White Paper Topic 1-slide Lightning Talks

Astrobiology and Subsurface Investigations

Astrobiology and Subsurface Investigations				
09:40 AM PDT	#1	Astrobiology on Mars: Organic Chemical Evolution on an Earth-like Planet	Alfonso Davila	12:40 PM EDT
09:42 AM	2	Mars as a Representative Habitable World and Prebiotic Environment	Aaron Engelhart	12:42 PM
09:44 AM	3	The Evolution of Habitable Environments on Terrestrial Planets: Insights and Knowledge Gaps from Studying the Geologic Record of Mars	Briony Horgan	12:44 PM
09:46 AM	4	Search for Modern Life on Mars: Compelling and Achievable in the Decade	Carol Stoker	12:46 PM
09:48 AM	5	Deep Trek: Exploring the modern-day subsurface habitability & life on Mars	Vlada Stamenkovic	12:48 PM
09:50 AM	6	Deep Trek: Technology & Mission Concepts for exploring the subsurface habitability & life on Mars	Vlada Stamenkovic	12:50 PM
09:52 AM	7	Trace Gas Consumption as a Metabolic Strategy for Life Beneath the Martian Surface and the Means to Detect It	Zachary Garvin	12:52 PM
09:54 AM	8	Mars Astrobiological Cave and Internal habitability Explorer (MACIE): A New Frontiers Mission Concept	Charity Phillips-Lander	12:54 PM
09:56 AM	9	MapX: An In-situ X-ray μ-mapper for Habitability and Biosignature Studies	David Blake	12:56 PM
09:58 AM	10	CheMinX: A Next Generation XRD/XRF for Mars Exploration	David Blake	12:58 PM
10:00 AM	11	Mars' Ancient Dynamo field and Crustal Remanent Magnetism	Anna Mittelholz	01:00 PM
10:02 AM		Discussion - e.g., thoughts on these topics? what's missing?		01:02 PM

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

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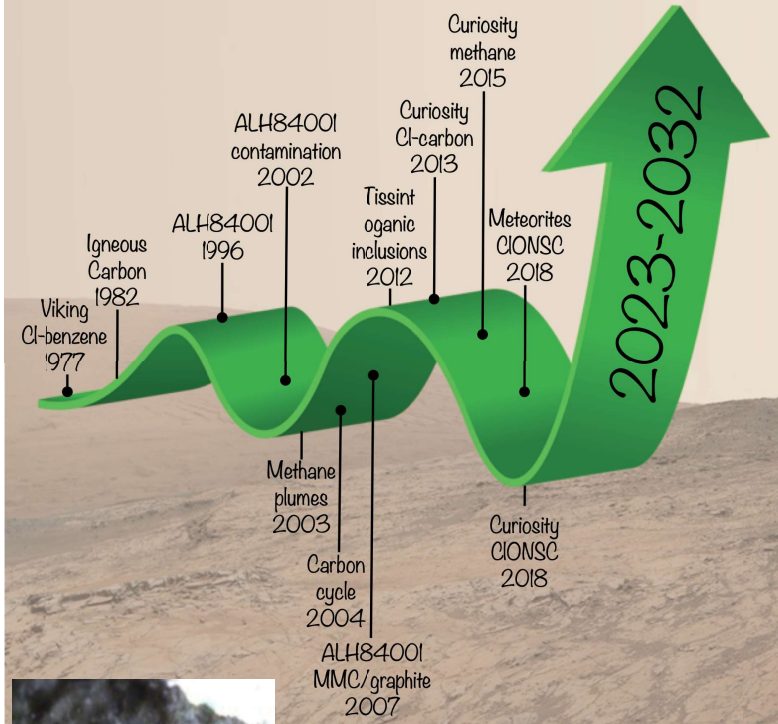
Astrobiology on Mars: Organic Chemical Evolution on an Earth-like Planet

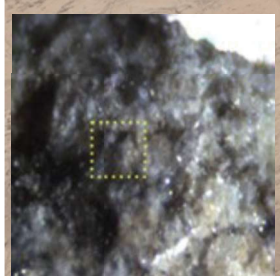


Recommendation: The next decade of Mars exploration should prioritize research into the origin, distribution, and chemistry of organic matter in martian geologic materials.

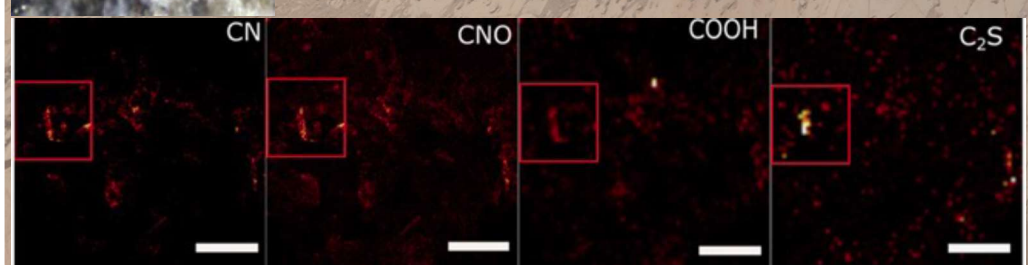
Organic matter in martian geologic materials:

(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

OCE= Organic Chemical Evolution



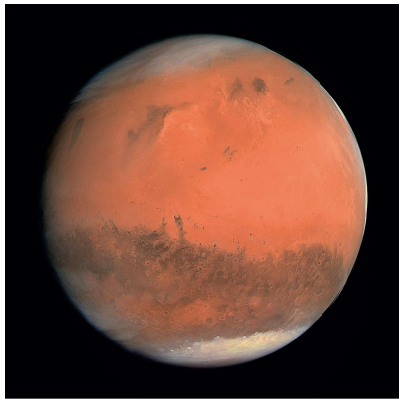
Mars Tissint meteorite
Steele et al. Sci Adv 2018



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)

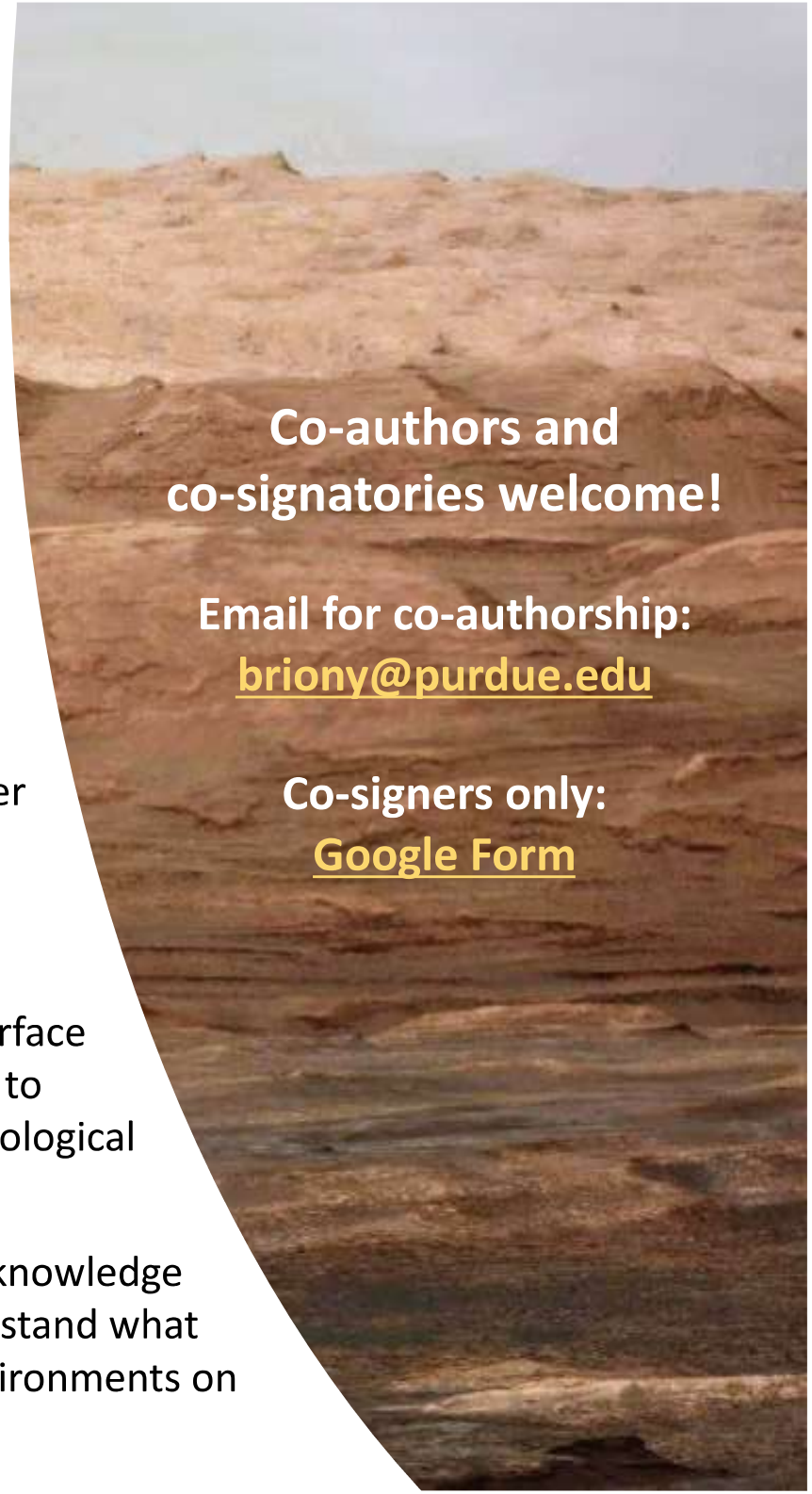
1-page summary

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.

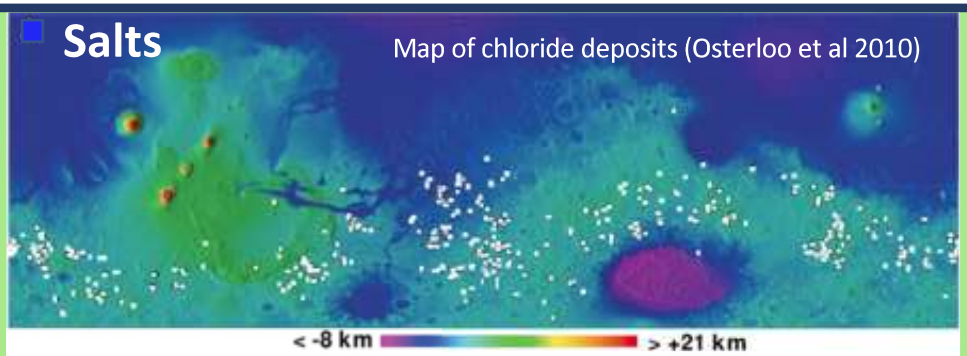
Significance to Planetary Science: Filling these fundamental knowledge gaps using data from Mars provides our best chance to understand what factors in planetary evolution lead to sustained habitable environments on Earth-like worlds.



Search for Extant Life on Mars: Compelling and Achievable in the Decade

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

Salts

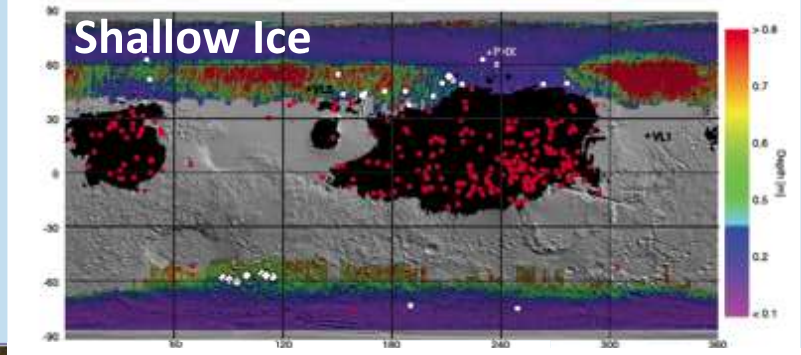


Map of chloride deposits (Osterloo et al 2010)

Endoliths growing in Atacama desert halite

Halophiles entombed in crystals

Shallow Ice



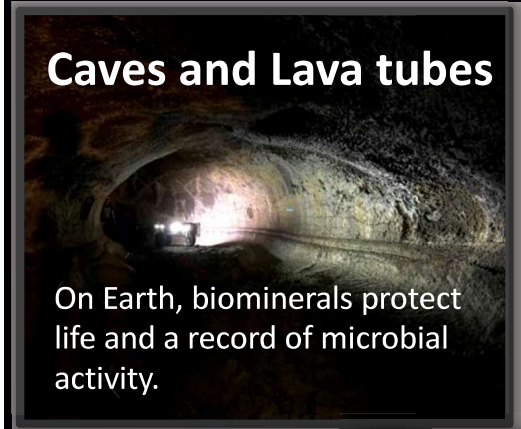
Global map of ground ice depth (Piquex et al. 2019)

Ice exposed by fresh crater at 39N

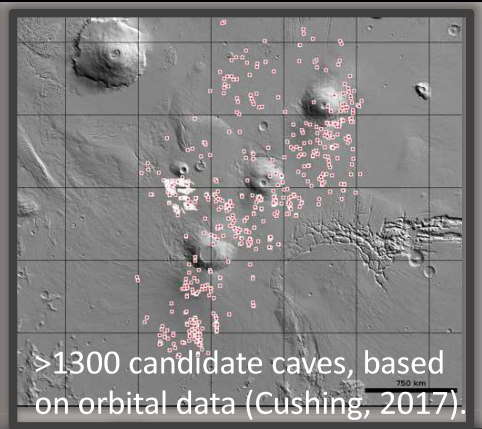
Ice exposed by Phoenix scoop 5 cm deep at 68N

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

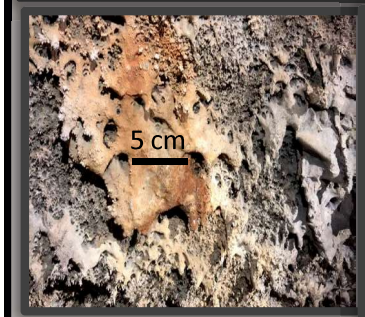
Caves and Lava tubes

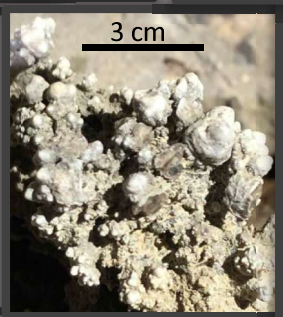


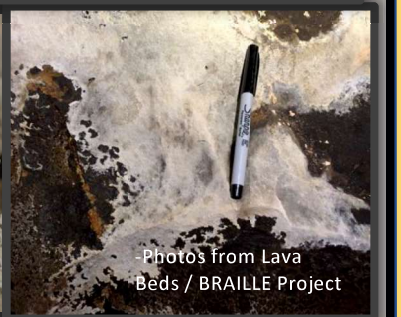
On Earth, biominerals protect life and a record of microbial activity.



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







Photos from Lava Beds / BRAILLE Project

Deep Subsurface

VALKYRIE (Volatiles And Life: Key Reconnaissance & In-Situ Exploration) mission concept for subsurface exploration and characterization of habitability.

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

Part 1 Science

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?

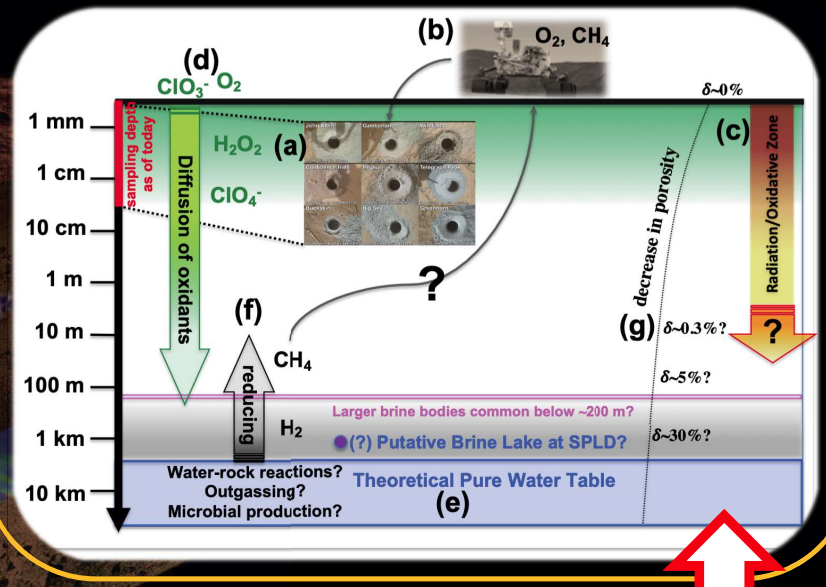
Longest-lived habitat

- 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

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Part 2 Tech/Missions

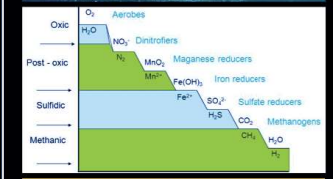
DEEP TREK: "Modern Subsurface Habitability"

* Volatiles And Life: KeY Reconnaissance & *In-situ* Exploration

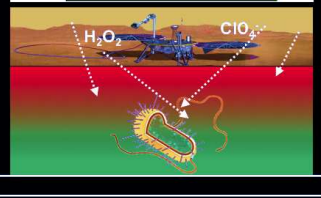
POC: Vlada Stamenkovic, Vlada.Stamenkovic@jpl.nasa.gov

Key subsurface measurements

- A. Liquid Water

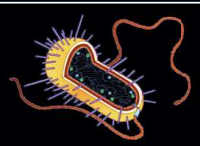


- B. Energy & Nutrients



- C. Cellular Stability

1. HABITABILITY

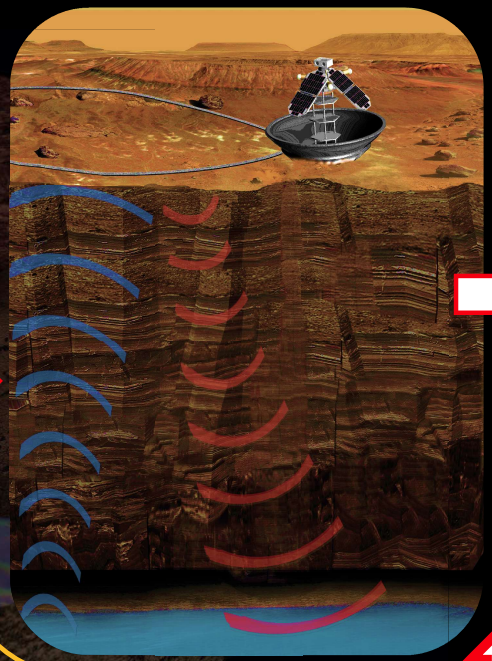


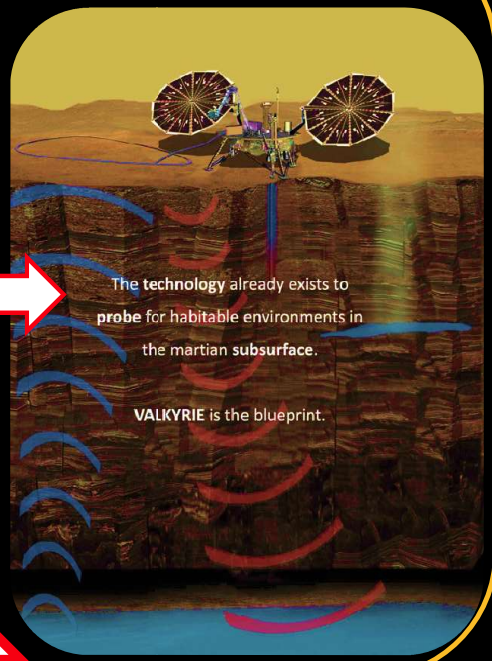
- D. Biomarkers & Signs of Metabolic Activity

2. LIFE

- GO DEEP (←NAS),
- but don't ignore the shallow.

SmallSats to New Frontiers: VALKYRIEs*





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

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MEPAG 38: Trace Gas Consumption as a Metabolic Strategy for Life Beneath the Martian Surface and the Means to Detect It

Zachary K. Garvin (zgarvin@princeton.edu), R. L. Harris, D. Nisson, R. Liang, T. C. Onstott

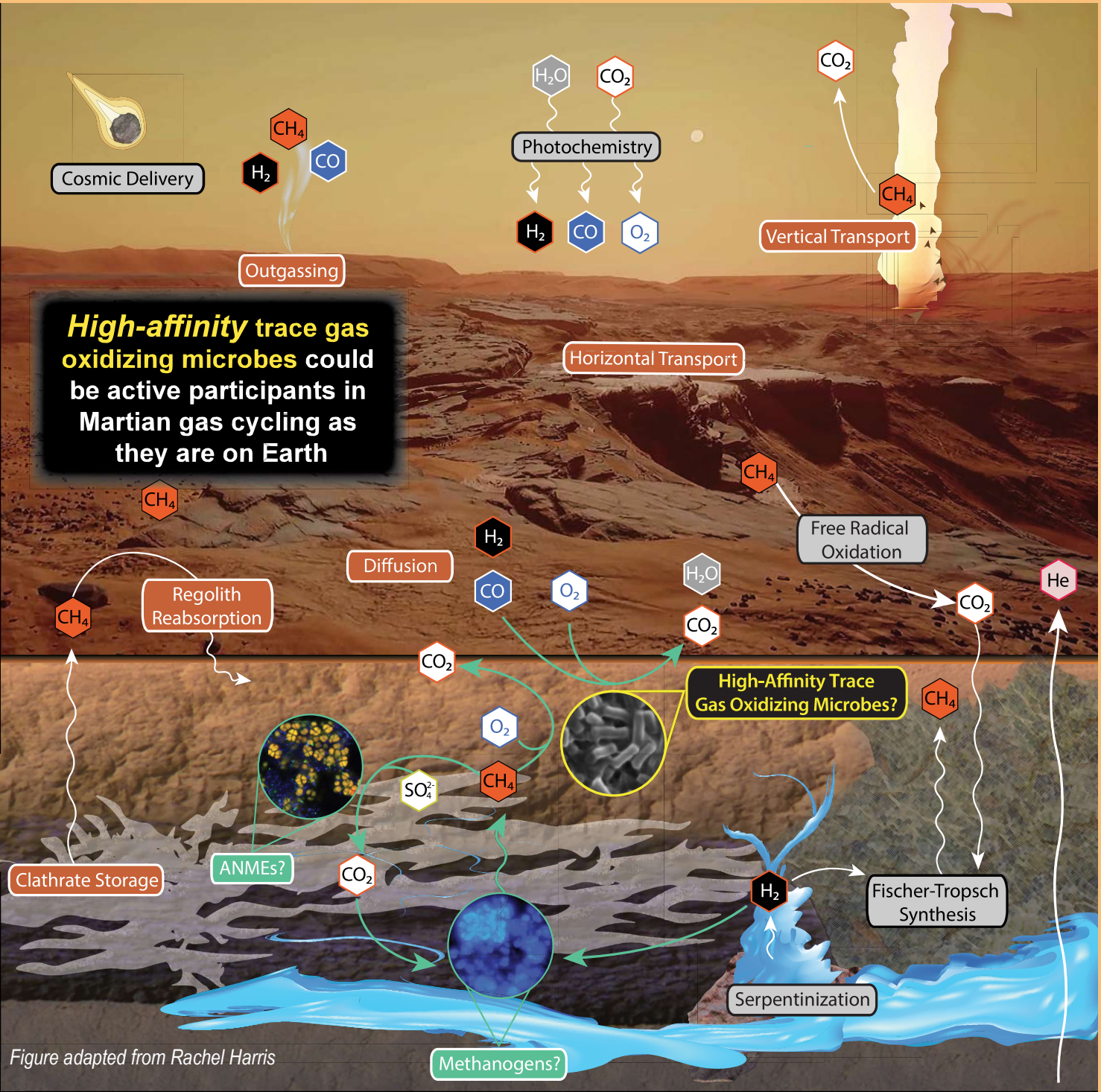
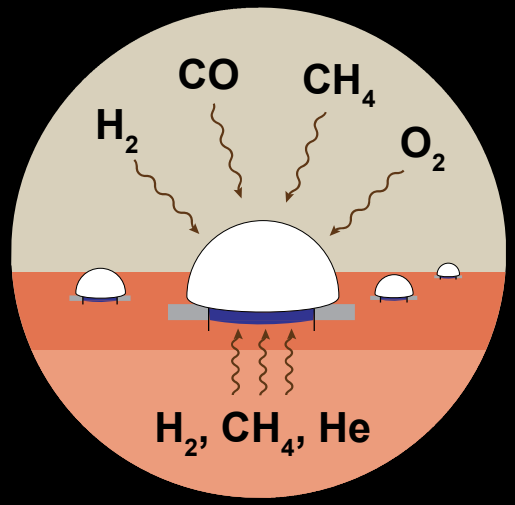


Figure adapted from Rachel Harris

"Targeted"



Regional...

Global...

Prioritize gas measurements via soil chambers/probes at multiple "hot spots" to:

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

Mars Astrobiological Cave and Internal habitability Explorer

MACIE

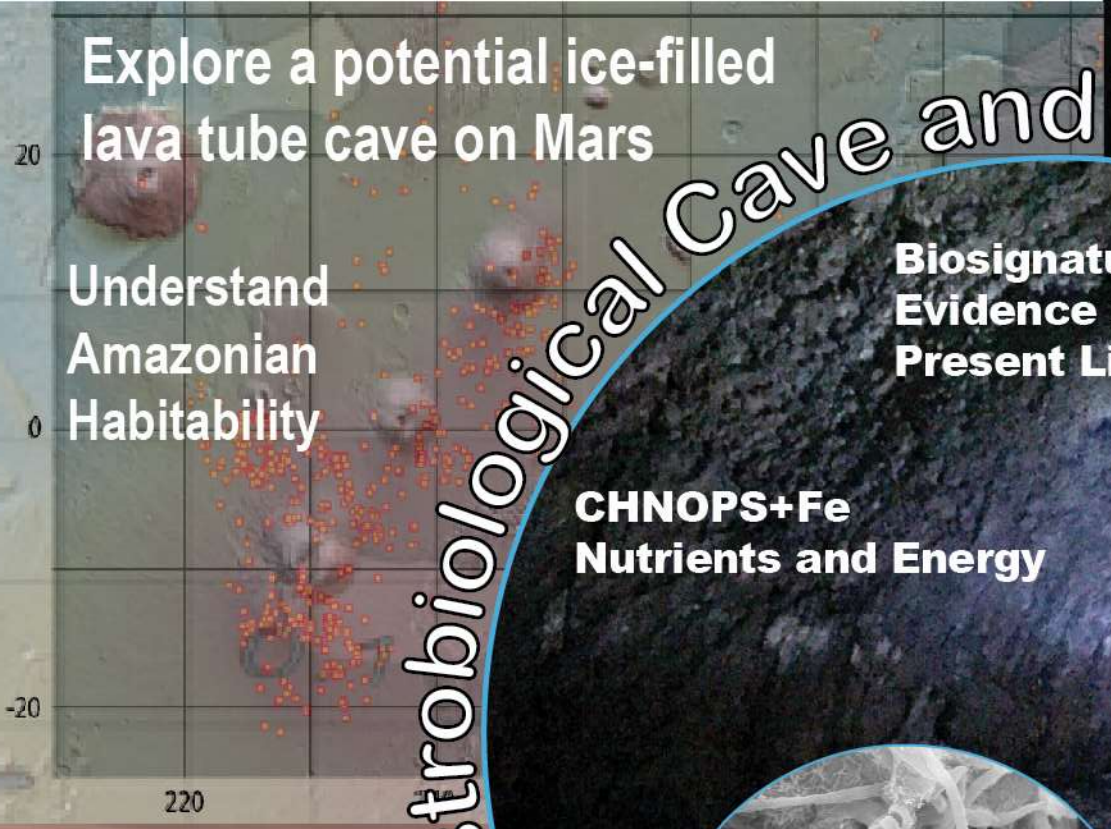
Biosignatures
Evidence of Past/
Present Life

CHNOPS+Fe
Nutrients and Energy

Evidence of
Aqueous Alteration

Presence of Ice

Explore a potential ice-filled lava tube cave on Mars

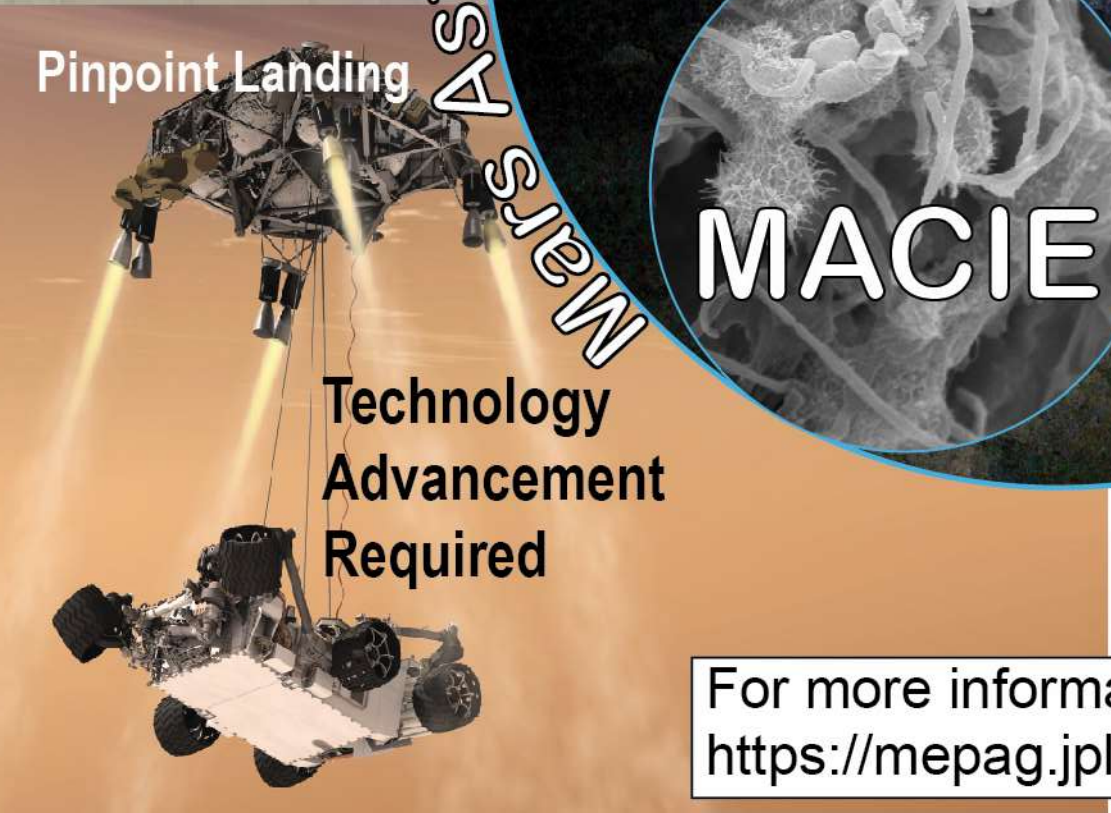


Understand
Amazonian
Habitability

Mission Architecture

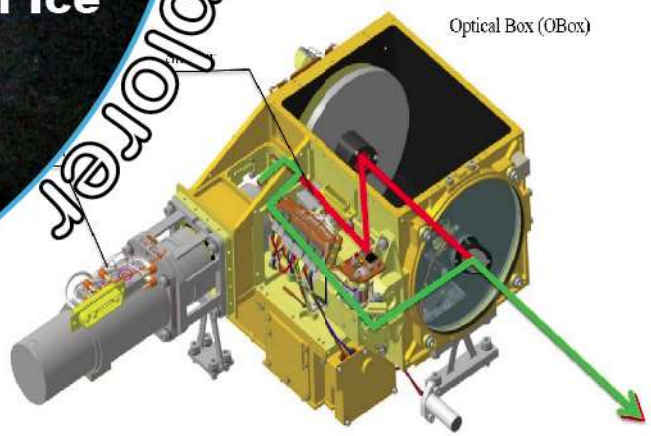
Possibly Leverage
Axel

Pinpoint Landing



Technology
Advancement
Required

SUPERCAM



Potential Instruments

For more information, please see our 1-pager at:
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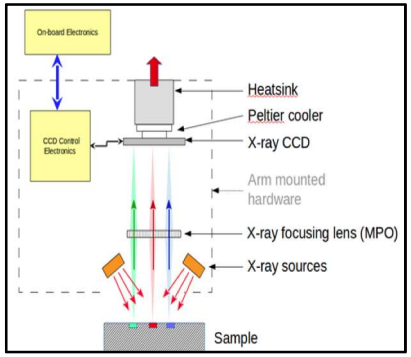
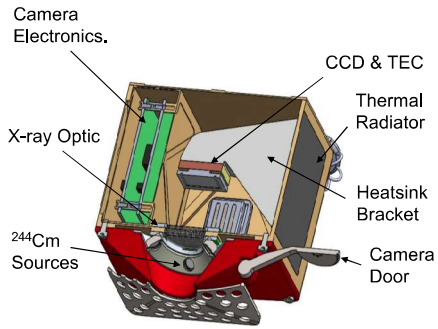
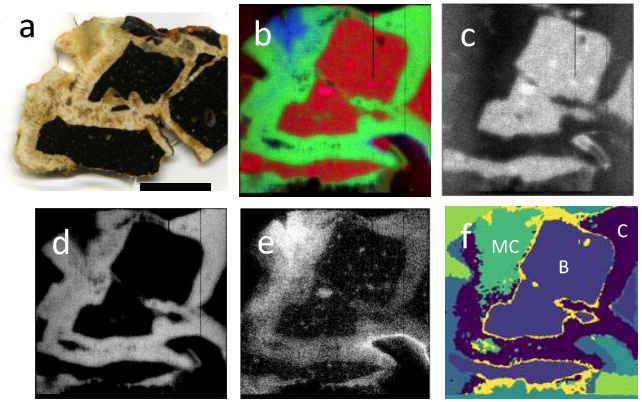
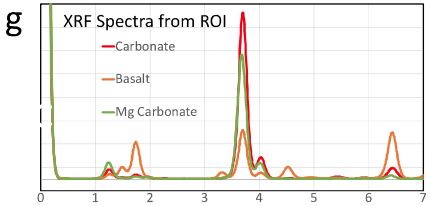
MapX: An In-situ X-ray µ-Mapper for Habitability and Biosignature Studies

David Blake, Ames Research Center









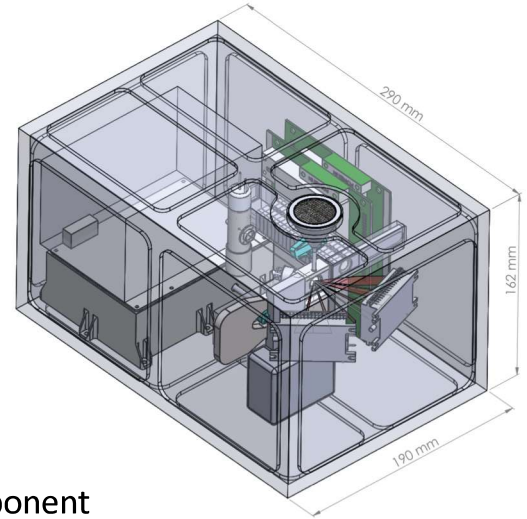
MapX: An "imaging APXS" or "imaging PIXE" instrument

- 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

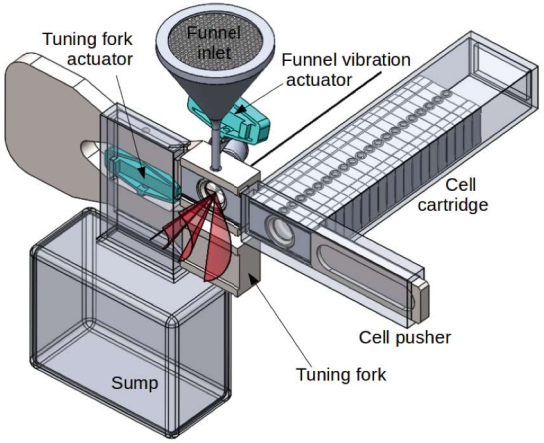
CheMinX: A Next Generation XRD/XRF for Mars Exploration

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, trioctrahedral/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**

Anna Mittelholz (amittelh@eoas.ubc.ca)

Mars' Ancient Dynamo and Crustal Remanent Magnetism

Currently with: J. E. P. Connerney, J. R. Espley, R. Fu, C. L. Johnson, B. Langlais, R. J. Lillis, A. Morschhauser, T. Ravat, F. Vervelidou, M. Volk, B. P. Weiss

Towards new science opportunities exploring the martian magnetic field

Questions

Nature of martian crustal remanent magnetism?

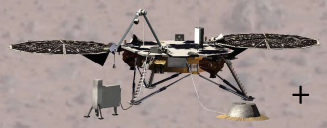
Magnetization acquisition processes?

Characteristics of the martian Dynamo?

Available Data / Current Limitations

Resolution!

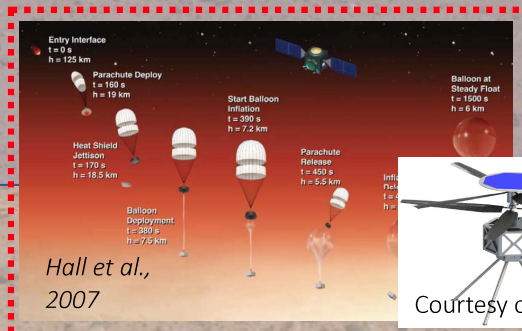
Geological Context?
Sparse sampling!



+ 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.



Hall et al., 2007

Courtesy of JPL

(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.