<table>
<thead>
<tr>
<th>Time</th>
<th>#</th>
<th>Title</th>
<th>Presenter</th>
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<tbody>
<tr>
<td>09:40 AM</td>
<td>#1</td>
<td>Astrobiology on Mars: Organic Chemical Evolution on an Earth-like Planet</td>
<td>Alfonso Davila</td>
<td>12:40 PM EDT</td>
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<td>09:44 AM</td>
<td>2</td>
<td>Mars as a Representative Habitable World and Prebiotic Environment</td>
<td>Aaron Engelhart</td>
<td>12:42 PM</td>
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<td>09:46 AM</td>
<td>3</td>
<td>The Evolution of Habitable Environments on Terrestrial Planets: Insights and Knowledge Gaps from Studying the Geologic Record of Mars</td>
<td>Briony Horgan</td>
<td>12:44 PM</td>
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<tr>
<td>09:48 AM</td>
<td>4</td>
<td>Search for Modern Life on Mars: Compelling and Achievable in the Decade</td>
<td>Carol Stoker</td>
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<td>5</td>
<td>Deep Trek: Exploring the modern-day subsurface habitability &amp; life on Mars</td>
<td>Vlada Stamenkovic</td>
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<td>09:52 AM</td>
<td>6</td>
<td>Deep Trek: Technology &amp; Mission Concepts for exploring the subsurface habitability &amp; life on Mars</td>
<td>Vlada Stamenkovic</td>
<td>12:50 PM</td>
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<td>7</td>
<td>Trace Gas Consumption as a Metabolic Strategy for Life Beneath the Martian Surface and the Means to Detect It</td>
<td>Zachary Garvin</td>
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<td>8</td>
<td>Mars Astrobiological Cave and Internal habitability Explorer (MACIE): A New Frontiers Mission Concept</td>
<td>Charity Phillips-Lander</td>
<td>12:54 PM</td>
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<td>9</td>
<td>MapX: An In-situ X-ray μ-mapper for Habitability and Biosignature Studies</td>
<td>David Blake</td>
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<td>10:00 AM</td>
<td>10</td>
<td>CheMinX: A Next Generation XRD/XRF for Mars Exploration</td>
<td>David Blake</td>
<td>12:58 PM</td>
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<tr>
<td>10:02 AM</td>
<td>11</td>
<td>Mars’ Ancient Dynamo field and Crustal Remanent Magnetism</td>
<td>Anna Mittelholz</td>
<td>01:00 PM</td>
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</table>

These slides and 1-pagers for each of these concepts can be found at: [https://mepag.jpl.nasa.gov/meetings.cfm?expand=m38](https://mepag.jpl.nasa.gov/meetings.cfm?expand=m38)

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Astrobiology on Mars: Organic Chemical Evolution on an Earth-like Planet

Recommendation: The next decade of Mars exploration should prioritize research into the origin, distribution, and chemistry of organic matter in martian geologic materials.

Organic matter in martian geologic materials:
(1) Suggests that OCE is active on rocky planets
(2) Shows that OCE occurred in martian environments that could have supported life
(3) Expands the record of OCE during the first Ga
(4) Provides an opportunity to study OCE under complex and dynamic planetary conditions

Mars Tissint meteorite
Steele et al. Sci Adv 2018

MMC in the Mars Tissint meteorite is a close chemical match to MMC found at Gale Crater using SAM

POC: Alfonso Davila (alfonso.davila@nasa.gov). Contributors: M. Cable; D. Catling; J. Cleaves; J. Eigenbrode; S. Johnson; A. Steele; J. Stern
Mars as a Representative Habitable World and Prebiotic Environment

-Prebiotic chemistry on Mars and other bodies
-Planetary protection
-Can we help/interact synergistically? Prebiotic chemistry as a way to de-risk missions - sample return or otherwise - searching for extant or past life

Point of Contact: Aaron Engelhart enge0213@umn.edu

For more information, please see my 1-pager at https://mepag.jpl.nasa.gov/meetings.cfm?expand=m38
The evolution of habitable environments on terrestrial planets: Insights and knowledge gaps from studying the geologic record of Mars

**Point of Contact:** Briony Horgan (Purdue)

[1-page summary](#)

We have evidence for an astounding array of habitable environments on ancient Mars, but we don’t yet have good constraints on:

- The evolution of these environments over time (timing, persistence, distribution)
- The conditions they occurred under (hydroclimate, water sources/chemistry)
- Effect of later processes on the geologic record and biosignatures (diagenesis)

**Significance to Mars Science:** Constraining the surface/subsurface conditions that these environments occurred under is critical to developing planet-wide models for the geological and astrobiological evolution of major parts of the Mars system.

**Significance to Planetary Science:** Filling these fundamental knowledge gaps using data from Mars provides our best chance to understand what factors in planetary evolution lead to sustained habitable environments on Earth-like worlds.

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Co-authors and co-signatories welcome!

Email for co-authorship: briony@purdue.edu

Co-signers only: [Google Form](#)
Search for Extant Life on Mars: Compelling and Achievable in the Decade

POC: Carol Stoker (carol.stoker@nasa.gov)

Salts

Map of chloride deposits (Osterloo et al 2010)

Endoliths growing in Atacama desert halite

Halophiles entombed in crystals

Shallow Ice

Global map of ground ice depth (Piquex et al. 2019)

Ice exposed by fresh crater at 39N

Ice exposed by Phoenix scoop 5 cm deep at 68N

1-2 m drill can explore ground ice for life on Mars.

Caves and Lava tubes

On Earth, biominerals protect life and a record of microbial activity.

>1300 candidate caves, based on orbital data (Cushing, 2017).

Deep Subsurface

Mars subsurface aquifers may be located by EM sounding, then deep drilling (>100m) can access samples to search for life.

VALKYRIE (Volatiles And Life: Key Reconnaissance & In-Situ Exploration) mission concept for subsurface exploration and characterization of habitability.
DEEP TREK: “Modern Subsurface Habitability”

POC: Vlada Stamenkovic, Vlada.Stamenkovic@jpl.nasa.gov

Data raise questions on the Deep
- Methane variability.
- Oxygen variability.
- Organics destroyed in near-surface environments.
- Liquid water at depth?

Longest-lived habitat
- Key modern habitat?
- Early key habitat?

Mars 2.0
- Unexplored world!

Science with depth

Beyond Mars science
- Ocean Worlds (life)
- ISRU/Human exploration

For more information, please see our 1-pager (#5) at https://mepag.jpl.nasa.gov/meetings.cfm?expand=m38
Deep Trek: “Modern Subsurface Habitability”

POC: Vlada Stamenkovic, Vlada.Stamenkovic@jpl.nasa.gov

Key subsurface measurements

- A. Liquid Water
- B. Energy & Nutrients
- C. Cellular Stability
- D. Biomarkers & Signs of Metabolic Activity

Beyond Mars tech
- Ocean Worlds subsurface sounding/access
- Moon ISRU & subsurface sounding/access

For more information, please see our 1-pager (#6) at https://mepag.jpl.nasa.gov/meetings.cfm?expand=m38
Prioritize gas measurements via soil chambers/probes at multiple “hot spots” to:

- calculate trace gas flux
- characterize atmosphere-regolith gas exchange
- determine potential to support biology

High-affinity trace gas oxidizing microbes could be active participants in Martian gas cycling as they are on Earth.
For more information, please see our 1-pager at: https://mepag.jpl.nasa.gov/meetings.cfm?expand=m38
MapX: An “imaging APXS” or “imaging PIXE” instrument

- 2.5 cm field of view, ~100 μm lateral resolution
- Depth of field ~1 cm with minimal loss of resolution (100μm-200μm)
- Detects elements 10<Z<35 (Kα) quantifies all elements >0.1% in 3 hours
- No moving parts
- “Full-frame imager”: sums ~10,000 0.3 sec images, but less integration still returns an image
- Returned data:
  - X-ray maps 10<Z<35
  - Instrument-selected “Regions of Interest (ROI) having common compositions
  - Quantifiable XRF spectra from ROI

a. Optical image, carbonate cemented basalt breccia (“Comanche Carbonate”)
b. RBG image, R=Fe, G=Ca, B=Mg
c. Fe X-ray map
d. Ca X-ray map
e. Mg X-ray map
f. ROI map
g. XRF spectra from ROI
CheMinX: A Next Generation XRD/XRF for Mars Exploration

David Blake Ames Research Center

CheMin XRD on MSL Curiosity rover: http://odr.io/CheMin

- 10.5 Kg., 30 X 30 X 30 cm., Power: 45 W, ~400W per analysis, resolution = 0.35° 2θ
- Identification of all minerals >1 %
- Quantification of all minerals >3%, structure states and cation occupancies
- Abundance of all major elements present in each mineral, H and above
- Valence state of all elements including speciation of multi-valent elements (e.g., Fe)
- Quantify amorphous abundance
- Identification and quantification of all clay minerals, triocathedral/dioctahedral
- Uses APXS data & mineral compositions to determine composition of amorphous component

CheMinX improvements over CheMin:

- 5 kg, 16 X 20 X 30 cm., (1/2 the mass, 1/3 the volume, 1/10 the energy of CheMin)
- Resolution = 0.30° 2θ; (1 CCD); 0.15-0.2° 2θ (2 CCDs)
- Analysis time per sample, 15 minutes to 1 hour
- Power: 45W analysis, 8W idle, 13W sample exchange, ~45W per analysis
- Overall elemental composition from internal SDD detector
- Direct beam intensity measurement (sample absorption; improved quantification)
- Suitable for deployment on a MER-class rover
Towards new science opportunities exploring the martian magnetic field

Questions

Nature of martian crustal remanent magnetism?

Magnetization acquisition processes?

Characteristics of the martian Dynamo?

Resolution!

Available Data / Current Limitations

Geological Context?
Sparse sampling!

+ Meteorites

Recommendations

(1) Aerial platforms such as drones and/or long-lived balloons to obtain low-altitude magnetic measurements over tens or hundreds of kilometers.

(2) Mars Sample Return: Begin planning for return to Earth of a variety of differently aged and oriented bedrock samples for magnetic and radioisotope analysis in terrestrial laboratories.