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# Biosignature Preservation and Detection in Mars Analog Environments

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- May 16-18, 2016
- ~90 attendees, 84 submitted abstracts plus additional invited talks
- Most attendees from academia (including significant graduate students and post-docs), NASA centers, and research institutes
- ~10% of the participants were international
- Sponsored by LPI, USRA and NASA

# Field Trip – Steamboat Springs, NV

# Conference Goals

- Discuss the attributes and preservation potential of a range of microbial biosignatures in **Mars analog habitable environments** on the Earth.
- Use the properties of these biosignatures on Earth as input into **discussion of strategies** for detection of potential biosignatures on Mars.
- Publish a **conference report** summarizing discussions from the workshop and putting them in context of additional research.

# Mars Analog Environments

Workshop was organized around common Mars analog environments on the Earth:

1. **Hydrothermal Springs Systems** - wherever they intersected the surface
2. **Subaqueous Environments** - including deltas, lakes, playas and shallow oceanic environments
3. **Sub-aerial Environments** - all environments where water comes from precipitation, snow melt or ambient-temperature groundwater
4. **Subsurface Environments** - all those below the active regolith, except those impacted by hydrothermal circulation
5. **Iron-rich Systems** - where circulating groundwater or hydrothermal systems mobilize iron

# Discussion Topics

For biomarkers in the environments outlined above, discussion focused on four key questions:

- How does the **combination of habitability potential** and **preservation potential** combine to create biosignatures in the geologic record?
- How do we use biosignatures to **interpret the presence or absence of life** in ancient analog environments?
- How might we **translate** what we learn about preservation of biosignatures in **Mars analogs** to the different physical conditions and environments on Mars?
- How could or should this knowledge **influence the strategies and priorities** for the astrobiological exploration of Mars?

# Major Outcomes (1/3)

1. **Subaqueous and Hydrothermal Environments:** Most submitted papers addressed biosignatures of microbial life in past subaqueous or hydrothermal environments on Earth. These two paleo-environments are common and well-studied in the Earth's geologic record.
2. **Subsurface Environments:** Almost no content relating to biosignatures of ancient life associated with the deep biosphere on Earth. Habitability of a modern deep biosphere on Earth is clear, but research into the biosignature preservation potential of these rocks is in its infancy. Potential for the Martian deep subsurface environment to preserve any biosignatures is much less certain than other environments.

# Major Outcomes (2/3)

3. **Silica:** Emphasis on silica for the preservation of biosignatures. Silica is stable relative to a variety of post-depositional geologic processes, including over long geologic time scales, and it can be very effective at protecting the objects that it encases.
4. **Spatial Mismatch:** Fundamental mismatch in scale between what can been observed from orbit (e.g., on Mars) and what has been traditionally looked for on the ground (in Mars analogs). On Earth, biosignature investigations typically involve hand-lens scale observation followed by laboratory work. It will be challenging to translate these lessons to key Mars efforts like site selection. This spatial heterogeneity of biomarkers distributed in the environment will also be a factor in sample selection.

# Major Outcomes (3/3)

5. **Time Scales:** Factors involving time scales highlighted fundamental differences between the Mars analogs and Mars itself. These factors included how old a particular deposit was, the duration of time for which a potential environment was habitable, and how long a preserved deposit had been exposed to the radiation/weathering environment on the surface of Mars.
6. **Application to Martian Environments:** Papers that specifically focused on the application of habitability and biosignature preservation lessons from Earth to the different environmental conditions on Mars, or the habitability and preservation potential of deep subsurface environments, were not sufficient to generate systematic analysis or consensus positions. These subjects would be good topics for future conferences.

# Review papers

- A short conference report and a longer review paper which supplements the discussions/topics raised at the workshop with details from published literature will be submitted to *Astrobiology*.
- The larger review paper also includes interpretations of how analog studies may be useful in guiding strategic planning for the astrobiological exploration of Mars, urgent needs for research, and future research directions.

Upcoming Community Effort:

# Critical Measurements in Martian Geobiology with Mars-2020: Finding Signs of Rock-Hosted Life

- **<u>Overarching goal</u>: articulate the suite of biosignatures produced by paleo rock-hosted life and establish which rock facies types may preserve them**
- We will fill a gap in existing Martian biosignature research by formulating an approach and measurement suite focused specifically on how to identify paleo rock-hosted Martian life (e.g., within aquifers in igneous or sedimentary rock, deep hydrothermal, weathering settings), considering units accessible at candidate landing sites. We will address:
  - What are potential biosignatures (textural, chemical, mineralogical, isotopic) from rock-hosted life?
  - What types of facies may preserve these potential biosignatures?
  - What measurements (if any) can Mars-2020 make in situ to identify these potential biosignatures?
  - What measurements can Mars-2020 make to collect samples with a high probability for hosting potential biosignatures that would be identifiable in terrestrial laboratories?
- We will conduct 3-4 pre-landing site workshop telecons in November and early December, inviting participants from NAI nodes, the NSF C-DEBI distribution list, the Deep Carbon Observatory, and experts in laboratory analytical techniques.
- We have applied for NASA funding to bring ~12 invited speakers who are experts on the topic, and intend to hold a 2-day, ~40 person face-to-face meeting in February 2017 to prepare a concise summary of all findings for presentation at the 3rd Mars-2020 landing site workshop and follow-on peer-reviewed publication.
- Those interested in helping to organize should contact TC Onstott (tullis@princeton.edu) and Bethany Ehlmann (ehlmann@caltech.edu).