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

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Transient and local habitable niches on Mars

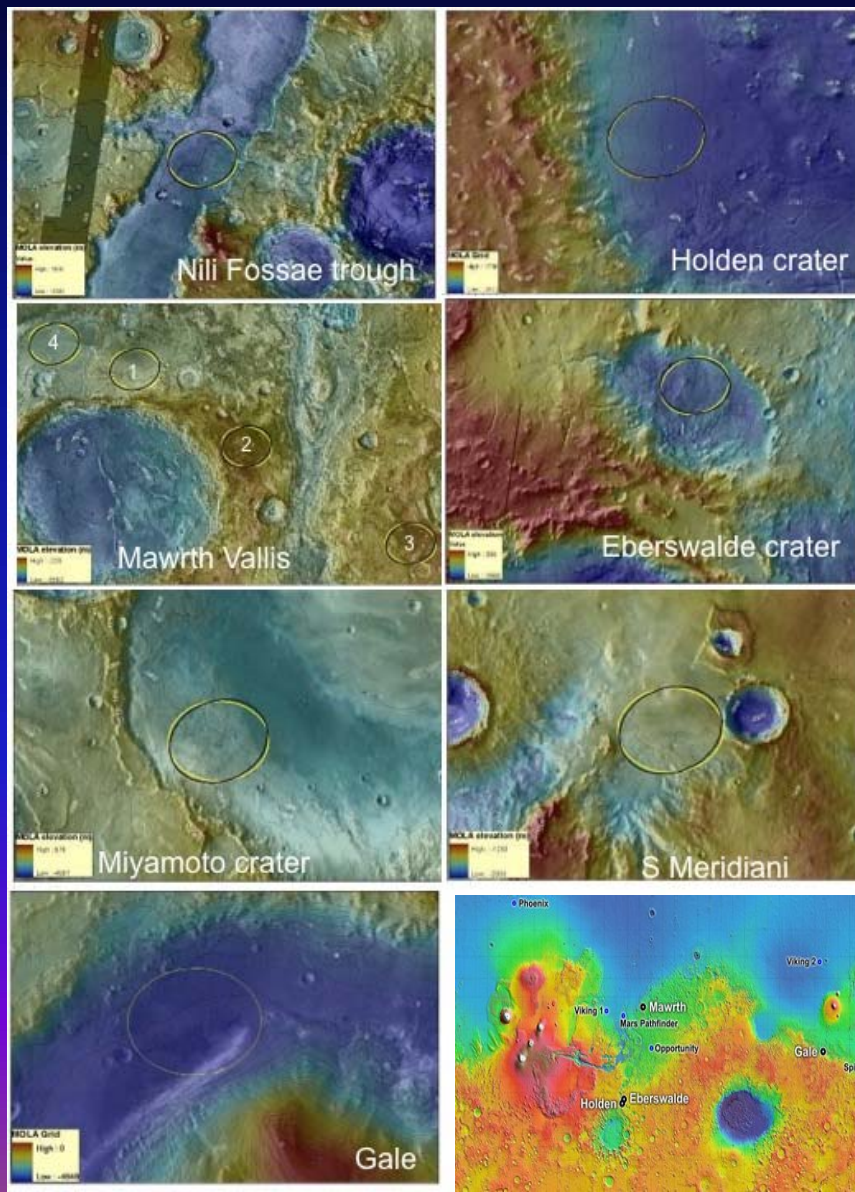
Transient environments:

- **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

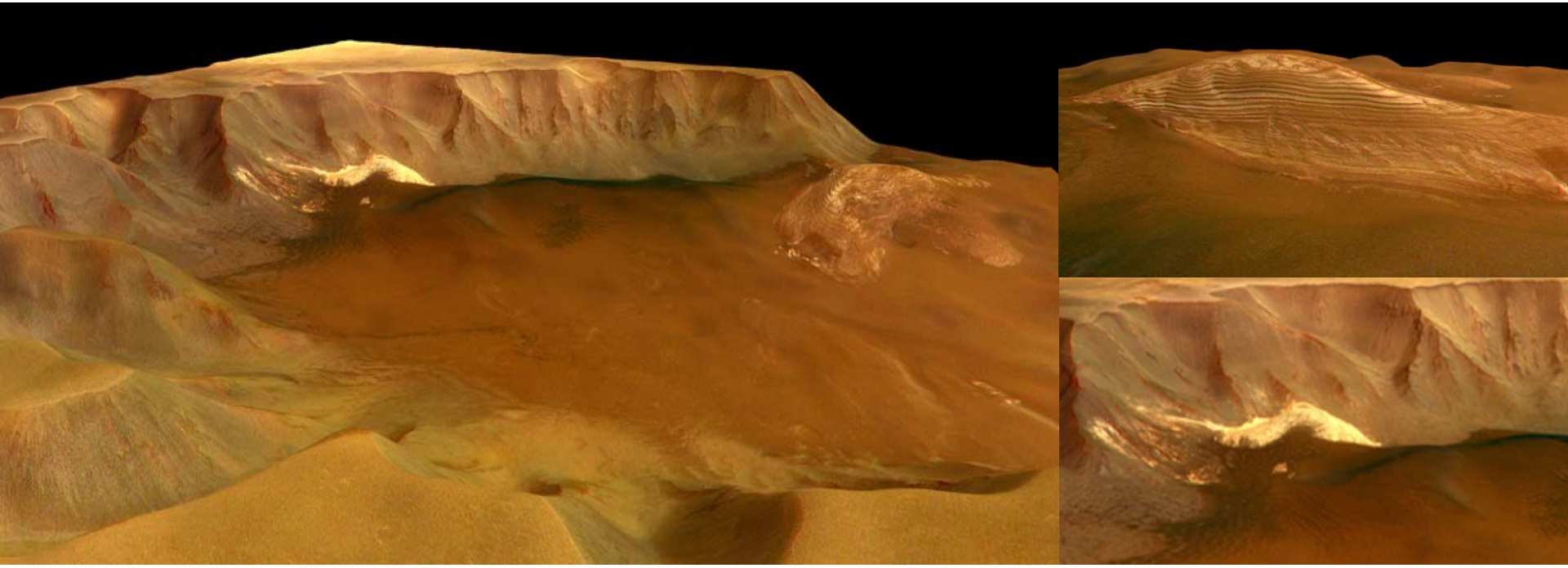
EuroGeoMars2009, DOMMEX/EuroMoonMars 2010-2011 (support of NASA Ames, ILEWG, ESA/ESTEC, and partners)

- **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**

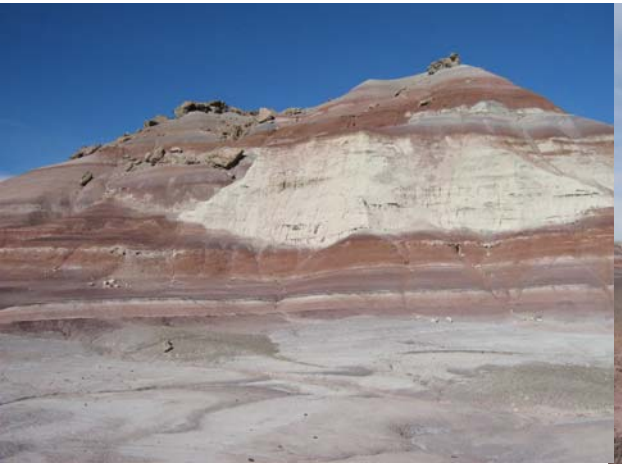
In-situ instruments/techniques relevant to Mars habitability:

- **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

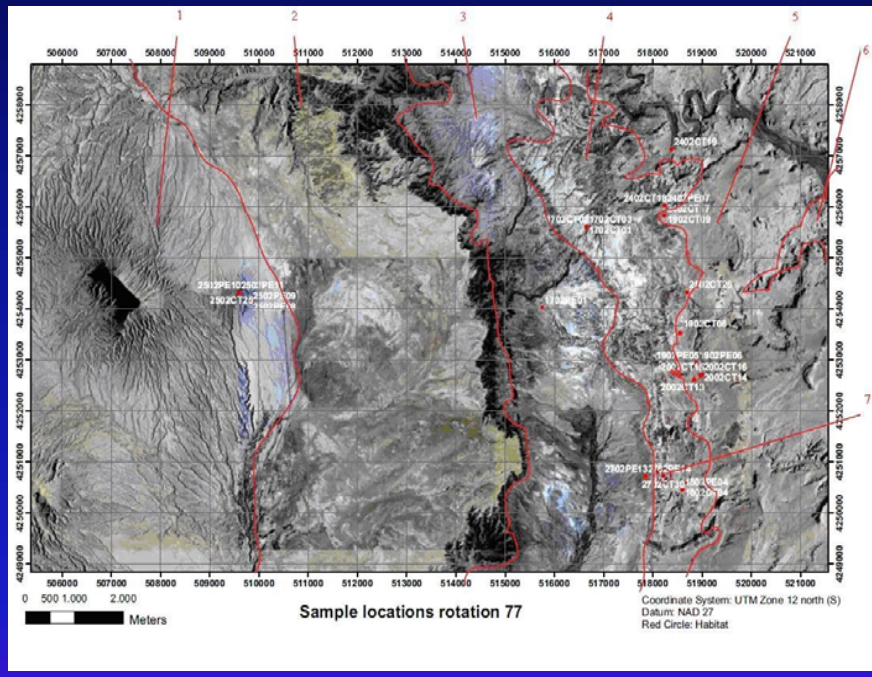
Complex channels

Thinly bedded laminated sandstone

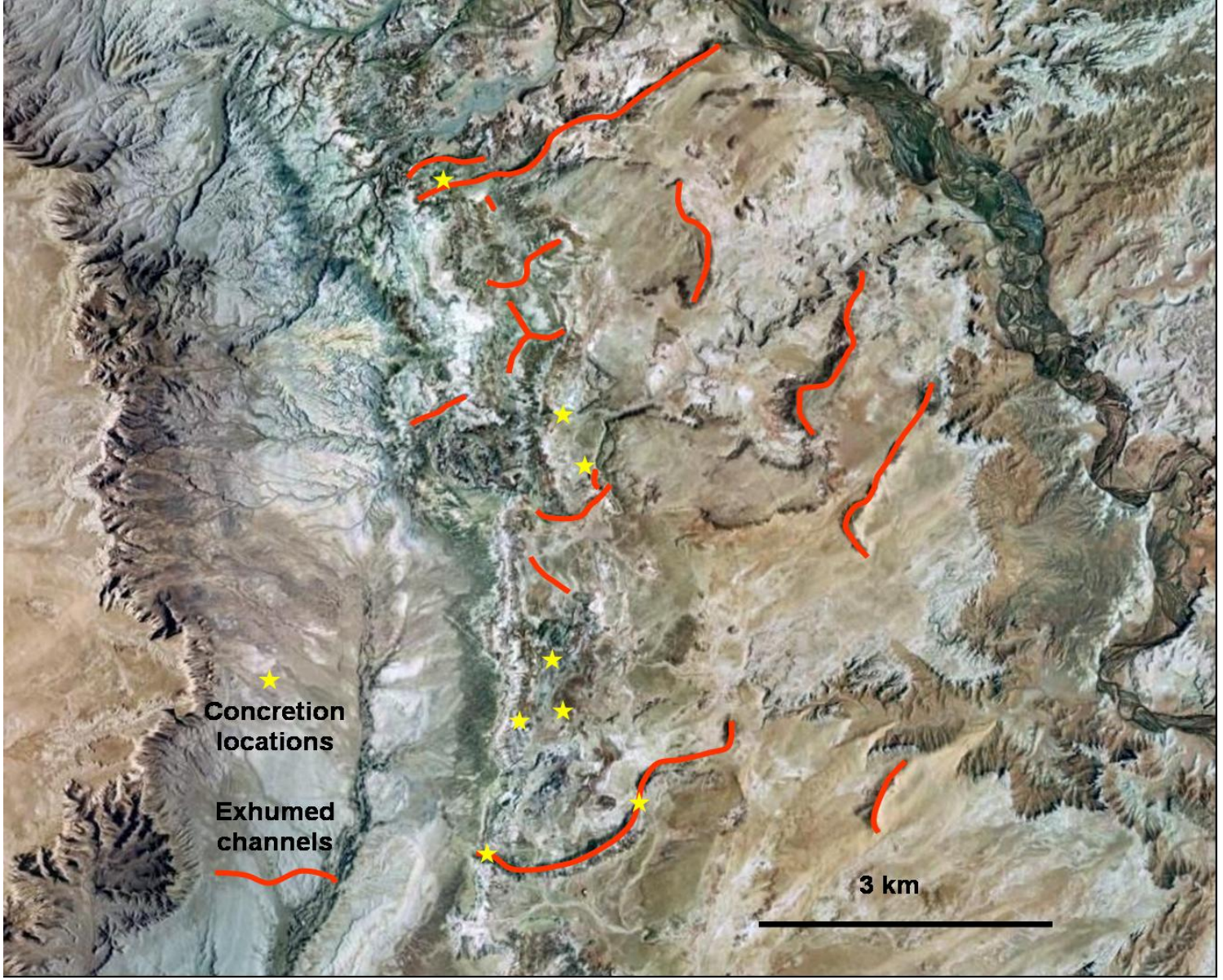
MDRS Analogue for Mars changing environments

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**

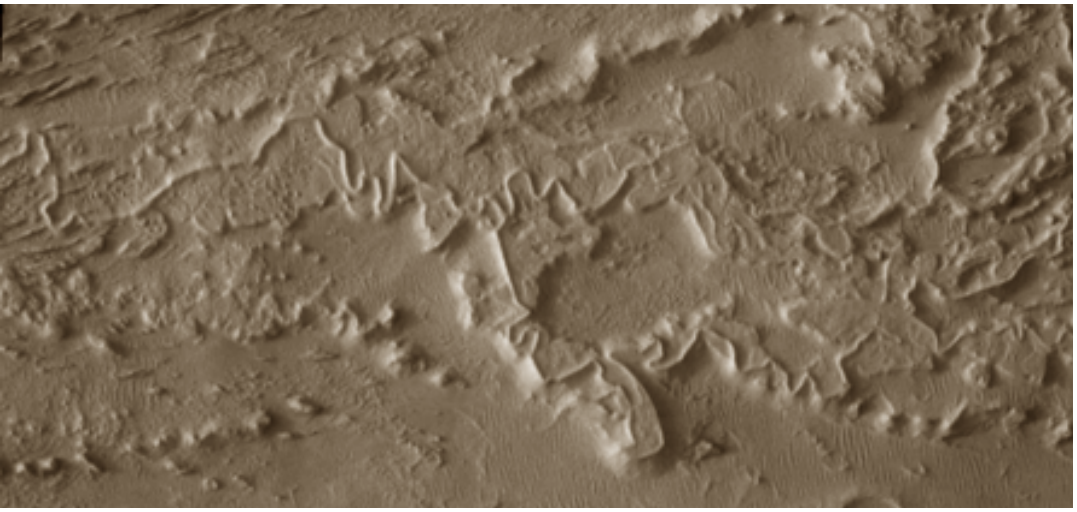


Sedimentary deposits of sands, evaporites and clays
Transient geological and geochemical episodes have affected local parameters (mineralogy, organics content, environment variations) and habitability



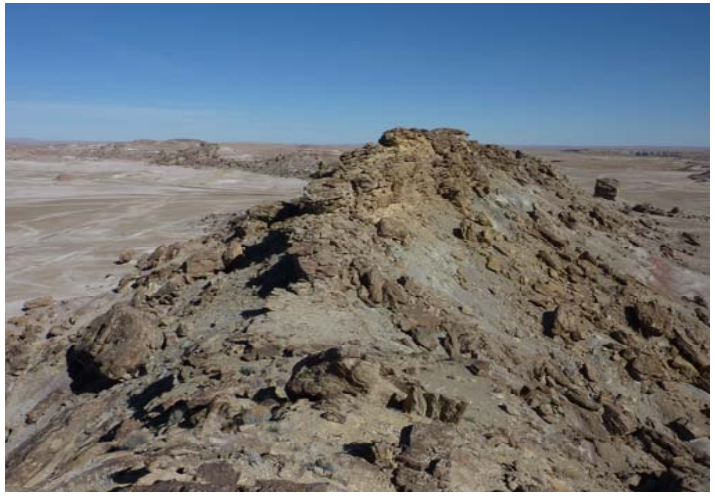
North-east flowing exhumed and inverted palaeochannels in the study area with sample concretion locations marked. Flow direction is to the northeast.
KCR Kissing Camel Range arrowed (Clarke & Stoker 2011)

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



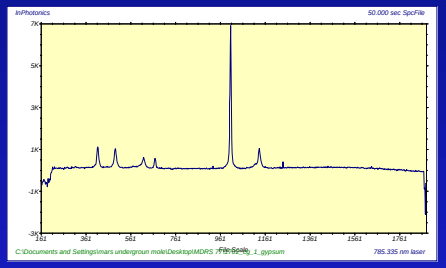
In situ concretions on Mars and at MDRS (Clarke & Stoker 2011)

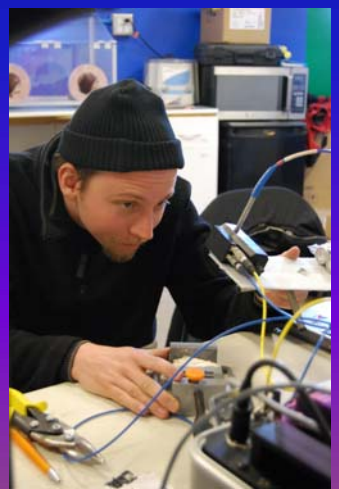
Concretions at "Berry bowl" location (Eagle Crater), Meridiani Planum (NASA MER)

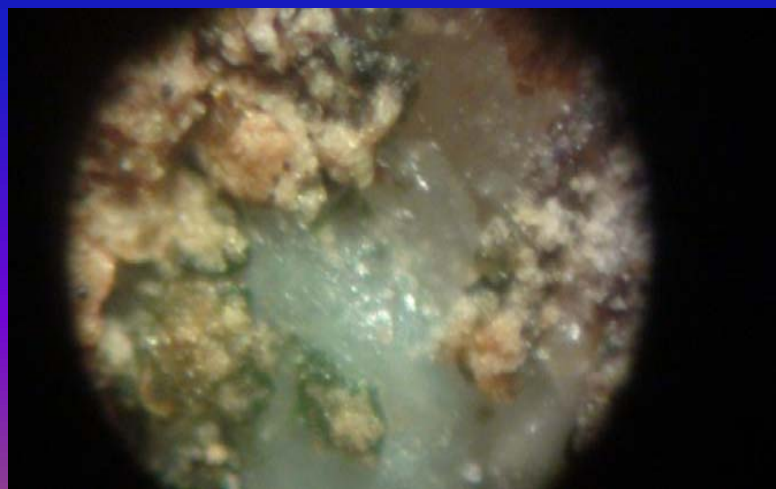
***In situ* concretions on side of Kissing Camel Ridge, Utah, (diameter 5-10 mm)**

Geochemistry sample measurements

- X-Ray Diffractometer/ X-Ray Fluorescence
- Visible-Infrared reflectance
- Raman spectroscopy
- Microscopy



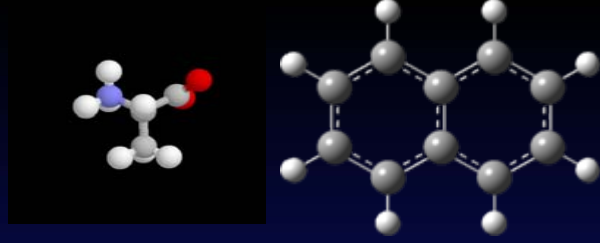




Sample	Depth	Formation	pH	P ppm	K ppm	nitrate ppm
P1	Gully	Mancos	7.6	5	250	7
P2	Cliff	Morrison	8.1	12	175	>75
P3	Surface	Morrison	8.0	12	205	<5
P5	Cliff	Morrison	9.0	100	200	>75
P6	Cliff	Morrison	7.6	85	190	75
P7	Riverbed	Morrison	9.6	10	180	10
P8	Surface	Mancos	8.5	5	250	65
P10	Surface	Mancos	8.5	5	190	7
P13	Surface	Dakota	8.7	100	140	7
P14	15cm	Dakota	7.0	80	225	30

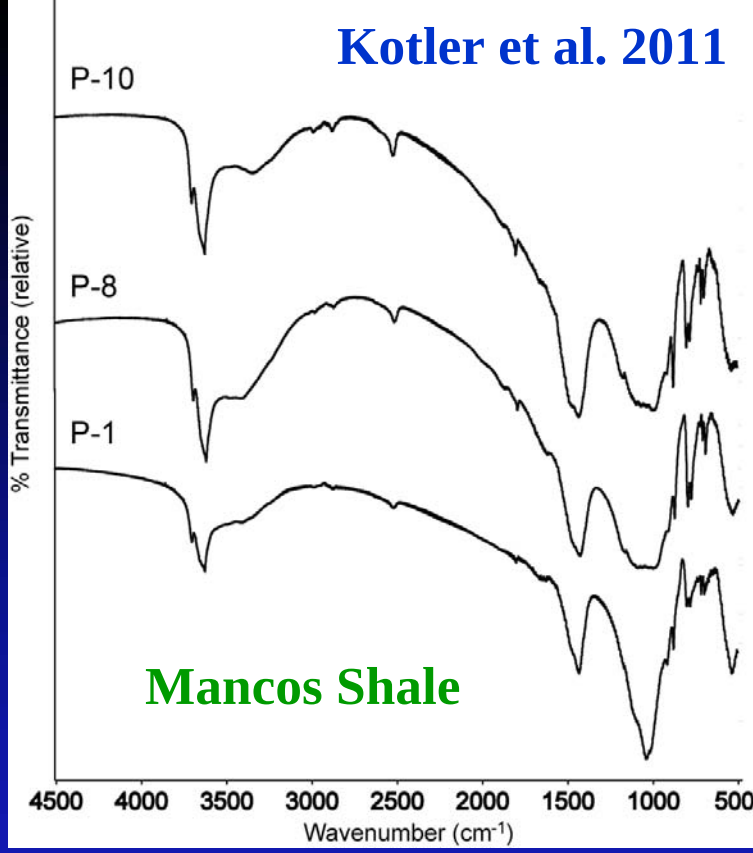
Sample location, pH value and in-situ soil kit analysis

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

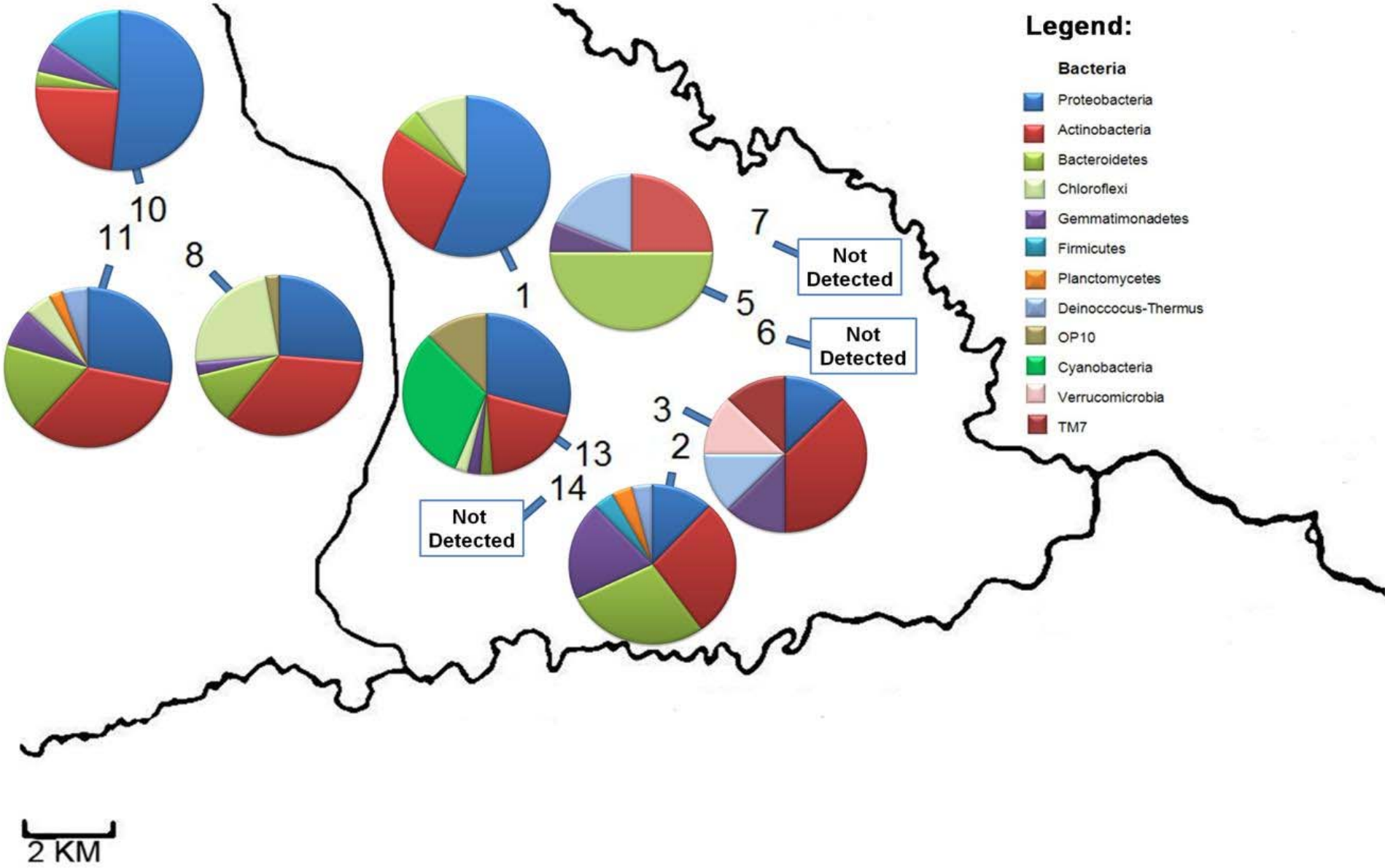
MDRS Mineralogy



- 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

Biota PCR analysis

Direito et al. 2011



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**