”: International Journal of Astrobiology 2011, in press [1-9] (Foing, Stoker, Ehrenfreund, editors)
Primary Landing Site Target	Mawrth, Eberswalde, Holden, Gale, Meridiani
Other	Logistics experience & support MDRS

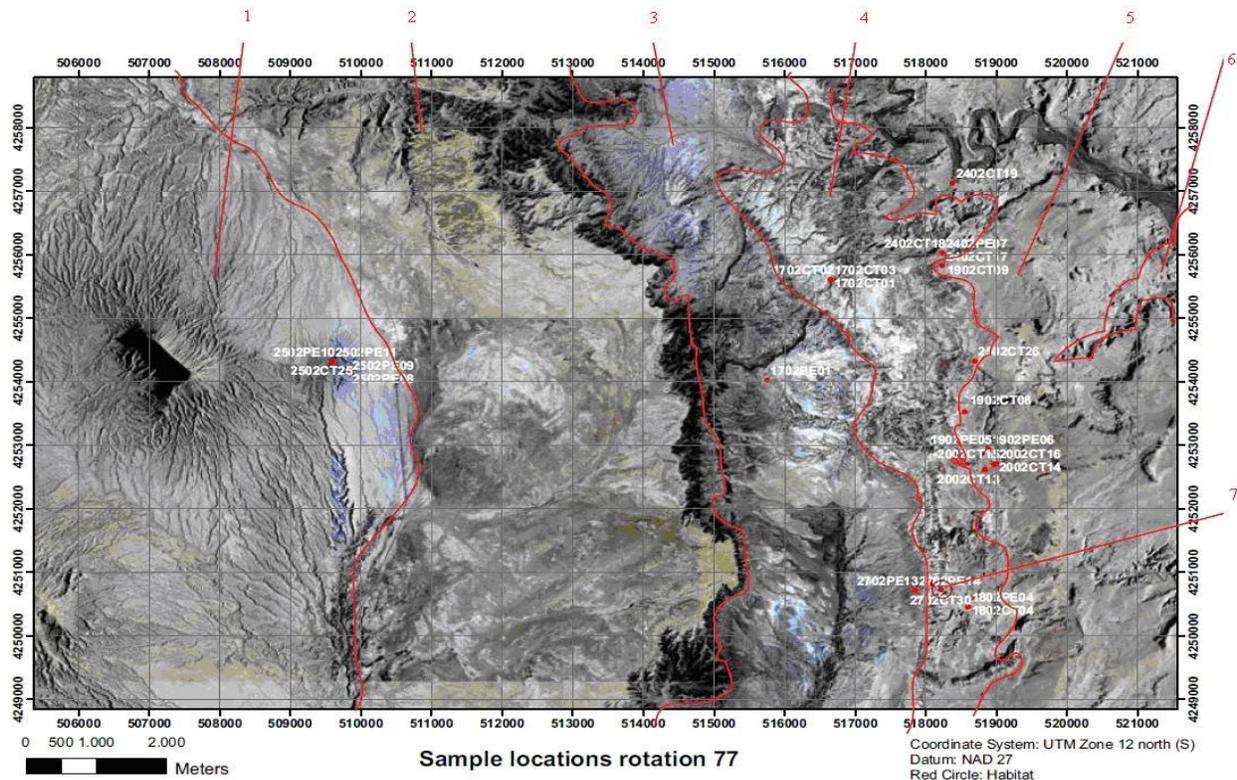


Fig. 1 Geology units around MDRS for EuroGeoMars2009 campaign, and positions of sampling areas (Foing et al 2011). The red lines (1-7) in Fig 1b indicate some of the geological formations and their member Mb (in clockwise numbered order from top):

Mancos Shale Formation (Cretaceous): Emery sandstone Mb.; Blue Gate Shale Mb (1); Ferron Sandstone Mb (2) formed as fluvial to marginally marine units; Tununk Mb containing bluish carbonaceous pyritic marine shales.

Dakota Sandstone Formation (Early Cretaceous) (3)

Morrison Formation (Late Jurassic): Brushy Basin Mb (4) consists of lacustrine and fluvial red brown clays/ mudstones, green-bluish-purple beds and sandstone lenses. Interbedded ash layers are weathered to smectite. This formation represents an analogue for some Martian terrains; Salt Wash Mb (5) from semiarid alluvial plain with cross bedded or conglomerate sandstones and local patchy halite and sulfate efflorescence.

Summerville formation (Middle Jurassic) intercalated siltstone and mudstone (6) locally containing gypsum beds and mud cracks that formed in a tidal flat environment.

Location of MDRS habitat is indicated in (7) within the Brushy basin Mb.

**References:** IJA in press, [1] Foing, B. et al. "Field Astrobiology Research Instruments and Methods in Moon-Mars Analogue Site" [2] Clarke, J., Stoker, C. "Concretions in exhumed channels near Hanksville Utah: Implications for Mars" [3] Thiel, C. et al. "PCR-based analysis of microbial communities during the EuroGeoMars campaign at Mars Desert Research Station, Utah" [4] Direito, S. et al. "A wide variety of putative extremophiles and large beta-diversity at the Mars Desert Research Station(Utah)" [5] Orzechowska, G.E. et al. "Analysis of Mars Analog Soil Samples Using Solid Phase Microextraction, Organic Solvent Extraction and Gas Chromatography/Mass Spectrometry" [6] Kotler, M. et al. "Analysis of Mineral Matrices of planetary soils analogs from the Utah Desert" [7] Martins, Z. et al. "Extraction of amino acids from soils close to the Mars Desert Research Station (MDRS), Utah" [8] Ehrenfreund, P. et al. "Astrobiology and habitability studies in preparation for future Mars missions: trends from investigating minerals, organics and biota" [9] Stoker, C. et al. "Chemical, Mineralogical, Organic And Microbial Properties Of Subsurface Soil Cores From The Mars Desert Research Station Utah: Analog Science For Human Missions On Mars"