Jet Propulsion Laboratory
California Institute of Technology

Biosignature Preservation and Detection in Mars Analog Environments

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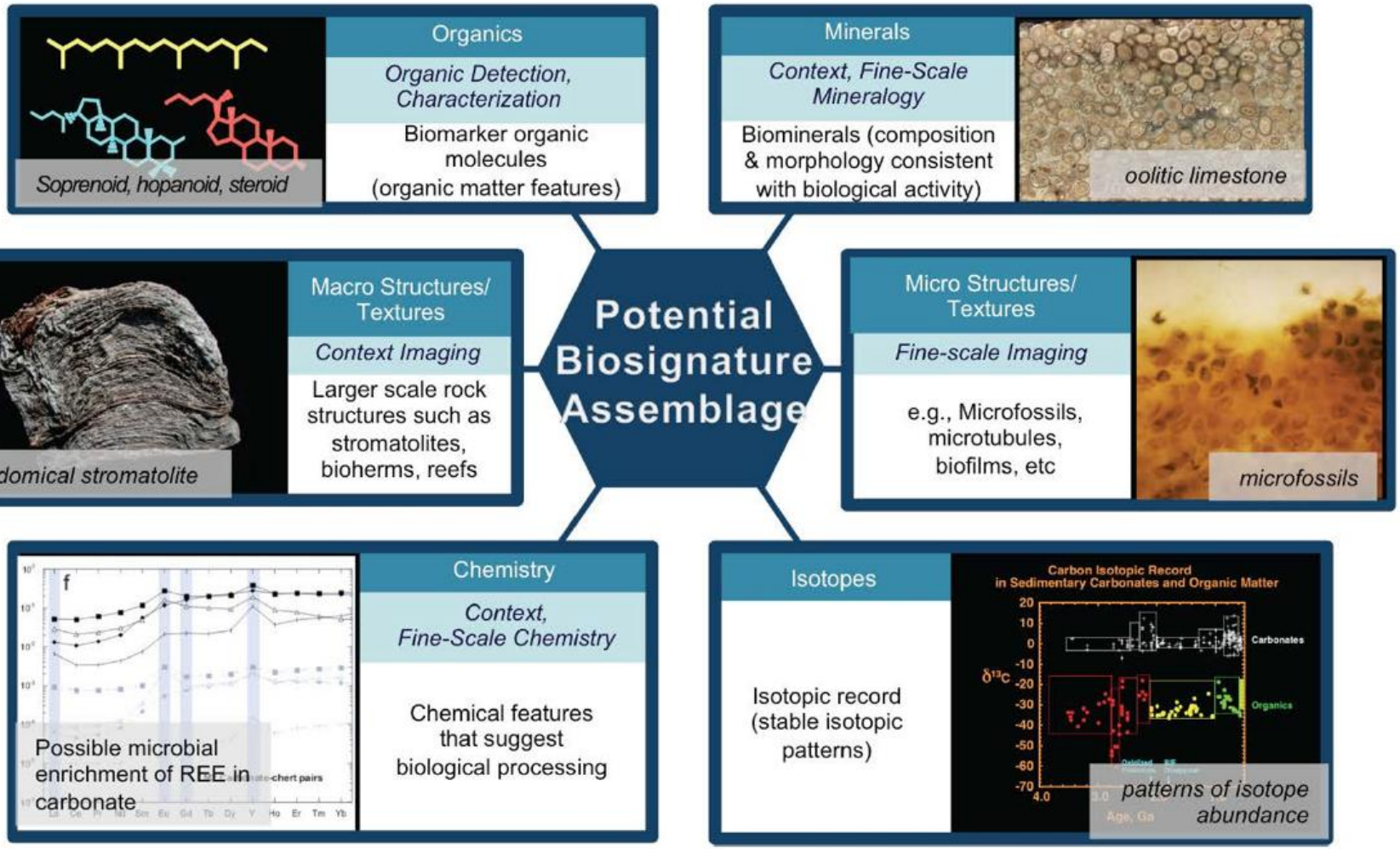
Workshop information

- Conference on Biosignature Preservation and Detection in Mars Analog Environments held May 16th-18th, 2016 with 90 scientists at Incline Village, NV
- Workshop Objective:

  Assess the attributes and the preservation potential of biosignatures in diverse Mars-analog habitable environments to develop strategies to detect a range of possible biosignatures on Mars.
- Workshop Output: Conference Report and Review Paper in *Astrobiology*

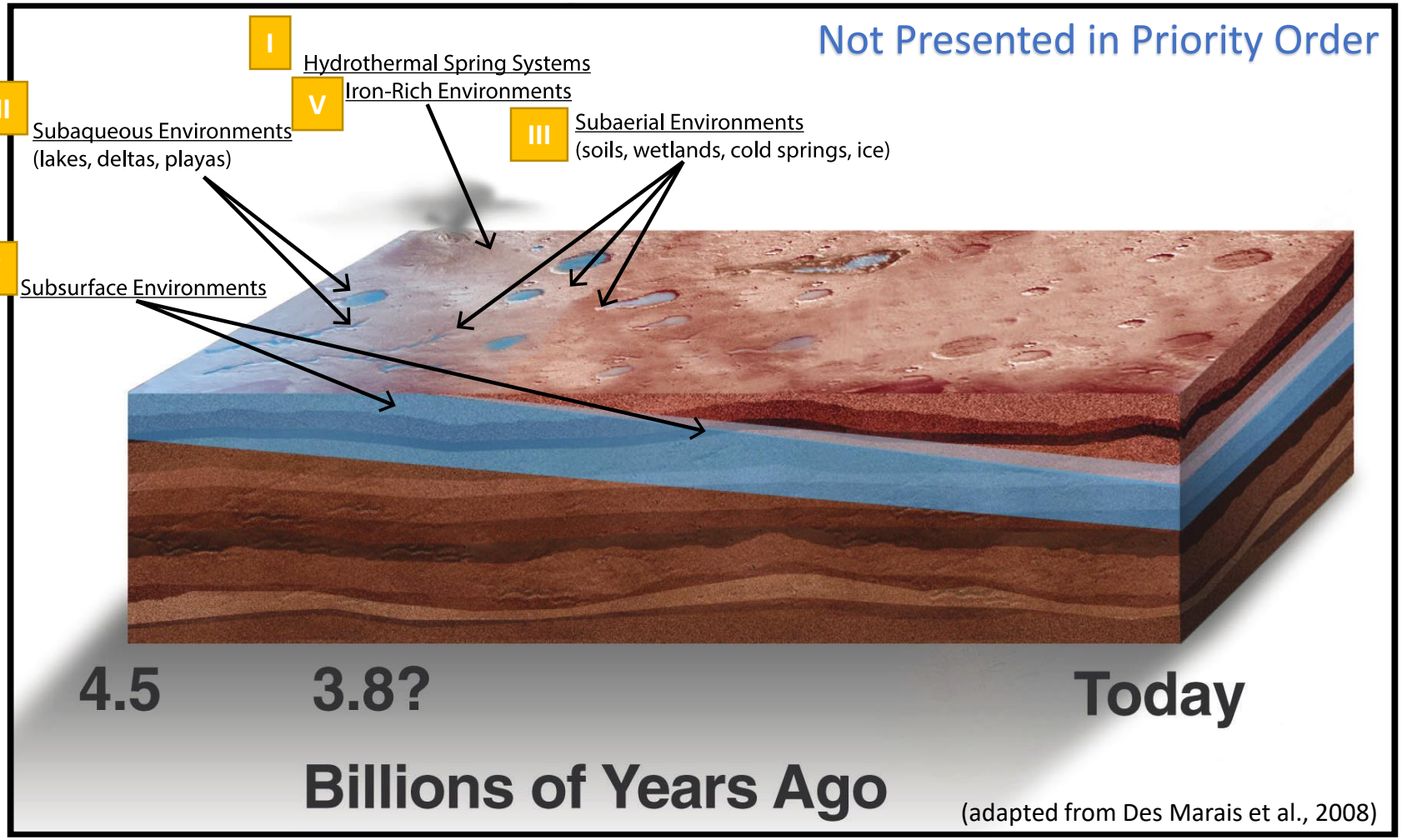
http://online.liebertpub.com/doi/abs/10.1089/ast.2016.1627

Six Classes of Biosignatures



(from Mustard et al. 2013)

Astrobiologially-Relevant Martian Analog Environments

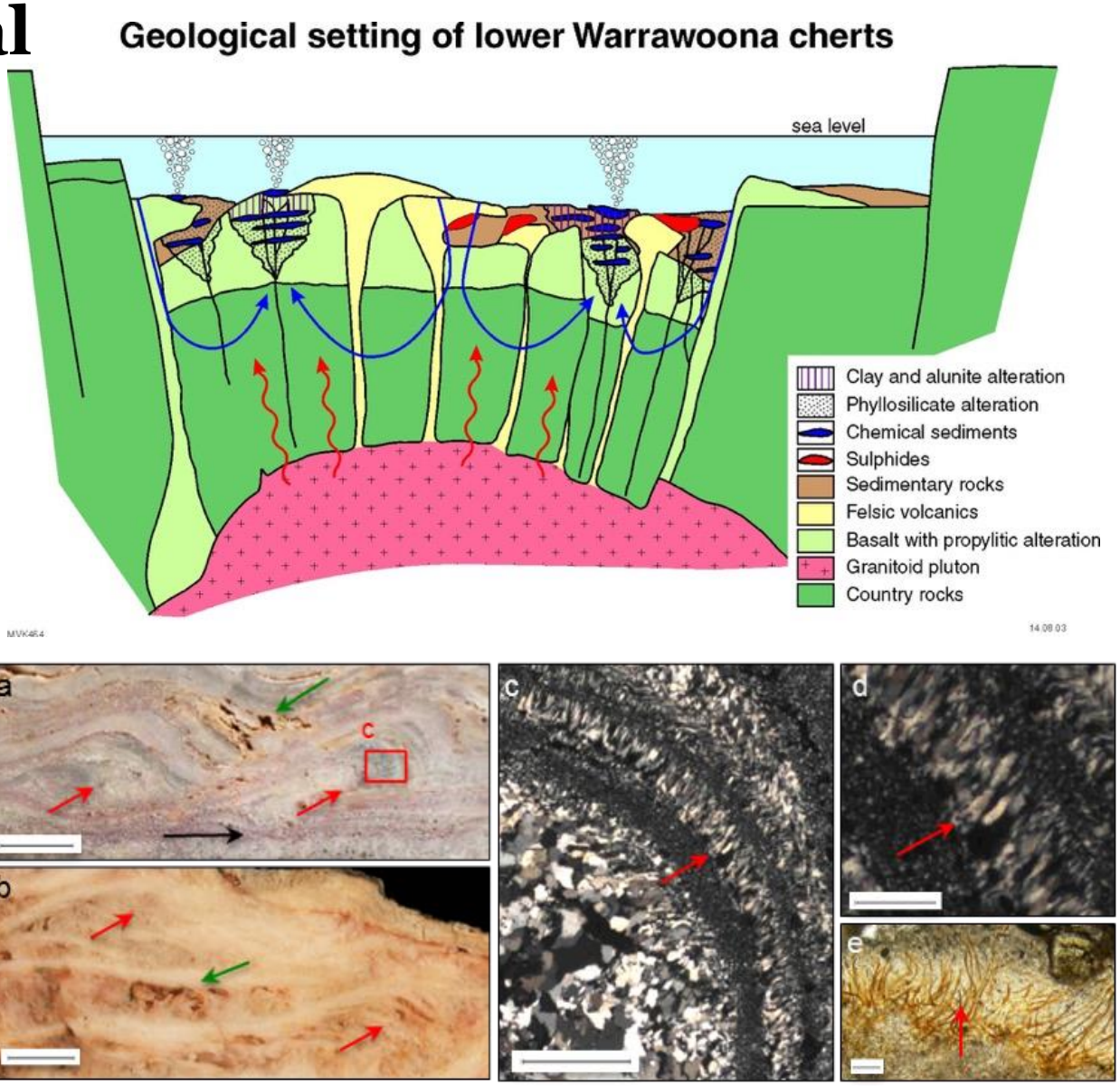


I. Hydrothermal Spring Systems

Description:

Where heat is transported convectively from hotter interiors (e.g., via volcanism or large impact) encounters water as it passes through rocky crusts.

For this study, discussion focused wherever these fluids intersected the surface.

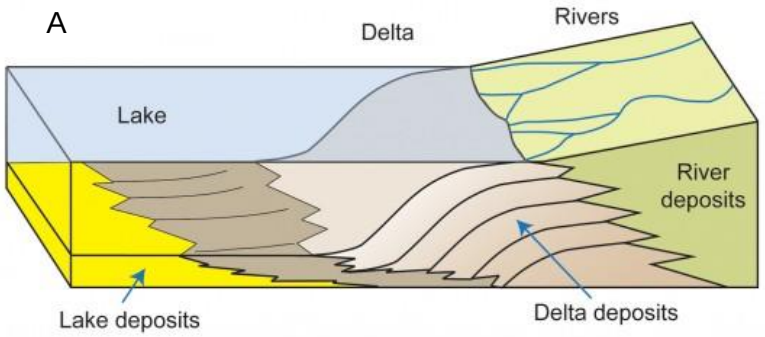


II. Subaqueous Environments

Description:

Subaqueous environments discussed here include deltaic and perennial lake systems (open and closed systems) as well as transient lake and playa systems, although many of the concepts apply to shallow oceanic environments as well, which may have existed on Mars.

A



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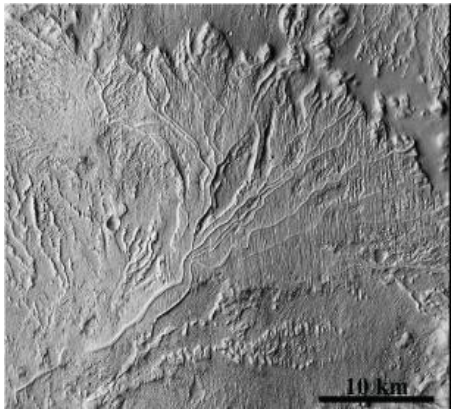


III. Subaerial Environments

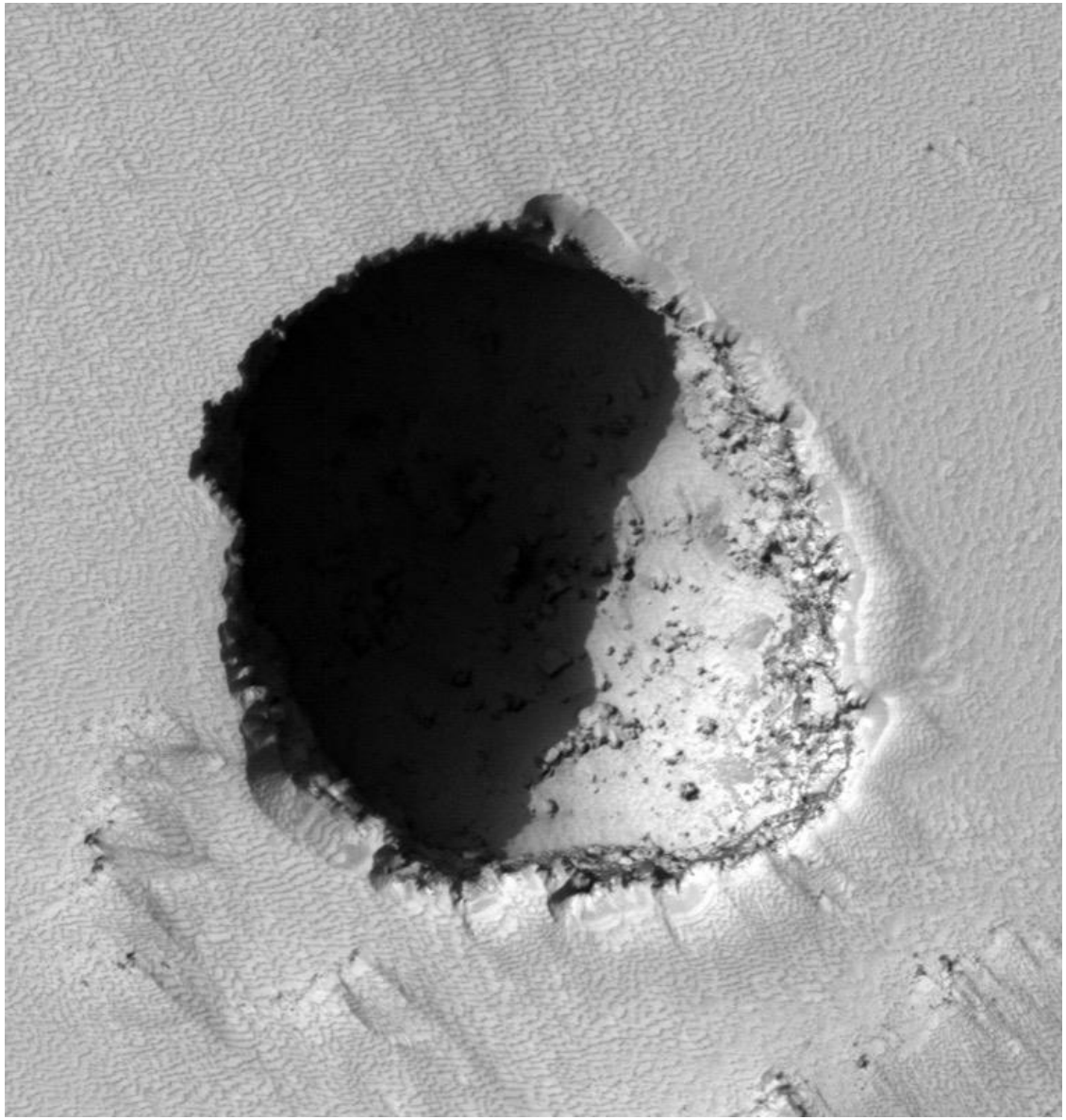
Description:

Sub-aerial environments includes all environments at the surface or in the near-surface not covered by a body of water, but where water is derived directly from precipitation, snow melt, or ambient-temperature groundwater. Thus, this diverse suite of environments includes soils, wetlands, and cold springs, as well as glaciers and snow packs.

IV. Subsurface Environments

Description:

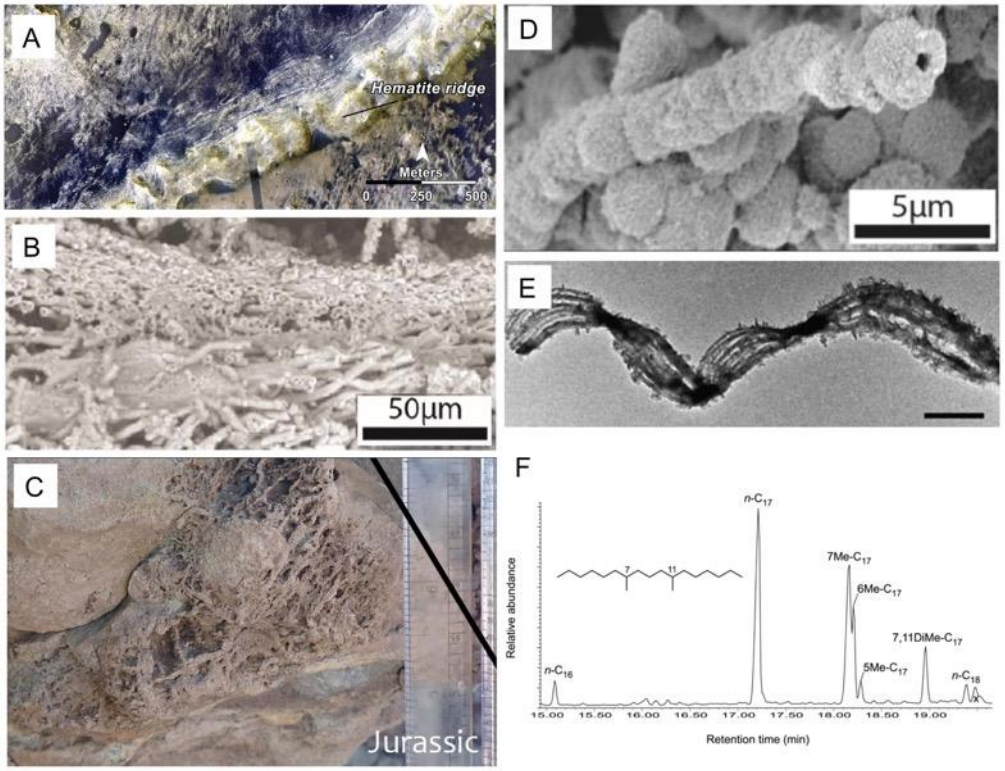
The subsurface is considered to include all environments beneath the active regolith, except for those directly impacted by hydrothermal circulation, including shallow aquifers with pore spaces filled with liquid water or ice, deeper igneous crust, deep sedimentary deposits, and caves.



V. Iron-Rich Environments

Description:

Where circulating groundwater or hydrothermal systems mobilize iron to provide habitats high in dissolved iron. These iron-rich waters can be expressed as groundwater circulating through permeable rock, ferruginous marine and lacustrine settings, deep-sea hydrothermal vents and at the surface to form subaerial habitats, such as seeps and springs where iron oxides precipitate from the waters.



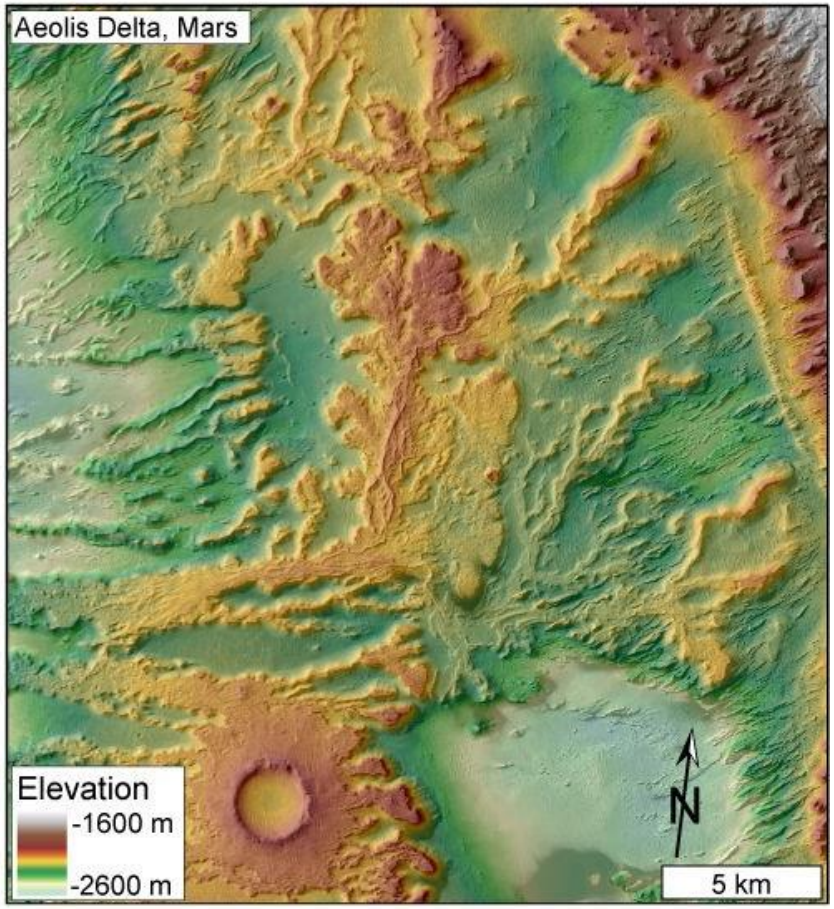
Exploring Past Habitable Environments on Mars:

Common Challenges

Strategies and Priorities

Urgent Needs and Future Research

Common Challenges



DiBiase et al. 2013

- The limit in resolution of our orbital assets potentially introduces a bias towards prioritizing environments that are more easily identified remotely, regardless of their potential for biosignature preservation.
- Orbital reconnaissance of many potential sites for exploration cannot provide a reliable indication of how long an environment may have been habitable.

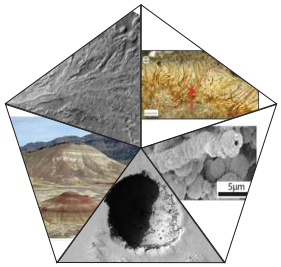
Common Challenges

- Fundamental mismatch in scale between what can been observed from orbit (e.g., on Mars) and what we have traditionally looked for on the ground.
- Spatial heterogeneity of the most promising deposits, which includes local, chemical or sedimentological variability.

Painted Desert ©Midwest Wanderer

Common Challenges

- Recognizing the particular features of a habitable environment in the absence of abundant life.
- Time Scales of a Deposit's History: Including how old a deposit is and how long a deposit has been exposed to the weathering and radiation environment on the surface of Mars.



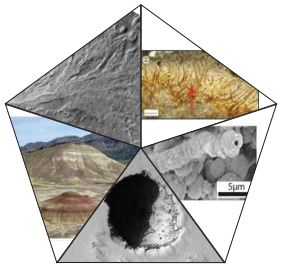
Strategies and Priorities

1. Better understanding of the dichotomy between habitability and preservation.
2. Studies of temporally appropriate terrestrial analogs of early Mars. [Note: preservation from early Earth environments might have differed in important ways from preservation in similar early Mars environments]
3. The astrobiological exploration of Mars must be coordinated across a broad range of spatial and temporal scales.

Strategies and Priorities

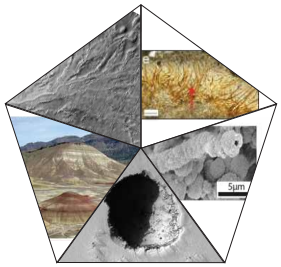
4. A site that includes a variety of geologic records indicative of habitable environments would be most desirable.
5. Although organic biosignatures received attention at the workshop, a consensus emerged that landed missions should also seek a diverse suite of potential biosignatures.

Aniakchak National Monument. ©Thomas O'Keefe.



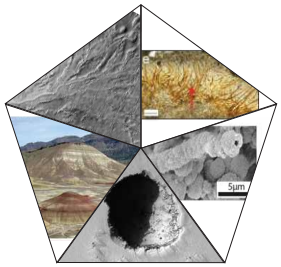
Strategies and Priorities

6. Missions should also seek environments on Mars where life conceivably might have originated, or where chemical reactions that could have spanned the prebiotic-biotic transition could have been present.
7. Investigations of certain analog environments (e.g., subaqueous settings, hydrothermal spring systems) are further advanced than investigations of others (e.g., subsurface), as is the state of the science of remote identification of these environments.



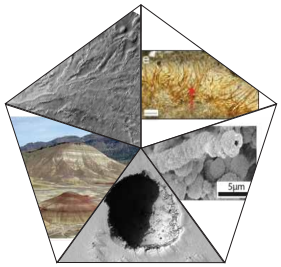
Urgent Needs and Future Research

- Two aspects of future mission development that would help astrobiological exploration were consistently highlighted in discussions:
  - Must improve spatial and spectral resolution of spectrometers and imagers on orbiters to support remote assessment of environments of interest.
  - Need to improve instrumentation on rovers that might detect and identify a diversity of potential *in situ* biosignatures. [Including designed to respond successfully to the unique complications of biosignature preservation on Mars].



Urgent Needs and Future Research

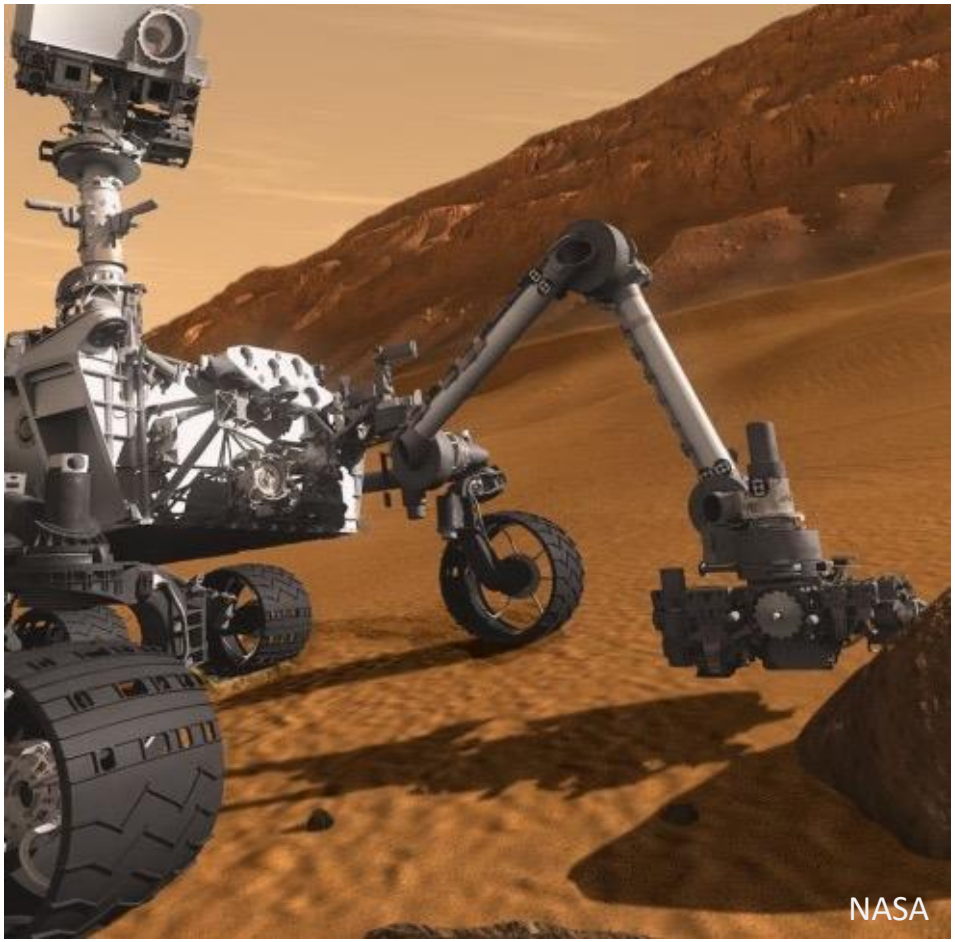
- The conference discussions clearly indicated that the distinctions between "subsurface" and "near surface" environments should be delineated more clearly. Research to more effectively characterize exhumed geological deposits from past subsurface environments regarding their habitability and their potential to preserve biosignatures.
- Research to improve our ability to adapt our current understanding of terrestrial life to the astrobiological exploration of martian environments. E.g. what the biosignature signals might be if photosynthetic microorganisms had not evolved, and instead the environments were only inhabited by chemosynthetic microorganisms.



Urgent Needs and Future Research

- Investigate how martian systems and environments might be chemically or physically different from Earth environments and might produce, preserve or destroy biosignatures at different rates or in different proportions than expected from terrestrial analogs.
- Strategies to search for past life on Mars are also relevant to the search for extant life. E.g. a campaign to identify potential biosignatures at sites that were habitable in geologically recent times could demonstrate that life persists elsewhere on Mars.

Urgent Needs and Future Research



- Need better understanding of how well instruments selected for Mars-2020 can separate the biotic signal from the abiotic background noise in different environments.